Microsoft

GROUP 29

A.Y. 2020/2021

POLITECNICO
MILANO 1863

DIGITAL BUSSINESS INNOVATION LAB

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DIGITAL TRANSFORMATION for the next PANDEMIC

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1. Introduction

1.1 The Covid19 outbreak

In December 2019, health authorities of Wuhan in China, detected an increase in cases of pneumonia with apparently unknown origin[1]. The cause of this disease was later identified to be a new virus named SARS-CoV-2; its presence was only reported to the World Health Organization two weeks later. Three months later, on 11 March 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a pandemic[2]. At the very beginning of the pandemic, almost every country was caught unprepared, highlighting inadequate and old pandemic protocols[3]. In this context, lockdowns became the main solution adopted to limit the diffusion of the virus.

1.2 Objectives: the digital role

Digital technologies have become a central part of our lives and have deeply changed it, to the extent that some have described the historical period in which we live as the digital age[4].

COVID-19 was the first pandemic that humans were able to face with the help of digital tools, taking advantage of technologies to block or at least limit the impact of the COVID-19. Many digital solutions have been developed, but a lot of them have failed in reaching their goal, with the most prominent case being the failure of the COVID-19 contact tracing applications[5].

Given this scenario, the objectives we wanted to pursue with this study were:

- **Understand the problem**
  The first thing to do was to understand what the deficiencies in the prevention and management of the pandemic were, not only from a technological point of view but keeping a wider perspective.
- **Divide the problem**
  COVID-19 is a very complex topic. It has several implications and the failure to limit the contagion has several root causes. With that in mind, we tried to deconstruct and breakdown the problem, attempting to better address one specific aspect rather than to try and solve the general problem with mediocre results.
- **Solution development**
  The aim is to tackle the problem leveraging the latest technological waves and Microsoft's resources and competences.
- **Make it sustainable**
  The solution developed should not only work within the context of the COVID-19 emergency, but also in view of future pandemics that are likely to come in an increasingly globalised world[6]. To do this, we need to build a long-term self-sustainable business model that could satisfy the different stakeholders involved in a win-win perspective.

2. Analysis

2.1 External Analysis

2.1.1 PEST analysis

The PEST analysis allows us to understand the external contextual factors where pandemic management solutions were adopted in order to plan for possible obstacles or identify possible key success factors. By studying the government policies and technological solutions adopted in some countries located in North & South America, Europe, and Asia, we were able to identify the following relevant political, economic, social, and technological factors that led to either the partial success or failure of the pandemic containment. The detailed country analysis is attached in the appendix *[Appendix A1].*

POLITICAL	ECONOMIC	SOCIAL	TECHNOLOGICAL
1. Communication from the authorities 2. Cooperation and Coordination issues between local and central authorities 3. Presence/Absence of a reliable and well managed healthcare system and health funding 4. Speed of response & level of bureaucracy	1. Subsidies and financial support 2. Economical distribution	1. Collectivism of society and civic engagement 2. Cultural aspects, engagement and privacy 3. Trust in Governments	1. Technological accessibility and inclusivity 2. Data documentation standard

Table 1- PEST Analysis: Key factors that lead to the failure or success of the pandemic management

POLITICAL FACTORS

P1. Communication from the authorities

Initially, with the virus being novel, there was miscommunication, undermining the dangers it has on human health. This was especially true in Italy[7] and the United States. Confusing mask guidance, downplaying the dangers, and sidelining experts all contributed to the spread of the disease[8]. On the other hand, Vietnam[9] and South Korea[10] did a very good job in communicating frequently with citizens, keeping them informed and involved in the public health response.

P2. Cooperation and Coordination issues between local and central authorities

There was a major issue of miscoordination in different countries in the world. This includes USA and Italy. In the US, different states applied different measures: some used different types of apps, others didn't[11]. In Italy, there was a lack of coordination between the different governmental entities, especially between different regions[12]. In South Korea, however, it was possible to achieve a quick response aided by the cooperation between the central and local governments.

P3. Presence/Absence of a reliable and well managed healthcare system and health funding

Our research shows that some countries were more successful in managing the pandemic due to past experiences that elevated their level of preparedness, especially on the health care level:

- In South Korea, a monitoring system was used for patients with mild symptoms in real time. In this way, the healthcare system could assist promptly critical cases[13].
- Vietnam's health care system is considered well-developed as public health expenditures per capita had been increasing at an average rate of 9% per year between 2000 and 2016. This was mainly due to past experiences of SARS epidemic in 2003 and avian influenza between 2004 and 2010, which boosted the attention in improving health infrastructure and brought to the development of a national public health emergency operations center and a national public health surveillance system[14].

P4. Speed of response & level of bureaucracy

The high level of bureaucracy delayed the response to the virus and related procedures. In Italy, as a result of bureaucracy supply chains were not resilient enough to address the spike in the need for protective equipment and other medical countermeasures[15]. On the opposite side, the South Korean government leveraged an already existing legal framework which was set in place following the MERS outbreak in 2015[16]. This helped the country achieve a quicker response and enabled it to contain the contagion successfully.

ECONOMIC FACTORS

E1 & E2. Subsidies, Financial support, and Economical distribution

In some countries, the failure of containing the virus was mainly linked to the economic fabric of the country itself. Countries characterized by a higher level of poverty and income disparity were less successful in limiting the contagion than those that are more developed. In India, for example, a large portion of the population which falls under the lower income bracket was marginalized by the mandatory adoption of the tracking app "Aarogya Setu" in order to access public services[17]. Moreover, the parsimony of government subsidies did not give the low-income workers, which represent a significant portion of the labor market, the "luxury" of staying home[18]. This is especially true for the informal workers with no legal protection. In addition to that, these low-income bracket individuals and families reside in highly populated urban slums, where the possibility of social distancing is impaired, along with access to clean water and proper sanitation[19]. Similarly in Brazil, the economic situation is characterized by an important difference between the wealthier classes and poorer ones. This disparity is reflected in the access to healthcare systems. While private healthcare structures seemed to be prepared to face an epidemy, public ones were not. Private healthcare is only available to those who can afford to pay for it, leaving the poor more vulnerable[20].

SOCIAL FACTORS

Our analysis demonstrates that some success factors can be attributed to cultural dimensions, not strictly related to the technological solution itself or policies set in place.

S1. Collectivism & Civic Engagement

A particularly important cultural trait is collectivism. In some countries, people are more likely to give up their data in favour of the overall wellbeing of society. Other countries, on the other hand, are more individualistic. This trait is strictly linked with the reported level of civil engagement in the fight against virus contagion.

In Germany, for example, the "corona data donation app" allowed citizens to voluntarily give or "donate" their data retrieved from smart watches or fitness wristbands[21]. This information was then be used to create "heatmaps" identifying specific regions with higher concentration of people experiencing fever symptoms. This solution was paired with other solutions including "corona warn app"[22], a decentralized transparent open-source approach used for contact tracing. In this manner, Germany seems to incentivize its citizens through instilling in them a strong sense of community thereby triggering them to autonomously volunteer their information for the benefit of the public health.

Moreover, in Vietnam, members of the public, including teachers, pharmacists, religious leaders, and even traditional medicine healers, were involved in event-based surveillance to report public health events[23].

S2 & S3. Privacy Concerns and Trust

The adoption of digital measure and data collection procedures raised the level of privacy concerns, due to lack of transparency and clear data collection policies and data treatments procedures. The population's availability to give up their data is also linked to trust in local governments. In India, privacy concerns were raised, since individuals were not given clear information as to what the personal data collected was to be used for[24].

TECHNOLOGICAL FACTORS

T1. Technological accessibility and inclusivity

Technological Accessibility tends to be overlooked when discussing health-related issues. As technology is becoming more integrated in healthcare and in general technological penetration has been increasing, technological inclusivity is becoming more relevant. However, technological inclusivity is strongly linked to the demographic and economic features of the communities. In underdeveloped countries, technology seems to be reserved to the wealthier individuals, leaving behind the poverty-stricken. Looking at two opposite approaches in South Korea and India during the COVID-19 pandemic this can be highlighted. On one hand, the South Korean government ensured technological accessibility to those who do not own a smartphone or are unable to use them through providing electronic wristbands for tracing, ensuring inclusivity[25]. On the other hand, despite India having one of the toughest lockdowns in the world, this did not slow down the spread of the contagion in the nation. This can be partially attributed to the technological exclusion of the solution applied by the government paired with the lockdown, the tracing app "Aarogya Setu"[26]. The government mandated the use of the app to access public services, but this decision marginalized around half of the population without giving alternatives to those who do not own a smartphone.

T2. Data documentation standard

Examining the responses of different countries during COVID-19, it is evident that the presence of diverse unstandardized data has hindered the capacity of governments to take decisions promptly on a local level. For example, the lack of standardized data documenting in Italy led to faulty inferences about the efficiency of the measures in place[27]. Countries who leveraged centralized standardized data were capable of tracking and limiting the spread of the contagion more efficiently. In Vietnam, for example, since 2016, hospitals are required to report notifiable diseases within 24 hours to a central database, ensuring that the Ministry of Health can track epidemiological developments across the country[28]. This useful centralization has played a decisive role running quarantine centers, assisting the government in making key decisions at a local level with targeted lockdowns. Specifically, through this system, they can identify clusters of people having similar symptoms that might suggest an outbreak is emerging.

2.1.2 Competitive Analysis – State of the art

In this section we explore the different technological solutions that have been used to tackle contact tracing and pandemic management issues during COVID-19.

- **Contact Tracing Apps:** Contact tracing have been the most adopted solution during COVID-19[29] pandemic. Various apps rely on different technologies: Bluetooth or GPS location data. Bluetooth apps were mainly used to notify about potential contact with infected people, while GPS ones to track the localisation of smartphones, that can then be used to predict the healthcare demand in a certain area, and to identify virus hotspot drafting heating map of how and where the disease is spreading.
- **Chatbots:** In recent years, chatbot use for health-related purposes has increased considerably, from supporting clinicians with clinical interviews and diagnosis to aiding consumers in self-managing chronic conditions. During the recent pandemic, they have been applied for self-report symptoms, telemedicine purposes and also for informational reasons. Microsoft in particular offers its Health Bot solution inside the Azure catalogue[30].
- **Drones & Robots:** With the purpose of finding infected people in a crowd, drones have been applied using thermic sensors and reducing hard-to-access location's limitations. Among others we have also delivery drones to reduce human interactions and medical drones to cut medical equipment delivery times. When it comes to robots, they play an important role during quarantine and can be implied for capturing respiratory signs, assisting patients with their treatments or food and more over[31].
- **Wearables:** To respond to the need for early diagnosis during this pandemic, wearables are considered both efficient and low cost. They can also be used for tracking purposes matching them with GPS or Bluetooth technology to implement distancing systems and heatmaps. Using wearables is also a way to overcome accessibilities barriers because they are easy-to-use and cheap[32].
- **Smart cameras:** One of the most common use of smart cameras or screens with infrared systems was to measure the body temperature. However, this is not the only way to use smart cameras, or more in general smart cities. China had more than 500 world-class smart cities in place in 2020[33], which often resulted in huge surveillance system infrastructures where cameras equipped with facial AI recognition were then exploited, together with drones, for active surveillance of population and quarantine monitoring. However, this was possible thanks to the centralized powered structure.

2.1.3 Technological trends

Apart from the adopted technological solutions, it can be useful to introduce some technological megatrends which can have an impact on the pandemic management[34]. Here we introduce five of them:

- **Internet of things:** IoT is based on the idea of 'smart' objects connected through a network able to collect and exchange the information they possess[35]. The IoT paradigm was born with the RFID technology, but nowadays these technologies have multiplied and developed, just as the many application areas have done. The installed base of active Internet of Things devices is now 13.8 billion units, and it is estimated to reach 30.9 billion units by 2025[36], showing the huge penetration of smart objects in our society.
- **5G Network:** 5G is the 5th generation mobile network with ultra-low latency, more reliability, massive network capacity and increased availability[37]. These characteristics, will enable a new kind of network that is designed to connect virtually everyone and everything together, including machines, smart objects, and devices. There are currently 236 million 5G global subscriptions and they are estimated to reach three billion by 2025[38].
- **Blockchain:** Blockchain allows to manage a ledger containing data and information in an open, shared, and distributed manner without the need for a central control and verification entity[39]. The application of this technology is mainly in the world of finance but is increasingly expanding into supply chain management and many other industries[40]. Because of its characteristics, blockchain can be a game changer when it comes to information reliability, disintermediation and security.
- **Cloud computing:** Cloud Computing is a set of ICT services accessible on-demand through Internet technologies, based on shared resources, characterised by rapid scalability and timely measurability[41]. The cloud paradigm can be a powerful enabler for new solutions and business developments, reducing fixed costs and allowing vertical and horizontal scalability of resources. Indeed, 81% of all enterprises have a multi-cloud strategy implemented and 67% of enterprise infrastructure are cloud-based[42].
- **Artificial intelligence:** Artificial Intelligence is the development of hardware and software systems with specific human capabilities, like learning, planning and decision making[43]. Usually, an AI needs the training phase to properly work, where high quantities of data are ingested by the AI algorithms in order to define patterns for the decision-making process. For this reason, AI paradigm comes together with IoT and cloud computing, since this two can provide the data availability and computational power. AI can be applied potentially in each industry, and it has already been to the COVID-19 issue, for instance searching for significant statistical correlations[44].

2.2 Internal Analysis

In developing this project, we had the opportunity to take the perspective of Microsoft, being able to exploit the resources and know-how of one of the best companies in the digital sector. However, it must be pointed out that today's Microsoft is quite different from the company that was a few years ago.

2.2.1 Microsoft's mission

In the words of Satya Nadella, Microsoft's mission is:

"To empower every person and every organization on the planet to achieve more."

Microsoft is not anymore just focused on selling products but rather on providing the digital tools that help individuals and organizations to develop their own solutions, products and services. Microsoft strongly believes in collaboration and the opportunity that resides in technology to address the world's challenges.

2.2.2 The cloud shift

Microsoft was born mainly as a software company, producing Windows, the operating system that has made it famous worldwide, and the Microsoft Office 365 suite, which both have an important contribution to the company's revenues. Other products were added over the years, including on the hardware side, but the key turning point came in 2014 when the CEO Satya Nadella has set the company's strategic direction toward the cloud computing business[45]. Microsoft is providing cloud solutions through Microsoft Azure which fall under three macro areas: Software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS). They are becoming the core business of Microsoft, exploiting the new opportunities that the emerging cloud paradigm can provide.

2.2.3 Key Resources and Strengths

Among the others, Microsoft possesses critical resources that could facilitate the adoption of a proposed digital solution.

- **Brand strength:** Microsoft's brand reputation, its **global pervasive presence** and **innovative culture** are all characteristics of a strong brand that the company can leverage on the identified context as they ensure important network externalities for the possible new solutions of the company[46].
- **Human resources:** Microsoft is an established company that hires only the top-notch engineers, data scientists, manager. These specialized human resources represent a strong asset for the company. More than 160k employees currently work for Microsoft[47].
- **Microsoft Azure Platform:** with more than 200 Cloud based solutions, Microsoft's intelligent cloud segment represents its fastest growing and largest source of profit. With that in mind, Microsoft Azure imposes itself as the main technological resource that the company can offer, as a comprehensive set of analytics features, Microsoft's computing power, data storage capacity and AI.
- **Easy-to-use API:** Microsoft with its cloud business offers high compatible products that third parties can exploit to create their own technological products thanks to easy-to-use API development for integration with partner solutions.
- **Microsoft Machine learning solutions and Artificial Intelligence services:** Microsoft portfolio for developer and data scientist regarding ML and AI solutions takes advantage of the decades of breakthrough research, responsible AI practices, and flexibility that Azure can offer.
- **Strategic Partnerships in the Healthcare and Insurance field:** looking at Microsoft's effort during the COVID-19 pandemic, it's possible to say that the company is committed to the cause and claims important and strategic partnerships in the Healthcare and Insurance Market[48].

