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Knowmads as Possible Mutants of Knowledge Workers in the Brave post-COVID World

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Abstract: The purpose of the present study is to capture the specific forces that are intensifying in the COVID-19 context, which stimulate the adaptation of some knowledge workers characteristics into mutated traits – the traits of knowmads. Also, the present study aims at exploring how this transformation is presented in the literature. Defined by John Moravec, the term "knowmad" describes those workers that stand out by being proficient in working with anybody, anywhere, at any time. As an autonomous knowledge worker apt to develop business ecosystems in real, virtual, or hybrid working environments, knowmads are not confined to employees of a single organization. A steady evolution in this respect has been visible for the last decade already. Still, it accelerated during COVID-19 pandemics, due to the global economic crisis. Studies show that the trend will continue to develop in the post-pandemic environment, as the prevalence of flexible, remote work during pandemics has increased from a niche occurrence to a widespread practice over the past nearly two years. Because of the COVID-19 pandemic, an unprecedented number of employees worked from remote locations, on flexible schedules, and were not under the direct control of their supervisors. This study aims to explore and capture the main forces powered by COVID-19 pandemics, which stimulated the change of certain knowledge workers characteristics into a mutation towards knowmads characteristics. The authors implemented a critical literature analysis, and a computer-aided bibliometric analysis performed with the help of VOSviewer version 1.6.17 software. Findings demonstrate that the COVID-19 context boosted the transformation of the knowledge workers into knowmads, and the process is not going to end soon. Also, the search performed with VOSviewer shows a significant absence of knowledge concerning the transformation of corporate knowledge workers into self-managed knowmads.

Keywords: knowmad, post-COVID world, knowledge worker, mutation

1. Introduction

Judging by its unprecedented reach, lasting presence, and multilayered impact, COVID-19 is an outlier, a historical action of crisis able to determine a cascade of reactions in all strategic fields of economics, business and social life (Baba et al., 2020; Bratianu, 2020; Bratianu and Bejinaru, 2021; Kumudumali, 2020; McKibbin and Fernando, 2020; Taleb, 2008). In January 2022, a little over two years after the presumed start of the COVID-19 global epidemics, there were more than 298 million confirmed infections of COVID-19 (www.covid19.who.int). It will prove difficult for specialists in various domains to match the impact of this disruptive event to any other similar event in the recent known history. Even though different parts of the world population often face contagious diseases, no other epidemic imposed similar governmental measures as the COVID-19 pandemics did in most of the world's countries. As the World Health Organization (WHO) defined and imposed strict rules to limit the spread of the virus, such as social distancing and prolonged periods of individual and community isolation, multiple domains have been affected drastically in their activities and processes (Baldwin and Weder di Mauro, 2020; Hasanat et al., 2020; Marcão et al., 2020; Ozili and Arun, 2020; Thumiki and Jurcic, 2021; Wang et al., 2020).

The COVID-19 pandemic appeared in China's health system, and then it spread worldwide at an accelerated speed due to globalization. Immediately, the effects of the health systems crisis were made visible in the economic field as the economic activity decreased following the constraints implemented to reduce the spread of the virus. The need for introducing social distancing generated an economic gap between producers, products, and customers, which developed a new business environment (Alvarez, Argente and Lippi, 2020; Aun, Lee, and Shin, 2020; Baldwin and Weder di Mauro, 2020; Chang and Velasco, 2020). Regarding the work-life changes, multiple authors agree that decision-makers and managers faced the tacit requirement to overcome the knowledge gap and help their companies adapt to the new normality of the dynamics of the post-COVID-19 pandemic by developing new knowledge pillars capabilities and emergent knowledge strategies (Bolisani and Bratianu, 2018; Garcia-Perez et al., 2020). In the new reality, both employers and employees faced the unknown, forcing them to put their old ways to the test and undergo specific transformations. Slowly, as isolation at home

became the norm, for the professions allowing it, remote working far from a manager daily, direct supervision became the go-to solution (Ale-Chilet, Atal, and Dominguez, 2020; Alvarez, Argente, and Lippi, 2020).

The remote working for knowledge managers revealed the possibility of getting more liberty in structuring their working programs and in developing their creativity for solving complex problems. Moreover, the pressure of the managerial control decreased, and the feeling of more liberty in the daily program and solution searching increased self-confidence and the level of risk acceptance. Teleworking allows for a new work-life balance (Belzunegui-Eraso and Erro-Garces, 2020), and for a new knowledge entropy of the organizations (Bratianu, 2019). A dramatic consequence of the COVID-19 pandemic is the increasing unemployment rate in the U.S. and European economies, especially among the young generation (Andriyev et al., 2021; Ice et al., 2021; Lambovska et al., 2021; Su et al., 2021). To reduce the pressure of uncertainty generated by the labor force dynamics during economic crises and enjoy the new work-life balance, many knowledge workers decided to work as independent professionals in the remote work system based on their digital competencies. Another phenomenon that attracted the attention of researchers is the "anti-work movement". That phenomenon "reflects millions of workers who have given up their jobs and want to see a new meaning in work and organizations supporting this personal aspiration" (Rocha et al., 2022, p. 2).

This transformation process of knowledge workers from employees of different companies into independent professionals, based on their digital competencies and their desire to eliminate the managerial control pressure practiced in many companies, generated a new typology of knowledge workers called *knowmads* by Moravec (2008). A *knowmad* is defined as "a nomadic knowledge worker – that is, a creative, imaginative, and innovative person who can work with almost anybody, anytime, and anywhere" (Moravec, 2013b, p. 9). Considering an analogy frequently used in science fiction, we may call these knowmads as possible mutants of knowledge workers in a new business environment defined by volatility, complexity, uncertainty, and ambiguity (VUCA) (Mack et al., 2016). However, this mutation process is in its developing stage, and the research focusing on it is scarce. Therefore, understanding it could be a challenge for us, and thus, we formulated the following research question:

RQ: What main forces, intensified in the COVID-19 pandemic, determined many knowledge workers to become knowmads?

Trying to find some answers to this research question, we explore the literature dedicated to knowledge workers and to knowmads reflecting on those forces which stimulate the transformation of some knowledge workers into knowmads. Also, we analyzed many published works contributing to the COVID-19 pandemic literature to understand how those forces were amplified as a result of government interventions in most countries to flatten the epidemiological curve. In parallel with the literature review, we performed a bibliometric analysis using VOSviewer, a professional software application, for finding the semantic clusters which contain the main concepts for this topic and the links density between them (Donthu et al., 2021; Van Eck and Waltman, 2010, 2011, 2020, 2021; Zupic and Carter, 2015).

The structure of the present paper is as following: after this short introduction, the key concepts and ideas for this research are presented as a result of the systematic literature review. We explain the methodology used and then we present the results and discussion. Finally, there are conclusions and limitations of the present study.

2. Literature review

The knowmad worker concept is a relatively new one, and it makes the subject of interest of many researchers and practitioners of the knowledge management field. The concept and its semantic field were introduced by John W. Moravec (2008) and further developed into dedicated field of the knowledge management literature (Bratianu, Iliescu and Paiuc, 2021; Cobo and Moravec, 2011; Iliescu, 2021a, 2021b, 2021c; Kubik, 2013; Moravec, 2008, 2013a, 2013b; Moravec and van den Hoff, 2015; Orel, 2019, 2020). The complexity of the post-COVID business environment shows that knowmads may constitute some mutants of the knowledge workers capable of better adaptation to the new normal. The concept of "new normal" has been used previously for describing the climate changes, but in the post-COVID context, it is used to show that the complex crises generated by this pandemic are irreversible processes with many residual changes. Understanding these changes will help managers develop emergent strategies that can revitalize their businesses. According to Harilal (2020), the COVID-19 pandemic "has caused major ruptures in the world system, which has serious implications for global

capital accumulation. It, therefore, presents an opportunity to reimagine the global division of labor and the international economic architecture" (p. 14). Knowmads represent one of the new trends in this global division of labor that influence both the managerial practices within the knowledge-intensive businesses and the new sharing economy platforms for knowmads with short-term contracts and the needed competencies for performing specified jobs.

Moravec (2008, 2013a, 2013b) indicates that a knowmad is a knowledge worker who can collaborate with any person, at any hour and from any location. Knowmads are descendants of knowledge workers who seek a new degree of autonomy by leaving behind the traditional gravitational pull of corporate life and carving out their tailored route in the economic world. Compared to knowledge workers, the knowmads are escaping the grip of the organizational limitations. They are becoming autonomous and setting up an entrepreneurial climate inside or outside organizations, in physical, virtual, or hybrid environments. These are the main traits which define the mutation process from knowledge workers to knowmads because the transformation of their mindset is irreversible.

On the other hand, Peter Drucker's knowledge workers (1969, 1993, 2001, 2008) are portrayed in the literature in opposition to industrial workers. They are individuals with extensive training or experience in their field of activity, capable of creating, sharing, and using knowledge (Davenport, 2005; Liu, 2020; Massingham, 2020; Nonaka and Takeuchi, 1995). Given the large-scale reality of that period, the different economic environment, and softer market competitiveness, knowledge workers did not hold the knowmads skills, essential today. In other words, the knowmads are a new generation of employees that have developed from the ranks of knowledge workers as vanguards prepared to prosper in a sophisticated and internationally encompassing knowledge economy (Iliescu, 2021a, 2021b). They fit very well with the requirements of knowledge-intensive business services (KIBS) (Zieba, 2021).

In this post-COVID brave new world, the knowmad worker aims to re-interpret his/her reality and re-contextualize his/her work (Moravec, 2013b). From the physical coordinates, such as the geography or work schedule, and up to their cognitive capabilities, the knowmads will design innovative and inventive solutions to a wide range of complicated challenges specific to the VUCA business environment, characterized by volatility, uncertainty, complexity, and ambiguity (Mack et al., 2016). VUCA is the context where autonomous, creative, and courageous knowmads thrive, as they are showing increased resilience, better adaptation strategies than their predecessors and more competitiveness on a global hyper competitive market (Cobo and Moravec, 2011; Hokanson and Karlson, 2013; Moravec, 2008, 2013a, 2013b; Moravec and van den Hoff, 2015). We can understand how, "knowmads represent both a consequence of the continuously changing technological and social environment and a solution to the volatile business context that these forces create because they are holding the key skills and competencies required by the job market" (Iliescu, 2021a, p. 106).

The post-modern work bricolage that knowmads are self-designing could be explained with the help of the job crafting concept, which is a relatively recent one as well (Bakker and Demerouti, 2007; Demerouti et al. 2001; Grant et al., 2010; Lyons, 2008; Tims and Bakker, 2010; Tims, Bakker and Derks, 2012; Wrzesniewski and Dutton, 2001). According to Wrzesniewski and Dutton's definition (2001), job crafting represents the customization of work implemented by individuals - they can design and arrange their work responsibilities, relationships, and knowledge in a personally meaningful fashion through job crafting processes. Job crafting is based on a personal vision of the evolution of the job market and a better understanding of the customers' behavior in the post-COVID new brave world facilitated by customer knowledge management. Enabled by the increased power and control over their work, the main advantage that job crafting brings to individuals is adding more value and meaning to their tasks and activities. Upcoming authors studying the concept are also considering the scenarios where, for example, job crafting can represent the process of skills acquisition and professional development that are not imposed or supported by the employer (Lyons, 2008). The concept can be best understood with the help of the job demands-resources (JD-R) model (Bakker and Demerouti, 2007; Demerouti et al., 2001). Based on it, Tims and Bakker (2010) define job crafting as utilizing all the permutations that the worker is applying to his/her work activity with the final aim to balance work requirements and resources – on the one hand – and individual competencies and values – on the other hand. Driven by their values of professional excellence but also personal fulfillment, knowmads become geographical and occupational nomads of knowledge (Cook, 2020; Horwizt et al., 2003; Kakiyama and Sørensen, 2001; Lee-Kelley et al., 2007; Nelson and McCann, 2010). Therefore, according to Bratianu, Iliescu, and Paiuc, "this new vision of the professional life requires new competencies like

self-management and cultural intelligence, mainly when the work implies collaboration with people from different cultures” (2021, p.90).

As we advance in the late and post-pandemic environment, increasingly more work market trends indicate a progressive shift in the workers' preferences towards knowmad-specific work behaviors (Andriyiv et al., 2021; Rocha et al., 2022). The most significant clues lay in the findings of large-scale corporate studies implemented over the past two years or more. The first hints of democratized wishes for more independence, a healthier work-life balance, the desire for a decentralized workplace, as well as a major preference for a flexible office amongst employees can be seen here. Employers seem to be also - to a certain extent – open to developing and integrating new tactics for adjusting their workplaces to contemporary and more agile ways of working (Deloitte, 2021; EY, 2021; McKinsey, 2021).

Further to the "Work Reimagined Employer Survey", Ernst & Young (EY, 2021) analyzed responses of more than 16,000 respondents across 16 countries, representing different industries. Findings indicate that employees' preferences regarding the future of work are changing, and employers' reactions should not delay meeting them. Therefore, while up to 90 percent of employees responded that they are looking for flexibility regarding the place and schedule of work in the post-pandemics' aftermath, less than half of the employers (40%) announced their plans to the employees, and up to 35 percent of employers are keen on having their teams back into the offices after the pandemics. Most of the employees from the last group have their jobs in fields where physical presence is necessary. Fine-tuning between the two groups' views is recommended, as 54 percent of respondents indicated they are ready to quit their current jobs if not provided with the desired flexibility (EY, 2021). The study identifies three typologies of respondents based on their feedback to critical questions: hybrid hopeful, office optimal, and remote ready. While the office represents the traditional work location, the remote ready category is explained by the buzzword of the present: "remote work". According to Google trends, at the date of present research (December 2021), while the interest for remote work existed, a substantial increase is visible as of March 2021.

In February 2021, McKinsey Global Institute published their research named "The future of work after COVID-19", developed over the course of multiple years of analyzing the future of work. The general conclusion of the study indicates that it is likely that not less than 25% more people than before will change their existing activity field in the context of a post-pandemic world, where remote work, automation of tasks, and electronic commerce are increasing their presence at accelerated rates (McKinsey, 2021). Extrapolated from the eight focus countries of the research (United States, Germany, United Kingdom, China, France, Japan, Spain, and India), up to 100 million workers are estimated to change their field of activity by 2030 (McKinsey, 2021). That is a significant trend for the mutation process for the knowledge workers to become knowmads, a trend with many implications for corporate management and possible new forms of virtual management for knowledge ecosystems (Bedford and Sanchez, 2021).

In their own study, "From survive to thrive: The future of work in a post-pandemic world" (2021), Deloitte focuses on companies and their survival, recovery, and thriving strategies in the COVID-19 and post-pandemic environment. Amongst others, one of the important aspects to be considered in the thriving step is the redesign of the workplace to integrate more flexibility. Deloitte's study introduces the idea of phy-gital workplace, "integrating the best of physical space with digital practice while embracing constant change" (Deloitte, 2021).

On top of the trends mentioned above regarding employees' preferences for the post-covid world, an additional knowmad's specific trait can be noticed at a larger scale. The particular ease and speed at which knowmads are changing their workplace, raising challenges for employers for a while now (Horwitz et al., 2003; Lee-Kelley et al., 2007; Nelson and McCann, 2010) can be currently seen at a large scale in the "Big Quit" or the "Great Resignation" phenomena. These expressions incorporate the meaning of a large-scale phenomenon. Identified by researchers as of mid-2021, the "Big Quit" is animated by workers from various sectors, roles, and expertise in the United States and Western Europe quitting their corporate jobs and looking for a more autonomous business environment. According to Peter B. Hirsch (2021), unhappiness related to employment circumstances has triggered a "Great Resignation" across a number of different industries. This phenomenon is convergent with the "Anti-Work Movement" (Rocha et al., 2022). Powered by the sense of freedom gained while designing their work away from crowded offices, employees developed a higher sense of autonomy, better understanding of their desires, and, most importantly, courage to seek meaningful career pathways or only quit the irrelevant ones for a while. Their thinking is dominantly nonlinear (Bratianu and Vasilache, 2009) and

probabilistic (Taleb, 2008) to better understand the complexity of the business environment. There is a significant change in their mindset and their behavior. It is a result of the mutational effect we discussed above.

Based on the above analysis, we may systematize the mutation process of knowledge workers into knowmads by identifying the main characteristics of the knowledge workers' organizational environment, the forces producing the mutation process, and the knowmads work environment as presented in Table 1.

Table 1: The mutation process systematization

Knowledge workers	Mutation forces	Knowmads
Certainty	Employment dynamics	Uncertainty
Long-term contracts		Short-term contracts
Corporate management	Managerial control	Self-management
Organizational performance		Individual performance
Rigid working program	Time management	Flexible working program
Imposed work-life balance		Chosen work-life balance
Job description	Job design	Job crafting
Constrained work framework		Work autonomy

(Source: Authors' research)

3. Methodology

Present bibliometric analysis has been implemented based on the research strategy presented in Table 2. The authors designed a bibliometric study using VOSviewer software version 1.6.17 software. They discovered research trends and patterns in peer-reviewed publications on the knowledge worker and knowmad topics, available in Scopus database. Following the logic of the research question, a mix of three text mining analyses have been run. The reasons for this approach include the up-to-date process supported by cutting edge technology, the academic field recognition of the method, and the option that bibliometric analysis software enables to sketching a unified and comprehensive visual overview of the researchers' contribution to a specific topic (Donthu et al., 2021; Janik et al., 2020; Janik et al. 2021).

Table 2: Research design

Step	Activity
Step 1: Defining the methodology of the research	1.1. Defining relevant search phrases for the study. 1.2. Defining relevant database considering available publications. 1.3. Defining relevant search parameters and analysis periods 1.4. Defining relevant export features from the selected database.
Step 2: Data definition (preparatory step for the analysis)	2.1. Gathering outputs obtained further to Step 1 parametrizations. 2.2. High-level data assessment. 2.3. Second run and in-depth data screening. 2.4. Establishing study's database list and export in a suitable format for computer-aid analysis.
Step 3: Uploading refined data into the bibliometric analysis software	3.1. Bibliometric analysis of refined data via VOSviewer version 1.6.17 software. 3.2. Building the visual mapping of analyzed data.
Step 4: Findings - presentation discussions	Examining and discussing the research findings.

(Source: Authors' research)

3.1 Step 1 - Defining the methodology of the research

The data for the study has been downloaded from peer-reviewed journals available in the Scopus database. Scopus is one of the most recommended sources for bibliometric analysis (Janik et al., 2021). The search terms have been decided: "knowmad*" and "knowledge worker*" and "knowledge worker* & covid*", and "knowledge workers and knowmads". These search terms have been defined such that the bibliometric analysis will reveal those papers having in their titles and keywords these constructs, among others which contributed to the cluster formation. This analysis aims to map all clusters that integrate semantic fields related to the search terms. The analysis of these clusters helps us understand how researchers studied the mutation phenomenon of knowledge workers into knowmads and the knowledge gaps associated with it. Also, in the next steps, we

read each paper containing the search terms to understand the main ideas and to integrate them in the whole analysis.

All publications containing singular or plural forms of "knowledge worker*" structures were retrieved. This feature has proven helpful for novel concepts like the knowmad concept and more popular ones, like knowledge worker or COVID-19. It ensured us that all variations on the root of these ideas are captured from early stages. All types of publications available on the platform up to date of research (2 December 2021) have been considered eligible, with no restriction on the subject areas. Main reason behind this choice is explained by the fact that knowledge worker, knowmad, and COVID-19 concepts are transdisciplinary, relevant for all research areas.

Temporal minimum and maxim dates of publication have been established for each of the concepts to accurately identify the forces behind the knowledge workers' mutation into knowmads in the COVID-19 context, as follows:

- "Knowmad*": 2013 (date of first publication available on Scopus) – 2 of December 2021 (current research date).
- "Knowledge worker*": 2020 – 2 of December 2021 (current research date).
- "Knowledge worker* & covid*": 2020 (date of first publication available on Scopus) – 2 of December 2021 (current research date).
- "Knowledge worker* & knowmad*": 2013 – 2 December 2021 (like for "Knowmad*").

We see how we defined relevant timeframes for our search terms in this first research step. First, the timescale of publications on the knowmad concept has been focused on the 2013 (year of the first publication available on the database) – 2021 interval. This is helpful because it lets us capture all relevant nuances of the knowmad concept, as known in the publications accessible via the Scopus database.

Second, as regards the knowledge workers concept, following the logic of the research question, we manually restricted the timeframe of research to the period when the effect of the COVID-19 pandemic could have become visible in research papers and peer-reviewed publications. The main objective is to identify possible mutations that knowledge workers have suffered during the COVID-19 pandemics.

Another important argument supporting the limitation of the publications' timeframe of the knowledge worker concept in the database search is represented by the enormous number of publications on this topic. When we considered all-time publications on this topic, we found more than 6,000 documents with thousands of keywords. Moreover, considering the yearly distribution of the publications, we quickly understood the noise risk for our analysis, considering that the relevant publications for the COVID-19 context (596 publications for 2022, 2021, and 2020) represent only 10 percent of the total amount of publications (6,253 publications for the rest of the years) as captured in Table 3.

Table 3: "Knowledge worker*" publications available on Scopus database, all years.

Year	Publications
2022	2
2021	319
2020	275
2019 - 1973	6,253

(Source: Authors' research. Scopus database at 02 December 2021)

Third, to identify the most relevant nuances of the knowledge worker literature in the COVID-19 context, we defined a third search term, "knowledge worker* & covid*" to compare and refine our findings. The purpose of this third search and analysis is to help us focus on even more specific nuances that might be missed in the larger threshold of documents and terms identified in the second research (a total of 596 publications for "knowledge worker*" term search). The search for the "Knowledge worker* & Knowmad*" had the purpose of identifying the interest of researchers for this link and transformation. The search revealed only 5 papers where these concepts appeared together, a situation that demonstrates a lack of interest in this connection between the two concepts.

3.2 Step 2 - Data definition (preparatory step for the analysis)

The previous step revealed 15 publications for “knowmad*” search item, 596 for “knowledge worker*” and 32 for “Knowledge worker* & covid*”. These values were considered for the first publications data cleaning, where we aim at focusing on complete publications, having their title, keywords, and abstracts available in English. Enabled by this objective, we removed one, four, and two publications from each group that did not meet our criteria. Next, those publications identified as thematically inconsistent were removed after a more in-depth review, eliminating four more publications from our “knowledge worker*” analysis threshold.

3.3 Step 3: Uploading refined data into the bibliometric analysis software

VOSviewer software version 1.6.17 enables researchers to implement a variety of analysis routes, such as term co-occurrence analysis focused on terms. The full counting option has enhanced this. In this context, a final data cleaning step is required, this time aimed at terms (Van Eck and Waltman, 2020).

Therefore, the authors excluded all terms related to research methodologies, authors, and very general terms from the relevant threshold of terms for analysis. This step allowed us to reduce the noise of the bibliometric study and provided us with direct access to research trends and correlations of novel yet complex concepts. Furthermore, to ensure a clean aspect of the findings, similar relevant terms have been harmonized into the larger concept that they belong to.

As mentioned in previous such studies (Iliescu, 2021c), one can erroneously let the quantitative ratio of terms guide the research. However, many of the most common terms can prove not relevant for the specific nuances of the research topic. Therefore, terms data cleaning is paramount in such endeavors.

4. Results and discussions

The VOSviewer program yields clusters which contain related constructs and show how those clusters integrate into the whole semantic map. Thus, we present in some tables the program's results structured on keywords, clusters, occurrences, links, and links' strengths. The only intervention we may have is to suggest a name for each cluster. We selected the first keyword as a label for the whole cluster. We can only interpret these data without having the liberty of restructuring them.

We have chosen to consider all terms for the knowmad concept analysis and not only those with a minimum number of occurrences (i.e., 5) due to the novelty of the concept. As presented in Table 4 below, most of the relevant terms have less than five occurrences, yet they represent essential components of our analysis. As such, for the knowmad concept, out of the total 80 initial terms, after data cleaning of terms, we obtained 28 unique and relevant words, grouped in 6 clusters, having 94 links and a total link strength of 108 for our terms co-occurrence analysis.

Table 4: Knowmad concept clusters by VOSviewer 1.6.17, after terms data cleaning.

Keyword	Cluster	Occurrences	Link	Link strength
Innovation; globalization; character strengths; cognitive values; creativity; grit; persistence	1 - Innovation (red)	3; 2; 1; 1; 1; 1	13; 12; 6; 6; 6; 6	13; 12; 6; 6; 6; 6
Education; learning; knowledge; competencies; information communication technology; leadership; sustainable development	2 - Education (green)	4; 3; 3; 1; 1; 1; 1	15; 10; 9; 4; 4; 2; 2	19; 13; 10; 4; 4; 2; 2
Digital nomadism; labor culture; collaboration; wellbeing economics; work-leisure relations	3 - Digital nomadism (dark blue)	3; 2; 2; 1; 1	10; 7; 7; 2; 3	11; 8; 7; 2; 3
Social changes; computer applications; social skills; holistic education	4 - Social changes (yellow)	4; 3; 2; 1	10; 6; 2; 5	15; 9; 4; 5
Knowmad; multicultural literacy; motivation	5 - Knowmad (purple)	6; 2; 1	15; 7; 2	21; 8; 2
Change management; value creation	6 - Change management (light blue)	2; 1	7; 4	8; 4

(Source: Authors' research)

While the bibliometric analysis software has determined the cluster and the terms distribution, the cluster labels have been chosen by the authors following the term that had the most occurrences for each cluster: Innovation (cluster 1), Education (cluster 2), Digital nomadism (cluster 3), Social changes (cluster 4), Knowmad (cluster 5) and Change management (cluster 6). Occurrences show how many times a concept appear in the searched publications. The higher the value, the more attention that concept received from researchers in connection with the searched item "Knowmad". Links show how many connections an item (i.e. a concept) has with other items. For instance, "Knowmad" has 15 connections with all the other mapped concepts, while "Multicultural literacy" has only 7, and "Motivation" has 2. Link strength is a number computed by the software based on the number of occurrences and the distance between two items on the map. The higher the link strength, the higher the interest for researchers to study those items connected by the respective link. The links strength values reveal the total occurrences of an item across all publications analyzed (Van Eck & Waltman, 2020) and the weight its links have in the relationships established with other items (Van Eck & Waltman, 2021). In other words, when enabling a co-occurrence term analysis as we did, the link strength values indicate the full count of documents where the reference term appears simultaneously with other terms from the analysis database. Moreover, the link strength value has a direct representation in the maps indicated by the size of each concept's sphere and the distance between different concepts – this shows the nature of their direct correlation (Van Eck & Waltman, 2010). Therefore, the link strength can indicate the concepts' affinity to one another, as a more significant value suggests a higher connection with other concepts in the cluster. As such, link strength values are helping us understand the conceptualization of the "knowmads" item in the studied publications. Looking for the values in the column of Link strength, we realize that "knowmad" has a quite high value by comparison with the other items, which demonstrates an increasing interest of researchers in studying its semantic connections with other concepts.

