FROM DIGITAL READINESS TO EPIDEMIC PREPAREDNESS: EUROPE RESPONSE TO COVID-19

Giulia Interesse

Peking University
giulia.interesse@gmail.com

Abstract

The demands imposed by the COVID-19 pandemic have contributed to a multilateral shift towards the digital transformation of governments and public services across Europe. Public administrators have adopted original and innovative solutions to cope with the epidemiological emergency, resulting in digital readiness becoming a key player in pandemic prevention and control. This research investigates such digitalisation efforts in the EU and the consequent learning strategy for pandemic management. Data retrieved from the latest Digital Economy and Society Index (DESI) and the INFORM Epidemic Risk Index suggest a close relationship between the government digitalisation readiness and epidemic response preparedness in the EU. At the same time, a closer look at measures adopted by the individual Member States represents an interesting case for discussion.

The COVID-19 crisis has proved the importance of digital transformation in ensuring the maintenance of governmental activities while securing the observance of health-related safety measures. Those countries that showed higher levels of digital readiness obtained more meaningful outcomes in crisis management. Moreover, an overview of the policy tools introduced to deal with the pandemic provided further examples of digital readiness applications to source real-life solutions. The conclusions are based on policy-oriented recommendations whose application can be adapted to the public spheres of digital infrastructure, capacity-building, and public services provision – both within and beyond the context of pandemic control.

Introduction

As the COVID-19 pandemic has forced the world to extended periods of lockdown and social distancing, the quest for innovative solutions has rapidly become a global calling. More than ever before, governments worldwide seem to be fully embracing their role as facilitators of the digital transition and guardians of the public interest. Since the epidemiological emergency has strengthened the demand for digital interventions, it is crucial to reflect on the progress made so far in furthering the application of digital technologies to disease prevention and health security.

Recent developments in government studies have led to the conceptual and empirical formulation of new mechanisms in the field of public governance. These assessment indices and case study reports on digital transformation disclose important lessons from different countries so that their innovation path can be replicable. In particular, the concept of *digital readiness* has emerged as a critical issue, becoming one of the key measures for evaluating the overall digital shift in society. Testing the readiness of digital public management tools is also essential when dealing with health emergencies. Arguably, a resilient national healthcare system is a valid indicator of high *health emergency preparedness* levels. In order to build one, competent and motivated experts, accessible infrastructures and the integration of innovative technologies must all be present.[1]

The main objective of this study is precisely to assess the integration of digital technologies within the pandemic control framework. By doing so, the correlation between digital readiness and health emergency preparedness is examined and interpreted as a meaningful criterion for public management

[1] "Country Preparedness and COVID-19", Prevent Epidemics, accessed on 9 November, 2020, https://preventepidemics.org/covid19/science/insights/country-preparedness-and-covid-19/.

evaluation during COVID-19. It is thus necessary to define these two concepts and find a way to measure them. Once the terminology has been clarified, the relationship between the two can be observed with more clarity. I hypothesise that digital readiness has a direct influence over the Member States' epidemic preparedness and management. I apply this hypothesis to the specific case of COVID-19 control in Europe – one of the earliest regions worldwide to be affected by the pandemic and yet presenting a notable concentration of high-income countries that provides consistent data on digital assimilation in public departments, and advanced healthcare provision.

The first part of this article deals with some fundamental concepts and definitions, establishing the difference between e-government and digital government, describing various forms of digital public management, and the premises for digital government studies. In this way, I lay out a comprehensive summary of the state-of-the-art in digital government research and its integration within innovative healthcare solutions. Indeed, because the characteristics of digital readiness are inherently complex, and its implications for the future are still largely unexplored, the field could benefit from a comprehensive account of the main theories and practices that have emerged around this topic. I then provide an overview of COVID-19 management practices, specifically by looking at the European case of the digital approaches to pandemic control against the theoretical frameworks for epidemic preparedness evaluation. A systematic literature review of the research trends in this direction facilitates this task.

The methodology section addresses such a need for theoretical transparency in detail while also clarifying the analytical tools employed for case study selection and scrutiny. The data breakdown reveals the importance

of digital integration in healthcare management, especially by addressing the effects on the *vulnerability*, *epidemic risk,* and *lack of capacities* factors. The empirical strategy of this study addresses two main research questions: what type of relationship exists between digital readiness and health emergency preparedness? How do individual factors (components or dimensions in each concept) relate to one another? The results from the multilinear regression are presented in the findings section and completed by a qualitative analysis of the digital policy tools employed by each Member State to cope with the pandemic. This overview provides some real-life examples and leads towards the concluding observations of the article.

Digital Government Readiness: A Measure for Digitisation

Digitalisation is among the key drivers of social, economic and political change: as such, its new rules guide modern societies through the digital age, independently from their current development level[2]. As digital maturity becomes a factor of competitiveness and innovation among countries, new assessment strategies for the digital transformation in the public sector are required. According to the UN E-Government Survey (2020)[3] over 65% of the countries worldwide present high or very high EGDI levels. Indeed, the COVID-19 pandemic has played a crucial role in driving digital transformation in government and societies. Moreover, a recent report measuring civic engagement amid the pandemic[4] reveals that most government officials believe that public institutions should become

[2] Lotte Frach, Thomas Fehrmann, and Peter Pfannes, "Measuring Digital Government: How to Assess and Compare Digitalisation in Public Sector Organisations," *Digital Government,* (2016): 25-38. DOI: 10.1007/978-3-319-38795-6_2.

[3] "United Nations E-Government Survey 2020," United Nations, Department of Economic and Social Affairs, accessed on 9 Nov. 2020, https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2020.

[4] "Civic Engagement Amid the Pandemic: Special 2020 BenchMark Report," Grancius, Accessed on: 9 Nov. 2020, *https://granicus.com/civic-engagement-amid-the-pandemic-benchmarks/*.

technologically advanced, expecting digital transformation to occur within their organisation during the pandemic. Thus, as the digital shift takes place at a faster pace globally, it is necessary to reflect upon the meaning of such a transition for future implications. To clarify the fundamental premises of this new paradigm, one must also be concerned with the terminology, development and issues addressed within the digital government literature.

In 2014, the Organisation for Economic Co-operation and Development (OECD) released several recommendations for digital enhancement strategies[5]. The document includes a clear distinction between e-government and digital government, defining the latter as a new stage in digital innovation[6]. This new phase of the digital shift implies a transition from mere automatisation of government services to a citizen-centred experience. Hence, the passage to digital government encompasses some typical practices of the private sector, placing the customer interaction and experience at the centre of service delivery. Similarly, the Ovum Report (2016)[7] found that government agencies globally began to adopt smarter initiatives to secure their mission, closely resembling a business-management approach. Consequently, the maturity of digital government will vary according to the synergy created with local citizens, that is, the relative establishment of transparent communication and reciprocal trust between citizen and State.