2.2.4 Weaknesses

We identify the following relevant weaknesses:

- **Market saturation for some product segments:** Microsoft's annual report of 2020 reveals that the operating income growth has slowed down compared to the previous years. In particular, growth has slowed down from 25% in 2019 to 15% in 2020. According to the financial statement, the revenue from commercial products and cloud services has been "offset in part by lower revenue from products licensed on-premises, reflecting a continued shift to cloud offerings"[49]. It seems that the licensed on-premises segment is becoming more and more saturated imposing expenses but lower returns. Therefore, there should be an adequate target re-definition towards more profitable product segments *[Appendix A2].*
- **Low return on R&D investment**: despite Microsoft spending a substantial amount of its budget on R&D (for example in 2020, Microsoft spent around $19 billion)[50], which places it among the top investors globally in innovation, its return on research capital (RORC) seems low with respect to its competitors in the technological arena[51]. This shows how Microsoft's investments not always reveal to be successful.
- **Unsuccessful acquisitions processes**: when a company has to develop a new product/service, it can rely on the use of acquisitions, to partially overcome existing entry barriers. But Microsoft's fewer acquisitions like WebTV, LinkExchange, Massive and Danger resulted in failures and divestitures. This may show the poor company capability to leverage acquisitions. On the other hand, Microsoft performs much better with partnerships [52].

2.3 SWOT Analysis

STRENGTHS	WEAKNESSES
• Global pervasive presence[53] • Specialized Human resources[54] • Microsoft Azure Platform[55] • Easy-to-use API[56] • Microsoft Machine learning solutions and Artificial Intelligence services[57] • Strategic Partnerships in the Healthcare and Insurance field[58]	• Market saturation for some product segments[59] • Low return on R&D investment[60] • Unsuccessful acquisitions processes[61]
OPPORTUNITIES	**THREATS**
• Increasing availability of 5G infrastructures[62] • Increasing concern for public health[63] • Increasing investment in the healthcare system and in healthcare related technologies[64] • Increasing number of smart cities[65] • Increasing importance of cooperation in healthcare, trade and politics worldwide[66] • Increasing diffusion of IoT technologies and smart objects[67] • Increasing interest in blockchain applications[68] • Increasing importance of data driven decision making[69]	• Lack of standardized procedures for data gathering and regulations for data storage[70] • Increasing concern for privacy[71] • Lack of cooperation between central and local governments[72] • Lack of collaboration between authorities and healthcare systems[73] • Timeliness and confusion in public guidelines[74] • Economic and technological discrimination both in healthcare and government measures[75] • Misinformation and miscommunication[76] • Not-inclusive technological design[77] • Lack of civic engagement in individualistic society[78]

Table 2 - SWOT analysis

2.4 Strategic Alternatives

In the following section we devise a set of strategic alternatives that leverage strengths and address weaknesses in order to exploit opportunities and tackle threats.

S1	Blockchain for data decentralization
	Using the blockchain to ensure the safety of the stored data coming from a tracking system.

At first, the decentralized nature of blockchain technology seems capable of addressing the problem of lack of trust towards governments that has hindered the adoption of contact tracing app solutions. However, existing tracking applications, from a technological point of view, show few problems in ensuring privacy of collected data. Privacy concerns are mainly related to the unconscious distrust of citizens towards companies and political entities. These concerns are therefore a matter of citizen perception despite the technology being safe. Since blockchain technology is incomprehensible to the "average Joe", it could even generate more suspicion than a tracking system would.

Leverage Strenghts:	Address Weaknesses:	Exploit Opportunities:	Tackle Threats:
- Easy-to-use API - Microsoft Azure Platform	None	- Increasing availability of Cloud Resources - Increasing interest in blockchain applications	- Increasing concern for privacy - Lack of standardized procedures for data gathering and regulations for data storage

S2	RFID technology to create heat maps

Exploiting basic and low-cost technologies like IoT buttons in venues and RFID placed in public indoor spaces to easily create heat maps in real time.

Accessibility and inclusivity are key aspects of an effective technological system. Smartphones for contact tracing proved to be less useful in those countries where the technological penetration is not sufficiently high and also among those older age groups that are less likely to own a smartphone. In this way, focusing on a more inclusive design-oriented system, it will be much easier to track the movements of the population still preserving privacy of people.

Nevertheless, this technology could not be used to keep track of the contacts of a tested positive person, but just to create heat maps around a region in order to detect the areas in which the risk of an outbreak is high and, as a consequence, perform prevention activities (e.g., increase availability of masks, sanitizers, hospital resources) or carry out targeted lockdowns.

Leverage Strenghts:	Address Weaknesses:	Exploit Opportunities:	Tackle Threats:
- Microsoft Azure Platform - Microsoft Machine learning solutions and Artificial Intelligence services	None	- Increasing diffusion of IoT technologies and smart objects - Increasing importance of data driven decision making	- Increasing concern for privacy - Not-Inclusive technological design

S3	Platform for standardization and collection of health data

Enabling the standardization of health data in order to achieve a fast and efficient communication among hospitals and between hospitals and governments.

Health information is critical for the government to make informed decisions. However, multiple standards already exist and can stand in the way of utilizing this information across regions and countries. In fact, each country collects data about health in different ways, thus hindering the power of a joint response. Solving this market friction is possible with a platform system that standardizes data collected in a centralized database, ensuring a more rapid response, facilitating collaboration and prompt decision making through big data analysis. Leveraging Microsoft experience in cloud technology and platform-oriented mentality, the start of a pandemic could be detected early thereby helping governments avoid nationwide lockdowns.

However, this solution would not work without an intelligent and proper use of the shared data coming from the hospitals, raising issues on the ownership of this centralized database and on the willingness of hospitals and governments to share data with third companies and organizations.

Leverage Strenghts:

- Microsoft Azure Platform
- Easy-to-use API
- Microsoft Machine learning solutions and Artificial Intelligence services

Address Weaknesses:

- Market saturation for some products

Exploit Opportunities:

- Increasing concern for public health
- Increasing investment in the healthcare system and in healthcare related technologies
- Increasing importance of cooperation in healthcare
- Increasing importance of data driven decision making

Tackle Threaths:

- Lack of standardized procedures for data gathering and regulations for data storage
- Lack of collaboration between authorities and healthcare systems
- Increasing concern for privacy

S4	Ecosystem based on wearables, smart cities and health app exploitation
	Leveraging the increasing usage of health app and devices, the data derived can be integrated in an ecosystem where individuals can choose to give up their personal data for the sake of overall health of the community.

The concern for personal health and desire for personalized medicine are increasing[79]. Thanks to this trend, sharing personal health information with doctors and hospitals directly from electronic devices such as wearables will probably be perceived as normal. This trend could be exploited to more easily convince people to share data and activate position tracking on their devices as people would be more open to renounce part of their privacy in exchange for something valuable[80], like a well-managed system for personalized health. Moreover, to enable the basic functionalities of tracking, providing simple wearables is not complicated and low-cost.

Unfortunately, this trend is just at its very beginning, so it would take many years to make this ecosystem become pervasive in the world population and to make matters worse, privacy concerns could weaken a lot the implementation of this solution and countries with the technology infrastructure suitable for a solution based on smart cities are still few.

Leverage Strenghts:

- Microsoft Azure Platform
- Easy-to-use API
- Microsoft Machine learning solutions and Artificial Intelligence services

Address Weaknesses:

None

Exploit Opportunities:

- Increasing availability of 5G infrastructures
- Increasing investment in the healthcare system and in healthcare related technologies
- Increasing diffusion of IoT technologies and smart objects

Tackle Threats:

- Not-Inclusive technological design
- Lack of civil engagement due to individualism in society

2.4.1 Strategic alternatives Assessment

In order to assess which strategic alternative is the most promising, each alternative is evaluated on a scale from 1 to 5 based on **two factors**: **Core to the business** and **Impact of the solution**. The first factor underlines how much the alternatives are easy to implement for Microsoft leveraging on its core strength and capabilities (i.e., Cloud Business, Platform and ecosystem making), measuring also the adherence with the company business strategy. The second aims at evaluating in a qualitative way the level of magnitude of the possible impact on pandemic management.

Looking at the scores for the first variable, we want to highlight that RFID technology is not part of the core business solution provided by Microsoft. Instead Cloud platforms, ecosystems of IoT devices and blockchain are more relevant into Microsoft's services catalogue, as pointed out in the company's strengths. With an eye on the impact instead, we evaluated more impactful those solution that exploits more opportunities and tackle more threats.

	Solution	Core	Impact
S1	Blockchain for data decentralization	4	2
S2	RFID technology to create heat maps	3	3
S3	Platform for standardization and collection of health data	5	4
S4	Ecosystem based on wearables, smart cities and health app exploitation	4	4

Table 3 - Strategic alternatives assessment Scores

Out of the previously listed strategic alternatives, **S3 'Platform for standardization and collection of health data'** is the most promising solution to address the issue at hand. This alternative exploits the increasing availability of big data, especially in the health sector, capitalizing on Microsoft's strengths of Cloud Computing and expertise in Artificial Intelligence/Machine learning and database management.

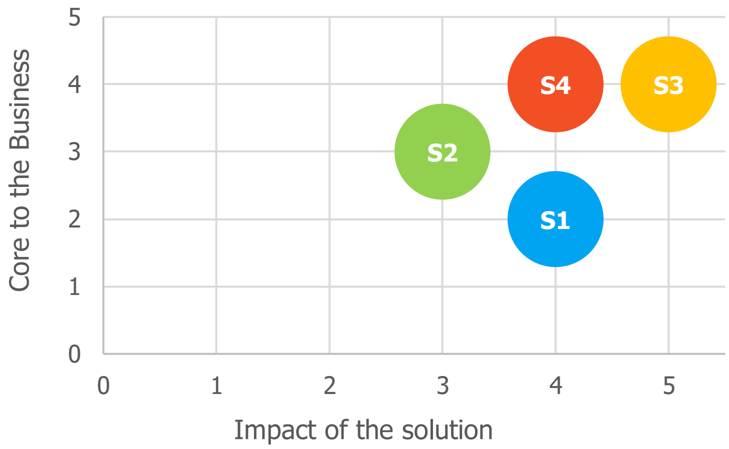


Figure 1- Strategic alternative assessment scores matrix

Moreover, Microsoft has a global pervasive presence and easy-to-use API which allows anyone to adopt the solution without prohibitive switching costs. Through APIs, other solutions can be further developed, built on top of, and integrated with other organizations and projects, being in line with Microsoft's mission to empower others. On the other hand, this allows Microsoft to cope with one of its weakness, indeed, strengthening its cloud business, Microsoft will reduce the risk of being in the mature and less profitable market of on-premises software.

The solution handles the arising threats related to data standardization, improving collaboration and cooperation between the healthcare systems and public administrations, enabling data-driven decision making, through the power of big data and AI.

2.1.5 Demand Analysis

Provided that the possible successful strategic alternative has been picked, we provision here a demand analysis referring to the healthcare sector. The aim is verifying the possibility to exploit an appealing market and evaluate the position of the company within it.

A preliminary analysis reveals that the healthcare industry represents an appealing market where cloud computing can be leveraged. In fact, the healthcare cloud computing market is expected to grow from USD 28.1 billion in 2020 to USD 64.7 billion by 2025 [81]. Moreover, open source can be an interesting strategy to be exploited by Microsoft, in line with its mission statement, in order to outperform its competitors in the cloud computing market. Statistics show that by 2022, more than 70% of new in-house applications will be developed on an open-source database[82].

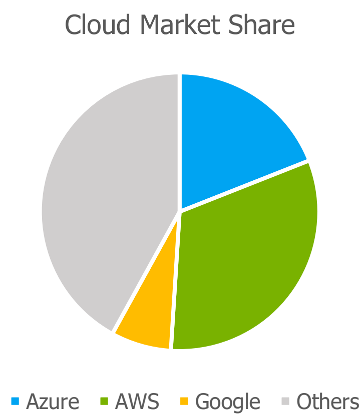


Figure 2 - Cloud Market Share graph

3. Proposed Solution

3.1 Overview

As illustrated in our external analysis, **data** resides at the heart of decision making which can aid governments in reacting more **promptly** in emergency situations such as a highly infectious viral spread. **Cooperation** and **collaboration** are fundamental to limit contagion but are hindered by lack of standardization. Data, being a sensitive topic, however, must be collected by **trustable** sources and on legitimate bases, while maintaining transparency and completely respecting privacy regulations and rights.

Healthcare data are particularly important to better manage the pandemic. In the past years, healthcare records have been increasingly becoming digitalized, and automated clinical decision support and other machine-based processing are becoming the new reality[83]. The state of the art in pandemic management exposes data driven decision making as the key to success.

3.2 Problem Definition

Data, if properly exploited, can create value for policy makers, research centers, and hospitals, enabling them to react quickly. However, data cannot be capitalized on if it is not standardized. In different countries and regions, data is collected and stored in different ways by various entities, which stands in the way of reaping the benefits associated with real time data driven decision making, collaboration, cooperation, and big data. As already shown in the external analysis, during the COVID-19 pandemic, hospitals and researchers have been struggling in finding the best treatment against the disease, understanding how it spreads, and how it can be detected. Moreover, governments have been suffering the economic repercussions because of nation-wide lockdowns.

3.3 Solution

The main goal of our solution is to create a **unified source of truth** that can be exploited by worldwide healthcare systems, increasing data **availability**. In this way, leveraging on **big data**, we want to **empower third parties to build on top of the proposed platform** to improve their systems, upgrading research, treatments and more.

Our solution therefore is a **centralized data platform** that collects input from healthcare centers in an anonymized way. Leveraging AI, applying intelligent data processing, it analyses big data to spot worrisome patterns that could warrant the start of the next pandemic. After anomaly detection, it sends alerts to hospitals and governments to take action in order to limit the contagion before it spreads out to other areas, thereby avoiding nation-wide lockdowns. The platform can also be utilized to achieve synergy by acting as a medium that facilitates **collaboration** among different entities performing activities that allow pandemic management such as researching the factors that lead to fast contagion, researching methods for better treatment, developing vaccines, etc.

3.4 Mission Model Canvas

The described solution for better pandemic management has a humanitarian primary goal rather than a monetary one. Therefore, the mission model canvas has been used to develop it in more detail.