Comparing the information from Table 1 and Table 4 shows that the mutational forces yield new features for knowmads. Employment dynamics (Table 1) is associated with globalization, digital nomadism, labor culture, collaboration, and social change (Table 4). Managerial control (Table 1) is associated with leadership, wellbeing economics, change management, and value creation (Table 4). Time management (Table 1) is associated with character strength, grit, persistence, work-leisure relation, and multicultural literacy (Table 4). Job design (Table 1) is associated with creativity, cognitive values, knowledge, competencies, and computer applications (Table 4). Also, forces mentioned in Table 1 can be associated with motivation, education, and holistic education (Table 4). All of these connections contribute to a better understanding of the changing process from knowledge workers to knowmads, although they focus on the final results and not on the whole mutation process, that remains a challenge of our interpretation.

Van Eck and Waltman (2020, 2021) explained that the visual distribution is directly related to the link and link strength values. As such, the higher the number of correlations between terms, the higher the value of their links and the closer to terms are on the visual map. Therefore, while the "knowmad" concept is placed at the relative center of the map, it is equally close to the transformational forces that we identified above. An important note would be that in the knowmad literature, education often relates to a holistic, informal, and continuous education, even accessible free of cost. In other words, knowmads' education, until designed specifically for the future requirements of the job market, is often a synonym of knowledge sharing networks that individuals create in virtual or hybrid environments in order to foster their skills and competencies.

Another interesting term highlighted by our analysis is the "labor culture" that has the second most powerful values in its cluster (cluster 2 – Education) and indicates that the philosophy of work itself, that knowmads tend to redefine in their self-creation and self-management processes.

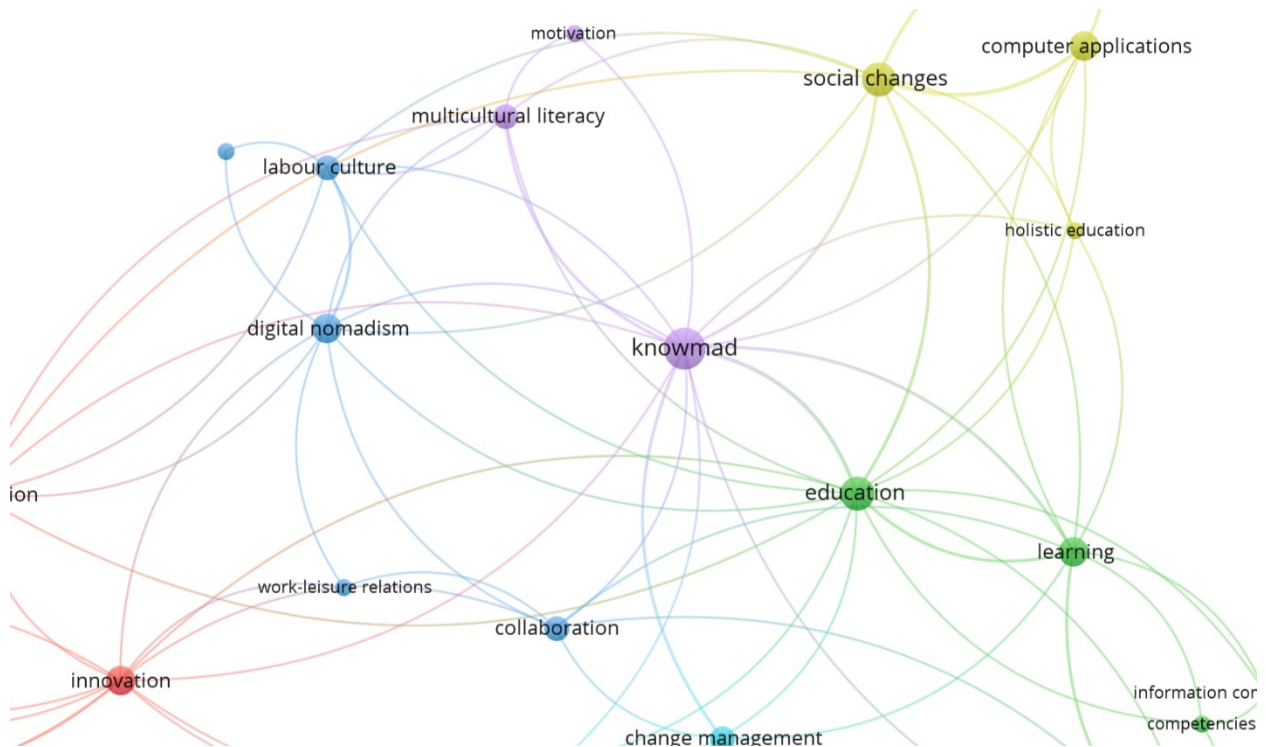


Figure 1: Network visualization by VOSviewer software version 1.6.17 for knowmads concept.

(Source: Authors' research)

Regarding the "knowledge worker*" search term, the initial 3,822 terms identified have been restricted to the 126 terms with a minimum of five times occurrences. Therefore 126 terms resulted, and they have been subject to terms data cleaning unifying similar terms, and removing irrelevant terms for conceptual analysis. After data cleaning of terms, we obtained 32 unique and relevant terms, grouped in 6 clusters, having 261 links and a total link strength of 846 for our terms co-occurrence analysis, presented in Table 6 below.

We notice how immediately after "knowledge worker", "knowledge management" and "knowledge work", the highest values in the occurrences, link, and link strength fields are registered by knowmad-specific ideas, such as "working from home" or "telecommuting", "work-life balance" or "wellbeing". The context for this shift of interest is, of course, the "COVID-19" context, powered by the rise of "digital technologies", "information communication technology" and "artificial intelligence". "Competition" is another incentive that is recently bringing much attention towards "productivity", "performance," and "personal knowledge management" of knowledge workers, just as it usually does for knowmads.

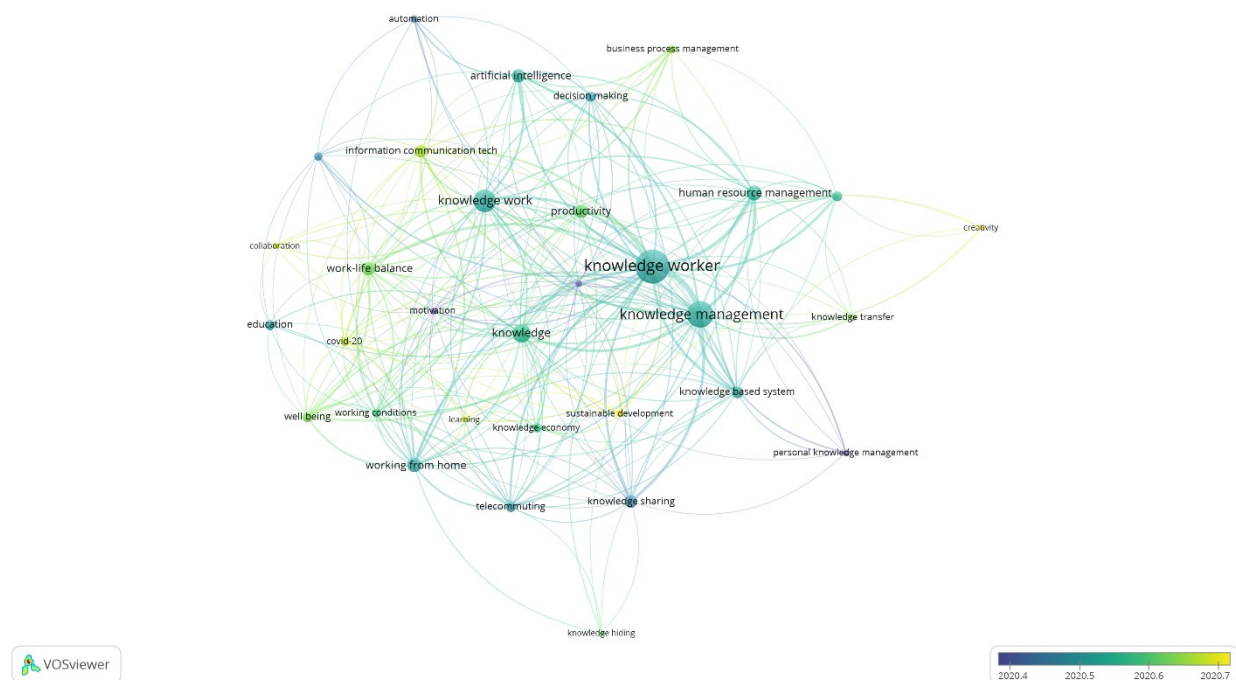
The bibliometric analysis results reveal how the knowledge workers are forced to transform and adapt in the COVID-19 context to stay relevant in a new, competitive job market shaped by technological advances and disruptive changes. Knowledge workers face a "work-life balance" dilemma, further to the imposed, long-term telecommuting experience. As such, they are presented in the literature as promoters of flexible working setups, similar to knowmads, as indicated by findings grouped in cluster 1 - Working from home. In cluster 5 we see another interesting phenomenon: the opposition between "knowledge hiding" and "knowledge sharing". Traditionally, as Davenport (2005) showed, knowledge workers generations were more likely to hide their knowledge. However, in the research papers published as of 2020 and indexed in the Scopus database, we see how the "knowledge sharing" concept's popularity is much higher than the one of "knowledge hiding". This represents another mutation of knowledge workers into knowmads, in the context of increased information sharing via "digital technologies" and "information communication technology".

Table 5: Knowledge worker concept clusters by VOSviewer 1.6.17, 2020-2022, restricted to minimum 5 occurrences after terms data cleaning.

Keyword	Cluster	Occurrences	Link	Link strength
Working from home; work-life balance; well-being; working conditions; COVID-19; digital technologies; motivation; education; collaboration	1 - Working from home	33; 29; 16; 12; 12; 13; 8; 16; 6	24; 22; 17; 18; 18; 14; 15; 9; 8	79; 64; 50; 42; 35; 22; 22; 12; 11
Knowledge worker; knowledge management; human resource management; knowledge-based system; performance; personal knowledge management; knowledge transfer; creativity	2 - Knowledge worker	189; 112; 37; 23; 18; 7; 8; 5	30; 30; 19; 23; 12; 8; 8; 4	283; 227; 83; 64; 31; 17; 14; 9
Knowledge work; information communication technology; artificial intelligence; decision making; business process management	3 - Knowledge work	82; 26; 28; 16; 11; 9	26; 19; 17; 15; 11; 9	104; 55; 54; 39; 24; 17
Knowledge; telecommuting; competition; knowledge economy; sustainable development; learning	4 - Knowledge	53; 18; 8; 14; 10; 6	24; 21; 28; 17; 13; 17	84; 54; 28; 24; 23; 17
Knowledge sharing; knowledge hiding	5 - Knowledge sharing	26; 5	19; 6	49; 8
Productivity	6 - Productivity	28	17	47

(Source: Authors' research)

Figure 2 below presents the “knowledge worker*” clusters and terms color-grouped by year of publication. This approach enables us to identify the most novel concepts in a literature block associated with a topic of interest.

**Figure 2:** Overlay visualization by VOSviewer software version 1.6.17 for knowledge workers' concept

(Source: Authors' research)

In our case, terms like "collaboration", "wellbeing", "learning", "sustainable development", "creativity" and "business process management" are the concepts approached by researchers in the second half of 2020 – beginning of 2021. The timeline distribution gives us an understanding of the academic interest evolution and trends.

Since we guided our previous analysis through high amounts of publications and terms associated with the “knowledge worker*” search phrase, we decided to limit our analysis threshold even more by creating a new search term: “knowledge worker* & covid*”. Out of the total 241 terms, we obtained 55 unique and relevant words after data cleaning of terms, grouped in 7 clusters, having 301 links and a total link strength of 374 for our terms co-occurrence analysis, presented in Table 6 below.

Table 6: Knowledge worker & COVID-19 concepts intersection clusters by VOSviewer 1.6.17, after terms data cleaning.

Keyword	Cluster	Occurrences	Link	Link strength
Knowledge work; social aspects; organizational ethics; information systems; digital nomadism; hypermobility; computer applications; human resource management; moral attitudes; future workplace; virtual work	1 - Knowledge work	14; 4; 3; 3; 3; 1; 1; 1; 1; 1; 1	36; 18; 17; 14; 13; 7; 6; 6; 6; 2; 1	67; 23; 21; 19; 14; 7; 6; 6; 6; 2; 1
Knowledge management; behavioral patterns; collaboration; e-democracy; face-to-virtual interaction; hybrid systems; motivation; power structures; system value; virtual reality	2 - Knowledge management	5; 1; 1; 1; 1; 1; 1; 1; 1; 1; 1	30; 10; 10; 10; 10; 10; 10; 10; 10; 10; 10	39; 10; 10; 10; 10; 10; 10; 10; 10; 10; 10
Covid-19; digital work; communication tools; virtual collaboration; agile; face-to-face interaction; affordance; smart working	3 – Covid-19	14; 4; 3; 2; 1; 1; 1; 1	43; 12; 11; 11; 7; 7; 6; 4	69; 17; 15; 13; 7; 7; 6; 4
Well-being; knowledge; telecommuting	4 - Well-being	4; 2; 31; 1; 1; 1; 1; 1	16; 17; 10; 10; 10; 10; 10; 10	23; 19; 13; 10; 10; 10; 10; 10
Experience; workplace transformation	5 - Experience	2; 31; 1; 1; 1; 1; 1	16; 14; 8; 8; 8; 8; 8; 8	18; 16; 8; 8; 8; 8; 8; 8
Remote work; work-life balance; flexible work; resilience; hybrid workplace	6 - Remote work	13; 3; 3; 2; 1	36; 16; 5; 3; 3	64; 19; 6; 3; 3
Future of work; individual factors; creativity; knowledge-sharing; perceived stress	7 - Future of work	2; 2; 2; 1; 1	14; 11; 10; 9; 4	16; 13; 11; 9; 4

(Source: Authors’ research)

By implementing this additional run, we see how entire clusters indicate the knowledge worker’s mutation to knowmads. For instance, in cluster 1 there are the following significant keywords: digital nomadism, hypermobility, moral attitude, and virtual work. Digital nomadism refers to the transformational phenomenon of knowledge workers as employees to knowledge workers as self-employed who can change the workplace, geography, and countries by becoming nomads. This mutation process contributes to developing knowmads hypermobility in time and space. Changing the status from a company's employee to self-employment means a different moral attitude and a total virtual work. In cluster 2, the mutation process's significant keywords are behavioral patterns, motivation, and system value. Knowmads have a different behavioral pattern than the knowledge workers who are long-term employees. Knowmads are self-employed and work based on short-term contracts with different companies in a global market. From this point of view, their motivation is much stronger than those who work as employees because of the higher risks of getting contracts. Their value system is different than of those who work as employees because they need full working autonomy, time flexibility, trust, and attractive problems to solve. Cluster 3 contains as significant keywords communication tools, virtual collaboration and smart working. All of these constructs show new competencies knowmads should have in order to remain competitive and successful. Cluster 4 refers to a new conceptualization of wellbeing and the availability for telecommuting. Cluster 5 reveals a workplace transformation both as content and geography, in a global market. Cluster 6 re-iterates the need for flexible and remote work, and a new work-life balance in concordance with the new value systems of each knowmad. Finally, cluster 7 suggests the importance of individual factors in this mutation process and a high level of creativity to construct solutions for any new and complex problem. Knowmads should be better prepared for knowledge sharing and perceived stress as a result of increased uncertainty and hypermobility.

5. Conclusions, implications and the limits of the study

5.1 Conclusions

This paper aims to find the main forces, intensified in the COVID-19 context, which stimulate the adaptation of specific knowledge workers characteristics into mutated traits – the traits of knowmads. Also, the paper is searching how literature reveals the process of transformation of many knowledge workers into knowmads. By implementing a systematic literature review and using VOSviewer software for data processing, we identified the main forces that enabled knowledge workers to go through a mutation process towards knowmads, during the COVID-19 pandemics. These forces are the following: employment dynamics, managerial control, time management, and job design. Employment dynamics is a phenomenon that has been amplified during the COVID-19 pandemic due to many restrictions introduced by governments to control the epidemiologic curves, like social distancing, teleworking, and closing down many businesses. The dramatic increase in the unemployment rates in U.S. and European economies stimulated many knowledge workers to become self-employed, changing the long-term working contracts with short-term ones. The managerial control force, which puts a lot of pressure on employees to contribute to the organizational economic performance, determined many knowledge workers to choose self-management and look for individual performance metrics. Related to this change is the force of time management that offers to knowmads a flexible working program and the liberty to realize a new work-life balance. This change has been accelerated by the teleworking solutions found during the COVID-19 pandemic. Finally, the force of job design made the transformation of a constrained job description and rigid requirements into a job crafting and work autonomy situation. Job crafting constitutes a powerful motivation for many knowledge workers because it allows a sustainable convergence between individual competencies and job requirements.

The bibliometric analysis performed with the Vosviewer software helps us in learning how the literature reveals this process of transformation of many knowledge workers into knowmads. Using metaphorical thinking, we call this process a mutation because it is almost irreversible. Once the knowmads enjoy the freedom of self-management, flexible working programs, new work-life balance, and full work autonomy, it is hard to go back to accepting a corporate status again. Figure 1 shows us all the most important concepts linked to knowmad, and all the main semantic clusters we may have. Table 4 offers details concerning the values attributed to these items' occurrences, links, and links strengths. Looking more closely, one may remark the main concepts searched in relation to the knowmad and published in the journals indexed in Scopus. Thus, researchers can learn about digital nomadism, education, collaboration, work-leisure relations, labor culture, multicultural literacy, social change, learning, and change management. These findings can be connected to specific traits of knowmads like digital competencies, social intelligence, emotional intelligence, cultural intelligence and change management. The search for "knowledge worker & covid-19" shows in Table 6 new features of the forces that accelerated many knowledge workers' transformation into knowmads.

Until now, knowmads represented a niche, trans-generational workers group, bravely surfing the global job market, relying on their capacity to re-construct their knowledge at fast paces, on their self-management skills, creativity, and multicultural literacy. Nevertheless, during COVID-19 pandemics, the democratization of knowmad philosophy towards work started to be visible. Therefore, the initial office knowledge workers, who enjoyed secured working arrangements, began to adapt to the disruptive and insecure reality. As shown by the results of our literature analysis, knowledge workers enabled the perks of digitalization and virtual collaboration tools to gain more independence and flexibility in their careers. Moreover, just like knowmads, they are empowered by the value of their knowledge, creativity, and individual assets and started to embrace the idea of flexibility and independence associated with work.

From the knowledge management perspective the transformation process of knowledge workers into knowmads has some significant implications on the whole dynamics of management and organizational behavior. Knowmads leave the companies to work independently. That means a serious human resources loss for the companies, and a change in the organizational knowledge entropy. From knowmads perspective, there is a significant increase in knowledge sharing and knowledge creation. Also, knowmads should develop new knowledge strategies, with the stress on emergent strategies.

Why it is important to study about knowmads and their relationship with the knowledge workers? Because it is a real phenomenon that has been amplified by the COVID-19 pandemic and it will continue to develop in the

post-pandemic new normal. Knowmads will challenge the corporate management and will request new forms of virtual management which already can be seen in the new sharing economy. Also, knowmads demonstrate that space and time are not anymore barriers in the global business and that instead of having job designs by corporate management, knowledge workers can enjoy job crafting environments and new work-leisure balances. They will induce changes in social life and business education.

The contribution of the present study consists in performing a critical literature search for exploring the forces which contribute to the transformation of many knowledge workers into knowmads. Because this transformation looks to be irreversible, we introduced the analogy with a mutation process that yields some specific attributes for knowmads. Both the critical literature search and the VOSviewer analysis show a clear trend of corporate knowledge workers' transformation into free knowmads capable of working from everywhere, at any time, and with anybody based on new managerial philosophies.

5.2 Implications

For researchers, the main implication is to focus on the transformation process of employed knowledge workers into self-employed knowmads, a process that can be metaphorically considered as a mutation process. It is important to understand the forces that power that process and the traits knowmads should have, for both the business environment and business education. The present analysis showed a significant absence of knowledge concerning knowmads and how they will change the business environment by creating new ecosystems based on the information technology infrastructure and contributing to the digitalization processes. The fact that VOSviewer searched for "knowledge worker* & knowmad*" founding only 5 publications demonstrates the need to focus on this research area. For practitioners, the implications are in understanding the new rules of the game and the mutations in the whole business environment. Also, it is important to develop the competencies for job crafting and the new work-leisure balance.

5.3 Limitations

The potential limitations of the present study reflect that both knowmads and COVID-19 concepts are relatively new notions that have been introduced into the literature. As a result, the knowmads occur in just a limited number of articles indexed in Scopus and a few proceedings and book chapters. While the academic interest in the COVID-19 crisis provides larger volumes of resources, specific effects of this particular phenomenon are still due to be experienced and understood. Finally, as proven by the findings of this research, the knowledge worker concept is currently a fluid one, shaped by disruptive forces like digitalization, automation of tasks, fierce global competitiveness, continuous learning and development, and evolution of organizational power-distance reports. The relatively small number of publications dedicated to knowmads and their mutation traits make it difficult to reach solid conclusions. Also, it is necessary in further research to apply quantitative methods to get a better synergy with the critical literature search.

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Modifying Knowledge Risk Strategy Using Threat Lessons Learned from COVID-19 in 2020-21 in the United States

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Abstract: 2020 and 2021 have shown us that the likelihood of extreme events is more significant than we would have expected. Due to extreme circumstances, organizational resources are stretched to their limits, making organizations more vulnerable to attacks affecting their knowledge systems and knowledge assets. This paper conducts an intelligence-based threat assessment by analyzing published reports on events during the 2020-21 period against a set of five knowledge risks to identify threats and determine if they increase the likelihood of these risks occurring. We identify six possible changes in knowledge risk strategy to mitigate these threats: proper knowledge identification, guidelines for employee online behavior, identification and evaluation of online communication channels, re-evaluation of how work is to be performed, creation of knowledge capture processes for departing personnel, and performing a knowledge risk re-assessment. Additionally, we conclude that organizations need expertise in identifying and countering misinformation and disinformation to defend themselves from these new cyber threats.

Keywords: Knowledge Risk, Risk Assessment, Knowledge, Threats, COVID-19, Knowledge Systems, Knowledge Transfer

1. Introduction

2020 was a year of upheaval and unrest (Gat Labs, 2020) that has continued to impact us through 2021 and into 2022. COVID-19 swept the world and shut down many countries, and once it seemed that COVID-19 was receding, we were hit by the Delta and Omicron variants of the virus. In addition to COVID-19, the United States has experienced various difficulties. These include:

- Widespread civil strife with rioting in many cities beginning in the spring of 2020.
- Multiple natural disasters such as several large wildfires in California, a severe hurricane season that affected the southeast United States, and a record polar freeze that knocked out the Texas power grid during record freezing temperatures in the winter of 2021.
- A controversial presidential election.
- Multiple cyber-attacks that affected hospitals, financial systems, and production systems in food process and gas pipeline transport.
- Widespread misinformation/disinformation campaigns about the election and the COVID-19 vaccine (Parakilas, 2020).
- The great resignation during the second half of 2021 (Luze, 2021).

These events challenged our understanding of knowledge risks and threats, and our strategies and approaches for managing them. Therefore, we need to summarize what was learned about knowledge threats from 2020 through 2021 and suggest how knowledge risk strategies should be modified. Thus, our research question is: "How should knowledge risk strategies be modified based on the new knowledge threats from 2020-21?"

While businesses and organizations faced many traditional security issues during the lockdowns and other crises of 2020 and 2021 (such as log4j and SolarWinds), this paper is not about those issues. Our analysis focuses on threats we had not considered when the pandemic started. We identify these threats as:

- Increased frequency of misinformation

- Increased frequency of disinformation
- Increased reliance and use of social media
- Increased social isolation of remote working employees
- Increased social justice movement
- Increased transience of knowledge workers due to the great resignation
- Increased frequency of large-scale natural disaster events

Our previous research discussed a generic set of knowledge risks and threats (Jennex and Durcikova, 2020); however, we did not anticipate how COVID-19 and the events of 2020-21 effected the above threats and ultimately knowledge risk. This paper discusses primarily the changes in frequency of these threats based on published surveys and reports focusing on the issues observed during the COVID-19 pandemic and other natural disasters in 2020 and 2021.

The rest of this paper is organized as follows: a background section that discusses terms use, COVID-19, other crises during 2020-21, and knowledge risk assessment; a section discussing the specific threat lessons learned from 2020-21; a section discussing how knowledge risk strategies need to be changed; and conclusions.

2. Background

In this section, to establish a common ground, we start with the definitions of terms used in the article. Then, we will explain the COVID-19 context that enabled new knowledge threats. To fully describe the context of our investigation, we also represent other crises during 2020 and 2021. Finally, we review the current literature on knowledge system risk assessment.

