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Assessing the Business Continuity of a healthcare organization through a data-gathering modality approach

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Abstract— Most business continuity planning methods help provide adequate precautions in case of a crisis situation to keep the organization’s main activities running uninterrupted in the moment of the crisis. One way to accurately improve the rules that arise from business continuity planning (BCP) would be to (i) proceed with the data multidimensions and multi-sources (physical, societal, financial, etc.) through a purpose-driven Information System (IS), (ii) build customized integral robustness indicators and (iii) use them to qualify the business continuity strategy. On this basis, this work’s findings make firms, particularly healthcare organizations, less sensitive to catastrophes by designing an interactive dashboard that pilots the business continuity indicators and highlights decisive components and resources.

Keywords— *Business continuity management, ISO 22301, System modelling, Data processing, Healthcare organizations.*

I. INTRODUCTION

Organizations must identify their major strategic vulnerabilities, priorities, important resources, and functions, and ensure that they have strategies in place to manage, maintain, and, in the case of a crisis, recover so that business can continue without or with little disruption [1].

During the last years, the crisis situations have been constantly rising causing more and more instability and harm to the organizations, systems and the environment. The instability can itself cause disruptions and affect the organization’s activities. To a certain threshold, the disruptions can be tolerated but in no case, it should affect the vital activities of the structure known as a pillar for the business continuity [2].

To implement these “maintaining-the-activity” strategies, the organizations must use different data sources within their internal environment and external stakeholders. Gathering a maximum of multidimensional data can allow enhancing strategies. Analyzing and contextualizing the variety of the gathered data is a pillar for developing more efficient decision-making tools [3].

The strategies that maintain an organization’s business continuity are defined within a Business Continuity Plan

known as BCP. The plan itself can be implemented within a Business Continuity Management System (BCMS) that requires regular maintenance. Basically, a BCMS is a system where BCP is implemented and improved. The organization must establish, implement, maintain and continuously improve a BCMS, including the necessary processes and their interactions. In general, a BCMS is composed of a (a) policy, competent people with defined responsibilities, (c) management processes (implementation, operation, performance evaluation, continuous improvement) and (d) documented information that supports operational management and enables performance assessment [4].

A BCMS is used to prepare, provide, and maintain the means of control and capabilities to manage an organization's overall ability to continue to function during disruptions. In achieving this goal, the organization: contributes to its strategic objectives (from a business activity perspective), reduces legal and financial exposure (from a financial perspective), protects life, property, and the environment (from a stakeholder perspective) and improves its ability to remain effective during disruptions while demonstrating proactive risk control in an effective and efficient manner (From an internal process perspective). In fact, business continuity is often unique to a corporation. Thus, defining a framework for the formalization and generalization of the BCP is one of this work’s objectives. However, its execution might have far-reaching consequences for the general public and other parties. External stakeholders on which an organization relies are likely to exist, as are those who rely on it. As a result, good business continuity management (BCM) leads to a more resilient society and organization [5].

On one hand, with the rise of risky events such as natural disasters and mortal pandemics which are due to the ultra-density and hyper connectivity of society, the tendency of the research works in the business continuity field of study is to evaluate the BCP and consolidate it by diversifying its inputs (all the available and relevant organization’s data) and customizing its outputs (recommendations and business-maintaining strategies). The qualification of the BCP, on the other hand, remains a difficult scientific topic since evaluating a tool whose primary goal is to ensure the continuity of operations entails measuring a purpose-driven

assessment tool. [6] In this particular context, the robustness of the BCP is defined as its ability to continue to function under disturbances without letting any interruption on the most important or “vital” activities of the business happen.

The main question that this paper aims at tackling is the following: **How to design a data-gathering process in order to evaluate a business continuity plan using robustness indicators, particularly in the case of a healthcare organization?**

Referring to paragraph 3 in the introduction, these BCP robustness indicators can be implemented within the parts (c) and (d) of the BCMS. To answer this question, this paper is structured as the following:

First, the paper exhibits a state of the art; related works and literature reviews within the BCM field.