KEY PARTNERS

World Health Organization (WHO) – DDI division

KEY ACTIVITIES

- Data management
- Deployment and support activities
- Data analysis and algorithm development
- Data Security and access control

KEY RESOURCES

- Microsoft Azure services
- Human resources
- Brand and platform makers reputation

VALUE PROPOSITION

- Enable hospitals to share medical data in a standard format receiving back a risk level and access to the platform
- Enable governments to apply real-time targeted restrictions
- Enable third parties to build their own solutions on our platform

BUY-IN

- Promote transparency
- Effective communication
- Propose FHIR API standard, with no additional efforts

DEPLOYMENT

- Create awareness and promote the platform.
- Complementors' innovations will increase the value for users
- Partnership with NPOs

BENEFICIARIES

- Hospitals
- Governments
- Third parties (companies' developers, researchers, end users)

ECONOMIC FEASIBILITY

COSTS < SAVINGS

Costs

- Architecture (FHIR, Databrick, Cognitive Services, Presidio, Support)
- Platform development
- Platform maintenance
- HR
- Cost of Acquisition (CoA)

Savings

- Expenses on R&D (data research and preparing)
- Expenses for each recover during the local epidemies or pandemics (worst case scenario)

MISSION ACHIEVEMENT

SAVE COSTS, SAVE LIVES

Tangible benefits

- Increased earnings for Microsoft
- Cost savings for hospitals
- Cost savings for governments
- Lower economic damage caused by lockdown for citizens

Intangible benefits

- Image reputation and market share for Microsoft
- Quality of decision making for government
- Quality of research, disease management and treatments for hospitals
- Increased satisfaction of end users

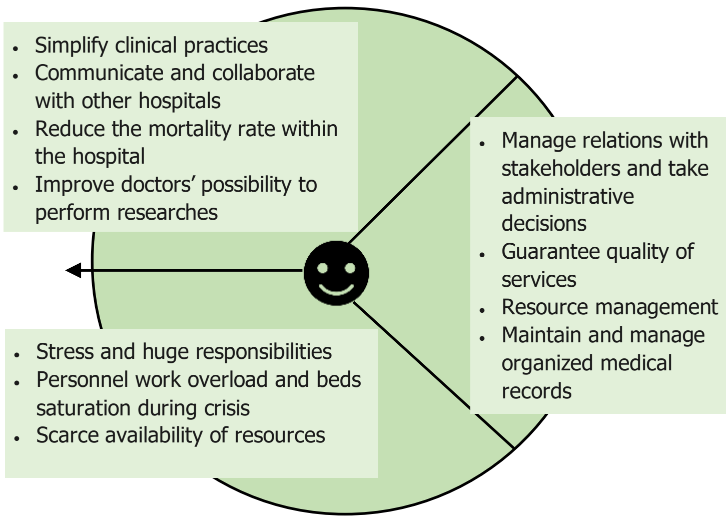
Table 4 - Mission model canvas

3.4.1 Value Proposition Canvas

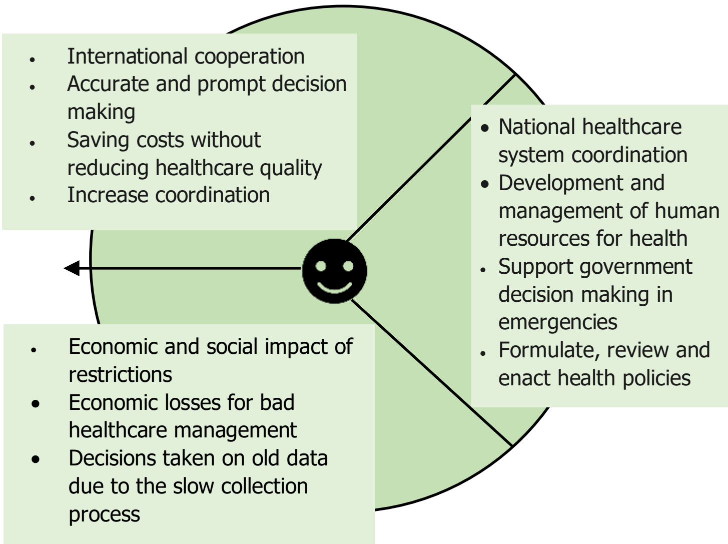
The value proposition canvas allows us to better understand our **main stakeholders** in order to explore their potential interest and willingness to adopt our solution. Specifically, we considered directors for hospitals, the minister of health for governments and developers in healthcare private companies, discussing the "gains" that our solution could create and the "pains" that it could help relieve.

3.4.1.1 Beneficiaries

Considering **directors of hospitals**, their job is to manage the hospital's physical and human resources in the most optimal and cost-effective way, whilst ensuring an appropriate service quality level. The hospital director should take the administrative decisions that are best for all its stakeholders including its patients, medical staff, investors, etc. while adhering to public health regulations. The issue of service quality could be compromised in crisis situations as experienced during the first wave of the COVID-19 pandemic when personnel underwent severe work overload under bed oversaturation. Making decisions under these stressful situations can be extremely difficult.

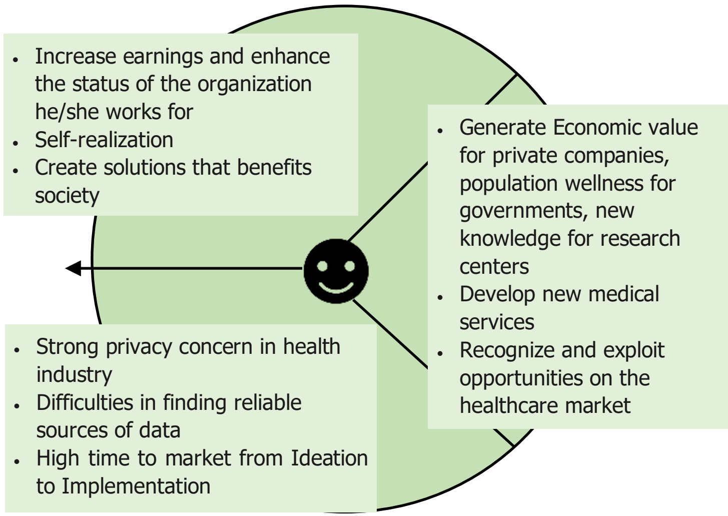


For governments we consider the **minister of health,** whose job is to formulate health policies that ensure public health protection, properly allocating health resources to health entities. In emergency situations, the health minister should support government decision making and provide a framework for management of human health resources by consulting the scientific community and experts. During a pandemic scenario, decisions undertaken by the minister can be faulty in absence of real-time data as the situation progresses quickly. Prompt decisions could be hindered by lengthy bureaucratic procedures, miscommunication and absence of coordination.



Keeping in mind that every citizen could potentially be an indirect beneficiary of our solution, hospitals and governments are the two main groups of entities involved and for which the solution has been developed.

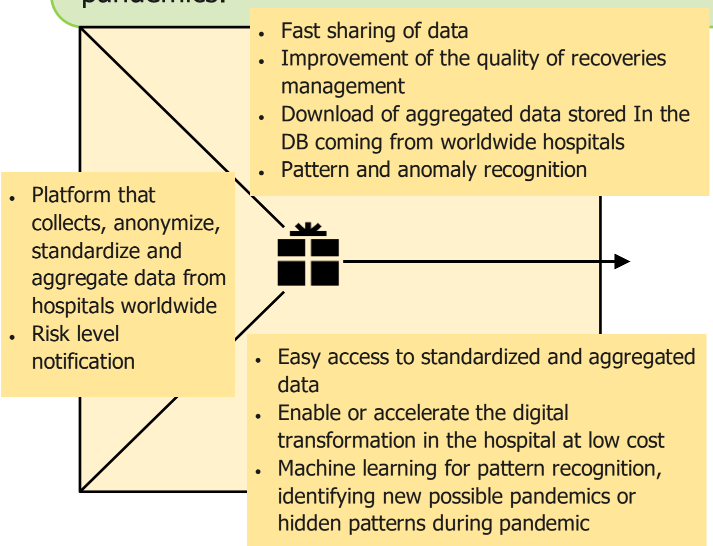
The third group is potentially composed of every organization, R&D center, and **developer**, and their job is to develop new medical services and solutions based on relevant data. They generate value for private companies, governments, and research centers. However, they could have difficulty accessing standardized, reliable, and clean data due to privacy concerns and legislation especially in the medical industry dealing with sensitive data. Diverse data reliability and aggregation could be time consuming, thus resulting in a high time to market and high implementation cost, that are extremely important especially today, in which the innovation rate is high and R&D expenses have to be amortized in a shorter time period (cf. Moore's Law).



3.4.1.2 Key proposition

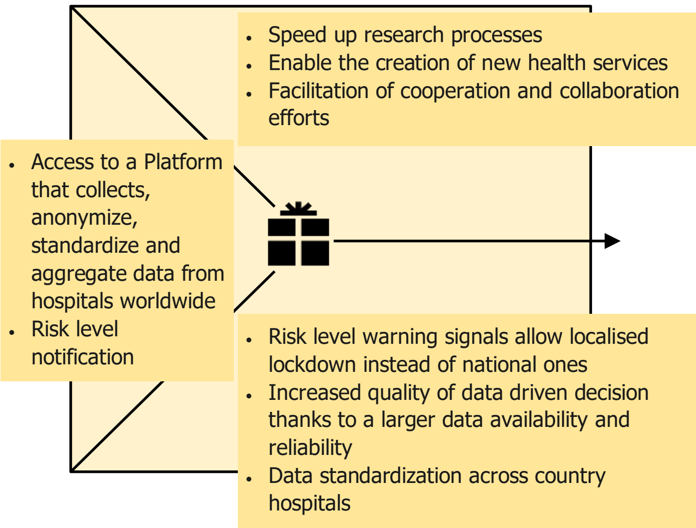
For each beneficiary described above, we designed a precise value proposition, that better fits each need.

Our platform will enable directors of hospitals to share and exploit medical data in a standard format, bringing together anonymized and aggregated data from all over the world into a single database owned by WHO. In exchange, they will be provided with a risk level notification to better spot and manage pandemics.



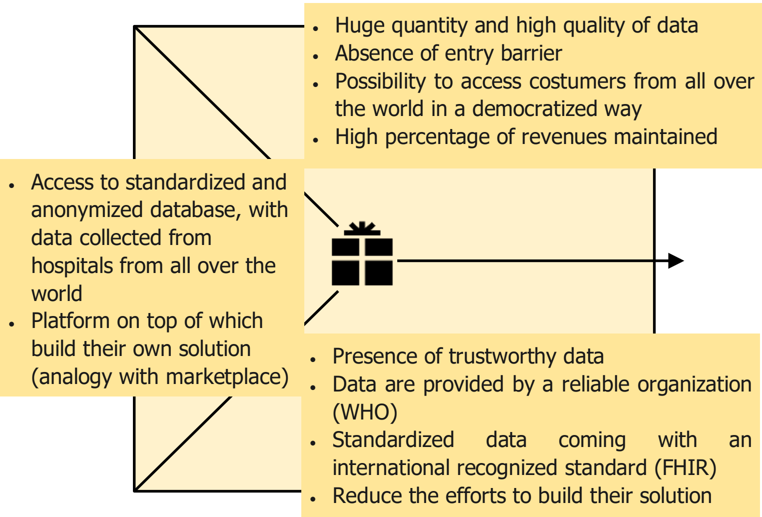
The solution can assist hospital directors by relieving them through **data driven decision making** powered by artificial intelligence & machine learning. It can have effects on reducing personnel stress and increasing their safety by detecting pattern anomalies which can represent dangerous viral diseases. It can also ease collaboration with other hospitals to progress medical research which could lead to better understanding the disease, how to treat and detect it, thereby reducing mortality rate, patient hospitalisation time, and consequently lowering hospital saturation. Medical collaboration and facilitated communication can also lead to quicker vaccination development.

The solution will enable governments, in particular the ministers of health, to set more targeted lockdowns, reducing their economic and social impact on the whole country.



Again, **data driven decision making** can ease governments pains by speeding up the critical analysis of the situation performed by AI algorithms, and thereby assisting them in taking quick actions when needed. In this way, our solution can reduce the economic and social impacts the pandemic can result in, leading to significant cost savings. By relying on an internationally trusted entity (WHO) and through anonymization, the solution could have the support of citizens and medical researchers around the globe, reducing privacy concerns and the risk of politically affiliated drivers. Moreover, it could represent an opportunity for international cooperation between nations.

Finally, Microsoft is providing third parties with the possibility to build on the top of this platform any possible solution exploiting a **centralised database** where data collected from all over the world flows.



It will also empower hospitals' R&D department, and organizations to develop better solutions exploiting the power of Big Data. This is eventually the advantage of having a platform: recognising the complexity of the problem, the platform is a way to empower anyone becoming complementors of the solution, creating externalities and increasing the effectiveness of the solution hand by hand with the increasing number of third parties.

To conclude, the **system map** below highlights the beneficiaries and stakeholders involved in our solution and the related flows.

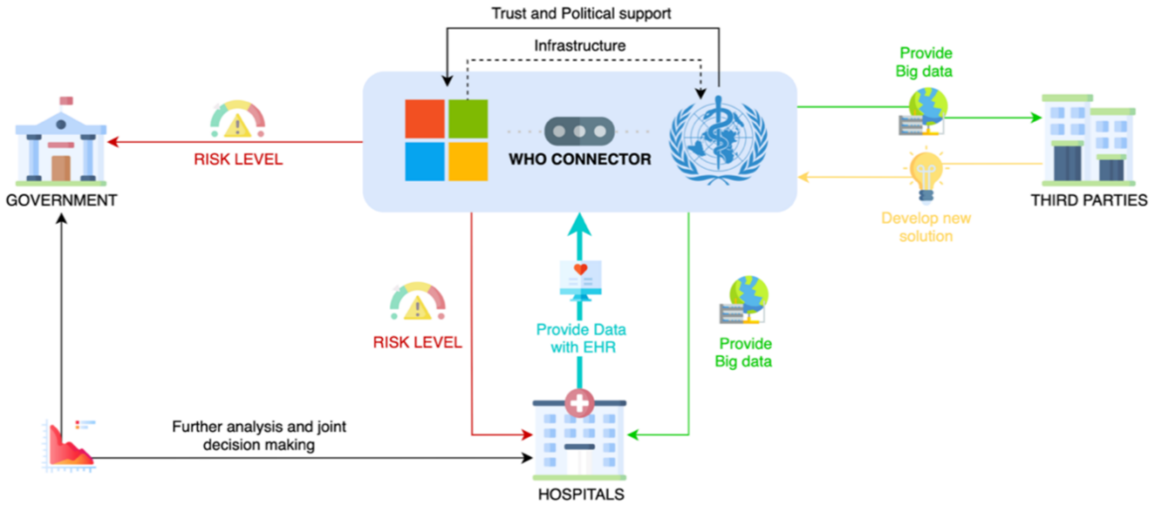


Figure 3 - System Map

3.4.4 Deployment

Leveraging on Microsoft Azure platform, beneficiaries will be provided with the FHIR connector [see section 3.4.7] in order to access the centralized database. The deployment process builds on the existing communication channels, mainly leveraging those of WHO, in order to raise awareness about the platform and to promote it. We also believe that the platform will benefit from complementors' innovations in the future, which will increase the value for users and at the same time it will create a lock in effect once reached the critical mass. This consideration arises by analogy with the digital platform use cases, which in most of the cases result in a winners-take-all configuration by leveraging on network externalities and bandwagon effect.

Finally, also partnership with NPOs such as medicine without borders can be interesting to promote the platform, especially for reaching local communities in less developed countries.

An example of the dashboard provided to both the WHO and the hospitals is displayed in the figure adjacent. In this example, a particular importance is given to the monitoring of the number of hospitalizations in each single healthcare structure. This data is compared with the average of stays in the previous periods to detect abnormal patterns and so notify a Risk Level. However, the experience of the researchers, with the help of the data scientists could lead to much more in depth analysis of the data stored, so that various variables can be explored thanks to the power of the Azure Analytics Services.