2.1 Definitions of terms used in the paper

Misinformation - is false, inaccurate, or misleading information communicated regardless of an intention to deceive. (Wikipedia, 2021a). Managing the spread of misinformation has become a contentious issue due to who decides what misinformation is, what is an opinion, and what is truth.

Disinformation - is false information intended to mislead, especially propaganda issued by an organization to a rival power or the media (Wikipedia, 2021b). Disinformation is a subset of misinformation, with the key difference being the intent to deceive.

Knowledge – is an evolving mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences into corporate decision-making (Davenport and Prusak, 1998). Knowledge is used to support decision-makers.

Knowledge Transfer - refers to the sharing or disseminating of knowledge by a knowledge creator (Alavi and Leidner, 2001). Knowledge transfer is vital in knowledge systems and relies on trusted creators of knowledge moving that knowledge to repositories where knowledge users can retrieve and use it.

Knowledge System/Knowledge-Based System – is a system that captures and uses knowledge from various sources to assist users with solving problems. These systems are primarily used to support human decision-making, learning, and other activities (Nissen, 2002).

Risk – is the net negative impact of the exercise of a vulnerability considering both the probability and the impact of occurrence (National Institute of Standards and Technology, NIST SP800-37, 2018). The negative impact of occurrence is defined in terms of the impact on the confidentiality-integrity-availability triangle. Usually, it looks at a loss or degradation of any combination of these impacts (Samonas and Coss, 2014). The impact of occurrence considers the likelihood of the risk can be broadly viewed as the likelihood of a hazard, an uncertainty, or an opportunity (Billington, 1997). Viewing risk as something more than a hazard is highly applicable to knowledge systems (Jennex and Durcikova, 2014). Additional discussions on knowledge risks come from Durst and Zieba (2019), who list 26 risks that affect knowledge and the five risks listed by Jennex and Durcikova (2020). Durst and Zieba's (2019) 26 risks are a mix of cybersecurity risks and knowledge risks, while the five knowledge risks of Jennex and Durcikova (2020) are focused solely on the misuse of knowledge as discussed by Walsh and Ungson (1991). Ultimately, the knowledge risks of Durst and Zieba (2019) and Jennex and Durcikova (2020) overlap. Further on risk, as KM relies on technologies for most KM processes, it is challenging to separate cybersecurity risks from knowledge risks (Durst and Zieba, 2019. Jennex and Durcikova,

2020). This paper discusses cybersecurity risks as aspects of knowledge risks, with the focus of the paper being on the threats that impact knowledge use. NOTE: we use National Institute of Standards and Technology, NIST, standards to define terms for three reasons: NIST standards are a partnership between academics, practitioners, and Government; the standard development process is a KM process using an expert panel to generate the standard that is then put out to the public comment before publication; and, NIST standards are available for free.

Threat – is any circumstance or event with the potential to adversely impact organizational operations (including mission, functions, image, or reputation), organizational assets, individuals, or other organizations through an information system via unauthorized access, destruction, disclosure, misinformation/disinformation, and/or denial of service (NIST, 2012).

Threat assessment - is the process of identifying threats that could cause risks to occur. Threat assessment uses as one of its tools in the process of threat hunting.

Threat hunting - is gathering and analyzing events' data, hypothesizing how the events could lead to increased risk, and testing the hypotheses (Bhardwaj and Goundar, 2019). This paper investigates data identified from the events of 2020-21 and hypothesizes how these events could increase the probability of the stated threats.

2.2 COVID-19

2020 was challenging for every country because of the global pandemic caused by COVID-19. As of August 3, 2022, the Covid-19 Healthdata reports that the United States has had 91.6 million cases of COVID-19, with 1.03 million reported deaths (IHME, 2022). Worldwide, Wikipedia (based on Johns Hopkins data) says there have been 579 million cases of COVID-19 with 6.41 million deaths (Our World in Data, 2022). To combat COVID-19, the United States and much of Europe, Asia, and Australia went through a series of shutdowns of most business and social operations. A rapid transition to online media and communication eased the problems these shutdowns created. Social media (Facebook, Instagram, TikTok, Twitter, etc.) and collaboration systems (Zoom, Teams) enabled communications between large numbers of people but with little content moderation. This leads to concerns about the spread of misinformation/disinformation and increased cyber-attacks via phishing and social engineering through social media and traditional email and text communications.

The following are some of the observed outcomes of moving business and life online:

- Workers and students spent extended time working remotely, using their private Internet connections rather than those provided by their organization or school (Kelly, 2021).
- Businesses, organizations, and schools moved business processes online.
- Payment systems went touchless/contactless.
- Tools such as Zoom and Teams were quickly adapted and used (Kelly, 2021).
- Travel and supply chains were disrupted.
- Social media such as Facebook, YouTube, Instagram, Twitter, and Tik Tok became the primary means of social interaction and sources of information.
- Most face-to-face communication outside of immediate family units ceased.

Shutdowns also led to the loss and transience of employees. Many businesses had to lay off employees when they could not continue operations. In addition, many employees left on their own during the great resignation due to burnout. This resulted in a loss of knowledge flow from departed employees and knowledge sharing among remaining employees (both face-to-face and remote). As operations are resuming, businesses are suffering from not enticing former employees to return or hire new, experienced employees, resulting in many organizations losing critical organizational knowledge. To counter the loss of organizational knowledge and knowledge sharing, organizations and businesses used knowledge systems to manage the storage, retrieval, and application of business and organizational knowledge. These knowledge systems had to be remotely accessed by employees during shutdowns. Security issues during the early part of the pandemic forced firms and organizations to defend their knowledge systems (to some degree) from cyber threats using best practices and risk assessments such as:

- Protect their boundaries, repositories, and equipment.
- Monitor for and respond to attacks and intrusions.
- Monitor and guard against phishing and other social engineering attacks.

- Be prepared for disaster response/business continuity.

Organizations and businesses also reduced risk to their knowledge systems by monitoring and guiding remote users on how to connect, what information systems to use, online behavior rules, and configuring the employees' home computers. However, businesses were unprepared for the large-scale remote access and remote system use experienced last year.

Remote work caused employees to communicate with others they did not know in a virtual environment. Virtual environments significantly reduced body language feedback and influence by organizational/corporate behavior rules with the following outcomes:

- COVID-19, social, and election misinformation and disinformation were rampant.
- Social justice, social change and upheaval have caused great uneasiness in organizations causing employees to be afraid to express thoughts or opinions for fear of being "canceled."
- Social engineering and phishing attempts have become the prevalent cyber-attack vector (Columbus, 2021).

However, 2020 and 2021 also presented organizations and companies with remote work issues and increased cybersecurity attacks and threats. These are discussed next.

2.3 Other Crises From 2020-21

COVID-19 was not the only event in 2020-21 that increased knowledge threats. The leading causes of increased knowledge threats were (1) natural disasters such as hurricanes, wildfires, and arctic cold; (2) cyber-attacks through ransomware and hastily implemented technology to support remote workers; (3) social upheaval from elections and riots; (4) misinformation/disinformation campaigns; the great resignation. These events generated more uncertainty and stress overall in organizations and individuals than had been previously experienced since perhaps the great depression. The uncertainty associated with knowledge use is one of the biggest challenges a knowledge system manager faces. This uncertainty can stem from rapidly changing technology and storage media, misuse of new and unexpected uses of knowledge, the basic understanding of the captured knowledge, or the loss of knowledge. Below are some threat issues that arose from these other issues in 2020-21.

- Misinformation/disinformation impacts procedural decision-making on hiring, purchasing, and customer service. This can lead to security issues such as internal threats, transferring funds to the wrong bank, or offending customers (Nabe, 2021).
- Misinformation/ disinformation leads to bad individual decision-making regarding which links to click on or which email to open. Misinformation/disinformation leads to many data breaches caused by human error due to phishing and other errors. The largest Twitter and Facebook hack in 2020 was caused by Twitter and Facebook employees falling for a phishing attack (Gat Labs, 2020; Newman, 2021; Osborne, 2021; Vijayan, 2020). The same is true for the increased ransomware attacks (Ponemon, 2021).
- Hundred-year storms (Texas recently, southeast over the late summer, California wildfires) challenge disaster recovery plans and potentially loss of knowledge; they influence the availability of systems (Alonso and Sanchez, 2020; Gramling, 2020; Timmer, 2021).
- The great resignation in the summer and fall of 2021 resulted in over 19 million people in the United States quitting their jobs (Luze, 2021) and causing larger than expected personnel turnover and knowledge loss, degrading organizational performance
- Organizational culture changes lower trust among workers resulting in less knowledge sharing and, most importantly, less sharing of knowledge critical to decision-making affecting security (bad sites, hacking attempts, social engineering, etc.)
- Organizational members upset at culture changes deliberately do not share knowledge or share disinformation leading to bad decision making
- Social isolation slows the sharing, capturing, and reusing knowledge needed for security decisions.
- Social isolation increases the use of social media leading to more potential disclosures, more opportunities for downloading malware onto worker computers used for home and work, and lower filters for determining misinformation/ disinformation (Vijayan, 2020).
- Generation Z felt the impact of the above issues more than any other group (Sherr, 2021).

The following section analyzes these observations using the threat vectors mentioned earlier.

2.4 Knowledge system risk

Assessing cybersecurity in the organization starts with threat assessment (NIST, 2012). Jennex and Durcikova (2020) discuss risk and threat assessment specific to knowledge systems and build the theoretical foundation for knowledge system threat assessment. In this paper, we apply this foundation in analyzing the events of the recent year 2020-21.

The knowledge system risks are assessed using the Knowledge Security Risk Management approach of Ilvonen, Jussila, and Kärkkäinen (2015) for knowledge security risk management. Ilvonen, Jussila, and Kärkkäinen (2015, p.13) define knowledge security "as the managerial process of organizations to identify threats toward important knowledge and secure the knowledge against those threats."

The point of interest in this definition is essential knowledge: the knowledge that is important to the organization needs to be identified in all the forms and locations that it resides in for the organization to be able to do any risk management measures with it. The knowledge risk assessment process thus begins with identifying knowledge assets by recognizing not only the documented knowledge within different systems of the organization but also the ways of knowledge sharing and transfer and the role of people and tacit knowledge within the knowledge system.

Jennex and Durcikova (2020) present a set of knowledge system-specific risks that need to be threat assessed by each organization. The six risks are:

- Failure to identify and capture critical knowledge in the knowledge creation process.
- Not having knowledge creation, capture, and use aligned with organizational strategy.
- Disclosing critical knowledge to unauthorized recipients in the knowledge sharing processes.
- Losing critical knowledge by not capturing it from critical human sources.
- Losing critical knowledge by not storing it on nonvolatile media, not migrating knowledge with changing storage standards, or not meeting legal standards for storing essential knowledge.
- Giving bad advice by not using appropriate knowledge or by using inappropriate knowledge.

Jennex and Durcikova (2020) provided an in-depth discussion and many examples of how the above risks have threats that impact knowledge systems. However, in 2020-21, because of COVID-19, natural disasters, social upheaval, misinformation, etc., generated more uncertainty and stress that resulted in increased threats in organizations and individuals than had previously experienced since perhaps the great depression.

The uncertainty associated with knowledge use, be it due to rapidly changing technology and storage media, misuse or new and unexpected uses of knowledge, or the basic understanding of the captured knowledge, is one of the biggest challenges a knowledge system manager faces. The following section will analyze the impact of this uncertainty and stress, events, and outcomes from 2020 and 2021 using the above knowledge system threats and the previously discussed process.

In addition to identifying the vital knowledge of an organization, risk assessment requires understanding where the threats can enter the organization and target the knowledge system. This paper uses three threat vectors: technical, behavioral, and legal (Jennex and Durcikova, 2020).

3. Methodology

Jennex and Durcikova (2020) created a generic set of risks for knowledge systems using basic knowledge system processes of knowledge (creation, sharing, and management). We then added misuse risks from Walsh and Ungson (1991):

- Automatic retrieval of knowledge may lead to a routine decision response when a non-routine decision response is warranted.
- The controlled retrieval of knowledge may lead to a non-routine decision response when a routine decision response was appropriate.
- A controlled retrieval of knowledge may be appropriately activated to elicit a non-routine decision response, but it may be implemented poorly.

Misuse of knowledge occurs when organizational members self-serving select knowledge to support positions that serve their political needs rather than the organization's (Walsh and Ungson, 1991).

Using Spears' (2012) misuse cases, we analyzed the above misuses to generate the following six knowledge systems-specific risks:

- Failure to identify and capture critical knowledge in the knowledge creation process.
- Not having knowledge creation, capture, and use aligned with organizational strategy.
- Disclosing critical knowledge to unauthorized recipients in the knowledge sharing processes.
- Losing critical knowledge by not capturing it from critical human sources.
- Losing critical knowledge by not storing it on nonvolatile media, not migrating knowledge with changing storage standards, or not meeting legal standards for storing essential knowledge.
- Giving bad advice by not using appropriate knowledge or by using inappropriate knowledge.

Misuse cases were used as they are an accepted technique for modeling how either outside users or actual users can abuse information systems/knowledge systems. Each of the knowledge systems' specific risks was then analyzed using intelligence threat hunting with three possible threat vectors (i.e., sources of attacks): technology, behavioral, and regulatory-based attacks applied to knowledge system processes (creation, storing, sharing, and management) to generate a set of knowledge system-specific generic threats. The six knowledge specific risks are listed in section 2.4 above

Hazel (2021) defines threat hunting as a purposeful and structured search for evidence of malicious activities that have not yet generated security alerts. This study uses published reports on COVID-19 issues identified through a Google search (using terms such as COVID-19 lessons from 2020, COVID-19 lessons from 2021, cybersecurity lessons from 2020, and cybersecurity lessons from 2021). We used these popular sources rather than those published in scientific journals to identify events/activities that have not yet been linked to knowledge risks. We decided to take this path because of the nascent state of research in the area of knowledge risks and because we wanted to implement the most recent events that have not been analyzed in scientific journals yet. Keeping in mind that not all popular sources are of equal quality and reliability, we focused on mainline American news outlets (e.g., sources such as Associated Press, Forbes, Wired, etc.).

4. Analysis of events and observations of 2020-21

Obasiolu (2020) found the biggest cybersecurity lesson from 2020-21 is that security starts within an organization. Specifically, security starts with top management creating a security culture and expectations of secure behavior. While we agree with this observation, we provide additional and more concrete observations below and specify how they create technical, behavioral, and legal threats to an organization. This section analyzes threats from 2020-21 with respect to the knowledge system/knowledge risks listed in 2.4 above with the exception of not having knowledge creation, capture, and use aligned with organizational strategy as it is determined that this risk is not impacted by events in 2020-21.

4.1 Failure to identify/capture critical knowledge in the knowledge creation process in 2020-21

With most workers working remotely, these workers were delegated to do all the decision-making. Being remote made it difficult for workers to stay current in the knowledge needed to support decision-making. In addition, remote work creates isolation from work networks, which slows the spread of knowledge and enables the spread of misinformation and disinformation. Remote work makes workers more susceptible to not identifying misinformation and disinformation and making wrong decisions as to what is critical knowledge. A focus on COVID-19 may lead organizations and workers to not keep automated tools up to date and collect essential knowledge. Finally, the rapid spread and use of new collaboration tools such as Zoom and Teams (Kelly, 2021) could have led organizations not to integrate these new tools into automated knowledge capture tools. Therefore, new knowledge generated and spread using these new collaboration tools may not have been captured.

Technical threats stem from the quick adoption of new collaboration technologies such as Zoom and Teams (Kelly, 2021). Threats include slow integration into organizational systems and the potential for automated tools not working with the new technology, and all made worse by technical staff working remotely and unable to access the physical systems.

Behavioral threats stem from widespread remote work and worker isolation, resulting in a flood of misinformation/disinformation pushed to socially isolated workers (Nabe, 2021). This increases the likelihood of missing critical knowledge and identifying misinformation and disinformation as critical knowledge.

Legal threats stem from new privacy laws (e.g., California) and a myriad of new social justice, health, and diversity/inclusion mandates, significantly increasing the risk of missing a legal requirement for capturing critical knowledge, not protecting essential knowledge, or identifying incorrect essential knowledge.

4.2 Disclosing critical knowledge to unauthorized recipients in the knowledge sharing processes in 2020-21

Employees replaced in-person socialization with online socialization with widespread remote work, social isolation, and significantly reduced supervision (Galanti et al., 2021). With reduced supervision, malicious employees were more likely to commit fraud (Nabe, 2021), considerably increasing the likelihood of disclosing critical knowledge. Social isolation makes humans more vulnerable to social engineering. New group/collaboration software increases the reach of hackers, including nation-state social engineers. Many instances of over-disclosure were revealed this last year in Zoom and Twitter attacks.

Technical threats stem from exploiting communication vulnerabilities common to all communication systems and focus on communication processes specific to knowledge systems. Additional threats are from storage media that does not correctly secure cloud and server storage access. 2020 increased these threat likelihoods because organizations quickly adopted collaboration software while not having the onsite staff to supervise and monitor installations and updates. These threats include Zoombombing (Downs, 2021) and large-scale hacks on Twitter (Waldman, 2021).

Behavioral threats come from several sources, such as: intentionally or accidentally failing to maintain access control lists for authorizing approved personnel to access knowledge, posting knowledge to inappropriate forums, not following disclosure processes, not encrypting knowledge in motion, falling victim to social engineering attacks, and either disclosing knowledge to unauthorized individuals or allowing malware onto their systems that are collecting and transmitting knowledge to unauthorized individuals (Columbus, 2021). 2020 saw this threat likelihood considerably rise by increasing the attack surface through social isolation and widespread remote workers (Nabe, 2021; Vijayan, 2020; Vodopyan, 2021). Additionally, workers could not create quality relationships with new organizational members as they could only meet remotely (Nabe, 2021). Examples of behavioral threats include social engineering attacks on Twitter (Downs, 2021; Vijayan, 2020) that had workers responding to disinformation.

Legal threats come from intentionally or accidentally not complying with disclosure laws, such as dealing with personally identifiable information or patient health knowledge. 2020 saw new privacy laws in California and myriad new social justice, health, and diversity/inclusion mandates, greatly increasing the risk of missing a legal requirement.

4.3 Losing critical knowledge by not capturing it from critical human sources in 2020-21

The pandemic has forced societies to shut down and many organizations have severely reduced or ceased operations, or moved to purely online environments. As organizations strive for survival, they have been forced to lay off many employees rapidly, discard a lot of old technology, and adopt new technological tools. In addition to layoffs, there have been extended absences due to employees' long-term illnesses and unexpected deaths. Finally, the great resignation, starting mid-2021, resulted in over 19 million workers suddenly leaving their jobs (Singh, 2022). All of these have resulted in losing critical knowledge.

Technical threats are linked to not utilizing established tools and processes for capturing knowledge from departing personnel. 2020-21 saw rapid shutdowns and employee loss that precluded organizations and companies from using their knowledge capture tools and strategies to capture knowledge from laid-off employees. Additionally, COVID-19 caused large numbers of deaths where most of these occurred in isolated wards, which precluded any possibility of capturing knowledge before the employee's death. Another threat stems from ransomware encrypting critical knowledge repositories and the organization or company unable to recover them through backups or by paying the ransom. Notable examples of companies paying ransomware to hackers include JB Swift, \$11 million (Associated Press, 2021), the Colonial Pipeline, \$5 million (Shear, Perlroth, and Krauss, 2021); and the University of California, San Diego, \$1 million to ensure their COVID-19 research data was not destroyed (Winder, 2020). 2020-21 increased the likelihood of the above threats mainly due to the quick adoption of new technologies and procedures while eliminating older ones. A final technical threat comes from

natural disasters (e.g., wildfires, polar blasts, hurricanes, and flooding). Natural disasters challenged disaster recovery and business continuity plans as remote workers could not access backup and recovery systems to support implementing the recovery and thus returning captured critical knowledge to use.

Behavioral threats come from intentionally or accidentally not identifying critical human knowledge repositories and taking actions to capture and store the critical knowledge, such as not capturing knowledge from those who are retiring or other reasons for departing the organization. 2020 saw increased employee stress as organizations changed how they were operating. As new systems and processes were implemented, the likelihood of knowledge loss increased. Knowledge was lost as employees were suddenly let go, got sick, or even died. Social isolation and loss of trust in the organization have reduced knowledge sharing and capture. The great resignation in 2021 saw millions quit their jobs rather than return to the office, with most of their knowledge being lost to the organization (Luze, 2021). Misinformation and disinformation created confusion as to what knowledge needed to be captured, resulting in some critical knowledge not being captured.

Legal threats originated from intentionally or accidentally not complying with required knowledge capture (an example of this was Nuclear Regulatory Commission requirements on nuclear stations to capture critical knowledge from employees before large-scale workforce layoffs). 2020 has lowered the focus on capturing knowledge from departing employees as organizations struggle just to survive. This is likely to become an issue in the long term, even if it has not been an issue in the short term.

4.4 Losing critical knowledge by not storing it on nonvolatile media/not migrating knowledge with changing storage standards/not meeting legal standards for storing critical knowledge in 2020-21

While COVID-19 did not directly impact this outcome, not having personnel in the office meant data migration to newer technologies was slow or non-existent. Natural disasters like California and Australian wildfires, Texas polar blast, hurricanes, and flooding in the southeast United States have affected power and communication grids, affecting secure storage facilities (Gramling, 2020; Weatherford, 2021).

Technical threats are rooted in storage media, hardware, and software failure. Additional threats are from technological obsolescence leading to the loss of knowledge as the organization migrates to newer technologies or the failure of obsolete devices. Other threats come from losing repository devices and not having an appropriate backup process in place or an installed tracking system. A final threat is from ransomware encrypting critical knowledge repositories and not being able to recover them through backups or by not paying the ransom. 2020-21 saw many successful ransomware attacks that resulted in large payouts (see section 4.3 for examples). Additionally, events that cause widespread damage or extended loss of power can cause storage devices to fail or be destroyed. 2020-21 saw a 100+ year winter storm that caused the grid to fail in the state of Texas (Timmer, 2021), wildfires in California (Alonzo and Sanchez, 2020) and Australia (Gramling, 2020) that destroyed miles of transmission lines and equipment, and record hurricanes and storms in the southeast United States (Gramling, 2020) that also destroyed miles of transmission lines and equipment. The technical threats come from failed equipment and backups. Security teams must review their disaster recovery/business continuity plans to ensure that the secure storage being counted on is safe from a power and communication point. Note that Y2K had many of the same issues, and it was important that the work to overcome Y2K technical problems was done swiftly as it was much worse than the public knew.

Behavioral threats stem from intentionally or accidentally not following technology procurement processes, selecting providers without checking their technology, not planning for obsolescence, not testing technologies before applying them or while using them, and artificially obsoleting technologies. 2020-21 saw significant disruptions in supply chains and purchasing decisions, significantly increasing this threat likelihood. Additionally, remote workers were more likely to not follow backup processes due to lack of system access or inability to follow new procedures.

Legal threats are liability issues associated with not following sanctioned or committed storage standards (such as those from NIST, Control Objectives for Information and Related Technology (COBIT), and the International Standards Organization (ISO). 2020-21 saw remote work with many office locations not staffed. This increases the likelihood of legal threats occurring as IT staff could not migrate to new storage standards or make changes to existing ones.

4.5 Giving bad advice by not using appropriate knowledge or by using inappropriate knowledge in 2020-21

This risk is perhaps the most likely, given the proliferation of misinformation and disinformation threats. The response to COVID-19 is replete with this happening. Perhaps the most egregious example of bad advice being that of deciding to send COVID-19 patients to nursing homes so that they could get better care but, in the process, infecting the most vulnerable. The most recent example is those deciding not to get the vaccine. There is misinformation and disinformation in COVID-19, the 2020 elections, the social justice movement, and virtually every other issue. New processes for identifying and censoring misinformation and disinformation significantly contributed to giving bad advice. Finally, remote workers have access to all this misinformation and disinformation but do not have support in determining what is true or false. The media in the United States has become politicized and partisan, and social media firms were trying to censor misinformation and disinformation, significantly impacting an employee's ability to judge information.

Technical threats come from search tools not finding relevant knowledge, improperly prioritizing some knowledge, not using integration tools that would allow knowledge pertinent to be incorporated into search results, or using visualization technologies that influence decision-makers to the wrong option. 2020-21 saw the rise of the use of AI tools to filter out misinformation and disinformation. However, the problem with AI tools is that they reflect the bias of their builders. Additional threats come from the classification of knowledge in knowledge systems. This effort is reduced by workers working remotely and not having access to all the knowledge gathered or the time to solicit and classify knowledge from other remote workers. A final threat comes from knowledge systems not having adequate processes for validating the accuracy of knowledge in the system.

Behavioral threats are from decision-makers using incomplete knowledge and inappropriately applying knowledge to unsuitable decision contexts. 2020-21 saw this likelihood increase as social isolation, social media use, and lack of interactions with organizational experts increased while reliance on media fact-checkers increased the likelihood of using weak knowledge for making decisions.

Legal threats are from decision-makers not utilizing due care or due diligence in assessing knowledge and focusing on politically correct or desired advice. Another threat is not giving advice based on limiting liability rather than stating the direction suggested by the knowledge system. 2020-21 saw a tremendous increase in social unrest, leading to new standards and laws on social justice and revised history, greatly increasing the likelihood of this threat. While not quite a legal issue (it is vigilante justice), society has taken to "canceling" individuals and organizations that don't support new norms. Knowledge systems risk not changing content fast enough to avoid not meeting new norms, which has resulted in canceling organizations and companies.