Therefore, the two terms represent separate developmental stages of the same phenomenon. On the one hand, e-governance emphasises the

[5] "Recommendation of the Council on Digital Government Strategies," Organisation for Economic Co-operation and Development, accessed 10 Nov. 2020, https://www.oecd.org/gov/digital-government/Recommendation-digital-government-strategies.pdf.

[6] Bonnie Gardiner, "E-Government Is Passé – Digital Government Is the Future: Report," *CIO*, accessed 10 Nov 2020, www.cio.com/article/3497027/e-government-is-passe-digital-government-is-the-future-report.html.

[7] Hafizah Osman "An E-Government is so passé: Ovum," ARN, accessed 09 Nov. 2020, https://www.arnnet.com.au/article/590461/an-e-government-pass-ovum/.

administrative and managerial aspects within public or private organisations – about its initial adoption of Information and Communication Technologies (ICT) – and, in particular, the Internet – to create multilevel management of organisational resources, policy actions and protocols. On the other hand, digital government represents the mature stage of e-government, which aims at a multilateral digital transformation involving the society at large, in which digital governance is necessary for the foundation of the collaborative administrative model, more focused on citizens' needs[8].

While Waheduzzaman and Miah[9] confirm the need for strategies in enhancing effective digital governance for the delivery of public services, Alghamdi et al.[10] suggest an overall organisational e-readiness framework to facilitate the adoption of digital structures in administrative settings worldwide. To meet context-specific needs, Dwivedi *et al.*[11] propose a unified model of digital government adoption (UMEDA) that includes and synthesises the main reference models for the implementation of IT while highlighting the most relevant constructs. The evaluation of digital government performance and the application governance effectiveness must adhere to a specific set of criteria, varying among different situations and

[8] Choong-sik Chung, *Developing Digital Governance: South Koreas as a Global Digital Government Leader* (London: Routledge, 2020).
[9] Wahed Waheduzzaman and Miah S. Jahan, "Readiness assessment of e-government: a developing country perspective," *Transforming Government People Process and Policy* 9, no.4 (2015): 512-513. DOI: 10.1108/TG-05-2014-0018.
[10] Ibrahim A. Alghamdi, Robert Goodwin and Giselle Rampersad, "A Suggested E-Government Framework for Assessing Organizational E-readiness in Developing Countries", 479-498. Paper presented at ICIEIS International Conference, https://doi.org/10.1007/978-3-642-25453-6_41
[11] K. Yogesh Dwivedi, P. Rana Nripendra, Jeyaraj Anand, Marc Clement, and Michael D. Williams, "Re-examining the Unified Theory of Acceptance and Use of Technology (UTAUT): Towards a Revised Theoretical Model." *Information Systems Frontiers* 21, (2019): 725-726. DOI: 10.1007/s10796-017-9774-y.

environments, and in some cases resulting in country-specific (as in, non-transferable) practices.

Over time, the literature has questioned various ways to assess digital government efficiency. Because the ideas underpinning the realisation of digital government are related to those of management – and because digitalisation itself is an all-around phenomenon that takes on both the private and the public sectors – these criteria should also be considered when asking how to evaluate and compare different models of digital government. Furthermore, considering digitalisation as a global movement, scholars had to establish standard criteria to investigate similarities and differences among the various countries/systems.

Maniam[12] notices that a growing number of governments are claiming to "go digital" by incorporating digital technology into their internal administration and service delivery. However, all the frameworks available for digital government assessment are often flawed and insufficient. The list includes many well-known indices of digital government evaluation – e.g. those compiled by the United Nations[13] and The World Bank Group.[14] Nonetheless, these studies disclose precious information about the scope of digital transformation. In a world where the process of digitalisation is both a matter of public governance as well as an economic-driven decision, the passage to a digital society must take on several dimensions, identified as different interest groups. Against this background, governments must

[12] Aaron Maniam, "How can we measure and rank digital government successes?," GovInsider, Accessed 10 Nov. 2020, https://govinsider.asia/connected-gov/what-digital-gov-success-looks-like/.

[13] "E-Government Development Index (EDGI)," United Nations, Department of Economic and Social Affairs, accessed 10 Nov. 2020, https://publicadministration.un.org/egovkb/en-us/About/Overview/-E-Government-Development-Index.

[14] "Digital Government Assessment: Recent Approaches and Methodologies," World Bank Group, accessed 10 November 2020, https://olc.worldbank.org/content/digital-government-assessments-recent-approaches-and-methodologies.

guarantee the delicate equilibrium between public demands and private interests.

Building on this extensive literature, the present study employs *digital readiness* as a multidimensional measure for estimating the overall level of government digitisation in EU countries. In this way, it contributes to the research field by covering the adoption of digital solutions under the COVID-19 pandemic, a topic that is still in its infancy and largely unexplored.

COVID-19 Control and *Health Emergency Preparedness* in the EU

In the aftermath of the 2003 SARS outbreak, the idea of *health emergency preparedness* has taken on a revived significance in the public sphere.[15] In response to the new risks related to the global emergence of viral diseases, the State Parties of the World Health Organization (WHO) co-signed an implementation of the International Health Regulations (IHR) in 2005,[16] intending to strengthen and coordinate the protective and control measures of the international healthcare system. By doing so, each country took full responsibility for securing the renewed requirements highlighted in the IHR. However, a subsequent assessment of the progress made in establishing suitable healthcare-emergency plans revealed a lack of consistency and a slow implementation pace. In a second moment, a Global Health Security Agenda (GHSA)[17] was launched, along with a new

[15] David M. Bell, "Public health interventions and SARS spread, 2003," *Emerging Infectious Diseases* 10, no.1 (2004): 1900-1901, DOI: 10.3201/eid1011.040729.

[16] "International Health Regulations (2005)," World Health Organization, accesses 7 November 2020, www.who.int/publications/i/item/9789241580496.

[17] "Global Health Security Agenda (2014)," World Health Organization, accessed 10 Nov. 2020, https://ghsagenda.org.

assessment tool for Joint External Evaluation (JEE),[18] that precisely targets the state's capacity of preventing, containing and managing possible disease threats. To anticipate the occurrence of epidemiological threats such as COVID-19, governments must allocate time and resources to the development of emergency plans, laboratories, special training, and advanced types of machinery.[19]

Europe is undoubtedly one of the regions majorly hit by the COVID-19 pandemic. As the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) continues spreading across its territory, the health emergency converges in a unique, multifaceted crisis over three different levels: governance, economy, and migration.[20] These issues present similar roots and reflect several shortcomings in the protection mechanisms for essential public good. Hence, acknowledging the intersectionality of these problems represents the first step in creating a Europe-wide response to the collateral emergency. On a governance level, the pandemic revealed dramatic deficiencies in regards both to the national mitigation policies and the administrative capabilities of the EU. In a series investigating the global response to the crisis, Hall *et al.* indicate the "*poor preparedness, indecisive leadership and discord between central, regional and local government*"[21] along with the Member States' failure in learning from each other. These observations reinforce the need to rely on a community-based organisational

[18] "Joint External Evaluation (JEE tool)," *World Health Organization, IHR (2005) Monitoring and Evaluation Framework,* (2018), accesses 8 November 2020, https://www.who.int/ihr/publications/WHO_HSE_GCR_2018_2/en/.