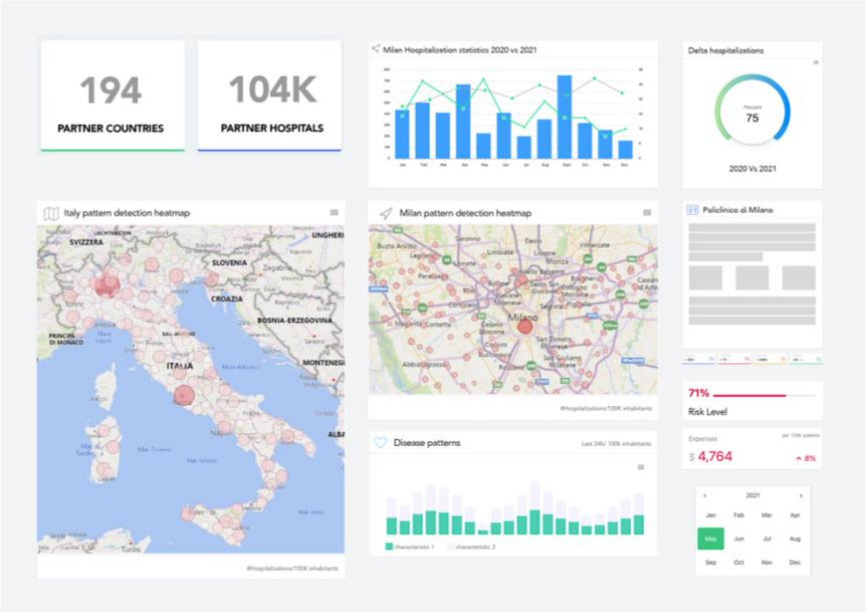


Figure 4 - Dashboard example

3.4.5 Buy-in/support

To get 'buy-in' from all the beneficiaries, Microsoft will promote **transparency** by giving the data ownership to WHO, which is already a trusted entity all over the world. Moreover, clear **communication** about the **huge impact** in terms of health and cost reduction for preventing nationwide lockdown should be provided. This should not be limited to the features that Microsoft and WHO will provide since the beginning but enriched by explaining the huge **value embedded in Big Data** and the benefits that can arise from their exploitation when developing solutions on top of the platform.

To gain hospitals consent the solution should not disrupt their way of work. For that reason, we propose the FHIR API which is able to standardize data format with **no additional efforts**. Indeed, change management could be complex and lead to opposition from end users, which can result in project failures when underestimated.

3.4.6 Key Activities

In order to deliver our value proposition to the identified beneficiaries, we identified several key activities to be performed.

Data management – anonymization, standardization, exchange and storage

Four steps of data management are considered after data gathering, that is only facilitated by our platform but that relies on already-in-place beneficiaries' procedures.

The first step is **data anonymization**. Data privacy is a sensitive topic heavily regulated by policy makers across the globe, especially in healthcare. As showed by our external analysis, privacy concern represents a potential threat to our solution. Personal data is defined as any data that can lead to person identification whether direct or indirect. Diving deeper into privacy legislation, data sensitivity can be tackled using anonymization tools. Hence, by adopting those tools, company trust is maintained, individuals are protected against data breaches, and data is provided in a consistent, clean and accurate way which allows to leverage big data and analytics while preserving privacy.

The following step is **data standardization.** Ensuring a standard for data presentation is crucial to align all the gathered data and unify them all under a centralized database. In particular, our cloud platform solution leverages on Health Level Seven International (HL7)'s **FHIR** (Fast Healthcare Interoperability Resources) **specification**. FHIR is a global standard that enables healthcare systems to communicate with each other and exchange data electronically.

Data exchange is the core of our value proposition. By enabling data exchanges, our platform will provide beneficiaries with a direct channel to upload and download data from the centralized database. This will place at every stakeholder's disposal the huge power of Big Data.

Finally, **data storage** is the last step of data management, and it is intended as all the activities and processed needed to store, maintain and protect data in a virtualized database that exploits the Cloud Computing power. More about data management will be explained talking about the key resources.

Data analysis and algorithm development

To provide analytics and in particular **risk level notification** to better manage pandemic outbreaks, data must be analysed properly. Data analysis comes together with data cleaning, pattern recognition, machine learning algorithms and all the power that Artificial Intelligence can bring. The objective will be developing proper algorithm and pattern rules with the aim of empowering WHO with a tool able to improve data driven decision making. Medical specialists must be involved to support algorithm definition, scope and rules.

Data security and access control

Data Security is a process of protecting files, databases, and accounts on a network by adopting a set of controls, applications, and techniques that identify the relative importance of different datasets (e.g., sensitivity, regulatory compliance requirements) and then applying appropriate protections to secure those resources. The core elements of data security are **confidentiality, integrity, and availability**. Those elements are important for organizations to keep their sensitive data protected from unauthorized access and data exfiltration. Since our solution relies on medical records, data security is cardinal. More particularly, a strict and precise access control protocols must be implemented to ensure that only certified authorities can exchange data with our platform.

Deployment and support activities

To reach out all the beneficiaries, deployment phase is a crucial part and thus, should be considered a key activity. Increasing awareness, reaching out healthcare centers and providing them the correct support is critical. Consequently, IT support for a correct integration of the platform in the state-of-the-art sanitary structures systems, as well as an informational and legal support for authentication and management processes are required. Moreover, support activities will also include customer relationship management and eventually technological assistance and clarification about the system. From Microsoft perspective, maintaining an enduring relationship with WHO is also going to be mandatory to deliver a high-quality service concerning both data storage and analytics.

3.4.7 Key Resources

Among the several resources that Microsoft possesses we can list physical, human and intellectual key resources needed to deliver our value proposition.

Brand, pervasive presence, and platform makers reputation

As mentioned in the Internal Analysis, Microsoft's brand equity and pervasive global presence represent key resources. The company's strategy is to emerge as a market leader in the platform arena, exposing platform-as-a-service (PaaS) products that third parties can use and build on top. Those intellectual and intangible resources will help Microsoft to **increase awareness**, **trust** and **ease negotiations** all over the world.

Microsoft Azure for data management and advantages of Cloud

Microsoft Azure is a cloud platform for building, deploying, and managing services and application anywhere. With the aim of creating a unified source of data, we need a technological architecture that comprises both a storage and a standardization tool. As explained before, the standard that we want to use is HL7's FHIR standard. Microsoft Azure provides an **API for FHIR** backed by a Platform-as-a-Service (PaaS) offering in the cloud. This allows anyone working with health data to employ Protected Health Information PHI in the cloud. By using the FHIR API, existing data sources that uses **EHR systems** are transformed into the same FHIR standard and can be promptly exchanged between different nodes of the network. The unified standard also permits mobile and web development, implying that developers and organizations can produce unlimited possible utilizations and applications of the data. The API's main features are security, easy maintenance, interoperability, and control data access at scale.

Microsoft Presidio for data anonymization

Presidio helps to ensure data proper management and governance. It provides fast identification and **anonymization** modules in text and images. In this way we want to democratize de-identification technologies, avoiding privacy issues and allowing only anonymized data to be uploaded in our platform.

Microsoft Azure AI and services for data analytics

Azure comes together with a large offer for empowering all developers with Artificial intelligence tools. Microsoft solutions come with powerful and scalable resources perfect for the solution architecture, including a security level based on different security layers. Particular attention must be reserved to two services embedded on Azure:

- **Azure Databricks** provides an easy-to-use platform for analysts who want to run SQL queries on their data lake, create multiple visualization types to explore query results from different perspectives, and build and share dashboards. Therefore, this is the main service used to display data on the WHO dashboard and make this data be interpreted by a multidisciplinary pool of experts.

- **Azure Cognitive Services** comprise various AI services that enable you to build cognitive solutions that can see, hear, speak, understand, and even make decisions. In our case, we are particularly interested in the new multivariate **anomaly detection** APIs which further enable developers by easily integrating advanced AI for detecting anomalies from groups of metrics. In this case, the service would be used for the monitoring of the data coming from the hospitals in order to generate the risk level notification if needed.

Human resources: IT, Data Analysist and Medical specialists, CRM resources

We need specialists like **IT engineers, data analyst and medical specialists** to run the platform properly. Their main goal will be developing the platform, managing the technological infrastructure, provide careful data analysis and manage risk level notification to check a 5-nine accuracy level. Moreover, developing algorithms for pattern recognition and better disease treatment is a work to be done through a tight collaboration between algorithm specialists and medical staff that can provide all the medical knowledge required to improve algorithm's quality.

Human resources are also key for customer relationship management in order to support customers during all the phases (installation, integration, maintenance and management).

3.4.7.1 Overall Technological Architecture

The overall technological architecture of our cloud Platform is represented below. We can recognize three different layers, each one referring to the different entities: healthcare centers, Microsoft and the WHO.

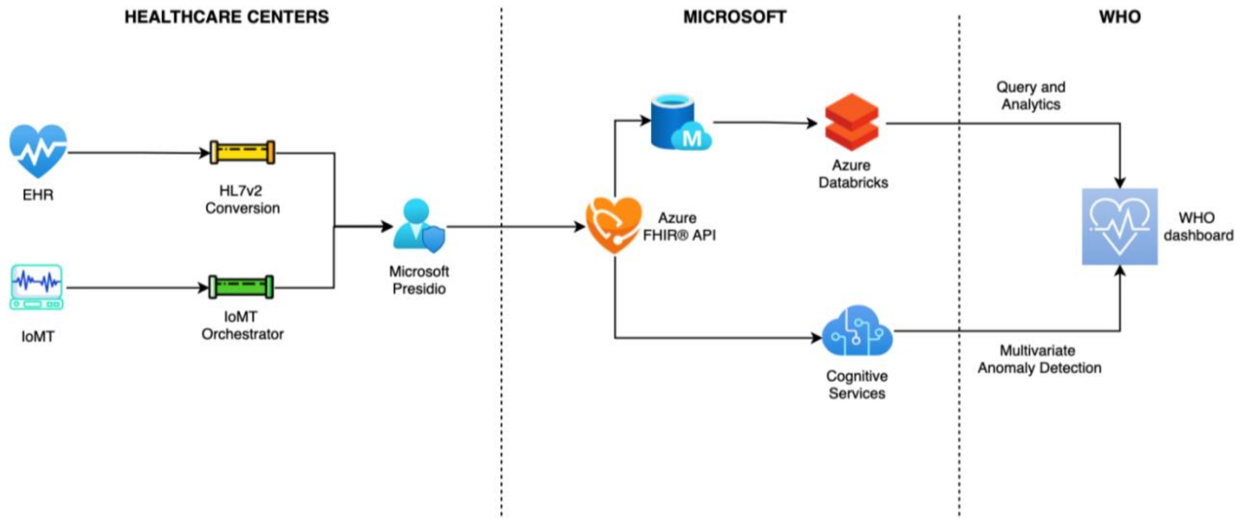


Figure 5 - Overall Technological Architecture

For more details *[Appendix A3].*

3.4.8 Key Partners

Being a centralized solution, one of the main questions that arise is **data ownership.** The center where all data is collected and managed should be a transparent source trusted by nations' leaders and citizens. Moreover, the owner should be experienced in managing health data through established frameworks, have an understanding of the international legal and privacy dimensions, can coordinate global efforts, and is incentivized by the overall wellbeing of humanity.

Working with 194 Member States, across six regions, and from more than 150 offices, the **World Health Organization (WHO)** represents a strong candidate for platform and data ownership.

It is a trusted authority that is already actively working with health facility data support for clinical management of patient, disease monitoring, health sector planning and more. WHO's role is to direct and coordinate international health within the United Nations system. Preparedness, surveillance and response together with communication and health systems are some of the major areas of the organization's work.

World Health Data Platform already exposes key data tools, data sets and databases, monitoring different aspects of health and providing **a unique source of data**. Moreover, WHO releases regular reports on data trends and analysis related to global health.

Especially, WHO **Division of Data, Analytics and Delivery for Impact (DDI)** encourage excellence in data and analytics to inform strategic policy dialogue by working with countries, regions and partners. One of DDI goals is improving data measurement, ensuring that every country has a robust data system, addressing data gaps and setting best practice for data collection, analysis and reporting.

Hence, WHO expertise, network and reputation are key for a pandemic management system that strongly relies on data and their availability and trustiness.

3.4.9 Economic feasibility

This section discusses the economic feasibility of the proposed solution. The analysis is done based on the very first phase after launching the platform, therefore just considering United States, United Kingdom, France and Germany as shown in the roadmap section *[see section 5].*

A sensitivity analysis is performed to demonstrate how strongly the solution holds economically under different scenarios. We will firstly go through the cost structure for Microsoft due to the provisioning of the service, then the benefit for the hospitals will be estimated in order to explore the feasibility of the solution. At the end, a pricing strategy is proposed to quantify the benefit for both Microsoft and the hospitals.

3.4.9.1 Cost structure

The most relevant costs for Microsoft are the following:

ARCHITECTURE

Azure API for FHIR, Azure Databricks and Azure Cognitive Services are the main components of the architecture, the costs of these services are considered to be equal to their public market prices set by Microsoft on its website, instead of its internal costs.

MAINTENANCE

The whole cloud infrastructure at the base of the platform needs to be constantly maintained.

HUMAN RESOURCES

Specialized human resources must be recruited for the platform and algorithms' development, data analysis, cybersecurity, legal and business advice. We also imagine a round table in which some of these specialists will take part together with healthcare experts and researchers made available by the WHO.

Considering all these factors, the **total costs will amount to around $165 thousands** *[Appendix A4]* **per year for each hospital addressed**.

3.4.9.2 Benefits Estimation

The two main benefits considered for the economic feasibility are:

1. R&D SAVINGS

2. HOSPITALIZATION AVOIDANCE

Indeed, we believe that our solution could bring savings to hospitals in terms of money and time both within and outside a pandemic scenario. In a normal situation, the platform brings benefits in terms of savings on

R&D through data gathering, cleaning, and standardization. In a pandemic scenario instead, in addition to savings on R&D, it helps hospitals avoid major costs through reducing infected patient hospitalization.

In high-income countries, an average of 0.0019% of the GDP is invested specifically in **R&D (GERD) inside the healthcare system** which means $62.61 billion every year for the four countries considered[84]. A relevant part of these investments can be attributed to activities related to data collection, data preparation and data standardization. Considering a total number of 14K hospitals in the four considered countries, we estimated that an averaged sized hospital invests around $4 million per year in R&D. We want to understand which percentage of this investment we should let hospitals save each year in order to have benefits equal to the costs of the service.

To determine possible hospital avoidance cost savings, three scenarios were chosen. These are the average cost per patient in Germany ($12k)[85], the average European cost equal to $20k[86] and the median US cost of $37k[87].

On average, there has been 263 hospitalization cases due to COVID-19 in one year in each hospital of the chosen countries[88]. Thanks to this information, we computed the total cost that a hospital had to spend for COVID-19 patients during the pandemic. For example, considering the lowest saving of $12k per patient, the total savings amount to $3.165 million per year.

If we consider a mere 10% effectiveness (i.e., only 10% of total number of patients can avoid hospitalization), a hospital could save $316.5 k per year thanks to our system. Assuming a pandemic occurs once every 30 years[89], and distributing this cost saving over the years, each hospital would save around $10.5k/year.

3.4.9.3 Feasibility

The target is feasible if hospitals savings on R&D due to data standardization are at least 2.6% in the best-case scenario (10% effectiveness, $37k per patient), up to 3.5% in the worst case (10% effectiveness, $12k per patient). Data scientists spend on average 80%[90] of their time in finding and structuring data. More specifically, data structuring represents 25%[91] of the annual healthcare organizations R&D cost. Therefore, from an economic point of view, the solution is feasible.

Following a conservative approach, the cost structure and the subsequent pricing strategy are built based on the worst-case scenario under a 10% effectiveness and R&D savings estimated to be equal to 10% of the mean gross expenditure on R&D for health.