5. Discussion

The purpose of this paper was to analyze and identify threats that impact risks to knowledge in the light of the recent COVID-19 pandemic and then make recommendations for modifying knowledge risk strategy. Obasiolu (2020) reports that companies did not know themselves well enough to implement a resilient security program to handle the many severe challenges faced in 2020-21. An organization cannot properly secure its knowledge assets if it does not understand its main business processes and validate these processes that create knowledge. The Organization for Economic Cooperation and Development (OECD) reports that cybersecurity risks significantly increase in crises because stressed organizations are more vulnerable to attacks (OECD, 2020). The Risk Management Framework in NIST SP800-37r2 (NIST, 2018) uses the above risk management process to guide organizations in creating a risk management strategy. NIST 800-37r2 guides organizations create a risk strategy by identifying the importance of the system or asset (i.e., knowledge assets) and specifying the organization's risk tolerance for these systems/assets. The organization then selects an array of controls for managing and mitigating the risk within the organization's risk tolerance (NIST, 2018). Knowledge assets tend to be critical assets. The purpose of the risk management strategy for these assets would be to mitigate/minimize the risk to the organization's risk tolerance. This paper has identified threats that can increase the likelihood or severity of the five knowledge risks, including knowledge systems under extreme circumstances, such as those created by COVID-19 and other natural disasters in 2020 and 2021. We identified five specific cases of knowledge risk and described threats enhancing the risk in terms of technical, behavioral, and legal threats. The following recommendations influence the actions/controls an organization should select to mitigate the threats.

The first recommendation is for controls for identifying misinformation and disinformation. Organizations can address this threat through a control focused on training employees to identify misinformation/disinformation (Wetherford, 2021) and control by creating a position responsible for monitoring and identifying misinformation/ disinformation (Levick, 2021). Additionally, technical controls using AI tools are needed to filter news, emails, and identify deep fakes, frauds, misinformation, and disinformation. This long-term solution will be critical for an organization to make sound business decisions using validated knowledge sources. Finally, an organizational communication control for informing their employees about misinformation and disinformation, frauds, and deep fakes, while not overburdening them with additional information is needed.

The second control is forming or rewriting guidelines and instructions for employee online behavior. Organizations need to focus on the social media usage of their employees for both knowledge sharing and knowledge reuse. Organizations' dilemma is creating rules that create acceptable social media usage without denying freedom of speech. Future research should evaluate the limit of what is acceptable and unacceptable to talk about on social media regarding organizations and their lives. There is a need to define the protocols of responding to questions in social media; for example, when an employee responds, should his view be treated as the organization or personal views? Guidelines about social media engagement during and after work hours are needed specifically for the remote workforce because of the blurry line between work and private life. The guidelines for social media engagement should also include a section on how to spot and evaluate potential misinformation and disinformation and the threat of downloading malware. A final aspect of the control is to review and update employee training of social media use and social engineering protection.

The third control is the identification and evaluation of communication channels. The social isolation of employees creates a unique problem. We have learned that employees miss socializing with their coworkers and that virtual social hours do not replace physical socializing. Especially Generation Z is very sensitive to social isolation, and organizations need to create special networking programs for these employees. Promoting socializing channels that help people get together and know each other helps the organization reduce the risk of employees falling prey to social engineering attacks. Proper channels for work-related socializing also reduce the risk of knowledge spillovers and helps promote job satisfaction among the employees, thus reducing unwanted employee turnover.

The fourth control involves re-evaluating the work itself. The resignation of approximately 19 million workers should be a wake-up call to organizations that work-life issues need to be addressed (Luze, 2021). Jennex (2014) proposed a risk assessment framework for determining the risk of losing knowledge from departing employees based on work-life factors. Workers in 2020-21 found out that they could be as productive with more control over their lives working remotely and are not eager to return to their old office. Controls need to be developed for the new work models designed to make the organization more resilient. Additionally, the Jennex (2014) framework did not consider remote work. A future work recommendation is that the Jennex (2014) framework should be adjusted using a required number of days in the office as a new metric and modifying its probability matrix (suggest including 1) required day in the office with the level 6 probability, 2) required days with the level 7, etc.). We urge organizations to develop a knowledge risk management strategy utilizing the Jennex (2014) framework and assessing other work-life balance of their employees to create a strategy that includes more remote work as a strategy for retaining employee knowledge.

The fifth action/control needed is for the organization to implement a knowledge capture process for departing personnel. Jennex (2014) outlines how this process could work with the key parts of this process being the organization knowing what is critical knowledge, where it is stored, and having capture processes and technologies in place that can be used even if the departing personnel cannot or will not participate in the knowledge capture process.

The sixth action/control is a major risk re-assessment is needed in most organizations. Jennex and Durcikova (2020) proposed a comprehensive knowledge risk assessment framework based on the Ilvonen, Jussila, and Kärkkäinen, (2015) knowledge risk framework. The probabilities of many events are higher than expected during 2020-21. Extreme disasters (wildfires, riots, floods, hurricanes, polar blasts, etc.) cause major disruption in the operations of a business. Organizations should use the Jennex-Durcikova (2020) framework to develop disaster recovery/business continuity strategies to secure knowledge when a natural disaster hits and when it may destroy knowledge sources or access to these knowledge sources might not be available. Re-evaluation of existing disaster response/business continuity and backup plans is needed, given that the likelihood of extreme

events is much higher than most organizations anticipated even a year ago. Knowledge systems that allow employees to share and retrieve knowledge must be not only defended against natural threats but also be easily accessible while working remotely. Additionally, the re-assessment needs to ensure that critical knowledge, knowledge holders, and knowledge repositories are identified and included in the security plan. Further, new systems added during COVID-19 are incorporated into the organizational security plan including the asset inventory, that system specific policies are created to guide the configuration of new systems, and that appropriate incident response and contingency plans are created/updated. Finally, the re-assessment needs to include a legal review of new privacy laws and other mandates issued during 2020-21.

6. Conclusions

2020-21 may be outlier years, but they have shown us that the likelihood of extreme events is greater than we like to admit. We conclude that organizations are more vulnerable to attacks on their knowledge systems and knowledge assets when under stress (OECD, 2020), additionally, knowledge systems and knowledge assets are at risk when the organization's environment is in turmoil.

This paper extends the threats to knowledge system/knowledge asset risk based on events in 2020-21 and conclude that knowledge risks are more likely to occur than previously thought. The knowledge system/knowledge risks being investigated come from Jennex and Durcikova (2020) and are:

- Failure to identify and capture critical knowledge in the knowledge creation process.
- Disclosing critical knowledge to unauthorized recipients in the knowledge sharing processes.
- Losing critical knowledge by not capturing it from critical human sources.
- Losing critical knowledge by not storing it on nonvolatile media, not migrating knowledge with changing storage standards, or not meeting legal standards for storing essential knowledge.
- Giving bad advice by not using appropriate knowledge or by using inappropriate knowledge.

However, mitigating many of these threats is outside the technical expertise of the traditional cybersecurity department. This paper proposes six actions/controls that should be taken by organizations to mitigate the likelihood of the threats identified in this paper so that knowledge risks can be managed to acceptable levels. These actions/controls are:

- Add controls to assist in identifying and blocking misinformation/disinformation
- Create/revise guideline controls for employee behavior in online social media forums
- Review organizational communication channels to ensure that employees working remotely are not socially isolated and remain in contact with other employees
- Re-evaluate the way work is performed, where, when, how long, and adjust the work processes to fit worker needs and to improve work/life balance
- Create a knowledge capture process for departing personnel
- Review the risk assessment that has been done to include higher likelihood of extreme events and adjust backups and infrastructure as needed. Additionally this review should include ensuring systems, data, and/or equipment added during COVID-19 are included in the risk assessment, that critical knowledge, knowledge holders, and repositories are also in the risk assessment, and that reviews are conducted to ensure new legal requirements and standards are reviewed and incorporated as appropriate..

To create the control for identifying and blocking misinformation/disinformation additional expertise in identifying and countering misinformation and disinformation may be needed (Weatherford, 2021). Identifying essential knowledge in the organization is not easy, which requires understanding employees' knowledge transfer and retrieval processes, and their practices of evaluating the knowledge they have access to. Thus, it is not enough for the organization that the cybersecurity experts can identify misinformation/disinformation on sight. They need to know how misinformation/disinformation reach the employees and help them spot them. This cannot be only the task of security professionals; the whole organization's involvement is needed and in organizations where misinformation/disinformation is severe they should add a position such as a chief misinformation officer. This position would be responsible for ensuring the organization can identify and block misinformation/disinformation as well as for training employees in how to handle misinformation/disinformation.

Finally, organizations and companies need expertise in organizational psychology to assist the organization in preparing employees to understand, identify, deflect, and reject misinformation, disinformation, and phishing

(Vodopyan, 2021) to aid in identifying the insider threat. Another value of having organizational psychology expertise is assisting employees in dealing with anxiety related to remote work and social justice issues. The bottom line is that the management must first address the human element of knowledge and cybersecurity if cybersecurity efforts are to be successfully implemented in any organization (Vijayan, 2020).

There are limitations to this research. The first and most important limitation is that the research and data used in this paper is United States specific. This makes generalizing the results to the rest of the world difficult. However, it is the conclusion of this paper that most if not all the recommendations and threat findings are applicable to any organization wherever it is located. The second limitation is that the data used for the analysis comes from media and practitioner sources making its reliability a little suspect. This limitation is considered acceptable as the paper is doing an intelligence-based threat assessment and is not quantifying the impact on increased frequency of the threat, just that the threat exists. The third limitation is that the paper does not quantify the impact of the threats on knowledge risks. This is also considered acceptable as the focus of the threat assessment is to identify risks, not quantifying the threats. Also, to quantify the impact of the threats the unit of analysis would have to be on a specific organization as threat quantification is unique for each organization.

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The Impact of Smart Working on Organization Performance

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Abstract: In the last years, several studies dealt with smart working (SW) and its evolution during the pandemic. Most of them discussed benefits, drawbacks and drivers for successful implementation. Few studies investigated the impact on organization performance. It is not clear to what extent SW, especially in the emergence phase of the Covid-19 pandemic, has impacted the organizations, both at macro- and micro- structure level, and whether it may result into increased productivity and better innovation performance. The paper aims at investigating whether and under which conditions companies that adopted SW during the Covid-19 pandemic improved their performance. To achieve such a goal, based on a literature review, we develop a theoretical framework to describe the impact of SW on organization performance. Then, we design and administer a survey to test it. In particular, a questionnaire to empirically test the framework is developed, administered, and validated. In the paper we present a preliminary analysis of the results of the survey, which offers some interesting insights for theory and practice. In particular, by analysing the impact of the implementation of this new work modality on the organization performance, the paper contributes to the research on SW. Also, by developing a valid and reliable questionnaire, we provide a useful tool to help investigate whether and to what extent SW allows for productivity increase and better innovation performance. The tools also help retrieving information about the workers' perceptions regarding the implementation of smart working in their own company.

Keywords: smart working, organization performance, survey, Covid-19 pandemic.

1. Introduction

The development and diffusion of digital technologies (especially those supporting communication, collaboration and social networking), along with the pervasive dissemination of powerful and easy-to-use mobile devices, may encourage organisations to implement Smart Working (Ahuja et al., 2007). The organizational literature proposes several definitions of Smart Working (SW), each of them focusing on different key aspects associated to this new work modality. In 2008 the Chartered Institute of Personnel and Development (CIPD) defined SW as “an approach to organizing work that aims to drive greater efficiency and effectiveness in achieving job outcomes through a combination of flexibility, autonomy and collaboration, in parallel with optimizing tools and working environments for employees”. Such a definition reveals both the objectives of SW and the ways to achieve them. According to McEwan (2016) “smart working practices are agile, dynamic and emergent. They are the outcomes of designing organizational systems that facilitate customer-focused, value-creating relationships that are good for business and good for people”. Finally, Smart Working Observatory (2018) means SW as: “thinking about work from a different, clever angle. It questions the traditional links with working times and locations and gives people a greater say in defining their working conditions, while at the same time making them more responsible for the outcome. Autonomy and flexibility, and giving people responsibility and trust are the bywords for this new approach to work”.

Besides stressing the implications of SW on flexibility (as to working spaces and times), the last definition remarks the concepts of responsibility and trust: employees are given the chance to achieve both greater professional efficiency and a better work-life balance in return for a greater responsibility and accountability on the outcomes they produce.

Covid-19 pandemic made the implementation of SW faster and widespread. A recent article from The Economist (2021) stated that “before the pandemic Americans spent 5% of their working time at home. By spring 2020 the figure was 60%”. Based on a survey administered to thousands of Americans, Barrero, Bloom, and Davis (2021) argued that, after the pandemic, an average employee would like to work from home nearly half of the working time. In Italy, for example, before the pandemic, SW was adopted (in formal and informal ways) by 58% of large-sized enterprises, 12% of small and medium-sized enterprises, and 16% of public

administrations, for a total of 570.000 workers (Smart Working Observatory, 2019). The situation has radically changed since March 2020 when, due to the Covid-19 emergency and the need to implement social distancing rules, the Government issued the decree of March 1, 2020, so de facto establishing the possibility to apply SW to any subordinate employment relationship, even in the absence of individual agreements, until the end of July 2020. In April 2020, according to the Ministry of Labour and Social Policies (2020), a total of 1,827,792 workers adopted the SW mode, 1,606,617 of them started after the epidemiological emergency. For some companies it was the implementation on a larger scale of a working model already tested and used, for others it was a first experiment.

Looking at the post-pandemic world, several studies are questioning about the future of SW and whether it will be adopted by companies as an established successful practice. Indeed, an essential part of the “new normal” after the Covid-19 pandemic will be a revision of the working methods (Bonacini, Gallo, and Scicchitano, 2021) to employ an effective combination of information technologies, computer networks, and mobile devices. Several tasks, if not certain jobs, can be accomplished in smart working. Nevertheless, the shift toward this new normal needs to be monitored. Mistakes in the design of sociotechnical systems, such as working organization, may go unseen until the consequences are measurable e.g., performance of some workers decreases. That would affect the performance of the entire organization. Assessing the impact of SW on company performance and understand under which conditions SW is positively correlated with company performance is then necessary for a successful implementation.

Several studies investigated SW implementation during the pandemic (e.g. Bonacini, Gallo, and Scicchitano, 2021; Fana et al., 2020; Ipsen et al., 2021). Most of them focused on the identification of benefits, drawbacks as well as implementation drivers. As to the latter aspect, many scholars pointed out a new paradigm shift that “is being driven by extreme changes in approaches to work, work cultures, business architectures, decision making, communications, and collaboration” (Boorsma and Mitchell, 2011, p. 2). Others referred to evolutionary changes in work and management practices that are enabled by technological advances and that foster both organizational agility and new workforce expectations (e.g., Bednar and Welch, 2019; McEwan, 2016; Zheltoukhova, 2014). Overall, what emerges from the different contributions are the key drivers for a complete and effective SW implementation. There is no doubt that a SW successful implementation requires changes in the organizational culture and individual behaviours, from both employees and employers’ side, managers and co-workers, and managerial practices, Information and Communication Technology-based solutions, and suitable workplaces (Birkinshaw, Hamel, and Mol, 2008; Elsbach and Pratt, 2007; Mann, 2012; Reyt and Wiesenfeld, 2015).

Research dealing with the impact of smart working on knowledge management practices is still scarce (Edwards, 2022). Few studies have analysed the impacts of SW on socialization and the implications for knowledge sharing (Bolisani et al., 2020; van Heck, 2010; Schallenmueller, 2016; Bednar and Welch, 2019). To that regard, the results of an international survey on SW in times of Covid-19 reveals that most employees are able to keep sufficiently good and fruitful interactions, but those results are also associated to the kind of job and to the availability of appropriate communication technologies. The survey also shows that working (only or prevalently) from home could diminish the intellectual productivity of knowledge workers when it is difficult to exchange knowledge with colleagues (Bolisani et al., 2020).

Finally, only few studies investigated whether and to what extent SW impacts on company performance. Some evidence suggests that when implemented, SW not only reduces infrastructure costs but also increases the workforce’s overall productivity (Angelici and Profeta, 2020; Barrero, Bloom, and Davis, 2021; Bloom et al., 2015; Bolisani et al., 2020). However, it is not clear to what extent smart working, especially in the emergence phase, has impacted the organizations at macro- and micro- structure level and whether it may be considered as a work method to increase productivity and improve innovation performance. Understanding the impact on performance is important because SW requires companies to invest in technologies, workspaces, HR management systems, competence and training (Antogiovanni, 2020). Such investments should be offset with appropriate benefits.

In light of this main objective, the paper aims at investigating whether and under which conditions companies that adopted SW during the Covid-19 pandemic improved their performance. To achieve such a goal, based on a literature review, we develop a theoretical framework to explain the impact of SW on organization performance. The framework includes some constructs and some propositions to link them. Then, to

empirically test the theoretical framework, we design an online questionnaire survey, where each construct of the model corresponds to a set of questions; then, we administer and validate the developed questionnaire. By analysing the impact of a sudden move towards this work modality on the organization performance, the paper contributes to the research on SW. Also, by developing a valid and reliable questionnaire, we provide a useful tool that may help investigating whether and to what extent SW allows for productivity increase and better innovation performance. The tools helps retrieving information about the workers' perceptions regarding the application of SW in their own company.

The remainder of the paper is organized as follows. Section 2 presents the theoretical framework and the key constructs based on the literature review. Section 3 describes the survey design. A first analysis of the collected data and the questionnaire validation are reported in Section 4. Implications and limitations of the study, future research directions, and concluding remarks are discussed in Section 5.

2. The impact of smart working on organization performance: A theoretical framework

In this Section we present the theoretical framework developed to describe the effect of SW on organization performance. In particular, based on the literature review and a conceptualization of the effect of SW on organizations at the level of macro- and micro-structure, the framework describes whether and under which conditions SW may improve the organizational performance, in terms of productivity and innovation performance.

As to the impact on structural dimensions of the organization, SW increases coordination needs because of the space-time separation of tasks. In the case of SW the normal division of labour into tasks is indeed combined with a further separation of workers who carry out their tasks in different points in time and space. That creates higher interdependencies among workers and requires several coordination mechanisms to be adopted. Standardization or hierarchical supervision could be not enough to manage the interdependencies, coordination mechanisms based on mutual adjustment and interpersonal relationships would be needed, thus increasing the attendant coordination costs (Carbonara and Pellegrino, 2021).

On the other side, SW produces changes in processes, knowledge flows, and activity workflows to the point of radically transforming the coordination mechanisms. In particular, by entitling employees to greater autonomy, SW reduces the need to adopt coordination mechanisms based on direct supervision as well as mutual adjustment mechanisms based on face to face interactions, which are replaced with virtual interaction, via "broad band" communication technologies (Arnaud and Schminke, 2007; Barney and Hansen, 1994; Serrien, 2008).

Based on this, we formulate the following hypothesis:

H1: SW has an ambiguous effect on organizational performance: it increases the needs of coordination due to the space-time separation of tasks, but puts in place alternative coordination mechanisms, which are equally effective and far less costly.

SW may impact on socialization processes and personal work styles (Bolisani et al., 2020; Mallia and Ferris, 2000; Troup and Rose, 2012). Some researchers agree that SW may create isolation, decrease socialization, and change the forms of interaction between colleagues (Dolan, 2011; Morgan and Symon, 2002; Raffaele and Connell, 2016), with consequent negative implications for the processes of knowledge sharing and knowledge management. Although extant knowledge management literature ascribed to information technology an important role in the knowledge management process (Bolisani et al., 2000), some information technologies can be less effective for interpersonal knowledge sharing due to their inability to transfer tacit or even explicit contents efficaciously (Dalkir, 2008; Hislop, 2002).

In the knowledge management literature, knowledge sharing is considered crucial to the generation of several organizational capabilities such as innovation which, in turn, is crucial to company performance (Kogut and Zander, 1996). In particular, some scholars recognize that, although sharing knowledge with colleagues may be very difficult, it is positively correlated to reductions in production costs, faster completion of new development projects, better team performance, improved innovation capabilities, and increased company performance including sales growth or revenue from new products and services (Arthur and Huntley, 2005; Collins and Smith, 2006; Cummings, 2004; Hansen, 2002; Hansen, Mors, and Lovas, 2005; Lin, 2007; Mesmer-

Magnus and DeChurch, 2009). Furthermore, explicit and tacit knowledge sharing practices not only have positive relationships with firm operational and financial performance directly but also influence innovation speed and quality, which are in turn related to organization performance (Choi and Lee, 2003; Davenport and Prusak, 1998; Hsu, 2008; Law and Ngai, 2008; Liebowitz and Chen, 2001).

Based on the above discussions, we propose the following hypothesis:

H2: SW decreases socialization among colleagues with negative implications for knowledge sharing, thus it negatively affects the organization performance.

As for the impact of the SW on some job characteristics, the micro organizational structure, it is widely accepted that the adoption of SW requires a profound change in the organizational culture and behaviour as well as the adoption of new managerial practices and leadership styles. In the new SW result-based culture, where the goals are defined collectively, and the individual is accountable for the results he/she accomplishes, employees have a greater level of autonomy and responsibility for making decisions about how to schedule their work and how to do it. Job autonomy is closely linked to the concept of employee empowerment, i.e. the freedom of employees to make decisions on how to schedule the job and on how to achieve the goals (Hackman, 1980). According to Blanchard, Carlos, and Randolph (2007), empowerment can raise the level of commitment and may result in better performance.

Based on that, we formulate the following hypothesis:

H3: SW enlarges job autonomy and empowerment that positively impact on job satisfaction.

A further key feature of Smart Working is associated to flexibility. Through appropriate Information and Communication Technologies (ICTs), SW allows employees to define where and when to carry out their work and, consequently, to be efficient wherever they are. So eliminating any time and space constraints. In the academic literature, there is clear evidence that flexibility in choosing both when and where to work positively affects work-life balance (Byron, 2005; Mesmer-Magnus and Viswesvaran, 2006; Shockley and Allen, 2007).

Based on that, we formulate the following hypothesis:

H4: By increasing flexibility, SW positively affects work-life balance and hence job satisfaction.

Academic literature provides many examples of how higher levels autonomy on the job, a trustworthy environment in which employees are given the possibility to acquire higher responsibility, and a higher work-life balance increase job satisfaction, and in some cases, motivation to perform the job (Boxall and Macky, 2014; Ezra and Deckman, 1996; Staines and O'Connor, 1980).

Based on that, we formulate the following hypothesis:

H5: A better work-life balance and a greater autonomy/empowerment increases job satisfaction and motivation, thus leading to better organization performance.

No one questions the central role motivation plays in shaping behavior and, specifically, in influencing work performance in organizations (Ambrose and Kulek, 1999). Nonetheless, as important as motivation is, it is not the only factor that determines performance. Several other variables affect performance. Such variables include ability, instinct and aspiration level as well as personal factors. Blumberg and Pringle (1982) classify these variables in three categories: the capacity to perform, which is linked to individual control of task-relevant skills, abilities, knowledge, and experiences; the opportunity to perform; and the willingness to perform or motivation. The presence of motivation per se, coupled with a capacity to perform, does not ensure positive performance, organizational support, i.e. availability of equipment, technologies, and organizational and managerial best-practices, is needed to create the opportunity to perform.

Based on that, we formulate the following hypothesis:

H6: The higher is the organizational support, namely the adoption of targeted interventions to raise awareness and knowledge on the subject, the implementation of SW programs and the provision of correct ICT tools to support SW, the better will be the organization performance.

SW does not simply involve staggering start times, rethinking support technologies for working from home, or stepping up training throughout the organization on basic digital competencies to effectively use collaborative

platforms. SW adoption radically transforms work methods and tools. Certainly, several tasks, if not certain jobs, can be done in SW with a minimal amount of effort, but when SW is adopted by a growing group of employees the shift toward SW requires a redesign of the sociotechnical systems and, more in general, it requires a revision of the work methods (Bonacini, Gallo, and Scicchitano, 2021). It also involves a profound change at each level of the organization and in each of its components (Barrero, Bloom, and Davis, 2021).

Change is what presses out of the comfort zone. For most people it is uncomfortable to change from one state to another, since the change process involves going from known to the unknown (Bovey and Hede, 2001). Workers in organization may not welcome change, simply because of their negative attitudes toward change. Evidence suggests that organizational change efforts can be very stressful experience for individuals (Elrod and Tippet, 2002; Grant, 1996) and the employees' negative attitudes to change have negative consequences for the organization, in terms lower job satisfaction and productivity (Iacovini, 1993; Eby et al., 2000; Rush, Schoel, and Barnard, 1995; Schweiger and DeNisi, 1991).

The change management literature also argues that a strong organizational support, in terms of leadership style, managerial skills, supportive work relationships, effective communication, may contribute to the formulation of positive attitudes to change and, therefore, to the success of a change programme so avoiding the risk of performance loss (By, 2005; Vakola and Nikolaou, 2005). Many studies suggested that in a change management process, choices and decisions that managers make are fundamental to mitigate the risk of failure of the organizational change program and avoid performance drop. Managers as leaders play a crucial role in helping workers leave past behaviour and move forward towards new and different ways of working, in increasing workers' propensity and motivation to change, in building organizational commitment so as to make easier for employees to work in a changing organizational environment (Iverson, 1996; Guest, 1987).

Based on that, we formulate the last two hypotheses:

H7a: SW requires change efforts that negatively affect organization performance.

H7b: The organizational support moderates the relationship between the change efforts, due to SW, and organization performance.

The overall theoretical framework is depicted in Figure 1.