[19] "Strengthening health security by implementing the International Health Regulations (2005)**,"** *World Health Organization*, accessed 8 November 2020, https://www.who.int/ihr/preparedness/en/.

[20] Kyavan Bozorgmehr, Victoria Saint, Alexandra Kaasch, David Stuckler and Alexander Kentikelenis,"COVID and the convergence of three crises in Europe," *Lancet Public Health* 5, no.5 (2020), S2470=S2472. DOI: 10.1016/S2468-2667(20)30078-5.

[21] Ben Hall, *et a,* "How coronavirus exposed Europe's weaknesses," *Financial Times,* 20 October, 2020, https://www.ft.com/content/efdadd97-aef5-47f1-91de-fe02c41a470a.

strategy to contrast the pandemic advance - and similarly, in other types of emergencies.

For this very reason, scientists and policymakers have joined forces to conceive a valuable COVID-19 management framework to orchestrate and assess the actions taken by individual governments. In line with the recommendations contained in the COVID-19 Strategic Preparedness and Response Plan (SPRP)[22] drafted by the WHO, the European Centre for Disease Prevention and Control (ECDC) proposes a monitoring and evaluation framework[23] to support the European Union (EU) and European Economic Area (EEA) countries and the United Kingdom in their attempt to assess the effect of the COVID-19 response protocols. The framework delineates several fundamental indicators for the evaluation of COVID-19 preparedness, prevention and monitoring activities.

Ibrahim et al.[24] similarly developed some replicable criteria for the assessment of COVID-19 management practices. These include, among others, international travel restrictions, social distancing implementation, randomised testing and increase in testing capacity, expansion of the workforce for Epidemic Intelligence Service (EIS), and quarantine of uninfected people. These non-pharmaceutical measures all reflect the implementation of digital means for strengthening public health response and

[22] "COVID-19 Strategic Preparedness and Response Plan: Operational Planning Guidelines to Support Country Preparedness and Response," *World Health Organization,* accessed 10 November 2020. https://reliefweb.int/report/world/covid-19-strategic-preparedness-and-response-plan-operational-planning-guidelines.

[23] "Monitoring and evaluation framework for COVID-19 response activities in the EU/EEA and the UK," *European Centre for Disease Prevention and Control*, accessed January 2021, https://www.ecdc.europa.eu/sites/default/files/documents/covid-19-framework-monitor-responses.pdf.

[24] Mustapha D. Ibrahim, Fatima A.S. Binofai and Reem M.M. Alshamsi, "Pandemic response management framework based on efficiency of COVID-19 control and treatment," *Future Virology* 15, no.12 (2020), 801-816. DOI: https://doi.org/10.2217/fvl-2020-0368.

control, to some extent. The surveillance aspect, in particular, is closely related to the question of digital readiness, as it requires specific infrastructures and capabilities to properly function.

According to the WHO, digital health can be defined as any field of medical knowledge or practice which allows the intermission of digital technologies for improving the overall performance of healthcare services[25]. While some studies[26] identified different ranges of digital health applications, emphasising the role of early prevention, others focused more on the perspective of centralised government control over society in case of extreme situations. Among them, Goniewicz *et al.*[27] adopted Breman's conceptualisation of population-based medicine[28] (PBD) to justify a deep intervention of the state over its citizens in cases of emergency. The PBD Theory of Management places the individual patient into a broader social environment that comprises the whole population and directly deals with the collective health community in emergencies. In the specific case of the EU governments actions against the COVID-19, six different operational areas are identified and reviewed within this original framework, namely: strict social distancing strategies, contact testing and tracing, testing for the virus antigen and its antibodies, isolation, and treatment modalities such as new mitigating medications, and finally, a vaccine. Chan *et al.*,[29] in their

[25] "Data and innovation: draft Global Strategy on Digital Health," World Health Organization, accessed 11 November 2020, https://apps.who.int/gb/ebwha/pdf_files/EB146/B146_26-en.pdf.

[26] Sohini Sarbadhikari and Suptendra N. Sarbadhikari, "The Global Experience of Digital Health Interventions in COVID-19 Management," *Indian J Public Health* 64, (2020): Suppl. 117-124. https://www.ijph.in/text.asp?2020/64/6/117/28559.

[27] Krzysztof Goniewicz *et al.*, "Current Response and Management Decisions of the European Union to the COVID-19 Outbreak: A Review," *Sustainability* 12, no.9 (2020): 3838. DOI: https://doi.org/10.3390/su12093838.

[28] Joel G. Breman, "Population-Based Medicine," *JAMA: The Journal of the American Medical Association* 252, no. 9 (1984): 1188. DOI: 10.1001/jama.1984.03350090064029.

[29] Emily Ying Yang Chan, *et al.*, "Sociodemographic Predictors of Health Risk Perception, Attitude and Behavior Practices Associated with Health-Emergency Disaster Risk

assessment of the citizens' response to COVID-19 containment measures and their application, reinforce the need for a top-down Health-Emergency and Disaster Risk Management (Health-EDRM) approach in limiting the chances of viral propagation. The same scheme is considered by Chan *et al.*[30] in another study, while assessing the application of a Public Health Prevention Hierarchy in support of Health-EDRM to create disaster-mitigation strategies and response programmes.

So far, the literature has demonstrated the need for *extraordinary* well-coordinated and centralised government actions (top-down management approach) in the early stages of emergency control and monitoring. Yuan *et al.*[31] also proved the importance of real-time monitoring of COVID-19 transmissibility and mortality rates, illustrating the use of real-time reproduction numbers (Rt) and case fatality rates (CFR). Starting from the same assumptions, Mavragrani[32] utilises infodemiology to correlate online virus-related searches with the increase in the number of cases in various European countries. This study is a good exemplification of the possible integration of digital tools in enhancing international surveillance and preventive efforts.

Management for Biological Hazards: The Case of COVID-19 Pandemic in Hong Kong, SAR China." *International Journal of Environmental Research and Public Health* 17, no. 11 (2020) 3869. DOI: https://doi.org/10.3390/ijerph17113869.

[30] Emily Ying Yang Chan and Rajib Shaw, *Public Health and Disasters: Health Emergency and Disaster Risk Management in Asia* (Singapore: Springer 2020).

[31] Jing Yuan, *et al.*, "Monitoring Transmissibility and mortality of COVID-19 in Europe," *International Journal of Infectious Diseases,* 95 (2020): 311-315. DOI: 10.1016/j.ijid.2020.03.050.

[32] Amarillys Mavragani, "Tracking COVID-19 in Europe: An Infodemiology Study (Preprint)," *JMIR Public Health and Surveillance*, (2020), 233-245. DOI: https://doi.org/10.2196/18941.