Percentage on R&D expenditure to save on worst scenario	3.517%
Percentage on R&D expenditure set	10%
Targeted hospitals	7.000
1-year costs, total	$ 1,159,335.74k
1-year costs for each targeted hospital	$ 165.62k
1-year hospitals savings, total	$ 3,160,072.76k
1-year single hospital savings	$ 451,44k

Table 5 - Economic feasibility Summary

3.4.9.6 Pricing Strategy

As a result, we could charge an average sized hospital around $300k per year, obtaining 81.14% profit margin on top of the cost of $165.62k, reaching earnings for Microsoft above $900 million. Part of this profit needs then be devolved to customer acquisition (e.g., discount, consultancy, marketing), and each hospital still maintains yearly savings of around $150k.

1 year price per hospitals	$	300.00k
1 year revenues from targeted hospitals	$	2,100,000.00k
Total MS earnings 1-year	$	940,664.26k

Table 6 - Pricing Summary

It is important to highlight that this business model is built considering only revenues from hospitals. In practice, there are other stakeholders that would benefit from our solution. Specifically, our solution achieves savings for governments and revenues for third parties. In fact, studies demonstrate that the economic effect of 1 year lockdown is at least 9% of GDP[92], which multiplied by an effectiveness of 10% would lead to savings of **more than $84 billion** for the four selected Countries. Concerning third parties, instead, the idea is to **incentivize them to build complementary solutions** which will bring value to the platform and to hospitals. The idea is to adopt a **revenue-sharing strategy** like Apple is doing with the Apple Store. Companies could develop their solution (e.g., AI algorithm for disease detection from lung scan images) benefiting from the **quantity and quality of data** the platform provides. Then, also through our platform, they could **access potential customers** (hospitals). In a way, the platform would act as a **"marketplace"** that would connect both sides. In exchange, companies give up a **percentage of their earned revenues** (e.g.,10%). However, we left out on purpose these other potential revenue streams to be more conservative.

3.4.10 Mission achievement

As described before, Microsoft's mission is to "Empower every person and every organization on the planet to achieve more." Our solution supports the achievement of this mission. In the context of a pandemic, our solution empowers hospitals to better treat their patients, governments to better set policies in place, and everyone with an idea to develop a solution that can benefit the society. Outside the pandemic case, we believe that our solution could help researchers from all over the world to make health science evolve in an easier and cheaper way. It also empowers the WHO, by facilitating international coordination and cooperation. The solution helps **save** economic **costs** that can result as a repercussion to strict lockdown regulations. It also helps **improve the quality** of care and reduce hospital costs, especially those related to the management. Most importantly, it can result in **saving people lives**.

Strategically, the solution can have multiple positive consequences on Microsoft. It helps solidify Microsoft's perception and image as a socially responsible corporation, fortifying trust in the brand name. It can also have positive outcomes on the marketing of Microsoft's products, especially in healthcare outside of the context of the pandemic, such as Microsoft Cloud for Healthcare. This solution exposes different entities to Microsoft's different tools, especially its analytical tools. As a result, it can be an eye-opener for healthcare centers looking for cloud service providers to enable their digital transformation.

3.4.10.1 Value Tree

The Value tree can better explain the benefits of our solution, both tangible and intangible.

Benefits

Tangible

- **Microsoft**
  - + Revenues
    - Earnings increase thanks to i) direct revenues coming from hospitals ii) revenue sharing coming from third parties when acting as a marketplace
- **Hospitals**
  - - Costs
    - Hospitals will be able to save money thanks to the number of patients reduction and the lower data acquisition and data standardisation costs for R&D activities
- **Governments**
  - - Costs
    - Governments will limit the economic cost consequent to lockdowns, having the capability to set more targeted restrictions
- **Third parties**
  - - Costs
    - Limiting lockdowns means reducing or avoiding the closing time of economic activities, thus reducing the economic impact on citizens

Intangible

- **Microsoft**
  - + Image
    - Microsoft's will be seen as socially responsible corporation, playing a key role in managing current and new pandemics
  - + Market Share
    - Increase the market penetration of Microsoft's solutions in the cloud business, especially in healthcare
- **Governments**
  - + Image
    - Enhance citizens' trust in governments since restriction decisions based on more reliable and transparent data
  - + Quality
    - Increase the quality of restrictions decision making, relying on data driven decisions and real time data
- **Hospitals**
  - + Quality
    - i) Foster medical research with the availability of big and higher quality data
    - ii) Capability to detect possible new viral outbreak faster
- **Third parties**
  - + Satisfaction
    - i) Increase citizens' satisfaction by reducing the entity of restrictions
    - ii) Fostering the medical research, management and monitoring of diseases has a positive impact on patients
  - + Quality
    - Companies & researchers can exploit standardized quality data to develop health services and a platform to sell their solutions

4. Validation process

4.1 Assumptions

A set of assumptions has been made while designing the solution and elaborating it through the Mission Model Canvas and the System map shown previously. Their riskiness is studied, in order to prioritize them and then validate the feasibility of the proposed solution assessing the riskiest ones.

The assumptions divided by stakeholder are listed below:

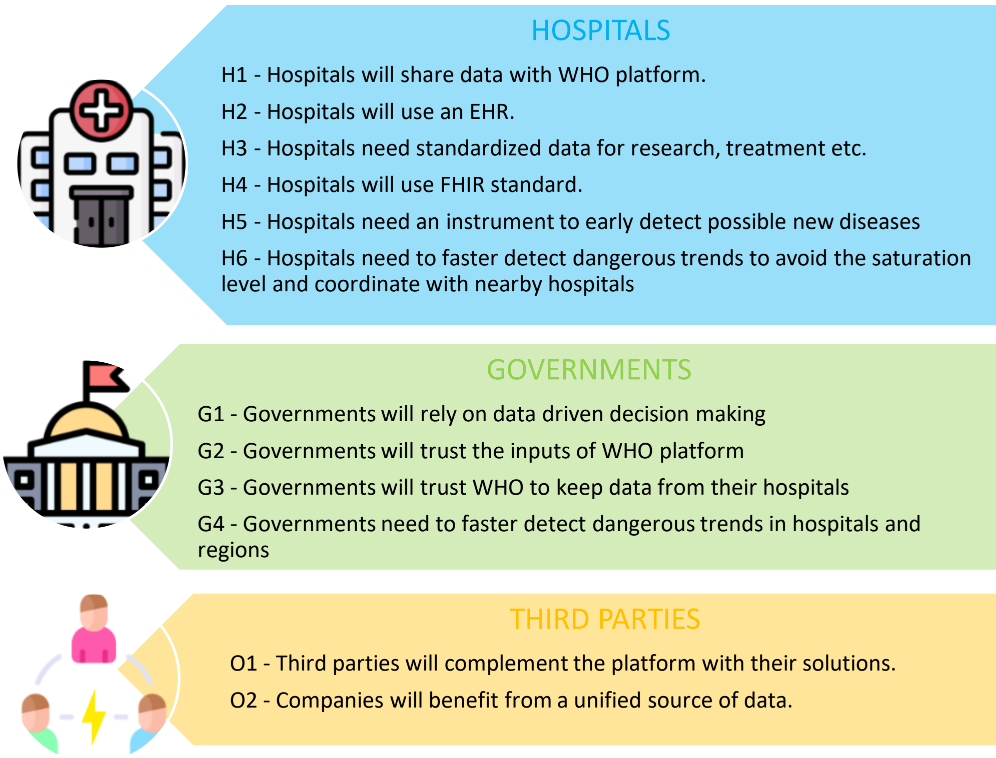


Figure 6 -Assumption list divided by stakeholder

After listing the assumptions, a qualitative evaluation of the riskiness of each assumption is performed, by assigning a value for two variables chosen after in-depth research:

- **Variable 1(V1)**: the **probability** that the assumption holds false
- **Variable 2(V2)**: the **impact** that the assumption will have on the solution if it holds false

After that, a risk matrix is used to visualize the results of the research and to extract the riskiest group of assumptions that must be validated with an experiment. In order to evaluate each variable, we used a scale from 1 to 10 *[Appendix A5].*

4.2 Risk assessment

In this paragraph the riskiness of each assumption is assessed with secondary sources, then the results are used to assign a value to V1 and V2. At the end, the risk matrix is displayed.

4.2.1 Probability (V1)

H1	**Hospitals will share data with the WHO platform**
WHO often creates partnerships with local hospitals in alignment with its mission[93]. However, country agreements with the WHO are non-binding. For example, if a country, such as China, does not want to	

collaborate with WHO, it is free to do so, without any relevant consequences[94]. For this reason, the risk assessed for this assumption is the highest and needs a process of validation.

H2	**Hospitals will use an EHR**
According to a 2015 WHO survey report,[95] **47%** of the health organizations in the world were adopting a national EHR system. However, the report also shows that the yearly cumulative adoption has been **increasing**. Therefore, based on this information, a relevant part of the health organizations in the world are currently using an EHR in 2021.	

H3	**Hospitals need standardised data (for research, treatments…)**
During COVID-19, many researchers[96] expressed concern around data availability and data sharing. When data was available, it was unaggregated, hard to standardize, and coming from **different typologies of data structures**. Based on this, the need of a standardized data structure is high. Even WHO, through an editorial[97], expressed the need for a faster and more efficient way to share and standardise data.	

H4	**Hospitals will use FHIR standard**
According to the official International Annual Report of HL7 released in 2019[98],"As HL7's newest standard, FHIR is not only recognized by many, but is also **changing the healthcare industry**". HL7 has developed a specific FHIR Accelerator Program in order to enlarge this community as much and as fast as possible, so "work continues within the FHIR community to facilitate migration from V2 and CDA to FHIR". Moreover, using the Azure API for FHIR, it will be much easier for every healthcare system to migrate to and use the new FHIR standard.	

H5	**Hospitals need an instrument to early detect possible new diseases**
An operational infection prevention and control (IPC) system is essential to minimize the risk of transmission of health-care-associated infection to patients[99]. In this scenario, hospitals and other healthcare facilities play a critical role in national and local responses to emergencies, such as communicable disease epidemics.[100]	

H6	**Hospitals need to faster detect dangerous trends to avoid the saturation level and coordinate with nearby hospitals**
One of the biggest issue hospitals had to manage during the pandemic was the availability of intensive care and qualified personnel to take care of the patients[101]. As the hospitals reach the saturation, giving adequate care to patients becomes much more difficult.	

G1	Governments will rely on data driven decision making

According to a report made by Deloitte for the European Commission[102] studying 10 European country cases,[103], decisions are already data driven. Hence, the risk of this assumption is not high.

G2	Governments will trust the inputs of a WHO platform

During COVID-19, some countries such as Somalia[104] and El Salvador[105] **co-operated** with WHO to achieve improvements on the health. WHO created plans for specific countries in collaboration with local health organizations[106]. Other countries are less cooperative, such as China[107] that **decided not to cooperate.** For this reason, a medium risk was assigned.

G3	Governments will trust WHO to keep data from their hospitals

Articles 2, 63 and 64 of the WHO **Constitution**[108] are about sharing data. The WHO **data policy**[109] ensures the security of the data shared by the countries "without any restriction on their use". Countries which sign the Constitution should be willing to share data, therefore the assigned risk is low.

G4	Governments need to faster detect dangerous trends from their hospitals

This report's external analysis demonstrates that countries were able to spot the clusters from hospital data in a lower time managed pandemic better *[see section 2.1]*. Therefore, the estimated risk is extremely low.

O1	Citizens are willing to share their health data with WHO

Protected Health Information or PHI is any information that can be linked to an individual through a set of 18 listed identifiers. In Europe, personal data is regulated by the GDPR while in the US, by HIPAA. According to the HIPAA, if the identifiers are removed, the information is considered de-identified PHI, which is not subject to the restrictions of HIPAA privacy rule[110]. Moreover, according to the GDPR, pseudonymization means the processing of personal data in a manner where that the personal data can no longer be attributed to a data subject without the use of additional information. Therefore, "the principles of data protection should not apply to anonymous information [...] including for statistical or research purposes."[111]

As a result, legally, hospitals **could share the anonymized data** with the WHO **without** the permission of patients.

O2	Third parties (e.g., researchers, companies, governments, end users) will complement the platform with their solutions

Data are nowadays one of the most important resources one company could ask for, and a centralized database with standardized and easy to analyse data coming from possibly thousands of hospitals from all over the world would be a precious source for a third party working in the healthcare sector. This could create the space for a market in which health data are exchanged between many actors such as WHO, healthcare organizations and private firms. In any case, the uncertainty is high, and so is the risk.

4.2.2 Impact (V2)

The impact of an assumption is estimated considering the area of our solution (A1, A2 or A3) which would be compromised if the assumption itself was false [Figure 7].

The value of the impact of the assumptions belonging to A1 (H1, H2, H3, H4, G3, O1) will be estimated as the highest: the solution only holds up if we are able to collect healthcare data, which mainly comes from hospitals. Then, the impact of assumptions belonging to A2 (H5, H6, G1, G2, G4) will be evaluated as more impactful than those belonging to A3 (O2).

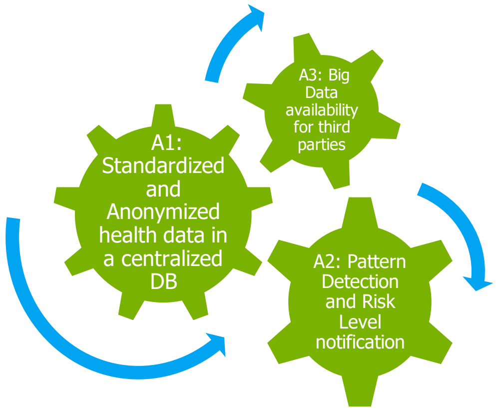


Figure 7 - Assumption prioritization: impacted area estimation

4.2.3 Risk Matrix

The graph below shows the final rank of the assumptions, where only the riskiest ones are going to be experimentally validated due to the short timeframe of the project. The complete set of data is stored in the Appendix as a table for the Risk Prioritization *[Appendix A5].*

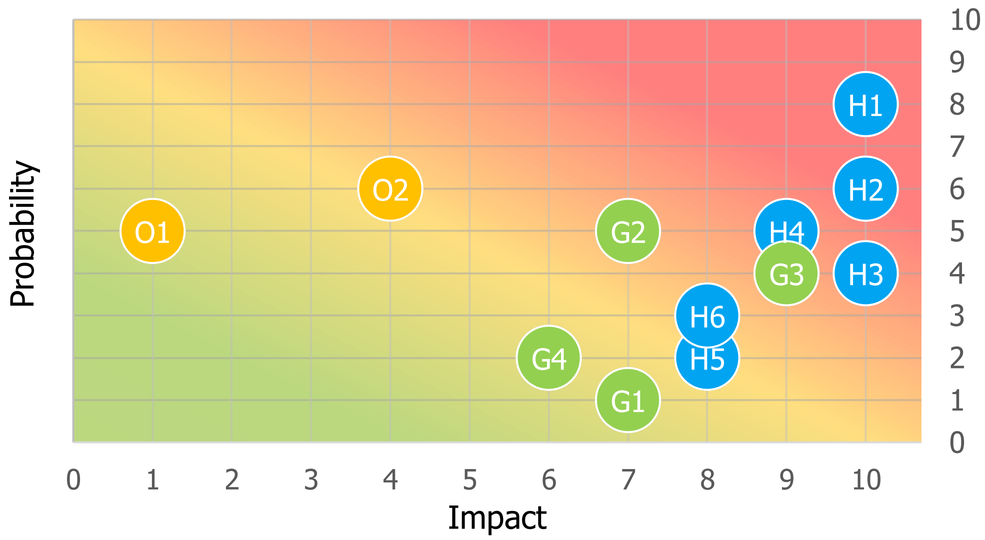


Figure 8 - Assumption prioritization: Risk Matrix

4.3 Testing the assumptions

In order to test the riskiest assumptions, we followed an empirical method.