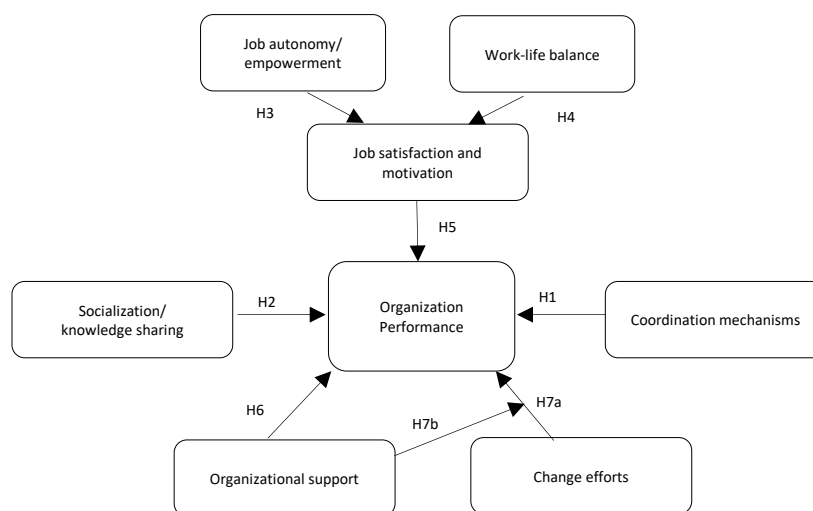


Figure 1: The theoretical framework

3. The empirical research design

After developing the theoretical framework, we designed an online survey by firstly developing a questionnaire with items that measure the constructs of the theoretical framework and by testing the quality and robustness of the questionnaire.

3.1 The questionnaire

The questionnaire comprises 28 questions. The first eight questions deal with socio-demographic information of the respondents (e.g. sex, age, role). Such information was used to disclose the presence of some control variables to take into consideration. The other questions deal with the workers' perceptions regarding the application of smart working in their own company and are used to measure the constructs of the theoretical model. In particular, three items are used to measure the impact of SW on coordination mechanisms. They reflect the need to intensify the relationships among employees and the facility with which they are established. Two items are used to measure the effect of SW on socialization within the organization and knowledge sharing. To measure the effects of SW on work-life balance, job satisfaction, and empowerment, we asked questions that aim at gathering information on each respondent's perceptions on the degree of time flexibility and spatial flexibility, on the level of job satisfaction and job autonomy, and on the level of control by supervisors.

The two questions associated to the "change effort" construct aim at assessing how much effort is required for the transition from traditional work to smart working and how much the working practices have changed due to smart working. To measure the organizational support, we asked four questions aimed at investigating the working environment of the company in which respondents work, namely the adoption of targeted interventions to raise awareness and knowledge on the subject, the implementation of SW programs, the adoption of managerial best practices, and the provision of correct ICT tools to support SW. Finally, the last four questions aim at measuring the effects of SW on the organization performance, in terms of productivity and innovation performance.

The first eight questions are either multiple choices or blank spaces that respondents had to fill in. The remaining questions are reported in the form of statements. In that case, respondents are asked to express to what extent they agree based a qualitative five-point Likert scale.

Constructs, items and questions are reported in Appendix.

3.2 Administration of the questionnaire

The questionnaire was administrated online from June 2020 to October 2020. Respondents were reached both via social media networks and through mailing lists. Data were anonymously collected through Google and Office365 platforms and analysed in aggregate form. To capture the early feelings of people that experienced SW in the emergence phase of the Covid-19 pandemic, the survey was promoted through the personal network of the authors (which include, among others, Industry Associations, Academics Associations, Individual companies, LinkedIn contacts) and by using a "snowball effect" (i.e. respondents were also asked to invite their friends to respond to the survey).

4. Results

In the present study, some preliminary analysis on the collected data have been performed: the descriptive analysis of the sample, the internal consistency analysis, and the analysis of the survey data.

4.1 Profiles of respondents

This section provides a complete overview on the respondents: 1,804 responses were collected, of which 1,648 were fully completed and reported in a database.

The characteristics of the respondents are shown in Table 1. The majority of the respondents were women (54%). Three age groups were identified, with 50% of the personnel aged between 30 and 50 years, 18% younger than 30, and 32% older than 50. The level of education is quite high: 54% of respondents declared to be graduated, 29% have a post-university degree and only 17% a high school degree.

Regarding the professional classification, 6 out of 10 respondents work in private companies (61%) and the remaining 39% in Public Administration. As for the former, 28% works in small and medium-sized companies, and 33% work in large companies.

The workers doing SW that answered the survey have different roles: Almost half of the respondents (49%) is an office worker, 16% works as manager, 4% as executive, 15% are school teachers.

Table 1: Characteristics of the respondents

Variable	N (%)
Sex	
Females	890 (54%)
Males	758 (46%)
Age groups	
< 30 years	297 (18%)
30-50 years	824(50%)
> 50 years	527 (32%)
Level of education	
High school licensed	280 (17%)
Post-Secondary Education	890 (54%)
Post-graduate degree	478 (29%)
Responsibilities	
Children at home	445 (27%)
Elderly people	198 (12%)
Caregiver for disabled	66 (4%)
No responsibilities	939 (57%)
Type of company	
Public Administration	643 (39%)
Small and medium-sized private enterprise	461(28%)
Large private enterprise	544 (33%)
Type of role	
Executive	66 (4%)
Manager	264 (16%)
Office workers	808 (49%)
School teacher	247 (15%)
Academic	82 (5%)
Professionals	132 (8%)
Others	49 (3%)
Distance between home and work	
0-5 km	1,034 (38%)
6-30 km	1,170 (43%)
>30 km	517 (19%)
Previous experience in SW	
Yes	610 (37%)
No	1,038 (63%)
Total	1,648 (100%)

Most of the respondents (81%) live and work in the same city or at least in a range of 30-kilometers, 19% live more than 30 kilometres away from the workplace. They have children at home in the 27% of cases, are responsible for elderly people in the 12% of cases, and have no responsibilities in the 57%.

Only 37% of respondents experienced SW before the Covid-19 crisis, for 6 out of 10 workers, smart work is a completely new experience.

Table 1 confirms that this is not a random sample of the Italian labour force, because it includes mostly highly educated professionals and managers, and a higher share of women.

4.2 Reliability analysis

Before using the results of the survey to test our theoretical framework, we test the quality and robustness of the questionnaire by performing an internal consistency analysis.

Cronbach's alpha was selected to measure the internal consistency of the questionnaire (Cronbach, 1951). This statistical indicator measures reproducibility over time and the homogeneity among the questions. Cronbach's alpha refers to the degree of correlation between the analyzed variables. After coding the items of the questionnaire, we transform the qualitative variables into quantitative ones, by using the five-point Likert scale ranging from "1" (totally disagree) to "5" (totally agree) throughout the questionnaire.

Cronbach's alpha provides information about the correlation level among the items of the questionnaire. The closer to 1 the value of Cronbach's alpha, the higher the level of correlation among items, thus each item provides a valuable contribution. Conversely, when the Cronbach's alpha is close to 0, the level of correlation among the items is low, hence some of them are not appropriate. In this case, it is necessary to eliminate the items that reduce the value of Cronbach's alpha (Cho and Kim, 2015).

Table 2: Analysis of internal consistency of the questionnaire

Construct	Item	Mean	St.Dev	Cronbach's Alpha when the item is deleted
Coordination mechanisms	Item1_coord1	3.95	1.38	0.79
	Item2_coord2	3.35	1.50	0.75
	Item3_coord3	3.20	0.84	0.78
Socialization/knowledge sharing	Item4_soc1	2.61	1.04	0.77
	Item5_soc2	2.90	0.88	0.78
Job autonomy/Empowerment	Item6_emp1	3.44	0.80	0.79
	Item7_emp2	3.13	0.77	0.80
Work-life balance	Item8_w/l-balance1	3.56	1.70	0.82
	Item9_w/l-balance2	2.91	0.97	0.78
Job satisfaction and motivation	Item10_satisf1	2.73	1.20	0.78
Change efforts	Item11_change1	2.64	1.04	0.80
	Item12_change2	2.46	1.11	0.81
Organizational support	Item13_support1	2.97	1.07	0.77
	Item14_support2	3.26	1.02	0.78
	Item15_support3	4.17	1.30	0.79
	Item16_support4	3.87	1.47	0.80
Organization Performance	Item17_perfm1	3.59	1.16	0.78
	Item18_perfm2	3.19	1.16	0.74
	Item19_perfm3	3.14	1.09	0.74
	Item20_perfm4	3.29	1.68	0.76

Cronbach's alpha value should be more than 0.70 in order to give good support for internal consistency reliability (Morgan, Leech, Gloeckner, 2007; Nunnly and Bernstein, 1994). Hence, we consider as acceptance threshold of this parameter 0.7.

We perform the analysis of internal consistency of the 20 questions used to measure the constructs of the theoretical model by using Cronbach's alpha. The analysis showed an overall standardized Cronbach's alpha of 0.79, corresponding to a very good reliability.

In the analysis by item the Cronbach's alpha ranges from 0.74 to 0.82, which are all higher than 0.7. In particular, the value of the alpha decreased to a minimum of 0.74 when the items 18 and 19, related to the impact of SW on the performance, were deleted. A maximum of 0.82 is reached with the deletion of item 8. Table 2 shows the mean, the standard deviation, and Cronbach's alpha of each item.

4.3 Findings and discussion

In the following, we analyse the survey data and provide some preliminary insights on the investigated issues. As regard to the impact of SW on the coordination mechanism, as expected, we find that SW requires more interactions among employees: 60% of respondents affirmed that the number of meetings in SW is greater than the one occurring when traditional work method were adopted and for the 39% the frequency of interactions with teammates has increased in SW. Space-time separation of labour and a greater level of delegation of authority due to SW require greater coordination between the diverse tasks and work positions. Meetings allow for the implementation of, at least, two main coordination mechanisms: mutual adjustment and direct supervision. However, the increased need for coordination is balanced out by the use of technology that facilitated the relationships among colleagues (Figure 2).

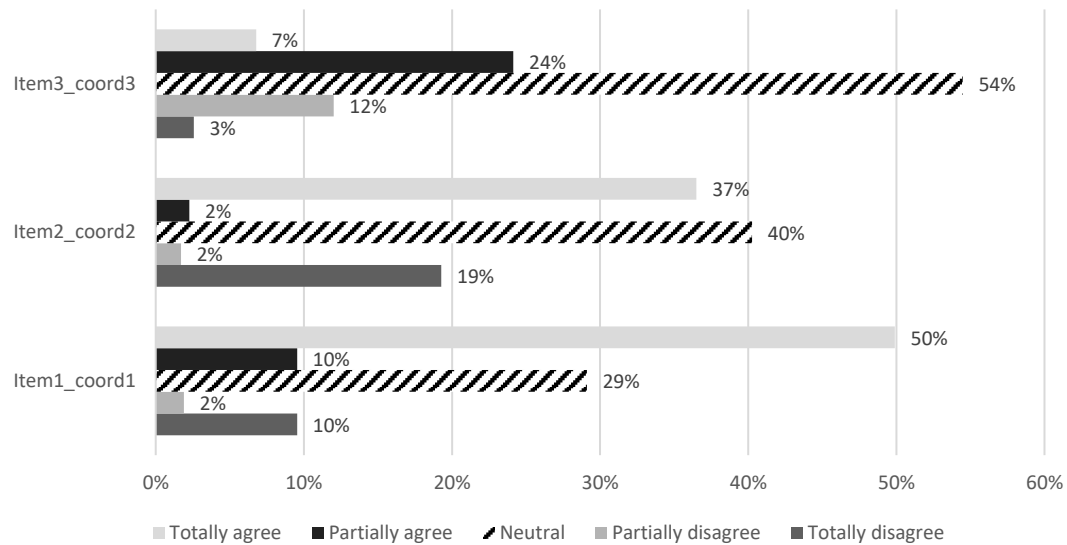


Figure 2: SW and coordination mechanism

As to the effect of SW on socialization within the organization and knowledge sharing, although for 57% of the respondents the relationships with colleagues remained unchanged, neither improved nor worsened, for the 44% of respondents SW negatively impacts on socialization among colleagues: they spent less time talking about non-work topics and chatting using instant messaging. In its current adoption, SW partially "fails" in supporting informal relationships and socialization.

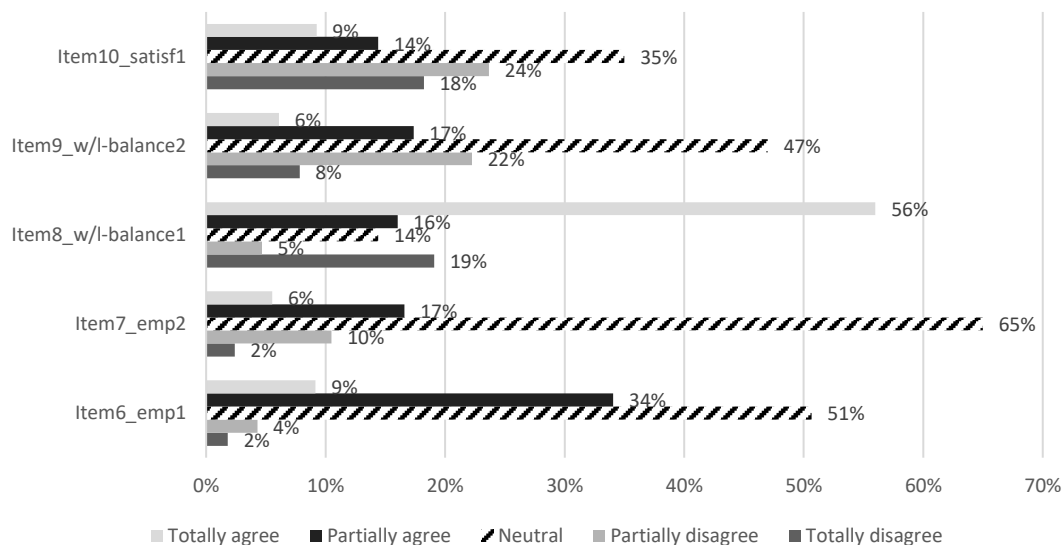


Figure 3: Impact of SW on empowerment, work-life balance, and job satisfaction

Participants were then asked to report their perception in relation to three work-related aspects (Figure 3), namely empowerment, work-life balance, and job satisfaction. More than 6 out of 10 respondents affirmed that the control exercised by the supervisor unchanged with SW and decreased only for 23% of respondents. However, this effect has contributed to increasing the autonomy of workers: 43% affirmed to have been more independent/autonomous in SW. Results show that SW improves the work-life balance by providing greater time flexibility (76% of respondents declared to have a more flexible working schedule) as compared to traditional work method. Responses to the question "in SW I feel to work in very suitable working spaces" show an average value (2.91) slightly lower than the middle (3), this may be due to the fact that most workers have adapted to their work needs the domestic spaces, surely not designed and organized to work. As for the perception on the job satisfaction, we gathered dispersed responses: 42% of respondents are not satisfied

with SW, 35% did not experience special gratifications nor problems, and 23% of respondents are satisfied with SW.

For the two questions related to the construct “change effort” we measure average values (2.64 and 2.46, respectively) lower than the middle (3). Results are counterintuitive as they mean that the transition from traditional work to SW did not require a profound change in the working practices as well as an additional effort for employees.

Responses to the questions concerning the organizational support show the greater average values: most of the respondents felt supported by their company in adapting their work to SW because of the adoption of targeted interventions to raise awareness and knowledge on the subject, the implementation of SW programs, the adoption of managerial best practices, and the provision of correct ICT tools to support SW.

Results of the questionnaire related to the organization performance are reported in Figure 4. Overall, the analysis of the responses proves that SW has not been detrimental for performance. 52% of respondents declared that they achieved performance goals more easily in SW as compared to traditional work method.

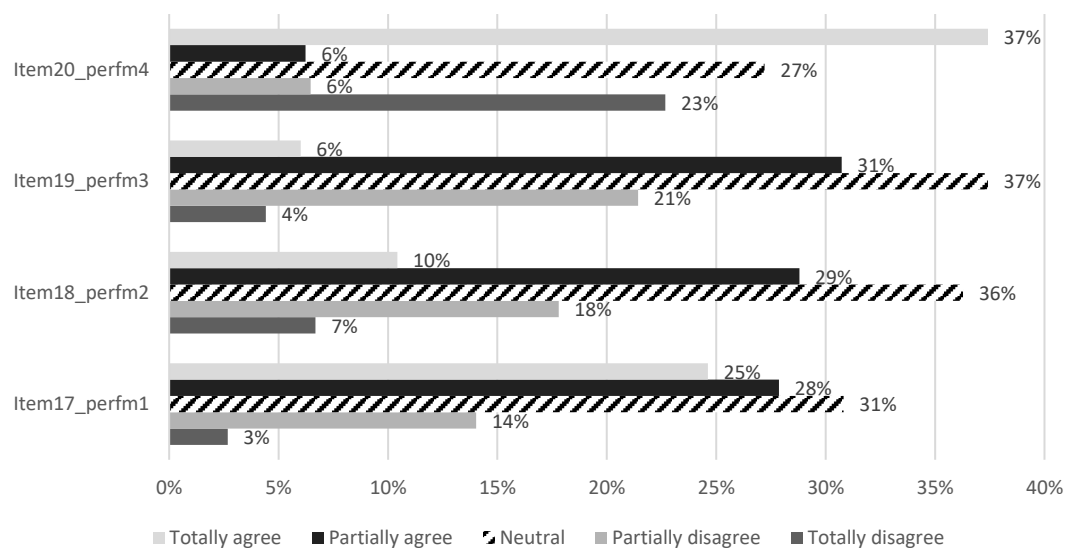


Figure 4: SW and organization performance

The preliminary analysis of results made some questions arise. From one side, thanks to new technologies, SW facilitates connections among colleagues. On the other side, more coordination efforts (at least in terms of more meetings) seems to be required. If processes are well designed, formalized and digitalized, new coordination needs should not arise. Maybe SW does not require a greater coordination, but simply makes coordination needs due to problems in process management (e.g. it is not clear who has to do what because the process is not formalized) more explicit. The perception of greater coordination needs, in other words, could simply be due to the fact that, before recurring to smart working, most coordination efforts were carried out in an informal and implicit way (e.g. by informally discussing with colleagues at coffee break or hearing colleagues’ discussions). So, the problem is not SW but the scarce formalization and digitalization of processes. The counterintuitive results, related to the construct “change effort”, could actually be explained as follows: if the working practices and processes are not formalized and digitalized before the implementation of SW, all coordination problems and needs will become explicit after SW implementation.

Almost half of respondents perceive a negative impact of SW on socialization. Such a result confirms the need to further investigate such an issue impact and, more in general, the implications of SW on knowledge management practices because they greatly affect organizational performance.

Finally, despite a greater flexibility, limited efforts to move towards SW, and a greater ease to achieve the work targets, 42% of respondent declared to be not satisfied with SW. The causes of possible employees' dissatisfaction towards smart working should be further explored.

5. Conclusions

Recently there has been a proliferation of studies reporting SW as a common practice due to the Covid-19 emergency. Looking at the post-pandemic world, several studies are questioning about the future of SW and whether it will be adopted by companies as an established successful practice. Providing an answer to such a question requires an investigation on whether and to what extent SW really impact on company performance.

Our research aims at investigating to what extent SW may contribute to improve organization performance and, in this vein, it can be considered a successful practice to be adopted in the post pandemic scenario.

The paper presents some preliminary findings of our research. In particular, based on a literature review and a conceptualization of the effect of SW on organizations, we firstly developed a theoretical framework that describes the characteristics of SW as a driver to increase organization performance. The framework encompasses a set of eight hypotheses - dealing with coordination mechanisms, socialization/knowledge sharing, job autonomy/empowerment, work life balance, job satisfaction and motivation, organizational support and change efforts - to assess whether and under which conditions SW may improve organization performance, in terms of productivity and innovation performance.

Second, to empirically test our theoretical framework, we designed a survey. To do this, we built a questionnaire with items that measure the constructs of the framework. Then, we tested the quality and robustness of the questionnaire. Results of Cronbach's alpha showed a good reliability, although the level appears variable through questions. Finally, we presented a preliminary analysis of the results of the survey. Based on the findings and analysis, some theoretical and managerial implications arise. In terms of implications for theory, the paper contributes to the still scant debate on SW (Torre and Sarti, 2020), going further the anecdotal vision and the collective imagination that associate with the SW a sort of working in relaxing conditions with better performance, which has become the premise for its adoption (Clapperton and Vanhoutte, 2014). Specifically, by using the perspective of organizational studies, we develop a theoretical framework that represents a first attempt to make a summary of extant literature on the topic and to empirically assess the relationship between smart working adoption and organizational performance. Also, a reliable questionnaire that could help investigate whether and to what extent SW allows for increasing productivity and innovation performance is provided. The questionnaire can be used to retrieve information about the workers' perceptions regarding the application of smart working in their own company. Finally, based on a preliminary analysis of the survey results, some issues to be further explored emerged: the relationship between smart working and process formalization and digitalization, the reasons of possible employees' dissatisfaction towards smart working and the impact of smart working on knowledge management practices. With this regard, there is no doubt about the challenges raised with regards to knowledge management practices by smart working. In a complete smart working organization (Gastaldi et al., 2014), the digital environment, composed of communication and collaboration tools, mobile workspace, corporate social network, and cloud-based solutions, can support those knowledge management processes traditionally associated with a condition of physical proximity between people, namely the processes of transfer and sharing of tacit knowledge, and can significantly increase the inter-organisational knowledge exchange (Al Mansoori, Salloum, and Shaalan, 2021). Advanced digital technologies can also support the processes of knowledge transfer and acquisition among smart workers. Such employees act differently from traditional workers. According to Comer (1991), traditional workers, thanks to their physical proximity, use passive means to acquire a large amount of information. They indeed observe actions and behaviors rather than directly ask others information about processes and procedures.

The paper presents some limitations. Firstly, only the first steps of the research are presented. The hypotheses of our theoretical framework have not been statistically tested. Nevertheless, the study contributes to research on SW and has the merit to call attention on a very relevant topic. Secondly, a non-probabilistic sample of respondents was used, which limits the generalizability of results and may create a bias in the results. On the other hand, the adopted method made it possible to collect a relevant number of responses, which provide an interesting picture of the investigated matter. Thirdly, answers given by respondents were

influenced by the particular conditions imposed by the lockdown: the pandemic had a strong impact on every aspect of people's life, therefore, the specific situation might have had an impact on respondents' attitude. As to the next steps of the research, we will use the results of the survey to test our theoretical framework. That will enhance the understanding of the effects of SW on organization, at the level of macro- and micro-structure, thus providing an answer on whether SW enable the achievement of productivity increase and better innovative performance and, therefore, if SW may improve organization performance. Understanding the impact of SW on performance is important to support company investment decision-making on, among the others, technologies, workspaces, human resources management systems, knowledge management practices, and training programmes, to be adopted to make SW an established practice also in the post-pandemic scenario.

5.1 Appendix

Construct	Item	Question
Coordination mechanism	Item1_coord1	Number of meetings in SW is greater than the one occurring when traditional work method is adopted.
	Item2_coord2	Frequency of interactions with teammates in SW is greater the one occurring when traditional work method is adopted
	Item3_coord3	SW facilitates the relationships among colleagues.
Socialization/ knowledge sharing	Item4_soc1	Socialization with teammates in SW improved (e.g you may consider the time to talk about non-work topics, chat using instant messaging) if compared to what happens when traditional work method is adopted
	Item5_soc2	SW improves the relationships among colleagues.
Job autonomy/ empowerment	Item6_emp1	The level of autonomy in SW is greater than the one occurring when traditional work method is adopted
	Item7_emp2	Compared to traditional work method, in SW my supervisor exercised less control.
Work-life balance	Item8_w/l-balance1	In SW the working time was more flexible as compared to traditional work method.
	Item9_w/l-balance2	In SW I feel to work in very suitable working spaces
Job satisfaction and motivation	Item10_satisf1	In SW I was fully satisfied/gratified by my job.
Change efforts	Item11_change1	My traditional work profoundly changed in the SW mode.
	Item12_change2	Adapting my traditional work to SW mode was very challenging.
Organizational support	Item13_support1	I felt fully supported by my organization in adapting my traditional work to SW mode.
	Item14_support2	In SW I had access to adequate technological resources to carry out my work effectively and efficiently.
	Item15_support3	In SW the objectives of meetings were clearly set by the supervisor.
	Item16_support4	In SW meetings were properly scheduled and organized by the supervisor.
Organization Performance	Item17_perfm1	In SW I achieved goals more easily than in the case of traditional work method adoption.
	Item18_perfm2	Team performance (e.g. new ideas generation, problems solving, process lead time) in SW improved with respect to what happened when traditional work method where adopted.
	Item19_perfm3	Remote interactions with teammates in SW are more effective than face-to-face interactions.
	Item20_perfm4	SW improved/shortened the decision-making process as compared to traditional work method.

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Trust And Governance in a Rethinking of Classical Knowledge Management Paradigms: Toolkits for Public Sector During the COVID-19 Emergency

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Abstract: The post Covid-19 world is characterized by new technologies and a smart city approach. For this reason, the public sector must shift from the classic paradigms to a new way, following a Knowledge Management (KM) approach, to perform its role in dealing with emergency situations. Starting from classical KM models, we conducted a regional case study, showing how the process of rethinking is boosted by citizens' needs and pushed by the trust of the stakeholders in the central authority. In fact, as highlighted by part of the international literature, local authorities' planning aims to achieve public value and alignment between stakeholders and policy making represents one of the main goals to be achieved. With an OLS regression we estimated the correlation between the trust of citizens and the statutory actions taken by central and peripheral government, showing that only with the alignment of public policies and the will of the citizens is it possible to overcome a crisis. Moreover, we underline the gaps in the literature and the missing links, with the aim of creating a KM model that can also be applied in the near future.

Keywords: Trust in central government, Knowledge Management in public sector

1. Introduction

Two years have passed since the first Covid-19 cases spread outside China and the WHO declaration of pandemic (Cucinotta and Vanelli, 2020). It is now clear that nothing will be the same as it was before (Caroppo *et al.*, 2021). It is equally clear that the shaping of the post-pandemic period is in our own hands (Katzourakis, 2022). Indeed, if it is true that, all around the world, we have been experiencing modifications that have had an impact on our lives, the important thing now is how we are escaping from this, and the possible legacies for our near future.