Holding a similar perspective, Blomberg and Lauer[33] extensively illustrate the role played by the European Research Infrastructure for Life Science Data (ELIXIR)[34] in providing the tools and workflows necessary to confront the pandemic. As highlighted by their study, the overall response of the EU includes a plan of federating existing platforms to connect European COVID-19 data spaces, applying good data management practices to support the access and future reuse of such datasets, and lastly, providing computational resources reproducible both in different times and geographic scopes. Such a strategy confirms, once again, the importance of creating integrated digital solutions at the EU-level (in terms of community), starting from the gathering of sub-national and national-level data (area-specific) and putting them at the service of the whole community for future prevention and support mechanisms.

The trend that eventually emerges from the review of recent studies is that of a decisive turn towards digital integration to the measures for epidemiological prevention. It is thus safe to assume that the two factors are mutually correlated. In the case of COVID-19 control strategies, understanding the significance of digital readiness over the response preparedness of different states, will generate essential knowledge for future search and, most importantly, well-rounded policy-making decisions. Because few researchers have addressed this model so far, the following sections examine the idea of digital readiness in relation to pandemic preparedness across the EU in the quest for early examples of innovative policy responses.

[33] Niklas Blomberg and Katharina B. Lauer, "Connecting data, tools and people across Europe: ELIXIR's Response to the COVID-19 Pandemic," *European Journal of Human Genetics* 28, no. 6 (2020): 719–23. DOI: 10.1038/s41431-020-0637-5.
[34] For further information on ELIXIR: https://elixir-europe.org/about-us

Research Methods and Data

The research design takes on a mixed-methods approach and is divided into three key moments, described as follows.

Defining digital readiness and emergency preparedness

In the preparatory phase, I identified the key factors underpinning the integration of digital strategies in the government response to the COVID-19 pandemic. A systematic literature review was performed to extract the existing body of knowledge related to digital readiness and epidemic control. Systematic reviews are considered in high regards due to their tendency to reduce biases, increase reliability, and potentially improve the communication of the findings.[35]

Following a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Prisma),[36] a standardised search on the Web of Science (WoS) and Scopus online databases was carried out, using the keywords ["digital government" OR "digital readiness" AND ["COVID-19 management/response" OR "epidemic preparedness"]. Because this first step aims to understand the latest trends in scientific research about these topics, the systematic search was limited to publications from the last five years (2016-2021). As expected, the results revealed a high concentration of studies in the areas of healthcare, computer science, education, and governance (even if publications in this area are still relatively scarce in comparison with the others). The highly cited and most relevant articles are acknowledged in this

[35] Saeed Pahlevan-Sharif, Paolo Mura and Sarah Wijesinghe, "A Systematic Review of systematic reviews in tourism," *Journal of Hospitality and Tourism Management,* 39 (2019): 158-165. DOI : 10.1016/j.jhtm.2019.04.001.

[36] A. Liberati et *al*., "The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Healthcare Interventions: Explanation and Elaboration," *BMJ*, 339 (2009): b2700–2700. DOI: 10.1136/bmj.b2700.

study's background sections, as they constitute the theoretical foundation and the logical premise for the construction of the linear model.

Studying the link between digital readiness and health emergency preparedness

In this segment, I present the microdata and estimation strategy. To define the causal effect of digital readiness on health emergency preparedness, I combine multiple indicators. An original dataset was obtained by extracting information from the Digital Economy and Society Index (DESI)[37] and the INFORM Epidemic Risk Index (compiled by the EU and the WHO agencies, respectively).[38]

The DESI is a composite index that presents a set of indicators on Europe's digital performance and tracks the progress of EU Member States in digital readiness. It includes five dimensions: *connectivity*, *human capital*, *use of internet services, integration of digital technology*, and *digital public services*. Each dimension comprises another set of sub-categories. As reported by the 2020 DESI (based on data gathered in 2019) all EU countries scored a remarkable improvement in the adoption of digital solutions. In particular, Finland, Sweden, Denmark and the Netherlands gained high ratings, counting as the top nation-drivers of digital transformation globally. Malta, Ireland and Estonia are also well-positioned, whereas some other countries performed below the European average.

The INFORM Epidemic Risk Index provides crucial information regarding the countries' capabilities of responding to epidemic outbreaks.

[37] "The Digital Economy and Society Index: Shaping Europe's Digital Future," *European Commission*, accessed November 2020. https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi.

[38] "INFORM Risk Index," European Commission, accessed 10 Nov. 2020, https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk.

Following the WHO's identification of the risk drivers of the epidemic, it comprises a set of values for *epidemic risk*, *vulnerability* and *lack of capabilities.* Each of these three dimensions is potentially a key factor for epidemic management, and thus, an indicator of countries' preparedness to health emergencies. None of the EU Member States figures as a "high risk" area. However, a few of them perform poorly in some of these dimensions – especially the *vulnerability* one.

After conducting a careful analysis of the two databases and selecting those measures that are the most meaningful for the purpose of this study, I combined the three indicators extracted from the INFORM Risk Index and the scores from each of the five DESI dimensions. In addition, basic demographics and other significant statistics related to the COVID-19 pandemic were also extracted from the EUROSTAT and ECDC databases. The final dataset included a total of n=27 observations (EU/EEA countries). Multiple linear regression was calculated to predict the health emergency preparedness based on each of the five dimensions from the DESI index – once combined, they express the average digitalisation level in each Member State: a measure for digital readiness.

On the other hand, the *vulnerability*, *epidemic risk,* and *lack of capabilities* indicators from the INFORM Risk Index, along with the total *number of cases* and the *sum of deaths*, serve as outcome variables and general measures for emergency preparedness. The period covered for the total number of observations goes from the first week of 2020 to the fourth week of 2021. Because of the variance in the number of cases and fatalities, I calculated the period prevalence for each case.[39] I identify the causal effect

[39] Prevalence indicates the proportion of individuals in a given population who have a particular disease or attribute. Period prevalence measures the occurrence of prevalence

of digital readiness on health emergency preparedness in the following reduced-form, multiple linear regression:

$$\hat{y} = \beta_0 + \beta_1(digital\ readiness) + \beta_2\ (GDP) + \beta_3(age) + \beta_4(R\&D)$$

where $\hat{y}$ is the expected outcome variable *health emergency preparedness* which takes first the value of *prevalence of deaths/cases*, and in a separate function that of *epidemic risk*, *lack of coping capacity* and *vulnerability.* This is because, to estimate the effect of digital readiness on the specific case of COVID-19 preparedness in the EU, it is first necessary to establish the existing relationship between digitisation and the measures of health emergency preparedness in general (as previously stated in this study, expressed by the three factors). The *digital readiness* coefficient is obtained by calculating the mean of the five key dimensions extracted from the DESI index. *GDP per capita, the median age* and *total R&D expenditure* are used as control variables.