This happened over two phases:

- **Phase 1:** we sent out a survey to healthcare professionals administered in Italian and English. Each question in the survey was linked to a risky assumption we wanted to analyse. We received 72 answers from doctors, researchers and medical directors. 51 answers came from Italy and 21 from 15 countries in North America, Europe, Asia and the Middle East. *[Appendix A6].*
- **Phase 2:** We reached out to figures with more decision-making power and with a higher knowledge of technical problems: the medical director of the civil hospitals of Brescia and medical executive in the ATS (director 1); the commissioner for the covid emergency in the province of Palermo (director 2); the medical director in Santa Chiara institute in Lecce (director 3). To respect their privacy, their names are not mentioned in this report and we will refer to them as directors 1, 2 and 3.

4.3.1 Findings and discussion

Here we discuss the results by assumption.

H1. Hospitals will share data with WHO platform

Around 92.8% expressed their willingness to share data with the WHO. Only a minority replied negatively, expressing concerns about the technical feasibility of data sharing, which in fact, our solution addresses.

Director 2 told us "I think we would be willing to share health data, as we often do for scientific work", showing that sharing medical data with research and statistical purposes is a common practice for hospitals, thus supporting our assumption.

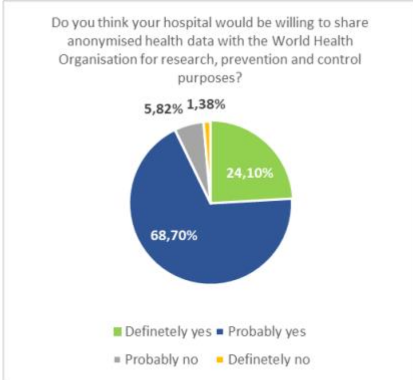


Figure 9 - H1 result pie chart

H2. Hospitals will use an EHR

In this part of the survey, we had a significative difference between the International and Italian samples. Adoption in Italy seems to be much lower (51%) compared to the international sample (90.5%).

According to the survey, in Italy, the main reasons for not-using EHR are implementation costs and difficulty of use by staff. This can be explained by poor healthcare investments over the years and low technological savviness of the older Italian medical staff.

On the other hand, in all the hospitals where EHR is implemented, correspondents expressed the main advantages behind its adoption to be cost reduction, ease of data access, less time wasted, higher comprehension of patients' records, and capability to share data between departments and hospitals.

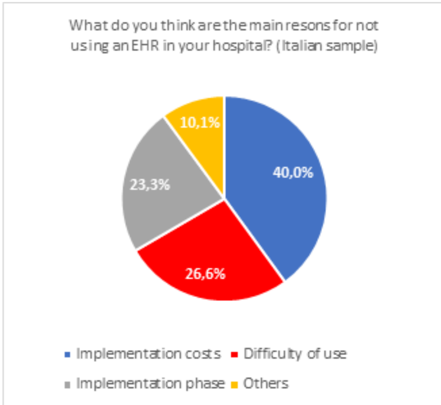


Figure 10 - H2 result pie chart

Almost 90% think that their hospital will adopt EHR standard in the next future.

To conclude, even if data are not quantitatively sufficient, results may show that Italy is not yet ready for our solution, while other countries seem to be better suitable. Specifically, the survey shows that healthcare investments and digitalization are important levers to evaluate which countries are more likely to adopt and benefit from our solution. Healthcare investments could be a proxy to understand if hospitals can afford an EHR, while digitalization reflects the capability of the medical staff to effectively use the EHR.

H3. Hospitals need standardised data (for research, treatments…)

The 78% of respondents believe that standardized healthcare data can be definitely useful for the healthcare system, to foster medical research, and another 21% think it could be probably useful. Moreover, director 1 stated, "Obviously yes, the more data are shared the higher the quality of the research".

This strengthens the importance of standardized health data as valuable source for the healthcare, confirming one of the main hypotheses on which we build our model.

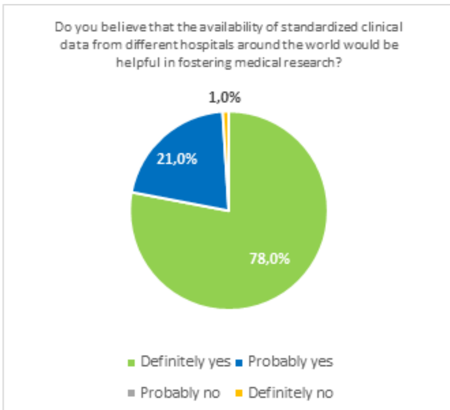


Figure 11 - H3 result pie chart

H4. Hospitals will use FHIR standard

The necessity for our solution to use the FHIR standard to share data from hospitals to the WHO was an assumption requiring some technical knowledge. Since doctors may not know enough about the willingness of hospitals to adopt this standard, we gave them the possibility to answer "I don't know" to this question. As expected, 72.8% of respondents chose this alternative.

Three directors told us they would adopt the international standard FHIR if well integrated with the other existing software. This has decreased the riskiness of the assumption, considering that Microsoft owns an API capable to transform the data from different standards to FHIR.

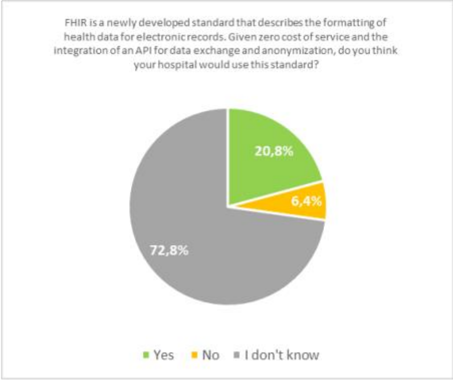


Figure 12 - H4 result pie chart

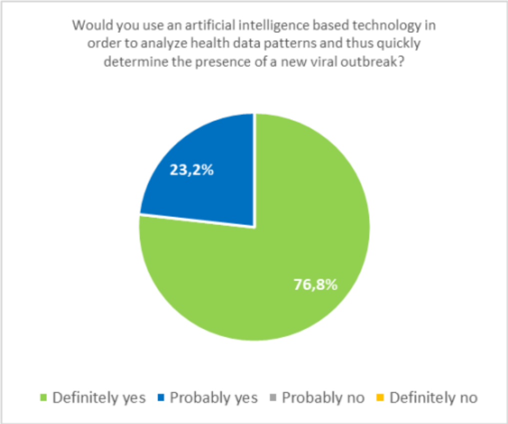


Figure 13 - H5 result pie chart

H5. Hospitals need an instrument to early detect possible new diseases

The possible faster detection of new diseases and viruses resulted to be fundamental for the respondents. Director 2 said, "This is an instrument that we need to get used to", highlighting that the future direction of the disease prevention is towards similar solutions.

H6. Hospitals need to faster detect dangerous trends to avoid the saturation level and coordinate with nearby hospitals

In the last part of the survey, we wanted to assess if the monitoring of epidemiological trends in their area and the coordination with nearby hospitals may be helpful for hospital to better manage pandemic. As for the previous assumption, we got positive feedback both from the survey and from director 3, who added, "It can certainly be useful, I strongly believe in cooperation, especially among nearby healthcare facilities."

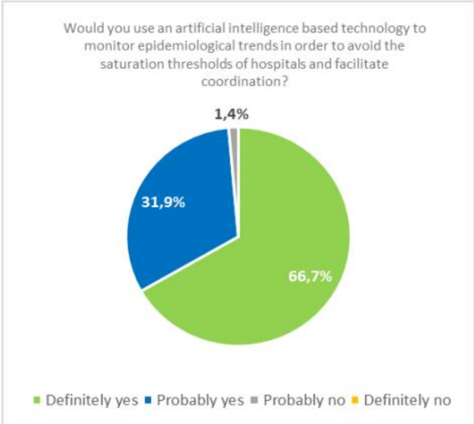


Figure 14 - H6 result pie chart

4.4 Limitations

Starting from the failure of digital technologies, we have shown how the standardization of medical data can be a source of value for the different stakeholders involved, for whom the cost of adoption is lower than the benefits our solution brings. After building the business model, we only needed to test the most dangerous assumptions. The validation process, however, suffers from a few limitations.

First of all, the solution is very technical. Therefore, to validate the assumptions, we needed to interact with specialists with high technical knowledge and decision-making power both in governments and hospitals. According to our risk matrix, the most dangerous assumptions were related to hospitals.

Through doctors' answers, the assumptions related to the need for standardised data were validated, showing that our solution was valuable for them. However, an average doctor does not have the IT competences, or the decision power related to the technological implementation (e.g., FHIR adoption). For this reason, we tried to reach medical directors, but we only managed to reach three of them. This has been a limitation of our assessment process.

Moreover, regarding the EHR usage assumption, the survey revealed that in Italy it is still not widespread, whereas in the other countries it seems to be widely adopted. From the survey we realized that technological penetration and healthcare investments are important levers for widespread EHR adoption in a country. And so, we used these two variables to evaluate which countries can be first adopters of our solution. This should be supplemented by additional research around EHR penetration and adoption in different countries.

The last limitation of the validation was the difficulty in reaching governmental officials, which hindered us from testing a relatively risky assumption related to governments sharing their data with WHO. To conclude, with a certain degree of confidence, we can say that our solution is feasible and would bring value to the healthcare system.

5. Scalability

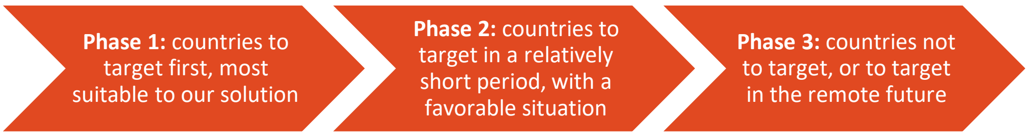
We discuss the horizontal and vertical scalability of our solution. We developed a geographic roadmap to assess which countries would represent the best starting point for phase one of adoption, successively followed by other countries in different phases. Then, we described some further applications that could be created on top of the platform.

5.1 Roadmap

Ideally, the solution is applied to every health organization of each country in the world. But, since the health systems' state of the art, investments and legal concerns (i.e. insurance) are radically different around the world, a roadmap dividing the different countries in groups is needed. To do so, we applied an analysis based on some selected countries and two dimensions.

- **Financial dimension**: quantitative dimension represented by investments on the healthcare. Countries with higher investments in healthcare are more likely to adopt our solution. A proxy to this dimension is the percentage of GDP spent on the healthcare system.
- **Technological dimension:** compatibility of healthcare organizations with the platform. Countries that have a less digitalized healthcare system are less likely to adopt our solution. The level of digitalisation in the selected countries is assessed qualitatively using complementary data about EHR adoption levels. Each country is assigned a number from 1 to 3, one representing a low level of digitalization. *[Appendix A7].*

The objective is to cluster countries to decide where to launch the platform first, starting with the most appropriate group, and then rolling it out to the rest of the world, phase by phase.



The chart below shows the different clustered country groups.

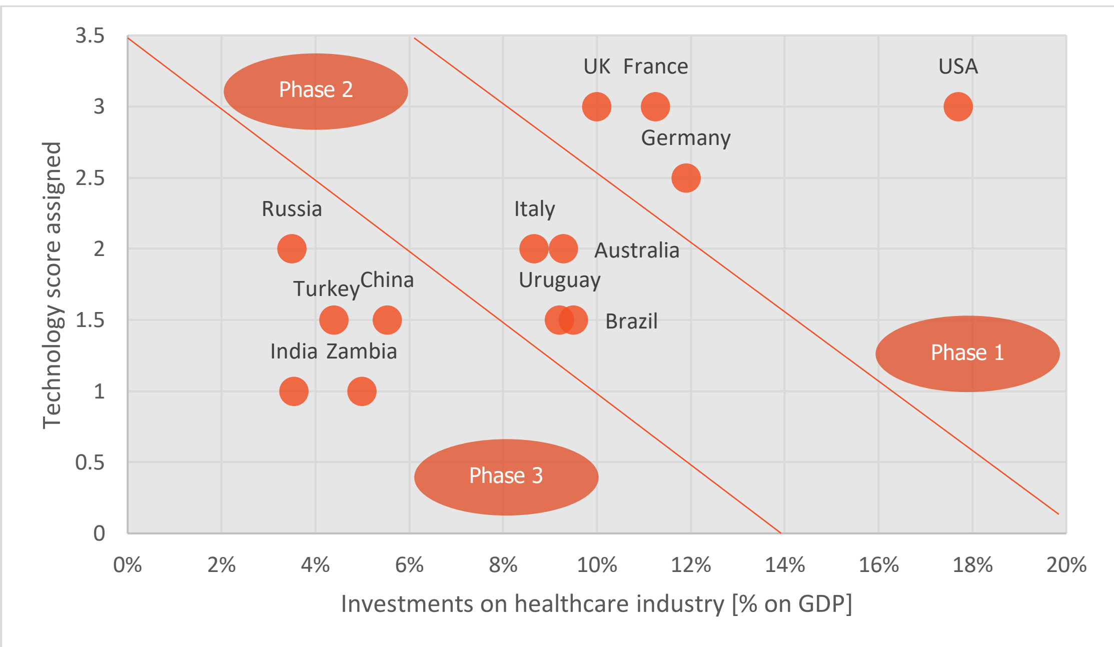


Table 7 - Roadmap chart divided by adoption groups

5.2 Further applications of our solution

After having described, analysed and validated some of the assumptions of the solution, we explore some possible further applications that can be built on top of the described platform. Indeed, the problem is too broad to be tackled by just one solution, and we believe that a whole ecosystem should work to fulfil the mission to spot earlier or better manage the current, or next, pandemic.

Beyond the warning notification the platform solution provides to governments and hospitals, the greatest value the solution brings to the different stakeholders is the unified source of standardized data.

As already mentioned, this data can be used by hospitals and researchers, to foster the medical research, by governments to improve the citizens' wealth, and by private companies as an input source for their businesses. Even already existing solutions exploiting AI would benefit from our database that ensures a larger quantity and a better quality of data that can be used to train the algorithm.

In this last section we want to provide some possible applications that might represent future solutions development based on our platform.

5.2.1 Correlation studies

Since its beginning, Covid19 revealed to be deadly for some people, while much less dangerous to others. Very little is known about how the individual characteristics can affect the outcome of the disease.

A good idea might be using our centralized source of data to train an artificial intelligence in recognizing the individual features that might cause a more severe manifestation of COVID-19 symptoms. For each patient, we have in our database:

- Variables about patients, like the age, diseases, if he smokes or not, his blood type…
- The outcome of the COVID-19 infection for that patient, that might be death, hospitalization with severe or mild respiratory failure or asymptomatic.

The availability of this large amount of quality data may help the artificial intelligence to faster detect correlations between individual characteristics and how the virus hits. For instance, we may have faster discovered that COVID-19 is much more dangerous for diabetics, thus protecting this category of patients.

5.2.2 Treatment management

An artificial intelligence can be also used to detect what are the best treatments and medical guidelines to follow when facing a totally new virus. Once data about the different treatments used and their effects are uploaded on the database, they can be used to statistically understand what the most effective treatments are. The artificial intelligence may be useful to identify if different treatments are better for different clusters individuals, thus giving the possibility to deliver ad-hoc cures.