The increased use of digital tools transformed our working arrangements as well as our interactions with relatives and friends. Pupils and students experienced different ways of learning and interaction. We modified our notion of freedom, and our shopping and leisure time arrangements were revolutionized, with consequences for logistics and delivery. Most of all, our respect for public health services and our ideas about medical research changed (Bargain and Aminjonov, 2020).

The objective now is to detect and improve those aspects that grew from the state of emergency of the pandemic and can be opportunely applied in the near future to guide us towards general systematic improvement.

Starting from the above considerations, this paper, based upon an Italian case study, focuses on the legacy, in terms of Knowledge Management, of the lessons learnt in the interaction between local administrations and public health services, on the one side, and citizens and users on the other. The relevance of Italy as a study case is given by the fact that it was the first country, after China, to decide to have a complete lockdown and to follow this with other extraordinary measures (Sebastiani, Massa and Riboli, 2020), while becoming, in autumn 2021, a country with one of the greatest numbers of vaccinated people (Mathieu *et al.*, 2021). It was one of the European countries which, in economic terms, suffered most in the first wave of the pandemic (Prometeia, 2020) and was then the one in Europe with the greatest growth in GDP in 2021 (Eurostat, 2022). A great role, in this turnaround from being hit by the pandemic and then having a recovery in terms of economic growth, was played by public bodies and by the local branches of the Italian national health service (Cepiku *et al.*, 2021).

Taking into consideration the fact that there is a long history of a lack of relevance, and especially of awareness, of Knowledge Management within the public sector (Cong and Pandya, 2003) and that measuring service productivity is challenging because of its intangible nature (Jääskeläinen, 2009), and also taking into account the relevance and specificities of Knowledge Management in the healthcare sector (Sousa, Dal Mas and Da Costa,

2021; Vold and Haave, 2020), we aim, in our paper, to contribute by defining the specificities regarding Knowledge Management issues related to public intervention in an health emergency situation.

In particular, using the Knowledge Management toolkit for the public sector (Robinson *et al.*, 2010), our aim is to investigate which positive indications led to change in the Italian situation, and, especially, to detect any future positive legacies to be applied elsewhere, we intend to answer the following research question:

Research question: Do trust and governance have an impact in the knowledge management toolkit for the public sector, and, if so, how?

Since it is part of a larger, and still ongoing, piece of research into the modifications of local public administrations and local national health services, this study presents the results of an investigation made in an Italian Region (Abruzzo), focusing upon the changes that occurred in the design and implementation of local public health services and on the possible positive legacies for the future. In particular, we focus on the “counterparts” in the interactions, that is, the citizens and users who positively considered the indications given by public bodies. We explicitly investigated, through the submission of questionnaires, the opinions and considerations of citizens and users, looking at their role in following and respecting, in a collaborative manner, the indications given by the public agencies. We are specifically interested in any possible gap between what was perceived and implemented by the local public agencies and what was understood and considered by the citizens and users, thus guiding their actions in playing an active role in the recovery of the whole community.

2. Italian reaction to Covid-19 pandemic

The Covid-19 health emergency represented the most dramatic international event since the Second World War, hitting the entire global population in a silent and universal manner. Italy was one of the nations that was most severely hit in the first two quarters of 2020 (Balmford *et al.*, 2020). In the first year of the pandemic, it had more than 90,000 deaths and over 2,500,000 Covid-19 cases (Senate of the Italian Republic, 2021). In 2020, faced with an international health emergency and to avoid the spread of the virus, the prime minister, Giuseppe Conte, ordered various restrictions on Italian citizens, with an initial severe lockdown lasting three months and then a series of other restrictions. This strategy strongly pushed, among other things, a rethinking of the way in which public services acted, based upon the rapid digitalization of the Italian public sector through Knowledge Management patterns, and thus a rethinking of the “public administration mindset” with a smart governance approach (Governo Italiano, 2022; Heeks, 2002, 2003).

The new government, guided by Mario Draghi from February 2021 onwards, although not dismantling the logic of the restrictions, invested a great deal in the new weapon that had become available: vaccination. Although it did not enact, before the end of 2021, any rule for mandatory vaccinations, except for those in specific risky categories (e.g. health professionals, personnel caring for the elderly, and teachers), Draghi’s government designed and implemented several measures aiming at a kind of “moral suasion” of citizens (Governo Italiano, 2022). Concurrently it designed and implemented specific logistic and delivery strategies to allow the “mass vaccination” of Italian citizens. In particular, the strategy foresaw the exploitation of the military logistical structure that already existed (Ludovico, 2021), together with the modification of already existing web-portals of the national health service and the national postal service, to allow the proper and careful booking of vaccinations, according to the priorities given to categories defined by age and health conditions (Carli, 2021).

At the end of 2021 the increase in deaths – despite the greater infectivity and incidence of the alpha and then delta variations that had arrived in the meantime (Pouwels *et al.*, 2021) – was 50,000 over the year, and the pressure on the health services was constantly decreasing (Dipartimento Protezione Civile, 2022). It is also important to note that this decrease occurred despite the fact that, from spring 2021 onwards, although there may still have been some restrictions, hardly any activities (the exceptions were discotheques and ski resorts) were still closed (Governo Italiano, 2022).

The turnaround was caused by the choice made by the great majority of people to continue to respect the rules for interacting with others (in places of work to places of leisure and on public transport) and, in particular, to choose, as soon as their turn arrived according to their age and health condition, to be vaccinated. The efficiency of the mass vaccination campaign designed by the government and implemented by the Italian Regions at local level led to Italy having, in autumn 2021 and while vaccination was still not mandatory, one of the highest percentages of vaccinated people (Mathieu *et al.*, 2021). In summary, respect for rules and vaccinations really

changed the situation in Italy (Marziano *et al.*, 2021). Indeed, even if there were, in Italy as in other countries all around the world, movements against vaccines, citizens' trust in science and public services was very high (Battiston, Kashyap and Rotondi, 2020).

The effects of this change on the situation of the fight against Covid-19 were important for the re-opening of economic activities. From the middle of 2021, along with the increase in vaccinations, a series of measures were enacted to allow people to enter activities open to the public (Governo Italiano, 2022). The so-called "green pass", and, especially, the consequent electronic control strategy (which was without precedent in Italy), allowed the unlocking, as safely as possible, of all economic activities open to the public (D'Eri, 2022).

The effects of the turnaround were very evident in terms of economic recovery. Indeed, although the European strategy, as set out in the Recovery Plan, did not start during 2021 (European Commission, 2022), there was a complete turnaround in the Italian economic situation. Indeed, hit by the first wave of the pandemic, the Italian economy lost 150 billion euros GDP in 2020, with a collapse in its gross domestic product (GDP) of 8.9%, more than double the percentage change in GDP across the world (-4.4%). The loss was divided as follows: 108 billion in consumption expenditure, 16 billion in investments, and 78 billion in facilities (Prometeia, 2020). By contrast, by the end of 2021, Italy had had the greatest increase in GDP among all the European countries, with an increase of 6.4%, while the EU average was 4.8% (Eurostat, 2022).

Considering the peculiarities of Italy, and especially the turnaround between the first year and the second year of the pandemic, this work presents the results of an investigation, conducted through the "Knowledge Management toolkit" (Robinson *et al.*, 2010), that aimed to look at the main reforms that took place. Guided by the toolkit, we concentrate our analysis upon the counterparts, that is, the citizens and users in respect of whom, and for whom, these changes were designed and implemented. In particular, we attempt to detect the components that allowed them to take an active role in ensuring the effectiveness of the enacted rules and services. Indeed, during the pandemic, the Italian public sector conducted a silent revolution led by two words: digitalization and Knowledge Management (Riege and Lindsay, 2006; Velasquez and Mejía Lara, 2021).

3. Research framework

It is widely known that organizations wishing to cope with an increasing rate of environmental change must create and share information and knowledge (Gore and Gore, 1999). Often, creative solutions appear when things are looked at in a new way and problems are redefined (Sternberg, O'Hara and Lubart, 1997). This requires knowledge creation and sharing, to change the point of view on an assumption that already exists (Koestler, 1989). Knowledge creation, in fact, emerges from interactions among individuals (Nonaka and Toyama 2005). In our research setting, we aimed to investigate the interaction between the enacting and delivery parties (public bodies) and the recipient parties (citizens and users), because this interaction is an important component in the efficiency and effectiveness of impactful public initiatives designed and delivered by one side and having an impact on the other.

We note that Knowledge Management in the public sector has historically revealed a lack of relevance, and especially of awareness (Cong and Pandya, 2003). An important aspect here is the relationship between social capital and the welfare state, where the latter might discourage civic engagement and therefore social trust (Stolle and Rochon, 1999). Indeed, if, on the one hand, the welfare state boosts trust by reducing inequalities and improving the performance of public bodies, on the other hand, it may stem from the erosion of social networks or individuals' morality (Tamilina, 2009).

When looking specifically at health services, it is known that measuring service productivity is challenging because of its intangible nature (Jääskeläinen, 2009), and Knowledge Management in the healthcare sector must be properly addressed (Sousa Dal Mas and Da Costa, 2021; Vold and Haave, 2020). When talking about innovation in a healthcare system, we should note that the rising number of internal and external collaborations between hospitals and other parties calls for a specific analysis of how healthcare innovation environments behave, and of how knowledge flows within them are managed (Polónia and Gradim, 2021).

Taking into account all the above, our aim is to investigate, using the Knowledge Management toolkit, the contribution of trust throughout governance decision-making policies on impactful healthcare services in the case of an emergency, where the risks are high and the tools for intervention are unknown (Cepiku *et al.*, 2021).

In particular, we consider that, in the case of public health, where there is an imposition upon the citizens from the public side (even though this imposition is enacted in the name of the greater community interest), the recipients must understand and agree with the public request, in order to act accordingly. If this happens there is public trust.

In our case, the impact of the pandemic on the Italian health system was devastating, to say the least, “as several governments indicate that they aim to push down the epidemic curve, the evolution of the epidemic in Italy supports the WHO recommendations that stricter containment measures should be introduced as early as possible in the epidemic curve” (Sebastiani, Massa and Riboli, 2020, 344).

As a matter of fact, the government, apart from the initial complete lockdown of three months, had to request citizens to modify their daily activities to limit the effect of the pandemic. In the second phase, from the beginning of 2021, the government had vaccines, but it had, on the one hand, to create a new system for mass vaccination and, on the other, to persuade people to accept vaccination.

In this scenario, Italian public administrations, from the central government to the local ones, adopted a political strategy inspired by the Knowledge Management Toolkit (Figure 1). This is a new approach that has been implemented for “knowledge sharing and dissemination mechanism to manage and safeguard knowledge for a competitive advantage through communities of practice” (Velasquez and Mejía Lara, 2021) and that has become the “Masterpiece” of planning to manage an emergency.

Although the model introduced by Robinson *et al.* (2010) was designed to support public–private partnerships, we considered the same KM approach to be valid in terms of “process management”. Indeed, as we will explain hereafter, we apply it to analyse the interventions to tackle the pandemic, with different variables also considered, to give a better fit for the model using the analysed case study.

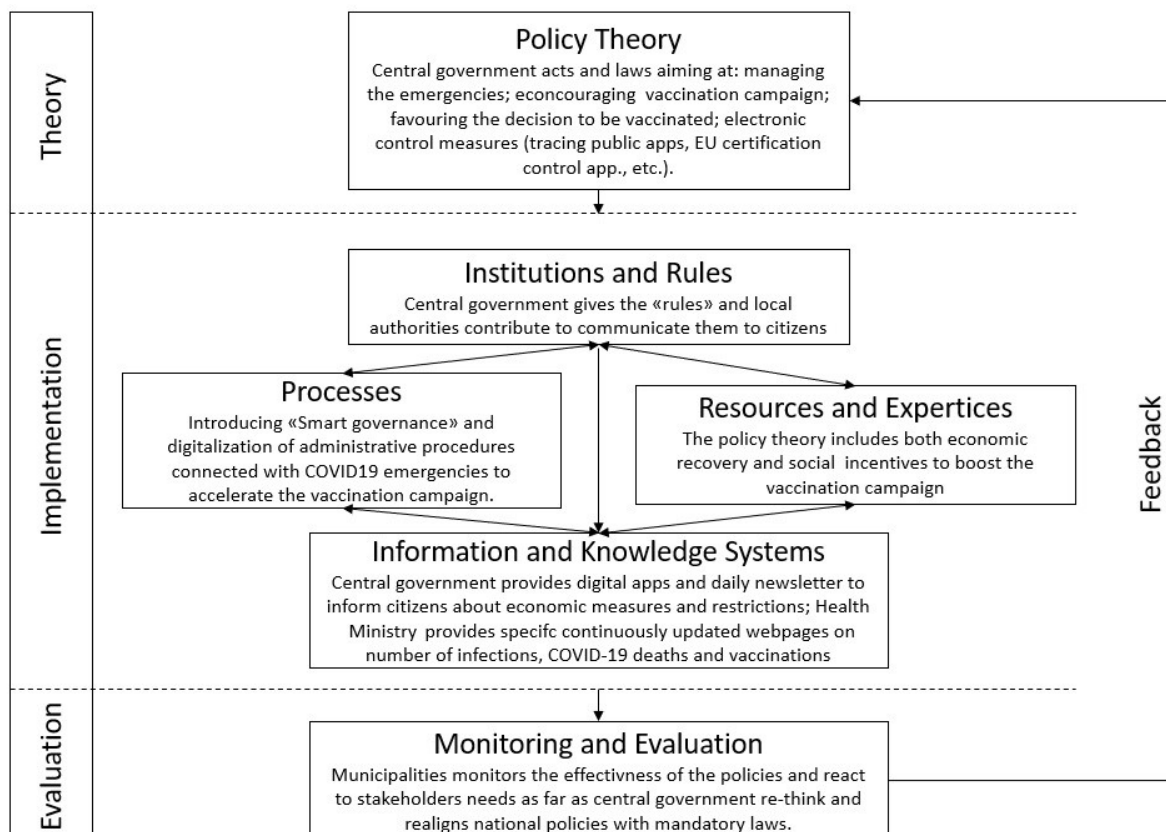


Figure 1: The Knowledge management toolkit for public policies (Robinson *et al.*, 2010) to manage the emergency

As a matter of fact, a KM approach in the public sector sets out a policy theory that is applied by institutions – within the management of processes, resources and information acquired “in the field” – to implement or

change the effectiveness of a policy (Bhatt, 2001; Massaro, Dumay and Garlatti, 2015). Moreover, considering new public management theory, this process achieves affordability in the long term (Boyne, 2002; Hood, 1991) when, as part of the management, the policy is monitored or at least evaluated.

As highlighted by some of the international literature, “decisions on the nature of public services required and how they should be provided are fundamental in public policy as the effectiveness of the policy framework influences the outcome of a policy. However, this depends on fundamental components such as the policy theory and objectives defining the types of services and outcomes expected, the institutions involved and their roles” (Berardi and Ziruolo, 2021).

The KM toolkit (De Gooijer, 2000; Robinson *et al.*, 2010) provides a key to understanding the measures adopted by the Italian public administration to slow the spread of the pandemic and introduce best practices – commonly used when interacting with the population (users / citizens / communities / stakeholders) – which have already proved themselves to be easy to implement and which could also have an immediate effect, according to Robinson *et al.*’s model (2010) (Figure 1), even if this is partially reset. What happened during Covid-19 in Italy was that, to deal with the emergency, classic models of management were blown away by the extreme urgency of saving lives. That was only possible if the citizens had deep trust in public policies and initiatives. Indeed, for as long as the numbers of casualties and cases were rising, the Italian central government introduced strict measures (including a total lockdown of the country for three months). This was possible only because the citizens had huge trust in the measures adopted by the public authority. Consequently, trust was necessary in the “evaluation phase” when planning the “exit strategy from the emergency”.

Figure 2 resets the Knowledge Management toolkit created by Robinson *et al.* (2010) by taking into account the measures adopted by the Italian government in the face of the Covid-19 pandemic, through a restrictive policy, in terms of social measures and the vaccination campaign, and it includes one additional variable: “Trust of people in policies and governance while a natural disaster is approaching” (Grossi and Vakulenko, 2022; Sargiacomo and Walker, 2021).

The toolkit divides the actions of the public authority into three phases: Theory, Implementation, and Evaluation.

In the first phase (Theory or “policy making”) (Kamara, Anumba and Carrilo, 2002; Robinson *et al.*, 2010), there was the formalization by central government of ad hoc laws that were aimed first at counteracting the onset of the pandemic and then at encouraging the decision to be vaccinated, while also respecting the vaccination slots provided according to age and health condition.

In the Implementation phase, the local authorities then acted, on the basis of the central mandatory laws, and reset the management of public actions. In this regard, the “smart cities” approach (Vial, 2019), in the way it introduces specific digital apps, acted as a “planning revolution” in the local authorities, contributing to the main goal of the theoretical policy: to save lives.

Local authorities therefore managed the emergency with a “smart approach” that contributed to building trust between government and citizens.

As a matter of fact, the municipalities started to “collaborate” with local communities to preserve “public value” and, during the Evaluation phase, when the citizens were directly committed to the local authorities’ actions, the policy makers had the opportunity to reset the “policy theory”. As citizens contributed to the Evaluation phase because there was trust, then, as fast as the trust between policy makers and local communities grew, vaccination rates increased, thus introducing a new variable to the KM toolkit: trust (Figure 2) (Prometeia, 2020).

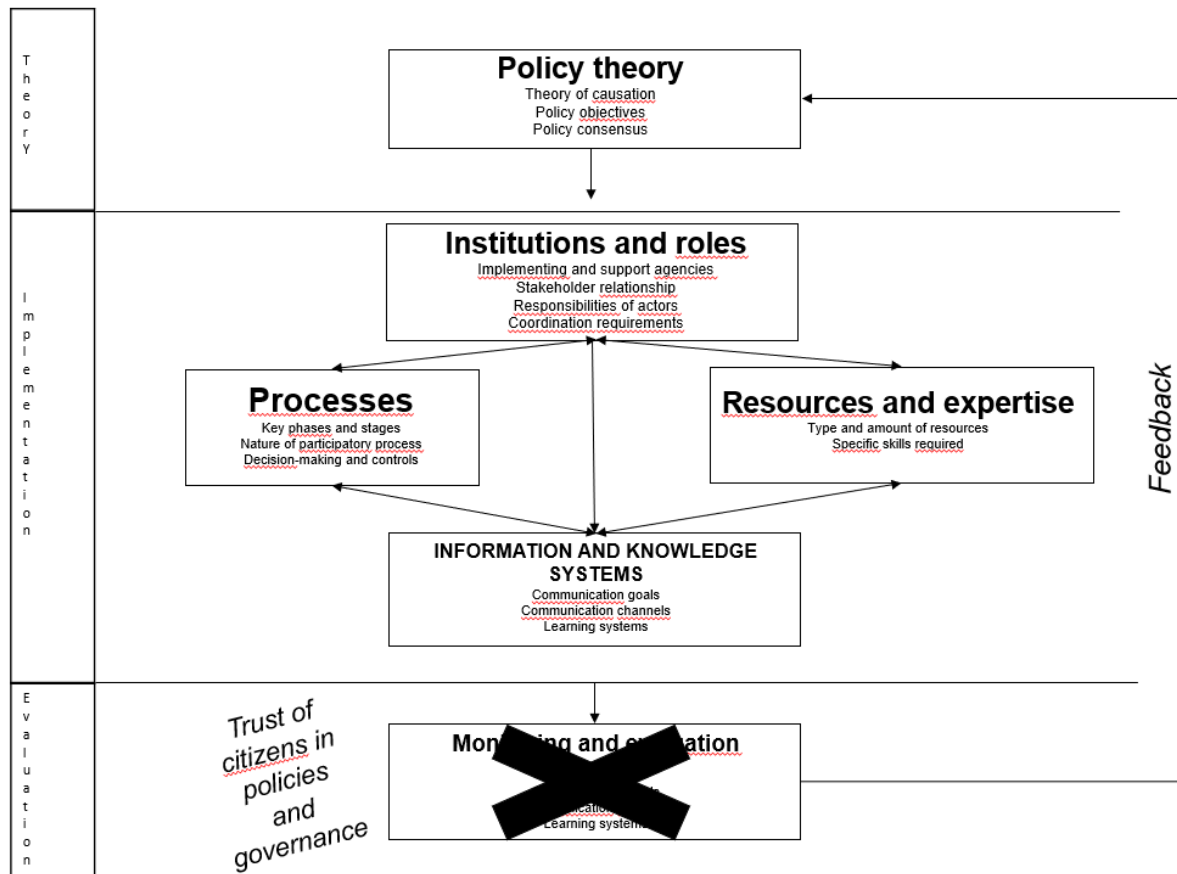


Figure 2: The introduction of new variables to the KM toolkit: citizens' trust in policies and governance

What emerges from this scenario is a direct correlation between the number of vaccinated people and the trust of the citizens in the central government actions. We conducted a quantitative study considering trust as dependent variable (Y) that, as we will highlight in the next section, empirically shows the correlation between KM toolkit and citizens' trust.

By investigating which positive indications led to this swift change in the Italian situation, and, especially, by fulfilling our aim to detect any future positive legacy that could be applied elsewhere, we intend to answer the following research question:

Research question: Do trust have an impact in the governance through knowledge management toolkit for the public sector and, if so, how?

4. Methodology

In the period when mass vaccination, open to all age categories, began (the second half of 2021), we submitted a survey to citizens who were attending for vaccination in the city's hub. We included in our data set the metropolitan area of Chieti–Pescara, where one-third of the entire Abruzzo population lives.

We organized our data collection by asking people to answer our questions while they were waiting their turn to be vaccinated by the local health service; the vaccinations were given within dedicated temporary structures appropriately arranged within areas usually used for exhibitions or for indoor sports. We chose one person from each queue to collect data on different days of the week and at different times to avoid any bias due to a possible greater presence of some categories on specific days and/or times (e.g., there was a greater proportion of schoolteachers on Saturday mornings). We had previously been specifically authorized by the local public body (the health service or municipality, depending on the site) to submit the questionnaire, and the public bodies had requested us, whether or not we had been vaccinated, to provide a negative swab before the data collection. We were in any case properly equipped to avoid any risk of contagion. The data were collected directly by us to avoid any exchange of papers, pens etc.

Although they were not obliged to, nearly all those present agreed to answer the questionnaire. The average duration for the data collection was around 15 minutes, with a maximum of 30 minutes. The longest interviews were usually with people aged over 70 who, in some cases, needed more explanation (specific control questions were asked in these cases to be sure there were no misunderstandings with the interviewees).

All the collected data were then manually transcribed onto electronic spreadsheets to allow us to work on the data (we initially tried to use tablets to collect the data directly, but we soon found that this was not practicable, because we could not repeat a question to check whether the answer was the same as previously given; moreover, in some cases, when asking the control question, we used local slang and dialect instead of Italian).

We collected 343 completed questionnaires. Table 1 shows the demographic characteristics of the respondents to the survey, reporting their age, gender, and level of school education,

Table 1: Demographic characteristics of the respondents

ITEMS	Citizens (343)	
	Frequency	%
Age		
18-30	46	13%
31-44	93	27%
45-59	157	46%
60-79	42	12%
80+	5	1%
Gender		
M	205	60%
F	138	40%
Education		
No schooling completed	7	2%
Nursery school to 8th grade	117	34%
High school	196	57%
Bachelor or Master's degree	21	6%
PhD	2	1%

The survey was structured with questions that required answers on a Likert scale (0-5) or with a binary choice (yes-no), and the degree of agreement of each respondent to the specific variables is described hereafter.

In accordance with the KM toolkit, each variable being considered was related to specific research items (Berardi and Ziruolo, 2021). These items, for which the results are reported in Table 2, refer to:

1. **Governance**, which measures the citizens' alignment with the emergency policy that was adopted (Policy theory in the KM toolkit). We decided to measure this through their perception of how the local policy met the national requirements; their own alignment with the imposed requests; and their confidence in the effectiveness of the adopted measures.
2. **Interaction with decision makers**, which measures the communication system and goals (Information and knowledge systems in the KM toolkit). We chose to estimate this through the citizens' participation in any public debate initiative or meeting with local administrators, while also considering opportunities for public debate about the measures adopted.
3. **Influence of public opinion**, which measures the interaction with stakeholders (Institutions and roles in the KM toolkit). In this case, considering the novelty of the role assumed by digital communication tools (especially during the lockdown period), we measured the perceived influence of these tools upon citizens' beliefs.
4. **Interaction with different governance levels**, which is referred to among the Processes in the KM toolkit. We measured this through the citizens' perceptions of the alignment and interaction among the different government levels (from national to local) and the possibilities they had to "interact" with them.
5. **Resources and expertise**. To measure this variable we decided to consider the citizens' willingness to follow the requested restrictions that had been decided on by the Wisemen Committee. This was done because we considered that if the citizens were following the enacted measures that had been fixed by the appointed panel of experts with the allocated budget, they must be considering them to be efficient and effective.

As shown in the literature (Boyne, 2002), an effective policy making strategy tends to build trust between citizens and administrators.

Therefore, following previous studies conducted on KM in the public sector (Carnevale, 1992; Berardi and Ziruolo, 2021; Bhatt, 2001; Ramirez, 2021), we tested the correlation with trust as the dependent variable, influenced by the independent variables defined as described above, with the results being shown in Table 3.

Through an OLS regression model, we estimated the correlation between the indicators in the toolkit and the “trust” of the 343 citizens who decided to participate in our research, taken from the almost 3400 citizens who received their vaccinations on the days we administered the survey (10% of those attending).