(cases/attributes) over an extended period of time, thus including both old and new cases/attributes that may appear at any time in the given interval.

Explaining the impact of digital readiness on emergency preparedness

The final stage of this study presents a set of policy measures adopted by some EU countries that are qualitatively described through Content Analysis (CA). CA approach allows an in-depth description and explanation of policy actions, providing strategic tools for summarising the principal information and cross-case study comparison. On the one hand, the results of this policy analysis serve as a descriptive tool for the quantitative results. On the other, they provide a complete account of the policy measures taken to control and manage the first waves of COVID-19. Particular emphasis is placed upon the success stories of those countries that performed well in epidemic preparedness and stood out for their remarkable achievements in digitalisation efforts.

Results and Discussion

Table1 includes summary statistics for all the key variables.

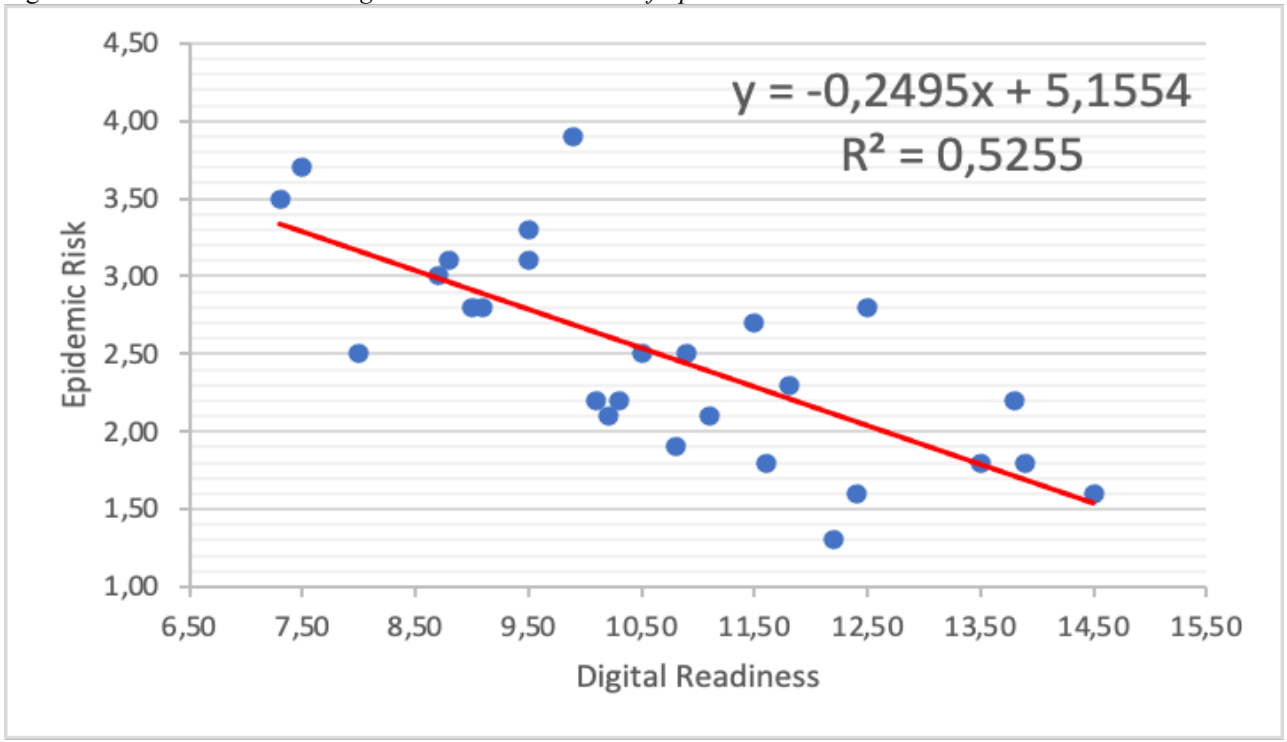
Table 1: *Summary Statistics.*

Y = Prevalence of Deaths / Cases 2020W1-2021W4		*Y = Epidemic Risk*		*Y = Vulnerability*	
Mean	0,021	Mean	2,485	Mean	3,856
Standard Error	0,002	Standard Error	0,130	Standard Error	0,127
Median	0,020	Median	2,500	Median	3,900
Mode	0,020	Mode	2,500	Mode	4,000
Standard Deviation	0,009	Standard Deviation	0,675	Standard Deviation	0,659
Sample Variance	0,000	Sample Variance	0,455	Sample Variance	0,434
Confidence Level(95,0%)	0,004	Confidence Level(95,0%)	0,267	Confidence Level(95,0%)	0,261

Y = Lack of Coping Capacity		*DESI mean*		*GDP per capita (2019)*		*Median Age in Years*		*Gross Domestic Expenditure on R&D*	
Mean	2,230	Mean	10,700	Mean	47,036	Mean	42,974	Mean	1,592
Standard Error	0,138	Standard Error	0,377	Standard Error	3,943	Standard Error	0,436	Standard Error	0,177
Median	2,200	Median	10,500	Median	42,670	Median	43,300	Median	1,320
Mode	1,900	Mode	9,500	Mode	#N/A	Mode	43,900	Mode	0,590
Standard Deviation	0,716	Standard Deviation	1,960	Standard Deviation	20,490	Standard Deviation	2,264	Standard Deviation	0,917
Sample Variance	0,512	Sample Variance	3,841	Sample Variance	419,834	Sample Variance	5,126	Sample Variance	0,841
Confidence Level(95,0%)	0,283	Confidence Level(95,0%)	0,775	Confidence Level(95,0%)	8,106	Confidence Level(95,0%)	0,896	Confidence Level(95,0%)	0,363