Also, there are many studies that use machine or deep learning methods to assess chest images of COVID-19 patients for disease testing[112] with the aim of distinguishing COVID-19 patients from non-COVID-19 pneumonia. This solution, as well as other AI solutions, will benefit from the larger database and higher quality data availability they heavily rely on, enabled by the centralized platform.

5.2.3 Our United Vision

We believe our solution, together with the solutions developed by Group 13[113] and Group 23[114] can build a more powerful and united response to the danger of a possible new pandemic outbreak. In fact, while we are addressing the direct needs of the hospitals and healthcare systems in general, Alba, the chatbot designed by Group 13 is facing the needs of citizens whereas the leadership social platform devised by Group 23 is solving the problem of miscommunication.

Alba can be a perfect ally for the collection of valuable data in the standardized FHIR format. This data, after being anonymized and aggregated, would be used to enlarge the set of shared information with the WHO dashboard, that, in that case, would offer a deeper and more meaningful overview of the global situation. At this point, the same data would be used to create ad-hoc insights for leaders and citizens through the platform of Group 23 in order to allow mutual and coordinated aid between different leaders and to help avoiding fake news in the population.

6. Conclusion

All the alternatives were born after a deep analysis that lasted weeks. However, this solution was only reached when we were able to detach from the idea that real life problems are well defined and it exists an optimal solution for the whole issue. Indeed, the problem was broad and complex. Acknowledged that, we reached a solution that does not attempt to solve every issue, but rather addresses the critical things that have the largest impact: the collection and standardisation of data, the "new oil". We thought about creating a **scalable solution, empowering third parties** to build their own solution and hence creating externalities and bringing value to our platform, and about **leveraging** at the most the technologies and resources **already existing**. *As a matter of fact, differently from inventors,*

"Many times, the Innovators are nothing more than smart Solution Brokers"

7. Group composition

7.1 Team members

The group is composed of three computer science engineers and four management engineers. Our heterogeneous competences resulted to be an important asset to tackle the problem both from a technical and a business point of view. Apart from this distinction, each member played a critical role in terms of team dynamics. Putting together the different views and approaches to the work has been a challenge but at the same time a relevant moment of learning. Each member of the group and his/her contributions are presented using the Belbin team roles model.

Salvatore Annunziata, Matr. 952097, <u>the monitor/evaluator</u>

Management engineer. Devil's advocate, hard worker. Key contributions: raising questions and challenges to reason on, highlighting missing angles. tends not to fall in group think but he fights for his ideas.

Federica Bucchieri, Matr. 968132, <u>the implementer</u>

Computer science engineer. Organized, self-disciplined and has a keen eye for design. Key contributions: maintaining structure and order both in terms of planning and the visual content, breaking down abstract ideas into concrete tasks with a time frame.

Martina Cataldi, Matr 953219, **<u>the team worker</u>**

Management engineer. Friendly, supportive. Key contributions: creating harmony in the group, providing team support and assistance through valuable work.

Lorenzo Cocchia, Matr. 968137, <u>the coordinator</u>

Computer science engineer. Excellent interpersonal and communication skills. Key contributions: promoting open communication and collaboration with other teams, arranging meetings and written communication with tutors and other team representatives.

Alessandro Corsini, Matr. 965163, the specialist

Computer science engineer. Dedicated, knowledgeable. Key contributions: leveraging his IT background and visionary approach to deepen research at a very high level of detail.

Natalia Sayed, Matr. 952528, the shaper

Management engineer. Extroverted, challenging. Key contributions: communicating work and collecting feedback from stakeholders, defining goals and prioritizing them, advancing team mission through product evaluation at every iteration.

Francesco Troccola, Matr. 939709, the completer/finisher

Management engineer. A perfectionist with a fine attention to detail. Key contributions: providing constructive critiques and quality assurance of the project.

7.2 The methodology

Given the complexity of the topic addressed and the need to have timely feedback about the project, we decided to adopt agile methodology. Particularly, we choose the **SCRUM** methodology, of which key components are **roles**, **ceremonies** and **artifacts.**

ROLES

Within our group, we chose Federica as the **Scrum Master**, acting as a servant leader to remove the impediments of the group and planning the ceremonies. Natalia had the role of the **Product Owner**, every time she tried to prioritize the work and to ensure the level of quality required by the clients, that in our case were the team itself, the university tutor, and the company manager.

Figure 15 - SCRUM key components

CEREMONIES

Each of our sprints lasted two weeks, at the beginning of which we had a **sprint planning** meeting. At the end of each sprint, we had the **sprint review** to validate the work done and the **sprint retrospective** to understand where to improve. For the latter, particularly useful were the discussions we had with the Microsoft manager, who helped us to grow as a team. Finally, we had **daily sprints** to revise what we did the day before and plan the next day.

ARTIFACTS

The report represented the **product** we had to improve, revise, and develop at each sprint. In this context, the chapter of our report became the requirements of the product, what in the SCRUM methodology is defined as **stories.**

In conclusion, this was a great opportunity for us to apply a new methodology, and as a learning outcome we hope to keep the values on which it is based, that are courage, the focus and commitment, respect and openness.

8. Appendix

[A1] – PEST Matrix

	POLITICAL		ECONOMIC	SOCIAL			TECHNOLOGICAL	
	Policy & Governance	Communication & cooperation	Economic	Privacy concern	Trust in Government	Cultural aspects	Accessibility	As is Digital Contact Tracing technology
BRAZIL	Under the pretext of shortening the public health crisis and protecting the economy, the Brazilian government has pursued a herd immunity strategy.	State and municipal government responses to the pandemic have been systematically obstructed. The president himself defined this as his "war" against government leaders who adopted disease containment measures.	Brazil's government had not sufficient money to support the solution, they come from a recession. Indeed, they approximately did nothing or at least, nothing sufficiently efficient.	NA	The president has not only held crowded public gatherings and travelled extensively around the country. he has also systematically pushed the public toward contagion.	Inequality in the country and federal state government situation blocked a unified and effective response to Covid.	The economic situation of the major part of the population seems to be a strong barrier in this country.	Not well-developed digital contract tracing system. Covid-BR app is an application used for information purposes rather than contact tracing. The only example of tracing technology has been some heatmaps used in the Northern states of Brazil. (NA)
INDIA	There was inadequate investment in preparation of health systems and personnel, and relief measures. The government proceeded with lockdowns but with a low impact on contagion rate.	Excessive centralization and top-down control, without co-ordination between central and state governments. Misplaced timing and delayed responses in several critical areas.	Around a third of the urban population live in dense urban slums, making social distancing unpracticable. Moreover, declining incomes forced many people to cut back on spending for even essential items.	The "Aarogya Setu" design prompted some privacy and data protection concerns because of personal data accessibility by a private company.	Government app for contact tracing was mandatory for the major of the population (base on the type of employment). This led to a lack of trust concerning data usage.	Young people less likely to abide by the containment measures put in place, older people less likely to know how to use technology as contact tracing apps	While the absolute number of app 'downloads' is high, it is only about 1/10th of the entire population. Low technology-penetration and digital literacy environment represent a strong barrier.	"Aarogya Setu" is the world's most downloaded contact-tracing app. The app also collects users' GPS co-ordinates every thirty minutes and continuously accesses Bluetooth data about nearby users and stores this data in encrypted form on users' phones.

• Negative point • Neutral point • Positive point • N/A

ITALY	An initial scepticism about the virus lead to a later response from political parties. Then the government started to adopt lockdowns on broader scale to prevent the spread of the virus.	Inconsistencies between regional strategies that alter the ability to set up uniform, robust planning for future responses to support overextended health and social care. Regarding communication, the country experiences a lack of initial guidelines and communication about Immuni data policies.	Italian economy is driven by SMEs: they have more difficulties in accessing capital. The government instantiated a lot of founds but bureaucracy made the process slower.	"Immuni" App dealt with privacy issues in a very good way. GPS data are not collected, there is a clear list of not collected data. Data are deleted when not necessary, but they remain to the users' phone in any case. Only anonymized data can be sold for scientific purposes.	Lack of initial guidelines insinuated a lack of trust in the population. Furthermore, the majority of the population refused to download the app because of lack of trust in the government.	Impossible to impose a mandatory contact tracing system. Italy is also a more individualistic society where the society goodness is not enough taken in consideration.	Sparse availability of tools for data integration and smart technologies deployable to support contact tracing, surveillance, and other public health interventions.	Open Source, low impact battery app Immuni reached a high number of downloads and sent around 94.618 notifications of exposure to the virus. Based on Bluetooth technology, Immuni functionalities were based on contact tracing exploiting closeness of mobile devices.
GERMANY	Germany's public health institute (RKI) and other scientific institutions produced data and analysis to inform Germany's response. RKI and scientists at other institutions mobilized in early January 2020 to launch a national crisis management effort.	Because Germany is a highly federalized country, the responsibility for public health lies with intermediate and local public health authorities in 16 federal states and approximately 400 counties. Coordination required a detailed national Plan together with generic preparedness plans and other disease-specific plans and documents. Also, direct decision were under region responsibilities.	The German government reacted to the pandemic with prompt economic plan to help the categories affected. This helped people to respect the restrictive measures adopted and, in some sense, to reduce the stress on the contact tracing system.	According to a survey of attitudes to contact-tracing across 19 countries in August, only 21% of respondents would be willing to provide contact information, due to privacy concerns. Citizens were worried about a possible tracking mobile phones of infected people without their consent.	More than 90% of the population supported closing public facilities, closing borders, and prohibiting public gatherings with more than 100 participants. A lockdown and strict stay-at-home order also received majority support. The overall trust in institutions is high.	German people evaluate the covid restrictions quite positively and in general supports the evaluation that the societal benefits of the lockdown outweigh its economic costs. On the other hand, digital solutions were judged as inefficient.	Together with "Corona warn app" other technological solution as chatbots were used. However, the overall penetration of this solution was relatively low. The main source of tracing remains Human contact tracing.	Germany was of the first countries establishing a capillary contact tracing system. The government exploited "Corona warn app" that works by asking individuals to report their positive test status via the app; Bluetooth connections between phones trigger alerts to people who have come into contact with someone who tested positive. It's used on a voluntary base, and it is open source.

• Negative point • Neutral point • Positive point • N/A

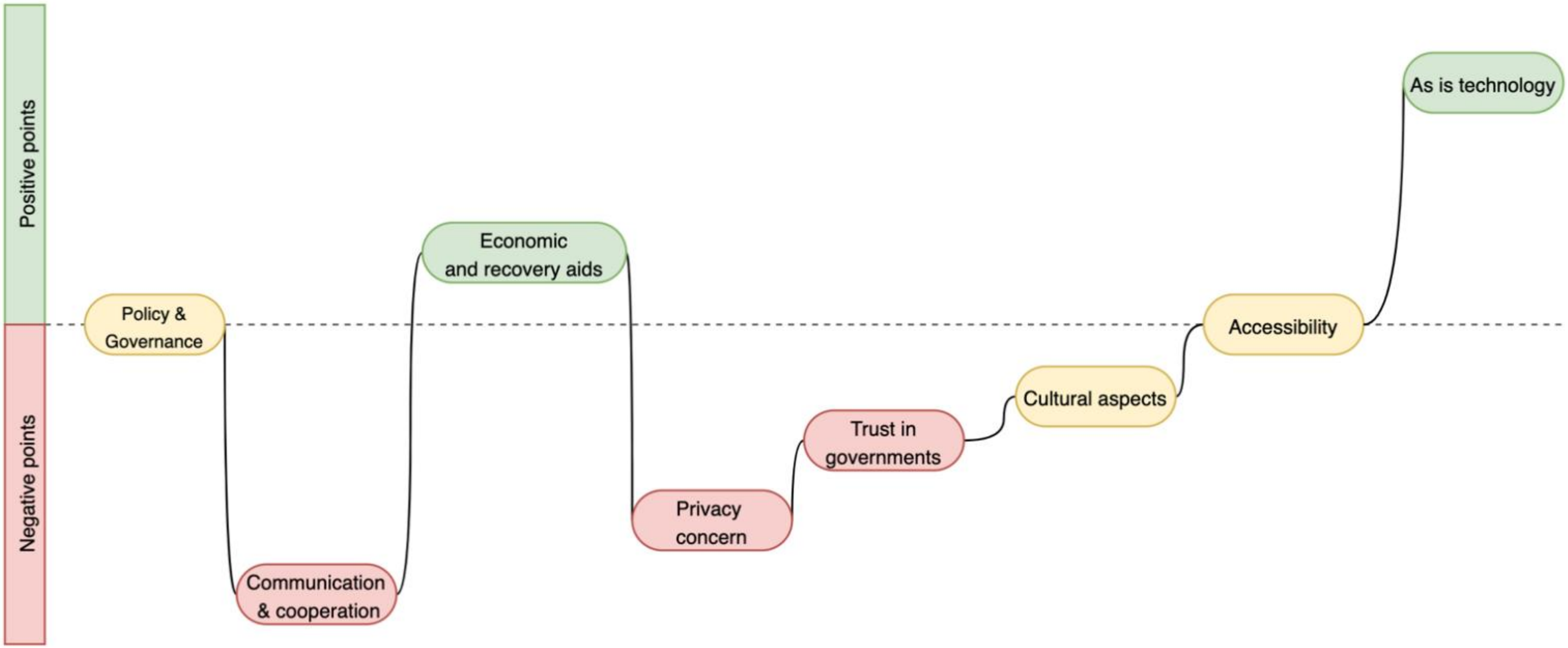
SOUTH KOREA	The Korea Centre for Disease Control and Prevention (KCDC) was granted greater authority and autonomy as the control tower for infectious disease control. The already established legal framework helped authorities to collect data.	From the communication perspective, the government has calmed social disruption by actively confronting fake news and introducing a five-day rotation face mask distribution system. On the other hand, a strong cooperation between central and local government was productive to achieve a quicker and cohesive response to the virus.	Export-Import Bank of Korea and the Korea Trade Insurance Corporation launched financial assistance. Plus, COVID-19 damage report centres were launched in 17 provinces and cities to help local SMEs and micro-business owners address difficulties.	Only around 80% of Koreans said that they would accept some privacy violations to protect public good. Nether the less, information published on the Korea government's website from digital contact-tracing is detailed and has the potential for privacy infringements.	The population experienced and unnecessary surveillance of citizens, questioning what really Korea government can do with those contact tracing technologies.	The Shincheonji religious sect was the epicentre of the virus spread. Furthermore, it could be claimed that Digital contact-tracing has contributed to or exacerbated, existing stereotypes, discrimination and stigmatization against the Church and the LGBT+ community.	The government ensured technological accessibility to those who don't own a smart phone or are unable to use them through providing electronic wristbands for tracing, ensuring inclusivity.	Digital contact tracking was only used when traditional contact-tracing provided limited. They used credit card transaction records, CCTV footages, and mobile phone GPS data. ICT-based contact tracing. 'KI-Pass (Korea Internet Pass)', which is QR codes-based entry log system was introduced in order to keep record of visitors to the facilities with a high risk of mass infection.
VIETNAM	In the wake of the SARS epidemic, Vietnam developed a national public health emergency operations centre and a national public health surveillance system. They implemented targeted lockdowns, travel bans, business closures, mass quarantines, and widespread testing.	This country's centralization found a balance in the numerous key decisions made at local level. Since 2016, hospitals are required to report notifiable diseases within 24 hours to a central database, ensuring that the Ministry of Health can track epidemiological developments across the country. Also, Vietnam did a very good job in communicating frequently with citizens.	Vietnam has invested heavily in its health care system, with public health expenditures per capita increasing an average rate of 9 percent per year between 2000 and 2016. I t is one of the few countries in the world currently experiencing positive GDP growth.	NCOVI app has drawn criticism from some privacy advocates. The Government also uses Facebook or Instagram posts to track position and behaviours of people.	The government communicated frequently with citizens to keep them informed and involved in the public health response. Those actions created an established trust in government's actions.	The society is typically collectivist, when there is a crisis, especially one from an external force, people come together like a strong fist. When it comes to major health issues, people want science and improvement.	Internet penetration in Vietnam stood at 70.3% in January 2021. Also, the wealth disparity between the working class and the rich is still vast.	NCOVI app was lunched. It helped citizens create a "neighbourhood watch system" that complements official contact tracing efforts and may have helped to slow transmission of the disease. The app allows watch real-time movement of people placed under quarantine, allows users to declare their own health status and report suspected cases. Social networks posts were also used to track peoples and their behaviours.