Table 2: Survey results by averages (Likert scale 0-5)

Items	Citizens' answers Likert scale average
Governance	3
Local policy making aligned with the national protocol	2.6
Citizens aligned with the prescriptions/restrictions	3.8
The protocol adopted is effective for public health	2.8
Interaction with decision makers	3
Public debate or virtual meeting to define a common strategy to avoid the spread of the virus	2
Opportunities for public debate on the measures adopted	4.7
Influence of public opinion	3
Any influence from social networks and media (including SMS and WhatsApp) on your opinion on the adequacy of the measures adopted	3.8
Any influence on your beliefs about the healthcare protocols	2.1
Interaction with different governance levels	2.6
Any opportunity to debate with national or local politicians or members of the “Wise Man Committee”.	1
Alignment with and respect for different local government prescriptions	3.8
Respect for health protocols	4.8
Personal compliance with protocols	4.7
Acknowledgement of the lack of respect for the measures shown by others	5

Once the indicators were defined, the following regression model was applied to take into account all the variables included in the survey:

In the equation below, α represents the constant of the model, β represents the coefficient of the estimation of the variables, $\log x_i$ represents the logarithmic conversion of the variables measured with Likert scale 0-5 as per the survey (Table 3), while ϵ represents the standard error (Bun and Harrison, 2019). The logarithmic conversion of some variables has been applied to reconduct the model to a Gaussian distribution. As a result we have:

Model 1

$$Y_{1i} = \alpha + \beta x_1 + \beta \log x_2 + \beta \log x_3 + \beta \log x_4 + \beta \log x_5 + \beta \log x_6 + \beta x_7 + \beta x_8 + \beta x_{9i} + \beta \log x_{10} + \beta \log x_{11} + \epsilon_i.$$

The combination of the 11 variables which were considered showed evident problems related to heteroskedasticity (Breusch–Pagan tests) and specificity (Ramsey test), as well as autocorrelation of some variables. It was therefore decided to proceed through step-wise regression to identify the combination of variables for the two models with the best performance.

Step-wise regression led to the identification of two new models:

$$Y_{1i} = \alpha + \beta x_1 + \beta \log x_2 + \beta \log x_3 + \beta \log x_4 + \beta \log x_5 + \beta \log x_{11} + \epsilon_i.$$

$$Y_{2i} = \alpha + \beta x_1 + \beta \log x_2 + \beta \log x_{10} + \beta \log x_{11} + \epsilon_i.$$

These models were found to be able to overcome, brilliantly, the problems related to the heteroskedasticity of the variables that had previously been encountered. The Breusch–Pagan test was performed again ($\chi^2 = 0.00$; Prob> $\chi^2 = 0.876$ for the Y_{1i} model, $\chi^2 = 0.00$; Prob> $\chi^2 = 0.937$ for the Y_{2i} model).

Furthermore, the Ramsey test relating to the “specificity” of the two models does not show significant specificity problems: $F(2.76) = 0.78$; $\text{Prob} > F = 0.373$ for the Y1i model and $F(3.03) = 0.06$; $\text{Prob} > F = 0.877$ for the Y2i model. Moreover, the Shapiro–Wilk test highlights the traceability to a normal distribution for the Y1i model ($p\text{-value} = 0.697$), which seems to be affected only in part by the limited numbers in the data set, and for the Y2i model ($p\text{-value} = 0.737$).

5. Analysis of the results

What emerges from the OLS regression is a direct link between the citizens’ needs and their trust in the government (Vial, 2019; Walker, Jung and Boyne, 2013).

Table 3 shows the variables that have been considered for Model 1 and Model 2 after the application of the “Step-wise regression” methodology (Bun and Harrison, 2019). Therefore, Model 1 shows a direct correlation between trust in the action of the government, the degree of interaction with decision makers and respect for health protocols, showing that measures became effective because of the “link” between government planning and the “citizens’ actions in the game”. As confirmed by some of the international literature, the effectiveness of a policy (Vial, 2019) is a direct consequence of “trust in the action regarding central authorities”. In this sense, this model shows that the experience of fighting against the Covid-19 pandemic, including the extraordinary measures that occurred in recent months, can be reliable and effective only if citizens have trust in the policy adopted by the central government.

Moreover, Model 2 emphasizes this correlation, as respect for the health protocols seems to be strictly connected to the central authority’s ability to be “concrete and at the same time effective”.

Table 3: Analysis of the proposed regression models

Item	Regressor	Model 1	Model 2
Governance	X_1	4.176* (2.510)	-2,106 * (2.433)
	$\log x_2$	6,678** (1.978)	-1,760 * (1,877)
	$\log x_3$	7.703*** (1.994)	
Interaction with decision makers	$\log x_4$	3,987* (1.731)	
	$\log x_5$	6,898*** (1,787)	
Respect for health protocols	$\log x_{10}$	- 0,267 ** (0.104)	2,367** (1,237)
	$\log x_{11}$	- 0,267 ** (0.104)	2,367** (1,237)

As shown in the first part of our paper, the extraordinary results of the vaccination campaign were achieved because of the capability of the central government to create a “government of trust” (Walker, Jung and Boyne, 2013), with performance objectives being planned as a long-term goal that must be achieved in order to create and preserve public value (Papi *et al.*, 2018).

The experience of the “management of the healthcare crisis” has shown that planning is only effective if there is a strict correlation between public policies and “citizens’ need”. In this sense, public entities must empower citizens during the “public auditing” phase, encouraging public debates and public meetings so that there is a thorough investigation into what the real needs of citizens are, rather than merely a formal planning phase. In this sense, some of the literature (Papi *et al.*, 2018) offers a direct contribution to this debate by showing that, even if the planning by a central government fits in terms of “formality”, there might sometimes be a misalignment of the planning because there is not a strong contribution by the citizens in the “planning phase”.

As happened during the emergency, the trust of the citizens in the government’s actions and plans increased as the local authorities “realigned the activity of planning measures regarding special needs of territories and specific areas”.

For this reason, there was no need for a penalty for non-compliance, since the trust of the citizens in the government's planning was strictly connected with the people's acknowledgement that the public policy ensured the achievement of public value in terms of the effectiveness of the services provided (Walker, Jung and Boyne, 2013).

We should only say that public value has been achieved if there is almost total alignment between the political will and the citizens' needs, even if there are no fines or "punishments". This contributes to a re-engineering of the processes, with the Knowledge Management approach being boosted by a smart governance "state of mind" (Heeks, 2002, 2003).

Moreover the "Monitoring and Evaluation" phase was completed when the trust of the citizens in public policies grew, leading to more vaccinations and a decrease in Covid-19 casualties.

6. Conclusions

This paper contributes to the debate in the literature about KM methods and systems helping processes of change. As regards the theoretical toolkit, we looked at how an "emergency situation" (Sargiacomo and Walker 2021; Grossi and Vakulenko, 2022) contributed to a rethinking of the management of local authorities and public health services, and we revised the KM public policies model (Cong and Pandya, 2003; Robinson *et al.*, 2010) by considering other variables such as trust.

In this sense, we showed that a resetting of the KM toolkit as framed by Robinson *et al.* (2010) can be useful for both practitioners and academics in setting up new studies or even models that rethink the traditional KM approaches for public bodies, especially when conducting initiatives that need immediate collaboration from the side of the users in order to achieve the result. The Covid-19 experience showed us, indeed, that a classical theoretical lens cannot be appropriate when the external context is changing so quickly. In this sense, changes to KM models, processes, and approaches can be taken from the challenges created by the pandemic, and used again when thinking about future policies and management theories.

The main aspect that emerges from our research is the importance of trust between policy makers and stakeholders, as suggested by some of the literature. Alignment between policy makers and stakeholders is key for managing a local authority and preserving public value (Al Ahababi *et al.*, 2019; Walker, Jung and Boyne, 2013).

The sharing of information and knowledge (Gore and Gore, 1999), along with the creative solutions that come from seeing things in new ways and redefining problems (Sternberg, O'Hara and Lubart, 1997), has been pushed by a "smart governance" approach that, during the pandemic, overcame the traditional management method of Italian local authorities.

As a matter of fact, the pandemic has been a booster for a general rethinking of policy making, public procedures and services, since citizens' attitudes have been aligned with local policies that are, in turn, aligned with national protocols.

Moreover, this investigation showed that a KM strategy tends to build trust. As the trust of the citizens grew day by day, the policies adopted became more effective, and this is also shown by the decrease in case numbers and numbers of casualties along with the increasing numbers of vaccinated citizens. This conclusion has practical implications for helping public bodies to design, set and implement strategies to deal not only with emergencies but with all cases in which the public body can achieve its aim only if there is active participation by users. In this sense the relevance of trust is fundamental, because some actions cannot be imposed on a long-term basis, as the initial phase of lockdown showed.

Even if this paper is limited by being tested only for a regional case study, the proposed KM toolkit has been used in all Italian regions, proving its effectiveness. So, as a matter of fact, starting from a "micro analysis", we have contributed to the literature by merging the traditional KM toolkits for public sector with new variables that have been considered, in the literature, to have a "positive impact" on KM (Jääskeläinen, 2009).

During the Covid-19 pandemic, all countries experienced a sudden change in their ways of living, working, producing, and consuming, and these challenges demanded immediate solutions to ensure continuity of service and operation in many areas.

So, the rethinking of local authorities with a knowledge management approach contributes to a positive rethinking for local entities and public local health services. Moreover, we also found that the re-engineering of the processes is strictly connected with a “smart governance approach”, as trust boosts the rethinking of public administrations and achieves public value (De Gooijer, 2000; Robinson *et al.*, 2010; Walker, Jung and Boyne, 2013).

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Healthcare Fusion: An Innovative Framework for Health Information Management

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Abstract: Perhaps the main goal of healthcare management is the attainment of effective, efficient, equitable, timely, safe, and patient-centered care. At the core of this lies the need for an integrated pathway for healthcare data storage, analysis, and utilization. The potential exists for a centralized, cloud-based system that links physicians, hospitals, public health agencies, insurance and pharmaceutical companies, and most importantly, patients. Such a system could improve clinical quality management and support the delivery of consistent and effective treatments. Undoubtedly, massive integration of personalized health and large-scale epidemiological and molecular data, coupled with the use of artificial intelligence and machine learning, is already in process. Here, we envision the healthcare fusion framework, which unites all stakeholders in healthcare. This fusion aims to achieve culturally and demographically relevant outcomes in precision medicine and population health, in ways that are convincing to stakeholders and investors. In addition, the proposed framework may prove relevant in informing governmental and private sector responses to sudden public health crises.

Keywords: healthcare fusion, big data, ROBIN, medical records, machine learning, artificial intelligence, cloud computing, precision medicine, population health

1. Introduction

Despite recent innovations in medical technologies, individual patients could become increasingly voiceless in the care process. Leaders in western medicine have therefore advocated for patient-centered care, in which patients' perspectives are heavily weighted in health-related decisions (Barry and Edgman-Levitan, 2012). Patient-centered care improves clinical outcomes and efficiency (Stewart et al., 2000).

To describe a data-driven, patient-centered care system, Leroy Hood proposed the term "P4 Medicine," where the four "P's" stand for predictive, preventive, personalized, and participatory (Hood, 2013). In recent years, health data have expanded along three vectors: volume, variety and velocity. Substantial progress has been made along the data trajectory, as advanced data analytics platforms are now available. However, lack of collaboration between the various stakeholders in healthcare continues to constitute a major barrier which prevents a complete rollout of patient-centered care and P4 medicine.

Even today, healthcare data are largely siloed and scattered across various discrete points of storage and exchange; this hinders medical progress, patient-centered care, and the effective management of population health risks. An enormous amount of data needs to be managed, and the advancement of precision medicine depends tremendously on interoperable and standardized data and systems.

To address these challenges, we propose a new framework, healthcare fusion, for the consolidation and leveraging of medical and data technologies to achieve culturally and demographically relevant outcomes in precision medicine and population health. Healthcare fusion centers upon the development of a single cloud-based repository for a nation's health and biological (omics and biobanking) data. In the interest of realizing financial and non-financial returns, stakeholders in healthcare, including healthcare providers, insurance companies, and pharmaceutical corporations, would participate and contribute data. Artificial intelligence (AI) and machine learning (ML) would be leveraged for data analysis. To this end, we propose a set of criteria,

enumerated within the acronym ROBIN (Responsive, Open, Bridging, Interoperable, Network-based; see Textbox 1), for the optimization of data processing machinery. Through stakeholder collaboration and data sharing, healthcare fusion could facilitate the widespread adoption of patient-centered care.

2. The Healthcare Fusion Framework

To advance patient-centered care and improve interoperability within healthcare systems, we propose the healthcare fusion model. In developing this concept, we aim to create an organized, regulated framework for healthcare data delivery and management.

At the core of our framework lies a centralized, cloud-based information management system (IMS) which would contain a nation's healthcare data (Figure 1). Stakeholders – including patients, healthcare and insurance providers, pharmaceutical corporations, social media, and governments – would contribute data to the IMS. Cloud computing platforms would leverage AI and ML to interrogate these data. Patient- and population-level health data, biological (omics and biobanking) data, and epidemiological, demographic, and socioeconomic patterns would be stored in the IMS. Stakeholders would have varying levels of access to these data. Healthcare and insurance providers, for example, would have access to personally identifiable data, while pharmaceutical corporations and epidemiologists would be limited to blinded (de-identified) clinical data. This framework could be applicable to a broad spectrum of healthcare systems, including public, private, and hybrid models; it could be modified and optimized to meet the needs of individual nations. In most cases, we anticipate that governments would ultimately bear responsibility for the implementation and regulation of the healthcare fusion framework. Depending on the jurisdiction, day-to-day technical operations could be managed by the government, a public-private partnership, or a contractor(s). As such, our proposed framework encompasses not only a shared data repository, but also effective stakeholder participation and rigorous system-wide oversight mechanisms, as explained below.

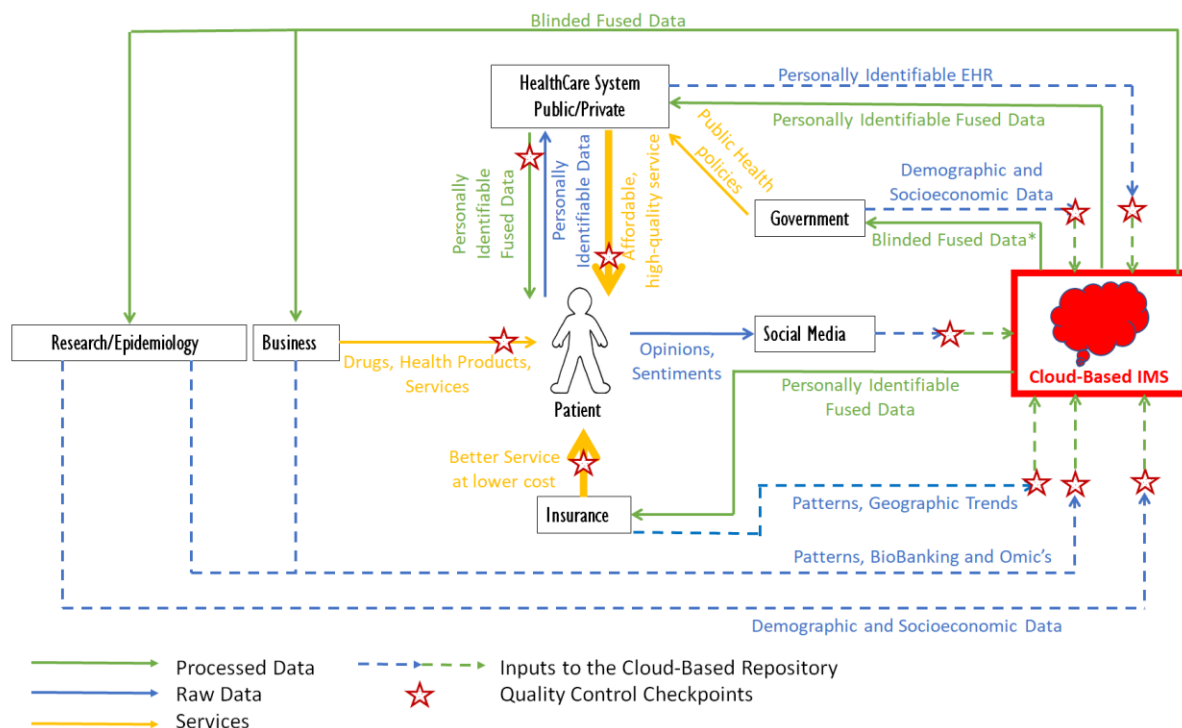


Figure 1: Overview of the healthcare fusion framework, a patient-centered approach

Stakeholders contribute to and oversee health-related data exchanged with a centralized, cloud-based repository. Artificial intelligence platforms are leveraged to analyze these data with high precision and throughput. In the interest of advancing patient-centered care, stakeholders will have varying levels of access to data within the repository. Healthcare providers and insurance companies would have access to personally identifiable records, while the business and research sectors would be limited to blinded data. To ensure system-wide interoperability and proper data packaging, security, and utilization, we suggest a number of quality control

checkpoints (indicated by red stars; see the ROBIN criteria in the text). *While we envision that governments would be limited to blinded data, governmental access privileges will vary between jurisdictions.

3. Stakeholders in Healthcare Fusion

The stakeholders in our proposed framework include all parties with a vested interest in the success of a healthcare system (as defined by measures such as patient satisfaction, profitability, and efficacy of care):

3.1 Patients

Patients are the primary beneficiaries of healthcare fusion. They seek accessible, timely, and effective care, delivered in the context of their physical, social, and emotional needs. They also desire participation in the care process and value continuity of care (Peckham et al., 2021). Data access, privacy, and security are also of great concern. Patients can contribute to the fused macrocosm by relaying their health data to healthcare providers, and by sharing their opinions on social media platforms. In exchange, patients would receive affordable, personalized, and evidence-based care. Moreover, our proposed IMS would create complete personal health records that could be seamlessly transitioned between various healthcare and insurance providers. Patients would therefore benefit from flexibility and improved consistency and continuity of care.

3.2 Healthcare Providers

Healthcare providers (e.g. hospitals, physician practices, etc.) may be governmental bodies, non-profit organizations, or private corporations. These entities interface directly with patients; they offer preventive and curative care, promote health maintenance, and field inquiries. Currently, healthcare providers have access to large bodies of data and medical expertise. Hospitals, multispecialty groups, and physician practices can contribute complete datasets – with patients' symptoms, treatment regimens, and outcomes – to our proposed IMS. In return, these stakeholders could benefit immensely from healthcare fusion. Firstly, by utilizing the IMS, healthcare providers would transfer data management responsibilities to an external entity. As such, these providers would no longer bear the overhead costs associated with data storage, transmission, and security. Furthermore, by adopting our proposed big data-driven framework, healthcare providers could optimize preventive and curative interventions, reduce readmissions, and improve patient satisfaction.

3.3 Insurance Companies

In privatized healthcare systems, insurance companies are financial intermediaries between patients and healthcare providers. Insurance agencies reimburse healthcare providers on patients' behalf. As such, these corporations benefit from preventive measures that reduce the need for costly curative ones. Like healthcare providers, insurance companies have access to vast repositories of personal health data. Insurance records may even be more complete than hospital records, as they include data from all parties that have cared for individual patients. Therefore, insurance providers can contribute valuable datasets to a fused healthcare system. In addition, given the large number of patients they cover, insurance agencies can also extract patterns with epidemiological relevance. With the adoption of healthcare fusion, insurance companies (like healthcare providers) stand to benefit from reduced data-related overhead costs. Additionally, via the IMS, insurance providers could rigorously monitor patient health, identify and respond to anomalies early on, and suggest preventive and lifestyle interventions. These capabilities could ultimately reduce the incidence of preventable diseases, and minimize spending on unnecessary treatments.

3.4 Pharmaceutical and Biotechnology Corporations

Pharmaceutical and biotechnology corporations are essential components of modern healthcare systems. The pharmaceutical sector develops drugs and other therapies, while biotechnology firms propose innovative treatments and solutions to challenges in healthcare. These entities aim to outcompete rivals and maximize profits. Medically-related businesses can contribute biological samples and data for biobanking, as well as a variety of omics data. In return for their valuable contributions to the IMS, these businesses would have access to aggregated, de-identified health data. These data could support drug discovery and market research, and allow corporations to anticipate and profit from major market events (e.g., COVID-19).

3.5 Social Media Platforms

Social media platforms are important public forums in health and medicine. For patients, social networks facilitate the sharing of opinions and sentiments related to healthcare. As such, social media companies have access to vast amounts of health-related data, which they can contribute to the fused cloud. Patterns extracted

from these data could be harnessed for epidemiology, market research, and other beneficial purposes. Within our proposed framework, social media platforms could profit by establishing partnerships with healthcare providers and businesses for informatics and advertising ventures.

3.6 Research and Epidemiology Organizations

Academic and private research entities are important players in the advancement of modern biomedical science and public health. This group includes basic science researchers, clinical researchers, epidemiologists, and sociologists – who often depend on raw data from other parties (e.g., patients, hospitals, insurance companies). Within our proposed framework, researchers can contribute epidemiological patterns, demographic and socioeconomic data, and biological data for omics and biobanking. In exchange for their support, the research and epidemiological sectors would gain access to vast datasets within the IMS. Complete, anonymized health records, for instance, would be available for retrospective and longitudinal studies. Moreover, data centralization could lower barriers to translational research, as the IMS would link biological data and clinical records.

3.7 Investors and Venture Capitalists (VCs)

This group of stakeholders constitutes the financial sector of a healthcare system. Through strategic investments, they seek to maximize returns. Investors and VCs possess financial resources which they can contribute to healthcare fusion. Their investments could support the development and modernization of data processing machinery, in the interest of advancing precision medicine and public health. As the healthcare field adapts to the digital era, investments in forward-looking businesses are likely to remain lucrative. Investors and VCs stand to profit immensely as corporations leverage data to optimize their operations, expand their market shares, and capitalize on market events.

3.8 Governmental and Regulatory Authorities

Governments are ultimately responsible for the health and wellbeing of their citizens. As such, legislative and executive bodies have an interest in ensuring timely, equitable, and effective healthcare delivery while containing costs. In pursuit of this goal, governments can contribute capital resources to the envisioned system. Additionally, public authorities can contribute demographic and socioeconomic data. Governments can moreover enact regulations and initiatives which protect stakeholder rights and encourage the adoption of healthcare fusion. In exchange for their investment, governmental agencies could realize substantial returns. A streamlined healthcare system would reduce national healthcare spending. Furthermore, our proposed IMS would facilitate the early detection of public health emergencies. Finally, governments could realize increased tax revenues as a result of increased profits by healthcare providers and businesses.

4. Data in Healthcare Fusion

4.1 Types of Data

Patient encounters, basic science research, clinical trials, and other healthcare activities generate a myriad of qualitative and quantitative data. The following types of data are prominent within the healthcare fusion framework:

4.2 Personal Medical Records

Personal medical records include vitals, medical images, laboratory results, medical histories, and free-text physician comments. Healthcare providers generate these data upon encounters with patients. Within our proposed framework, healthcare providers would package personal medical data and upload them to the fused IMS.

4.3 Patient Opinions and Sentiments

In advancing patient-centered medicine, individual patient opinions and sentiments are of great importance. Patients may express their sentiments during encounters with healthcare providers; these thoughts could be captured as free-text records and uploaded to the IMS. Social media is another avenue through which patients may openly convey their perspectives (Strang and Sun, 2019). Qualitative records from social media could be collected (1) in-house, by social media companies; (2) by governments; or (3) by third parties. These records would be de-identified and uploaded to the IMS.

4.4 Biological Data (Biobanking and Omics)

Biomedical research operations, biotechnology firms, and pharmaceutical companies generate diverse biological outputs. ‘Omics’ technologies, such as genomics, proteomics, and metabolomics, produce highly specific data at the patient and population levels (Hasin et al., 2017, Alyass et al., 2015). Biobanks store cell and tissue lines, pathogen specimens, blood, DNA, RNA, and other samples (Coppola et al., 2019). For the purposes of healthcare fusion, our proposed IMS would serve as a centralized repository for omics data. Applicable individual and population omics data would be attached to patient records and could enhance diagnosis. Moreover, the IMS would function as a comprehensive catalog unifying existing biobanks, in the interest of improving interoperability and data accessibility. The merits of centralized biobanking programs are demonstrated in countries such as Iceland and Finland, where interconnected biobank and EHR records facilitate population-level studies (Wolford et al., 2018).

4.5 Patterns

Epidemiological patterns are critical for public health. Elucidation of these patterns requires large quantities of healthcare data. Our envisioned IMS would aggregate, organize, and de-identify these data, and then make them available to research organizations and businesses. These entities could subsequently leverage AI platforms to analyze and extract patterns from the blinded data. Furthermore, insurance companies would have access to complete patient records; as such, they would also be well equipped to search for patterns. Identified patterns would be uploaded to the IMS, aggregated, and made accessible to relevant stakeholders.

4.6 Demographic and Socioeconomic Data

Geographic metadata pertaining to homelessness, familial status, tobacco use, and educational level can be highly beneficial in assessing the socioeconomic implications of disease. Through census, taxation, surveillance, and other records, governmental organizations have access to large volumes of relevant metadata. Under the healthcare fusion model, these data would be uploaded to the IMS and attached to patient records on a geographic basis. As such, healthcare providers could better understand and respond to patients’ physical, social, and economic needs, without excessive intrusions of privacy.

4.7 Information Communication Technology (ICT)

Health-related data are stored and transmitted through Information Communication Technology (ICT). There are six major types of ICT:

1. Electronic Health Records (EHR)
2. Health Information Exchanges (HIE)
3. Patient Health Records (PHR)
4. Telemedicine
5. Apps and Wearable Sensors
6. Social Media

Currently, HIEs aggregate data and facilitate information sharing between disparate EHRs. PHRs, or Patient Portals, allow patients to view some of their medical data. Healthcare fusion would merge EHRs, PHRs, and HIEs to create a centralized, secure, cloud-based repository for health data. This IMS would enable the stakeholders in health to access relevant data in a streamlined and controlled fashion. In this way, patients and their PCPs are “kept in the loop” and can be assertive in the development of healthcare plans (Mamlin and Tierney, 2016). Additionally, the IMS would improve interoperability within healthcare systems. Currently, patients seeking to transfer between healthcare or insurance providers often face challenges migrating their medical records between disparate systems. A centralized IMS would facilitate smooth transitions for both patients and providers, and ensure continuity of care.