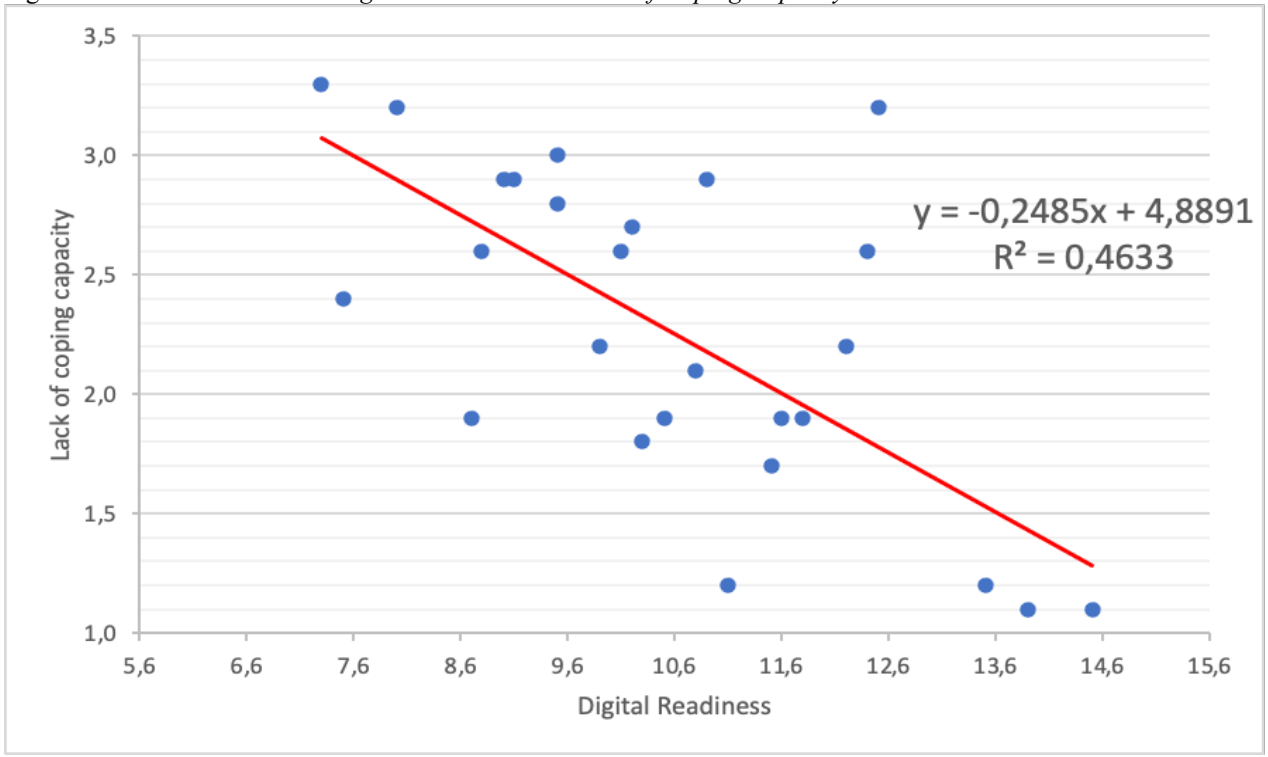
The results of the multiple regression analysis are significant with the initial hypotheses for a number of reasons. Using cross-sectional indicators on digitalisation readiness, epidemic risk and response preparedness, the data demonstrate a significantly negative correlation tendency. That is, on the total number of observations, countries with better integration of digital technologies and delivery of digital services, and resourceful human capital, present lower exposure to epidemic risk, on average. Figure 1 shows the linear regression between *epidemic risk* and the *digital readiness* indicators. The first represents the average of the values obtained from the three dimensions that make up the INFORM risk management index - hazard, vulnerability, and lack of Capabilities, while the latter is an average obtained from the five components of the DESI and considered indicative of the level of digitisation of a state at the time of the study. With a square r-value of 0.52 and a negative tendency, the proportion reveals that the two parameters are inversely proportional. That is, as the skills of digital government increase, the risks associated with epidemiological exposure are significantly mitigated. This confirms the initial hypothesis that the most digitally prepared European countries have put in place more effective tools in containing the pandemic.

Figure 1: *Correlation between Digital Readiness and Lack of Epidemic Risk.*



The same is reaffirmed by the correlation studied between digitisation and the lack of coping capabilities which present, as estimated, an inverse relationship (Figure 2). In a certain sense, the definition of the latter precisely includes the digital tools of control, monitoring, and adequate infrastructures for the realisation of a digitally active, cohesive, and fair community. Therefore, the lack of these latter skills certainly denotes a lack of preparation to face risks that involve the whole community and requires governance measures that are up to the situation. Therefore, the lack of skills is also synonymous with a lack of digital skills, and it is in this sense that the relationship between the two must be interpreted. Increasing management and response skills in crisis situations means integrating the same digital skills into daily governance practice.

Figure 2: *Correlation between Digital Readiness and Lack of Coping Capacity.*



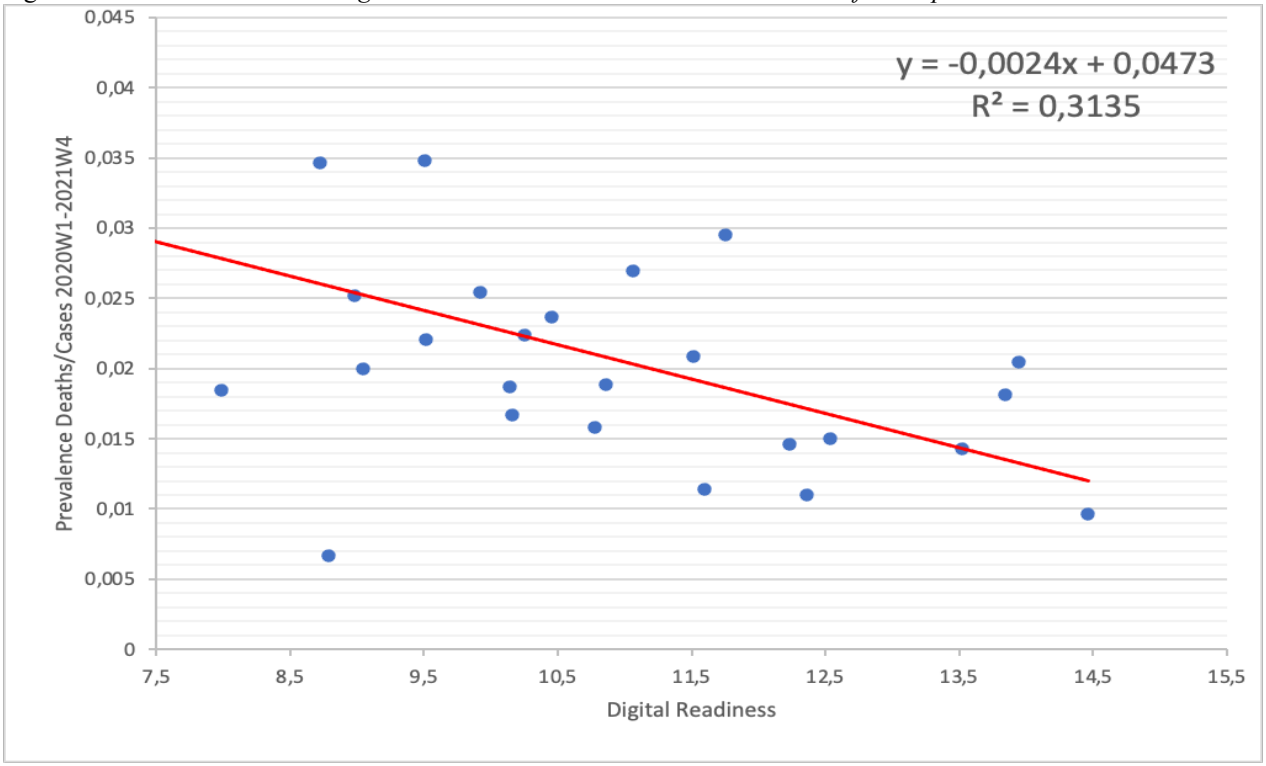
The last consideration is finally treated in reference to the specific case of the prevention and control of COVID-19. In this case, the most effective measure was found to be the calculation of the period prevalence in relation to the number of deaths out of the total number of cases in each of the twenty-seven states taken into consideration. The correlation of this last datum with the independent variables proves to be, once again, inverse. This confirms a trend towards inverse proportionality, whereby as digital integration in society increases, the number of deaths decreases in proportion to the cases collected in the period considered, which covers the entire duration of 2020 and the beginning of 2021. This is motivated both by the presence of a solid insertion of digital health in society and by the adoption of other practices for the prevention and control of the spreading of the pandemic. Thus, this last observation confirms what has already been assessed by Jiang and Ryan,[40] Stockenhuber,[41] and Ippolito *et al.*[42] among others. This study presents the most successful digital policies in the prevention of COVID-19 by those countries, among those considered, that have proved to be most susceptible to this data.