• Negative point • Neutral point • Positive point • N/A

UNITED STATES	Trump government Downplayed the danger and side-lined experts. Confusing guidelines were given about masks and the government didn't' help in the early stages of the pandemic. Under President Joe Biden's administration, government science agencies and health officials have been given renewed respect and independence.	There was not a Not a national strategy about tracing contact systems and the country response was strongly decentralized. No government app was launched but a lot of different apps were launched on different states. Google and Apple cooperation in this field was a huge boost in contact tracing app development.	Covid-19 small business loans and assistance comprises a lot of economic measures, like the COVID-19 Economic Injury Disaster Loan, the Paycheck Protection Program, the Shuttered Venue Operators Grant and more.	U.S. has no baseline data protection law that would protect the sensitive data obtained through contact tracing apps. Without such protections, there's no assurance that this sensitive data won't end up in the hands of insurance companies, employers, creditors, identity thieves, or stalkers, to be used in ways that could harm or discriminate against individuals.	Lack of trust in the tech companies or the government to collect, use, and store their personal data, especially when that data involves their health and precise whereabouts. According to a survey of the Washington Post, there is a strong lack of trust derived from anonymization on data.	Strong individualistic society. It is a nation that prides itself on personal reasons, this implies difficulties in implementing restrictions like isolating and quarantines. Moreover, Structural racism fuelled health inequities: Black and Hispanic individuals and other people of colour were sickened with, and died of, COVID at disproportionately high rates.	The high internet penetration in the country and the high number of mobile connections are strong bases for a digital ecosystem. However, only 21% of the U.S. population, now have access to a Covid-19 app, according to a CNBC analysis using U.S. Census data.	10 states that have published alert apps using technology from the Apple-Google partnership. Their open-source solution was cheaper and faster and was based on Bluetooth signals and established data policy frame. Every phone with a Covid alert app sends out Bluetooth Low Energy signals to detect if two people were close together for an extended period of time.
OVERALL	Inadequate preparation for pandemic situations, except for countries that already experiences an epidemic outbreak	Lack of communication and coordination among different countries and between local and central governments resulted in disorganization and low effectiveness response.	The average of the countries responded to Covid 19 with monetary support and economic programs for the country economy	Lack of transparency and standardized procedures for data gathering resulted in high concerns for individual privacy	Lack of initial guidelines and procedures for pandemic management resulted in low trust in governments	Collectivistic society are more willing to prepend community good over individuals.	Internet penetration and average age of the population are the main creators of accessibility barriers	Digital technologies for contact tracing seem to have no weaknesses

• Negative point • Neutral point • Positive point • N/A

Results of the Pest Matrix – Qualitative assessment



• Negative point • Neutral point • Positive point • N/A

[A2] – Internal Analysis Weaknesses – Segment Results of Operation

SEGMENT RESULTS OF OPERATIONS

(In millions, except percentages)	2020	2019	2018	Percentage Change 2020 Versus 2019	Percentage Change 2019 Versus 2018
Revenue					
Productivity and Business Processes	**$ 46,398**	$ 41,160	$ 35,865	13%	15%
Intelligent Cloud	**48,366**	38,985	32,219	24%	21%
More Personal Computing	**48,251**	45,698	42,276	6%	8%
Total	**$ 143,015**	$ 125,843	$ 110,360	14%	14%
Operating Income					
Productivity and Business Processes	**$ 18,724**	$ 16,219	$ 12,924	15%	25%
Intelligent Cloud	**18,324**	13,920	11,524	32%	21%
More Personal Computing	**15,911**	12,820	10,610	24%	21%
Total	**$ 52,959**	$ 42,959	$ 35,058	23%	23%

[A3] – Overall Technological Architecture

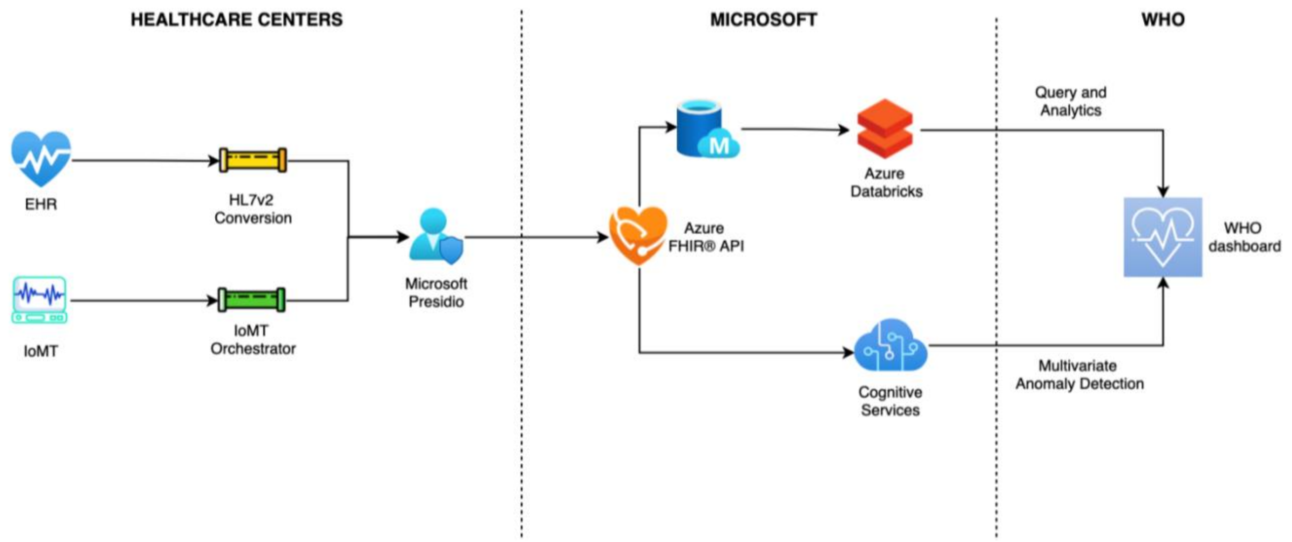


Figure - Overall Technological Architecture

1. Starting with the first layer, we identify in the patient data the input to the overall architecture. Those data are stored in the Electronic Health Record (EHR) of the **healthcare centers** and our architecture takes the lead from there. Data are anonymized using Microsoft Presidio entirely eliminating personal information and possibility of re-identification. Then, data are standardized with the use of the Azure API for FHIR®, that has to be integrated inside the IT system of the hospital. This API transforms the structure of the patient data into the standardized FHIR structure, transforming everything into a Resource based convention. [115]
2. Data are now ready to be sent to the **Microsoft Data Layer**. The second layer takes care of the incoming data storing them in the FHIR Servers protected with multi-region failover. The Azure API for FHIR implements a layered, in-depth defence and advanced threat protection for the data. At this point, the Cognitive Services are used to make computations on the standardized data.
3. Who takes now the lead is the **WHO**. We are offering a dashboard for data visualization and analytics management and control based on the Azure Databricks Service, providing access to AI and Machine Learning virtual instances for processing all the collected data. In particular, the Risk Level Notification System is generated as a result of those analytics algorithms and connect the third layer of our architecture with the first layer, creating a benefit loop that fuels the overall system.

[A4] – Architecture Cost Estimation

Microsoft Azure Estimate				
Architecture Cost Estimation				
Service type	Region	Description	Estimated monthly cost	Estimated upfront cost
Azure API for FHIR	North Europe	730 Hours Service runtime, 4 x 100 RU/sec x 730 Hours, 50 TB Structured storage	$13.115,36	$0,00
Azure Databricks	North Europe	All-Purpose Compute Workload, Premium Tier, 1 D3V2 (4 vCPU(s), 14 GB RAM), 3 year reserved, 0.75 DBU x 730 Hours	$301,13	$2.717,09
Azure Cognitive Services	North Europe	Anomaly Detector: Standard tier, 1,000,000 transactions	$314,00	$0,00
Support			$0,00	
Licensing Program			Microsoft Online Services Agreement	
Total			**$13.730,49**	**$2.717,09**

Considering that the costs for maintenance of the infrastructure and the costs of the human resources are included inside the prizes of the services set by Microsoft, we estimated the total yearly costs as the results of the costs of one months that is 13 K multiplied for 12 months which is a total amount of around 165 K per year.

[A5] – Assumption Prioritization

	#	Name	ASSUMPTION	PROB	IMPACT
HOSPITALS	1	H1	Hospitals will share data with WHO platform	7	10
	2	H2	Hospitals will use an EHR	6	10
	3	H3	Hospitals need standardised data for researches and treatments	4	10
	4	H4	Hospitals will use FHIR std	5	9
	5	H5	Hospitals need an instrument to early detect possible new diseases	2	8
	6	H6	Hospitals need to faster detect dangerous trends to avoid the saturation level and coordinate with nearby hospitals	3	8
GOVERNMENTS	7	G1	Governments will rely on data driven decision making	1	7
	8	G2	Governments will trust the inputs of WHO platform	5	7
	9	G3	Governments will trust WHO to keep data from their hospitals	6	9
	10	G4	Governments need to faster detect dangerous trends in hospitals and regions	2	6
OTHERS	11	O1	Citizens are willing to share their hospitals data with WHO	5	1
	12	O2	Third parties (e.g. Researchers, companies, governments, end users) will complement the platform with their solutions	6	4

[A6] – Proposed survey for assumptions validation (English version).

https://forms.gle/r8eVNWbkGqYETe4e6

Digital transformation for the next pandemic management | Trasformazione digitale per la gestione di nuove pandemie

[English]
Hello! We are seven engineers from Politecnico di Milano and we are working in collaboration with Microsoft for a project of digital innovation. Specifically, the objective of our research is to understand what were the problems in the current crisis management, in order to improve the prevention and the control of future possible pandemics.
To this end, we would like you to fill this short anonymous survey.
We thank you for your support and remind you that the answers to the survey will be used exclusively within the scope of our project.

[Italiano]
Salve! Siamo sette ingegneri del Politecnico di Milano impegnati in un progetto di innovazione digitale in collaborazione con Microsoft. In particolare, l'obiettivo della nostra ricerca è capire quali sono stati i problemi nella gestione dell' attuale crisi, per poter migliorare la prevenzione e il controllo di future pandemie.
A tal scopo, vorremo chiedere il suo aiuto, compilando questo breve questionario anonimo.
La ringraziamo per il suo supporto e le ricordiamo che le risposte al questionario saranno utilizzate esclusivamente nell'ambito del nostro progetto.

*Campo obbligatorio

Choose the language | Scegli la lingua *

- ○ English
- ○ Italiano

Avanti

Digital transformation for the next pandemic management | Trasformazione digitale per la gestione di nuove pandemie

*Campo obbligatorio

Digital transformation for the next pandemic management

What country do you live in? *

La tua risposta

In what region or city is the hospital for which you work located? *

La tua risposta

What is your role within the hospital? *

- ○ Medical director
- ○ Primary doctor
- ○ Doctor under medical training
- ○ Altro: ______

Do you think your hospital would be willing to share anonymised health data with the World Health Organisation for research, prevention and control purposes? *

- Definitely yes
- Probably yes
- Probably no
- Definitely no

If no, please provide reasons for your response.

La tua risposta

Does the hospital where you work have an electronic health record system already implemented? *

- Yes
- No

If yes, what do you believe are the benefits that the digitalization of medical records brings?

La tua risposta

If no, what do you think are the reasons for not using this tool?

- ◯ Implementation costs
- ◯ Personnel difficulties in using the tool
- ◯ It brings no value added with respect to the current tools we use
- ◯ We never considered to use it
- ◯ It is in the implementation phase
- ◯ Altro: ____________________

In case you don't use it, do you think your hospital will adopt such electronic health records in the next future?

- ◯ Definitely yes
- ◯ Probably yes
- ◯ Probably no
- ◯ Definitely no

FHIR is a newly developed standard that describes the formatting of health data for electronic records and facilitates their exchange. Given zero cost of service and the integration of an API for data exchange and anonymization, do you think your facility would use this standard? *

- ◯ Yes
- ◯ No
- ◯ I don't know

Do you believe that the availability of standardized clinical data from different hospitals around the world would be helpful in fostering medical research? *

- ◯ Definitely yes
- ◯ Probably yes
- ◯ Probably no
- ◯ Definitely no

Would you use an artificial intelligence based technology to monitor epidemiological trends in order to avoid the saturation threshold of hospitals and facilitate coordination? *

- ◯ Definitely yes
- ◯ Probably yes
- ◯ Probably no
- ◯ Definitely no

Would you use an artificial intelligence based technology in order to analyze health data patterns and thus quickly determine the presence of a new viral outbreak? *

- ◯ Definitely yes
- ◯ Probably yes
- ◯ Probably no
- ◯ Definitely no

Indietro Invia

[A7] – Roadmap dimension assessment brief

Country	Investments on healthcare industry [% on GDP][116]	Digitalization indicator (internet users as % of population)[117]	Percentage of EHR declared (2015 – in primary facilities)[118]	EHR adoption indicator (2018 – Europe – from 1 to 4)[119]	Technology score assigned (from 1 to 3)
USA	18,000%	90%	82%		3
Germany	11,900%	94%		3.082	2,5
France	11,258%	91%		3.331	3
UK	9,997%	96%		3.432	3
Italy	8,668%	83,7%	25-50%	3.356	2
Turkey	4,400%	75,0%	> 75%		1,5
Russia	3,500%	82,6%	50-75%		2
China	5,531%	65,2%	> 75%		1,5
India	3,544%	45%			1
Uruguay	9,200%	76,9%	< 25%		1,5
Brazil	9,510%	75%			1,5
Zambia	5,000%	14,3%	25-50%		1
Australia	9,286%	89%	25-50%		2

[A8] – Additional material

In order to complement our work, we want to point out the reader attention to some of the working documents produces by the team during the project development.

1. Economic feasibility scenario analysis – Excel Document

https://polimi365-my.sharepoint.com/:x:/g/personal/10623885_polimi_it/EUNNz1BqbZBOjplkHso7eMEBYABue2Qs-UQRGIvYCmjFOw?e=uq9hNm

Comprises:

- Savings analysis based on data gathering and standardization
- EHR country census
- EHR adoption rate from 2000 to 2015
- EHR barriers of adoption by country
- Hospital census by country
- Covid cases and related data by countries (UK, Germany, France)
- GDP analysis of chosen countries and continents
- Chosen countries covid data analysis
- MS Azure estimated costs
- Project cost estimations
- Project Economic feasibility
- Worst case scenario analysis

2. Miro board: team collaboration tool

https://miro.com/welcomeonboard/aHhzZmo3aVVEeUJEN3R6WUFuUmE2dG5laG51YmYyMTVnNGhvem5DNkdwN2Y0VTlZMmdoQ21JMEc5ck5aOFpuT3wzMDc0NDU3MzUxMDE2ODA3NTA3

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