Another ICT, telemedicine, has progressed over the past two decades as a technology which facilitates healthcare delivery over long distances. One example is teleradiology, which minimizes the need for both on-site radiologists and patient travel to often distant hospitals. Our proposed cloud-based IMS would aggregate patient data (e.g. medical images) and streamline their transmission to relevant physicians. As such, our framework would improve interoperability between traditional and telemedicine providers through data centralization.

In the age of mobile phones, health data can be generated by wearable sensors, and processed and displayed in software applications (apps). It has been proposed that this ICT could be linked with EHRs, such that patients

may access medical information on their mobile devices, and wearable sensors may input data directly into EHRs. Healthcare fusion takes a more limited approach with regard to mobile sensors. Within our framework, these sensors would provide data directly to patients in a comprehensible manner. Patients could retain these data for private use, or share them with healthcare providers. Physicians would then screen the data for validity and plausibility, and upload the data to the centralized IMS if appropriate. In this way, patients can retain control over their mobile data, as these data would not be pushed to EHRs or the IMS without their consent. Additionally, data screening by healthcare providers would prevent automatic population of patient records with inaccurate or inappropriate data.

Social media allows for rapid and large-scale communications which transcend socioeconomic barriers. Given their ubiquity among younger people of all backgrounds, social media platforms can reduce healthcare disparities (Huo et al., 2019). Furthermore, online networks for healthcare providers can promote best practices, knowledge transfer, and cross-checking of diagnoses and treatment plans (Grajales et al., 2014). Healthcare fusion would maximize utilization of valuable social media data to gather patient perspectives and sentiments. Social media is also an indicator of “buzz” or “hype” about diseases and treatments at the population level. Within the fused macrocosm, data on social media trends would be available to physicians, to enable them to better understand patients’ thoughts.

4.8 Big Data Analytics

The volume of quantitative healthcare data available today is vast and expanding exponentially; these data have important medical applications (Brown et al., 2018, Kayaalp, 2018, Mooney and Pejaver, 2018, Sanchez-Pinto et al., 2018, Zhang et al., 2017, Austin and Kusumoto, 2016). Today, the challenge is to store, transmit, and analyze these data on a sufficiently large scale. In this regard, an essential component of healthcare fusion is the synergy between various modern computing technologies, namely AI, ML, big data, and cloud computing, for analysis of qualitative and quantitative data (Figure 2). These technologies are described below:

4.9 Artificial Intelligence (AI) and Machine Learning (ML)

AI deals with independently intelligent systems which exhibit efficient, human-like cognitive and intellectual capabilities. These systems are driven by algorithms which facilitate self-learning and pattern recognition. Within the scope of healthcare, AI may expedite and optimize diagnosis and treatment, and minimize medical errors (Truong et al., 2019, Miller and Brown, 2018, Loh, 2018). In 2018, UK Prime Minister Theresa May announced that the UK will leverage AI to prevent and treat chronic diseases by 2030, indicating political recognition of the immense potential applications of AI.

ML, a subset of AI, is the ability to train machines to “learn” from data, self-improve, and make decisions. ML employs algorithms which iteratively leverage data to generate and refine decision-making and predictive models. Clinical, structured data (e.g. demographics, medical notes, physical examination and laboratory results, and images) can be used by AI applications for ML. Further, deep learning and natural language processing tools can “learn” from unstructured data (e.g. narrations and free-text records). Algorithms have already been trained with hospital data to predict outbreaks of chronic diseases such as cerebral infarction (Chen et al., 2017).

Our envisioned IMS would aggregate, store, and retrieve amounts of healthcare data that are far beyond the limits of human analysis. As such, AI and ML are indispensable. Appropriately “trained” AI platforms would scrutinize patient records for useful etiological and epidemiological patterns to feed into the IMS. Other systems could examine patient omics sequences to elucidate the molecular bases of disease. AI would also be leveraged to interrogate social media and other qualitative records. Finally, AI platforms would categorize data within the IMS, and control the release of data to stakeholders.

4.10 Cloud Computing

Healthcare data analytics programs are limited not only by human and intellectual factors, but by hardware as well. As data are largely siloed in discrete physical locations at present, each stakeholder is constrained by its in-house computational infrastructure. Healthcare fusion leverages cloud computing, or computing over the Internet, to address this. Cloud computing allows users to process and store vast datasets in remote data centers, and thereby makes big data analytics possible and cost-effective (Avula et al., 2012, Gao et al., 2018). Our proposed IMS would be a centralized, cloud-based point of information storage and exchange that would effectively circumvent the limits faced by individual stakeholders.

4.11 Databases

AI platforms can rapidly produce a large volume of data-linked outputs that can be utilized for ML if stored in appropriate databases. A goal of data mining is to discover patterns in datasets to enhance predictive and decision-making power (Itani et al., 2019, Mitchell, 1999). AI systems can undergo ML by scouring diagnoses and their corresponding data for patterns, and utilize the “learned” information to improve diagnostic efficiency and accuracy. In our proposed framework, data-linked outputs would be uploaded to the cloud-based IMS, which would eventually replace existing databases. We envision that through the IMS, AI platforms could iteratively leverage a nation’s entire body of healthcare data for ML and data mining.

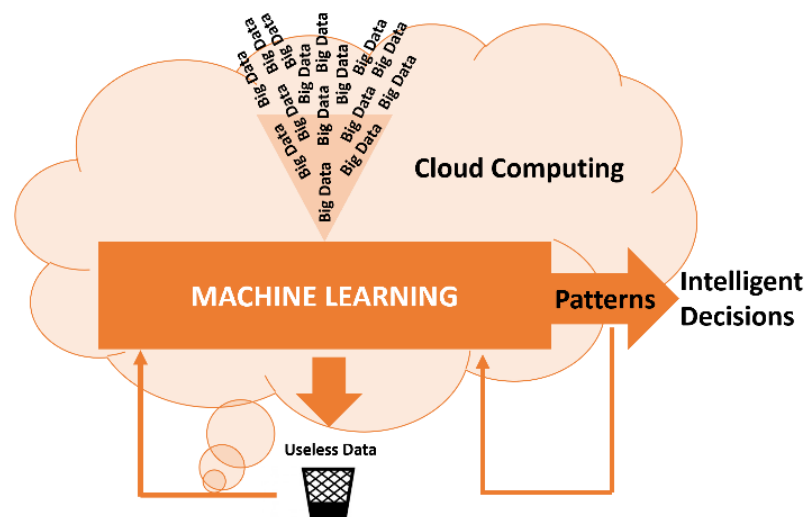


Figure 2: Synergy between modern machine learning, big data, and cloud computing technologies

Cloud computing facilitates storage and processing of immense amounts of (big) data by AI, while machine learning is a mechanism through which AI systems identify patterns and develop algorithms for data analysis.

4.12 ROBIN

To process healthcare data at an enormous scale and achieve the goals of healthcare fusion, data management systems must meet certain criteria for efficiency, accessibility, and efficacy. Five such criteria are enumerated within the acronym ROBIN, the components of which are presented in Textbox 1.

The ROBIN Criteria:

Responsive to shifting demands and technologies: in a rapidly changing field, big data analytics systems must be versatile enough to accept new types of data inputs and remain compatible with all sources of health data.

Open to patients and providers: to achieve patient-oriented precision medicine, all stakeholders in a patient’s health should have access to relevant data. Patients, especially, should be able to view their data at-a-glance. However, big data systems must comply with HIPAA regulations and maintain rigorous security policies.

Bridges individual and population data: big data systems should contextualize individual patient data with relevant population-level data whenever possible. Utilizing stratification, diagnoses and treatment plans can be determined through pattern-matching between individual and population data.

Information is shared between systems: Interoperability is key for efficient data analytics systems. Compatibility between ROBIN-ized systems facilitates efficient information transfer without the need for intermediaries (e.g. HIEs).

Networks with apps and wearable sensors: a key factor in patient empowerment is access to health data (as previously discussed). Patients must have an active role in the process of analysis, diagnosis, and treatment; as such, user-friendly data visualization interfaces are necessary.

Textbox 1: An overview of the five ROBIN criteria and their implications

In practice, the ROBIN criteria would constitute an oversight mechanism to maintain the quality and integrity of data in a fused system (see quality control checkpoints in Figure 1). Our proposed IMS would be fully “ROBIN-ized,” such that it supports access to stakeholders, integrates patient-specific and epidemiological data, and

remains relevant as new health-related technologies arise (see Textbox 1). Moreover, AI platforms within our framework would also adhere to ROBIN; in this way, data packets could be transmitted between stakeholders and the IMS without the need for extensive unpacking and repackaging. The aim of capital investment in healthcare fusion is to facilitate the enhancement of existing big data analytics systems to meet the ROBIN criteria, as well as the design and implementation of new, “ROBIN-ized” systems. In the case of pandemic diseases and public health emergencies, healthcare systems constructed with ROBIN in mind are capable of early detection of abnormal cases, and can unify stakeholders to facilitate rapid and decisive responses.

5. Healthcare Fusion Outputs

5.1 Biomedicine and Personalized Medicine

Biomedicine is a form of evidence-based medicine (EBM) which utilizes medical, surgical, psychological, lifestyle, and other interventions to prevent and treat disease (Gaines and Davis-Floyd, 2003). Under the EBM approach, healthcare providers combine their individual medical expertise with basic science and clinical data for diagnosis and treatment (Sackett et al., 1996). The “evidence” which fuels EBM includes biological, epidemiological, socio-cultural, and mechanistic patterns. Data processing within the healthcare fusion framework would leverage AI to efficiently elucidate these patterns, and aggregate them in the proposed IMS. A centralized repository of “evidence” could improve biomedical knowledge and support the development and enhancement of evidence-based interventions.

At its core, healthcare fusion aims to promote patient-centric healthcare delivery and research, as patients are the greatest stakeholders in their own health. Within a fused macrocosm, our proposed IMS would create individual patient profiles by aggregating all relevant data. A profile would include the following:

1. Complete Patient Medical History
2. Complete Family Medical History
3. Omics Records (*e.g.*, gene and protein sequences)
4. Epidemiological and Treatment Patterns (based on the patient’s age, gender, race, zip-code, etc.)
5. Non-Specific Demographic and Socioeconomic Data (based on the patient’s zip-code)
6. Buzz/Hype on Social Media

Profiles of this nature would only be accessible to those parties who require personally identifiable health data – namely patients, healthcare providers, and insurance companies. Within our current framework, patients’ requests for their profiles would be approved by their physicians, to ensure patient safety and avoid misinterpretation. In some jurisdictions, governmental authorities would also require access to the profiles.

With complete patient profiles at hand, physicians could consider the wide variety of genetic, environmental, and social factors at play. Omics records could be useful in understanding individual patients’ molecular susceptibility to certain diseases. Epidemiological patterns may likewise prove relevant to diagnosis. Moreover, patterns in outcomes after treatment could be invaluable to physicians. Upon their output from the IMS, these outcome patterns would be stratified by patient age, gender, ethnicity, intervention type, and other attributes. Therefore, in an evidence-based manner, physicians could determine suitable treatments for each patient. In developing treatment regimens, physicians could also utilize non-specific demographic and socioeconomic data to account for non-medical constraints. Finally, physicians would be aware of and capable of adequately addressing the online hype their patients may have been exposed to.

Looking to the future, personalized medicine will constitute a merger between patients’ clinical and biological (*e.g.*, omics) data (Karczewski and Snyder, 2018). Healthcare fusion would facilitate the combination of individual medical and biological data with epidemiological data. Together, these data could be leveraged to create personalized mechanistic models with predictive power (Viceconti et al., 2015, Shaikh et al., 2014, Costa, 2014). Furthermore, cloud computing, coupled with data from mobile applications and wearable sensors, can be utilized by patients for real-time health monitoring (Strang and Sun, 2019, Sobeslav et al., 2016).

5.2 Population Health

The components of healthcare fusion which drive biomedicine and personalized medicine can also deliver population-level impact. Key benefits of our proposed framework include surveillance and predictive power. The centralized IMS would contain all of a nation’s health data; healthcare providers and other stakeholders would relay updates, amendments, and new data to the IMS regularly. Data aggregation would reduce record gaps and

reporting delays, and support real-time population health monitoring. Analysis of aggregated data can reveal patterns and trends in the occurrence and spread of diseases (Strang and Sun, 2019, Grajales et al., 2014). As such, AI platforms would regularly scan records within the IMS in search of patterns and abnormalities; this could constitute an early warning system for infectious diseases. Discovered patterns could be utilized for ML, in the interest of developing predictive power.

Academic and research organizations would have access to blinded patient data from the IMS. Researchers could then conduct their own analyses, and relay patterns to the IMS. Governmental access to data within the IMS would vary between jurisdictions; in all cases, however, the IMS would relay epidemiological patterns and abnormalities to public health authorities. With access to up-to-date, comprehensive population data, governmental agencies could respond efficiently and decisively to public health emergencies. Furthermore, to provide nationwide equitable care, public funding could be allocated based on the epidemiological disease burden in each locality.

5.3 Profits

There are numerous ways to profit within the healthcare continuum. Outcomes in precision medicine and population health are highly profitable; investments in preventative and curative care drive revenue production (Cohen et al., 2008). Pharmaceutical and biotechnology corporations stand to profit from the vast amounts of data to be managed under healthcare fusion. Via the IMS, these businesses would have access to blinded health data; this data sharing model allows for corporate research and development without intruding excessively on patient privacy. Pharmaceutical companies, for instance, could leverage data within the fusion framework to accelerate drug discovery. De-identified omics and biobanking data could be utilized to identify therapeutic targets at the molecular level, while the centralized IMS could streamline clinical trial enrollment, monitoring, and data reporting. Moreover, these companies could scan anonymized clinical records to assess the demand for certain drugs on a geographic basis. They could subsequently optimize their operations to reduce costs while maximizing revenue.

Within the pharmaceutical sector, development of novel products and technologies is linked to high returns (Roberts, 1999). To realize these returns, pharmaceutical and biotechnology companies could use health patterns to anticipate and capitalize on market events. COVID-19, for instance, may have been detected early on in a fused system. Based on blinded data, businesses which anticipated the impending demand for masks, ventilators, and vaccines could have begun preparations in advance. Upon the full onset of the disease, those same businesses would be strategically positioned to maximally profit from the situation.

Finally, businesses in the health sector would have access to aggregated and de-identified social media records. These blinded data could prove instrumental for market research purposes. Utilizing patient sentiments, pharmaceutical and biotechnology companies could refine sales tactics, improve customer service, and identify niche roles within the market.

6. Implementation and Management of Healthcare Fusion

Ultimately, a governmental agency, public-private partnership, or private contractor(s) could oversee our proposed framework. Given the many stakeholders and interests in play, different expertise would be necessary to oversee each “arm” of a fused macrocosm. Here, we suggest several “departments” or sections that could be included in any supervisory body:

6.1 Technical Management Section

Day-to-day management of the IMS would be delegated to a section comprised of data scientists and software engineers. This branch could oversee AI platforms, implement system-wide software and firmware updates, analyze data, and resolve technical concerns.

6.2 ROBIN and Quality Control Section

Quality control checkpoints are necessary to ensure system-wide interoperability and streamline data transmission and utilization. A centralized quality control department would ensure that data entering or leaving the IMS are appropriately packaged (*i.e.*, “ROBIN-ized”).

6.3 Interface and Outreach Section

Staff within this section would maintain relationships with stakeholders in the fused macrocosm. Outreach personnel could encourage stakeholder participation through advertisements and incentives. Moreover, technicians and support staff would handle data-related inquiries. Finally, a public Relations team could compile data for public release.

6.4 Data Security Section

This section would maintain data integrity and patient privacy within the healthcare fusion framework. Data scientists and cybersecurity experts would oversee a rigorous security system for the IMS. These personnel would also develop solutions to protect data in transit. In addition, a centralized security department could perform audits to ensure stakeholder compliance with established regulations.

6.5 Regulatory Section

A regulatory branch would likely fall under the auspices of a governmental agency. Officials in this section would draft and implement system-wide policies on data management and security, stakeholder rights, and other pertinent matters. Importantly, regulators would balance patient and business interests in controlling access to data within the IMS.

Today, nations utilize a wide variety of healthcare and governmental models; as such, interactions between stakeholders vary on a national basis. Our proposed framework and business strategies could be adjusted and optimized to meet the needs of individual nations. Here, we discuss implementation and management strategies for healthcare fusion in three types of national healthcare systems. We are fully aware, however, that numerous intermediate and hybrid modalities also exist worldwide (*e.g.*, Canada and the United Kingdom, which have more socialized systems); our framework is agile enough to adapt accordingly.

6.6 Decentralized Government, Public Healthcare System (*e.g.*, New Zealand, Estonia)

In this group of countries, government hospitals and clinics constitute the majority of healthcare providers. Patients fund these providers through taxes, and receive low-cost or free care in exchange. As such, government is a dominant stakeholder in healthcare, along with patients and businesses in the health sector.

Implementation of healthcare fusion in government-run healthcare systems would be relatively straightforward. Based on central directives, system-wide changes could be made to modernize healthcare data infrastructure and link public care facilities to a cloud-based IMS. Importantly, private sector motivation and patient consent must be sought. In this interest, governments could provide incentives to patients and businesses in exchange for their participation. Finally, our proposed IMS would likely be publicly funded. We expect governmental agencies to take responsibility for data security and regulation. However, public-private partnerships may be established for technical management, quality control, and outreach. Based on public sentiment, limitations on data access by governmental organizations could be imposed (*i.e.*, governments may only have access to blinded data).

6.7 Centralized Government, Public Healthcare System (*e.g.*, Qatar, Oman, China)

Government is the major healthcare stakeholder within this category of countries. Through their tax dollars, patients fund government-run healthcare systems which provide low-cost care. Patients in these countries may have reduced control over their personal health data; this could streamline the adoption of healthcare fusion.

As discussed above, in-house changes within government-run healthcare systems could be accomplished efficiently. Patient participation and data sharing could be mandated through governmental directives. Health and social media corporations could likewise be required to contribute relevant data in order to continue business operations in a country. A cloud-based IMS could be constructed rapidly; governments may assume responsibility for all aspects of management of the fused macrocosm. It is likely that governmental agencies would have access to all data (unblinded) within the IMS.

6.8 Decentralized Government, Privatized Healthcare System (*e.g.*, United States)

Within countries such as the United States, a network of private care systems serves patients in exchange for insurance reimbursements. A limited number of public healthcare systems exist. Considering their financial role, insurance providers can exert great influence on healthcare delivery. These companies can regulate patient

access to specialists and mandate diagnostic workups. As such, insurance companies are major stakeholders in healthcare. Other stakeholders include patients, healthcare providers, pharmaceutical and biotechnology corporations, and social media companies. Compared to the decentralized-public and centralized-public models, the role of government may be reduced.

In a landscape dominated by private interests, rollout of healthcare fusion may prove difficult. Governmental authorities facilitating the adoption of fusion would face the challenge of unifying a multitude of stakeholders and technologies. A variety of financial incentives could be utilized to accomplish this goal. Private healthcare providers, for instance, could be offered grants to modernize their data management infrastructure. These providers, along with insurance, pharmaceutical, biotechnology, and social media companies, could contribute data to the IMS in exchange for tax breaks. Further incentives could be offered to encourage patient participation. Our proposed IMS could be developed solely by the government, or via a public-private partnership. While a governmental agency would likely regulate the fused macrocosm, responsibilities for technical management of the IMS, quality control, outreach, and data security could feasibly be delegated to a private contractor(s).

American political institutions are notably willing to adapt to shifting healthcare technologies. Extensive political action in favor of EHR and electronic health data has taken place; some examples are presented in Table 1. In supporting a national health database, allocating funding for EHR, and regulating data privacy, the US has taken its first steps toward fusion.

Table 1: Examples of United States political actions pertaining to EHR and electronic health data

This list highlights some landmark actions encouraging the implementation of data storage and processing technologies in healthcare.

Legislation	Purpose/Effect
<i>HIPAA</i> (Health Insurance Portability and Accountability Act, 1996)	Regulates the sharing of personal health information.
<i>ARRA</i> (American Recovery and Reinvestment Act, 2009)	Provides \$19 billion for health information technology.
<i>HITECH</i> (Health Information Technology for Economic and Clinical Health Act, 2009)	A part of ARRA which includes a set government incentive to encourage medical facilities to implement EHR.
<i>CMIA</i> (Confidentiality and Medical Information Act, 2012)	California state law that supplemented pre-existing federal protections of personal medical records.
All of Us Research Program, 2015	Federal program which aims to collect health data and metadata from 1 million volunteers, and create a national database to facilitate large-scale longitudinal studies (Sankar and Parker, 2017).

Concerns regarding data privacy and security are key points of contention in the implementation of healthcare fusion and related initiatives. Numerous perspectives on patient data rights and data management standards are currently available from all players in the healthcare sector. Pharmaceutical corporations and other health-related businesses could benefit immensely from access to patient data. On the other hand, patients may justifiably oppose the use of their data for commercial (or even research) purposes.

Conflicts between stakeholders have notably crippled fusion-related efforts in the past. In 2013, the UK government announced the care.data initiative, which aimed to create a centralized data repository with patient records and relevant metadata. This program was paused in 2014, and ultimately canceled in 2016, due to public discontent. Presser et al. identified the following major shortcomings of the initiative: (1) developers failed to properly consult with patients, providers, and other stakeholders; (2) unattainably high expectations were established for data management and privacy; and (3) healthcare providers faced contradictory regulations regarding data sharing (Presser et al., 2015).

To avoid the pitfalls of previous efforts, healthcare fusion aims to encourage stakeholder participation and shared returns. In all cases, universal best practices must be developed and implemented to prevent the stealing and selling of personal medical data (Mamlin and Tierney, 2016). Beyond this, stakeholder rights and responsibilities vary between nations. Implementation of our framework could be highly efficient in public

healthcare systems and nations where stakeholder compliance can be enforced rather than encouraged. However, we believe that healthcare fusion is adaptable to a variety of political and social contexts.

7. COVID-19 and the Need for Healthcare Fusion

Amidst the COVID-19 outbreak, it is evident that the status quo of healthcare systems is unsustainable. Delays in drug development, legal barriers to public health measures, and equipment shortages place patients and medical staff at risk. Many of these shortcomings stem from incoherent data management and sharing schemes.

For early detection, valuable data can be gleaned from EHRs in an interconnected system. Emergency department triage diagnoses, for example, can be analyzed to detect outbreaks of epidemic disease with high sensitivity and specificity (Olszewski, 2003). Social media is another relevant ICT – posts by individuals may alert public health authorities to unusual outbreaks. Under healthcare fusion, governments, hospitals, patients, scientists, and private industry are connected. Elements of fusion were visible in China's initial response to COVID-19: due to efficient data sharing between hospitals and central authorities, the initial outbreak was detected and reported to the World Health Organization (WHO) after only 27 cases were diagnosed (Wu and McGoogan, 2020). New Zealand's COVID-19 response further demonstrates the value of collaborative, synergistic responses to public health crises.

In responding to pandemic diseases, hospitals and research institutes must interconnect to drive translational research. This was seen in China, as within a month of the detection of the first abnormal case in Wuhan, researchers identified the causal factor of COVID-19 (Wu and McGoogan, 2020). Pharmaceutical corporations are major stakeholders in vaccine development and drug discovery – both of which depend on reliable data from hospitals and epidemiologists; they should be connected to the governmental and clinical sectors to (1) access relevant, blinded clinical and basic science data for research and development, and (2) make incentivized contributions to local and national responses.

As the pandemic progressed, national and international efforts to promote fusion materialized and matured. The US government has increasingly adopted measures to connect local and national datasets – beginning in March 2020 with a mandate for all state laboratories and hospitals to report COVID-19 test results to the Centers for Disease Control and Prevention (CDC). At the international level, countries have formed consortia, while novel initiatives have linked basic and clinical COVID-19 researchers with other scientists worldwide. These are all emerging examples of international healthcare fusion.

8. Conclusions

A significant pitfall in today's notion of healthcare is the cavalier attitude toward synergy. This poses a serious barrier to entry for innovation in healthcare. We see an urgent need for a new healthcare macrocosm to link the currently isolated microcosms of governments, healthcare providers, private industry, and patients. In this regard, we propose healthcare fusion, a data-driven and holistic framework with a cloud-based IMS at its core, for patient-centered healthcare delivery. One immediate advantage of the fusion framework is that it aligns the interests of research, business, and government to ensure robust and profitable outputs.

Within our framework, a centralized, cloud-based IMS could efficiently connect stakeholders in health and medicine. Big data analytics systems, optimized through our proposed ROBIN criteria, could analyze aggregated medical data. Data-linked outputs of AI analysis could support personalized medicine, preventive care, epidemiology, market research, and other pursuits. By distinguishing between blinded and unblinded data, regulators can allow stakeholders to access data within the IMS, without compromising patient privacy. This is of paramount relevance to the emerging fields of personalized medicine, eHealth, and telemedicine.

Implementation of the healthcare fusion framework would firstly require political will, and then the contribution of patients, governmental authorities, healthcare providers, and the private sector. These stakeholders could be mobilized through incentives and regulations, which would vary between nations. A proof of concept may be examined in nations that are progressing towards comprehensive, digitized, big data-based healthcare systems.

In closing, we envision healthcare fusion as a novel, holistic approach to healthcare data management and utilization. Healthcare fusion is not only a centralized IMS. Rather, it is a comprehensive framework encompassing the stakeholders in healthcare, the healthcare data themselves, the system-wide quality control

and oversight mechanisms, and the data repository. Our framework is novel in that it broadly leverages demographic and socioeconomic data in support of socially and environmentally conscious healthcare. Healthcare fusion also includes social media companies as key stakeholders in health, and utilizes “buzz” and “hype” from social media records to better inform and warn patients and physicians. Finally, we suggest the ROBIN criteria as a system-wide quality control mechanism.

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