[40] Nan Jiang and Julie Yang, "How Does Digital Technology Help in the Fight against COVID-19?," *World Bank Blog*, 29 May 2021, https://blogs.worldbank.org/developmenttalk/how-does-digital-technology-help-fight-against-covid-19.

[41] Stockenhuber, "Did We Respond Quickly Enough? How Policy-Implementation Speed in Response to COVID-19 Affects the Number of Fatal Cases in Europe," *World Medical & Health Policy* 12, no. 4 (2020): 413-429. DOI: 10.1002/wmh3.374.

[42] Giuseppe Ippolito, *et al,.* "Lessons from the COVID-19 Pandemic - Unique Opportunities for Unifying, Revamping and Reshaping Epidemic Preparedness of Europe's Public Health Systems," *International Journal of Infectious Diseases* 101, (December 2020): 361-366.

Figure 3: *Correlation between Digital Readiness and Prevalence Cases/Deaths for the period considered*



There are multiple implications to these findings. First, the model will serve as a basis for future research as it provides an original link between the two concepts of digital readiness and emergency preparedness. Because the relationship has been argued and demonstrated, it will provide a solid base for future research in the field both of health emergencies, as well as other unforeseen exogenous risks/disasters. Indeed, it can be controlled as part of the framework for disaster management, but in this case the focus is placed upon the specific use of digital solutions in the field. Because the variables composing the final digital readiness measures were carefully selected, they are also individually meaningful to the overall situation of a country when evaluating its digital score, as well as the application of such performance to daily public management circumstances. On a more practical point of view, the results constitute the ultimate judgment criteria for policymakers and public administrators to attribute more importance to the matter of digitisation. This would translate into policies that target R&D expenditure in innovation and adoption of digital solutions. Run against the background of the COVID-19 pandemic, this study reveals the importance of accelerating the transition to digital government, both in the EU and worldwide.

Digital solutions for COVID-19 prevention and control

Table 2 illustrates the mean DESI score of each country considered in this study. Given that the European average is around eleven score points, several countries rank above it, distinguishing themselves for accelerated integration of digital systems in their government and public management strategies. Estonia, Sweden, Finland, Denmark, present promising values both in terms of digital readiness and in terms of risk preparedness, ranking among the countries with a low risk of epidemic incidence. In the case of

Estonia, Nemec *et al.*[43] already reported the unremarkable response of the country to the pandemic.

In fact, Estonia, which appears among the most digitised countries in Europe, has long since transferred many aspects of everyday life in a remote and smart management environment, and these measures have allowed citizens to observe the distancing rules (to which the WHO invites), and at the same time to continue one's life in an almost completely unaltered way, about the broad-spectrum educational and economic functions. Digitally simulated distance outpatients' consultations were introduced as early as March 2020, providing a valid alternative to in-person visits, and drastically reducing people's need for personally going to hospitals and health clinics. Parallel organisations have also made sure to create a digital database containing all the information about health workers availability and location during the lockdown. A national app was launched to monitor cases via contact tracing.

Table 2: *Digital Readiness Coefficient by country*

EU/EEA	**Digital Readiness Score on Average**
Estonia	14,46
Sweden	13,94
Ireland	13,84
Netherlands	13,52
Malta	12,538
Denmark	12,362

[43] Juraj Nemec, Wolfgang Drecbsler and Gyorgy Hajnal, "Public Policy During COVID-19: Challenges for Public Administration and Policy Research in Central and Eastern Europe," *NISPAcee Journal of Public Administration and Policy* 13, no.2 (2002): 11-22. DOI: 10.2478/nispa-2020-0011.

Finland	12,228
Belgium	11,754
Luxembourg	11,594
Spain	11,512
Germany	11,06
Austria	10,864
Lithuania	10,778
France	10,454
Slovenia	10,25
Czechia	10,16
Latvia	10,144
Romania	9,924
Croatia	9,514
Hungary	9,502
Slovakia	9,05
Poland	8,984
Cyprus	8,786
Italy	8,726
Portugal	7,984
Greece	7,464
Bulgaria	7,286

Denmark offers a brilliant case for demonstrating the efficacy of government expenditure in R&D: substantial funding was allocated both to vaccine research and in support of the country's preparedness and surveillance strategies to be implemented through digital technology. Screening and contact tracing were carried out using a Mobile Proximity App and an on-line questionnaire was also launched to provide citizens with vital information. Similarly, Sweden launched a symptom-tracker app to educate

people and prevent the spreading of misinformation about the virus. Also in this case, contact tracing has proved to be a powerful ally in preventing possible outbreaks, especially in the early phases of the pandemic. Similarly, the Finnish strategy was also largely based on screening, monitoring, and testing, with the support of an application developed to break the possible chains of contagion. Moreover, all the countries listed here as examples of digital solutions for COVID-19 management and control, have also adhered to the EU-launched program for the creation of a larger common database to share data and create an interoperability network among the Member States to uniform the preventive and monitoring measures. As such, this also represent a valid example for national and regional integration of smart solutions.

These results are particularly revealing when investigating the use of digital technology as a tool for pandemic preparedness and response. Similar conclusions were shown by Whitelaw *et al.*[44] who analysed the monitoring measures adopted by several countries that showed relative success in containing the advance of the pandemic during the first wave. The result of their study flows into a framework that sees within itself the main areas of digital application in epidemiological control, and which largely correspond to four macro-phases: planning and tracking, screening, and infection control, contact tracing, quarantine, and self-isolation. For each of these areas, different digital technological tools are listed, such as migration maps, open-access visualisation dashboards, and the creation of telephone applications for case tracking.

[44] Sera Whitelaw *et al.,* "Applications of Digital Technology in COVID-19 Pandemic Planning and Response," *The Lancet Digital Health* 2, no.8 (2020): E435-440. DOI: 10.1016/S2589-7500(20)30142-4.

The same criteria are also confirmed in another study conducted by Budd *et al.*[45] – who also include the important component of public communication as an essential tool for sharing knowledge and awareness in the so-called platform society. The authors push the boundaries of their research one step further, conveying a few possible obstacles to the implementation of such policies and risks related to them. The combination of these elements is used in Table 3 to summarise the most successful strategies in the cases considered, in the implementation of digital technologies in control and prevention efforts.

[45] Jobie Budd *et al, "*Digital Technologies in the Public-health Response to COVID-19," *Nature Medicine* 26, (2020): 1182-1192.

Table 3
Best COVID-19 management practices from EU countries with high digital readiness.

	Planning and Tracking	***Screening and Contact Tracing***	***Public Information***
Denmark	The Government has made €20 million available for both public and private research institutions to conduct vaccine/care-related studies. The Novo Nordisk Foundation allocated €2.7 million to support R&D measures for enhancing the country's epidemic preparedness and surveillance levels. The funds will be largely distributed to smart technology development, digital health and vaccine studies.	Because of the limited quantities of tests available, the Ministry of Health issued specific rules for the prioritisation of testing. A weekly questionnaire was distributed among volunteer citizens and COVID-19 patients, in order to gather information on their health conditions. The Mobile Proximity App utilises is employed for contact tracing. It utilises Bluetooth technology to detect protracted contact	The Daish Medicine Agency launched a national challenge called "Denmark helps Demark" that allows any type of organisation to pitch solutions to logistics and technical problems related to COVID-19. Intensive public information campaigns are implemented over several platforms in order to educate citizens to respect of extraordinary norms.

		with other users in close proximity.	
Estonia	Distance outpatient specialist consultations were introduced as of 16 March, thus providing an alternative to in-person visits. In addition to the consultation by phone, special online consultations have been added as a new service. An NGO has set up a database indicating the information of health workers available to fully volunteer during the epidemiological emergency.	The HOIA app was developed for contact tracing, alerting users of possible cases in close proximity.	
		The Finnish Institute for Health and Welfare (THL) invites citizens to randomly take part in a study addressing the spread of the	

Finland		new coronavirus in the population. Finland's strategy is big on testing, tracing and surveillance. Extensive testing is applied along with invasive contact tracing measures. Koronavilkku application was developed in late August 2020 to detect and break chains of COVID-19 contagion.	
Sweden	Plan on the distribution of Digital Vaccination Certificates by Summer 2021, to facilitate population monitoring and tracking and efficient distribution of vaccines.	Contact tracing was used at the beginning of the first wave, in particular, to detect and prevent possible outbreaks, although the use of contact tracing apps is not embraced.	A symptom-tracker app was launched to educate citizens and respond to their questions and needs.

Source: European Observatory of Health Systems and Policies COVID-19 Health System Response Monitor.

Based on these models and taking a closer look at the digital strategies adopted by these countries to cope with the pandemic, the link between governments who show higher levels of digital integration and management capabilities emerges more evident. All things considered, starting from the empirical observations in this study, one can safely assume that the success of Denmark, Sweden, Finland, and Estonia in implementing digital solutions for controlling the spreading of the COVID-19 pandemic is largely based on a pre-existent network of digital infrastructures which involves both the public administration and the human capital of the whole population (digital alphabetisation and digital access). This can be also perceived as a valid reason why tracking, surveillance, and monitoring mechanisms (all built upon the integration of digital tools into public health and safety) has worked in a more effective manner in these countries rather than others, where overall pre-existing conditions of digital readiness were scarcer.

Conclusion

The purpose of this article was to assess the integration of digital technologies within the context of pandemic prevention and response. So far, research has shown little interest in this relationship and has tended to focus more on the implementation of digital health and other innovative strategies to strengthen the economic response to the crisis rather than the direct influence of digitisation over the overall pandemic control and government adaptation. Even less has been

addressed with concerns to public management – indeed, because of the complex and multifaceted character of the pandemic itself.

Therefore, the lack of studies on the level of digitisation of each country at the beginning of the pandemic, and how this factor may have contributed to the implementation of effective prevention and containment strategies, represents a great opportunity for further exploration and understanding. In particular, the central research question required the study of the interaction between two concepts, namely, digital readiness and epidemic preparedness, along with the type of interaction between them. Taking Europe as a case study, it was assumed that countries with a higher level of digital integration in their governance have an advantage in responding to the pandemic over others.

This study addressed the issue of digital integration in the management and control of the COVID-19 pandemic. Having defined the terms of this research through a systematic literature review, the concepts of digital readiness and epidemic risk/preparedness were alternately correlated and measured, together with the individual indicators that compose them. The results are significant both from a statistical point of view and, above all, as regards the practical implementation of the measures adopted by policymakers. On the one hand, the vulnerability dimension of European public institutions appears influenced by various key factors, including access to digital infrastructures, connectivity, and the extension of capabilities, among others. On the other hand, all the indicators of digital readiness are inversely proportional to those of epidemiological risk, establishing

what was already hypothesised at the beginning of this research, and (more importantly) suggesting clear indications for future trends. Countries that have performed best in terms of digital readiness have also implemented strong strategies to stem the COVID-19 situation by fielding innovative solutions.

Several limitations to this study must be acknowledged. First, because this topic is still very much in its infancy and the COVID-19 pandemic is an ever-changing phenomenon, the results of this research are limited in their impact: if on the one hand, it is true that they indicate a reasonable trajectory for future observations, on the other the situation is very sensitive to both endogenous and exogenous factors that mutate very rapidly over time. The empirical model attempted to control some of these variables, however, it is likely that outcomes such as the ratio of deaths/cases might be influenced by other concurring contingencies.

With reference to the model design, the outcome variable has a double effect and could be used as an independent variable (causal variable of digital readiness) in other studies, starting from the assumption that the digitisation process in many countries was not only adapted to mitigate the epidemiological emergency but it was also accelerated and strengthened at the same time by the pandemic itself. Future research could address and improve these aspects of the relationship between the two. Moreover, as time passes more data is available concerning experimental innovative methods applied by different countries in coping with the situation: as such, the field

would also benefit from a complete policy review/memo on these strategies, which I did not address because of time constraints.

Given the future threat of possible new epidemic outbreaks, policymakers, and the scientific community of European states as well as of the whole world should mobilise together towards the adoption of digital governance systems that have people at their centre, and at the same time take care of providing smart solutions and above all, alleviating the risks that weigh on the health, economic and social systems of all nations. Research, in this sense, must not be limited to clinical technicalities (digital) health or economic repair (online businesses): instead, it should take this opportunity to reflect upon issues of governmental nature. International cooperation is required to guarantee a digital transition that respects the characteristics of each state yet allows the adoption of common strategies and solutions to be shared at the community level, encouraging mutual learning.

Giulia Interesse is a PhD candidate at Peking University School of Government. Her doctoral research investigates the implementation of innovation policies in international technology transfer and cross-country cooperation for development. She takes on a multidisciplinary approach that encompasses the fields of public management, international relations and sustainable development. Her research interests also involve Chinese politics and political culture.