Second, it explains a pre-established data model and different classes of data types taken into consideration while evaluating a BCP. As well, the approaches that were pursued to gather different types of data (physical, societal, etc.).

Third, it demonstrates the relevance and impact of the collected data on the business continuity through the exposure of a Proof of Concept (POC); Design of some β -version indicators, that was developed internally with consideration of a specific case study: a healthcare organization during the first lockdown in France which led to staff shortages and patients not coming as scheduled.

II. STATE OF THE ART

In different ways, studies and approaches have sought to address the question of how to evaluate BCP relying on diverse data sources. Several research works have suggested some methods for improving the business continuity policies (competitors to this research work), others have suggested methods for analyzing the data, creating data models, dashboard, performance and robustness indicators (contributors for this research work). Hence, this section is organized as the following:

Improving the business continuity and evaluating BCP: **The other research works**

About data modelling and performance measuring: **The contributors' related works**

The gap this research work is trying to tackle: **The scientific contribution**

A. *Improving the business continuity: The other research works*

The business continuity, being basically managed by the BCP, can be evaluated and improved by following different approaches, some of them are explained within the following paragraphs.

On one hand, the majority of business specialists recommend starting with business continuity planning and then focusing on disaster recovery for the most crucial aspects of the organization which comes under the third step in the four phases of crisis management (Prevention, Preparation, Response, Recovery [7]. Regardless of the sort of disaster, a BCP focusing on restoring the organization's ability to conduct business may encounter many types of distractions. In this way, disaster management planning should incorporate disaster preparedness employing Strategic management, Business risk management analysis, awareness,

and Information life cycle management for the construction of a business continuity plan, in addition to the traditional disaster response planning. Integration of these five critical criteria should offer a solid foundation for managing and responding to possible risks (fires, storms, pandemics, etc.) [8].

On the other hand, although most companies admit that certain calamities are unavoidable, far too many firms are unprepared to deal with them [9,10]. Only 20% of firms feel they have a strategy for Business Continuity in place that will be effective in the case of an emergency [11]. To avoid such circumstances and better prepare for crisis situations, some firms tend to prepare a BCP and additionally implement an audit process for it. However, as a way of raising management awareness, a fully designed and performed BCP audit is insufficient. A series of Best-in-Class case studies must be added to the audit to identify the firms, the creation and implementation of their BCP procedures, and the subsequent advantages realized as a consequence of these processes. Firms must be willing to participate in the management education process. Identifying appropriate BCP benchmarks and metrics can figure as important steps to efficiently build the business continuity strategy as well [12]. BCP is designed for a "general" crisis, without considering the fact that the turmoil caused by attacks, pandemics, or floods is not of the same nature. This should always be examined, given the diversity of the nature of organizations, as the firm is also as specific as the obstacles it may experience. In addition, BCPs are predictive, but rarely based on actual past crises. Given that expectations are never clear, the COVID19 crisis shows how unprepared we are and how much we have learned. In conclusion, preparing a “traditional” BCP to be strictly applied doesn't seem to be effective all the time, as BCPs should be tested and improved regularly. Throughout a continuous and purpose-oriented evaluation process of the BCP, hazardous events can be well-managed with the least effect on the structure's business continuity [13].

B. *About data modelling and performance measuring: The contributors' related works*

For several purposes, analyzing the data can be a useful tool. As circumstances proliferate, the data gets larger and the purposes get more complex. Thus, building a model to classify and cluster the data (sources, types, domains, etc.) remains a must. For example, structured, unstructured, machine and sensor-generated data, batch and real-time processing data, biometric data, human-generated data, and business-generated data are all descriptive words for a thriving data domain. Data domains can be the following: (a) Machine-generated data (b) Human-Generated data. From the same assorting perspective, the data types can be either descriptive, predictive or prescriptive [14].

As stated before, analyzing the data within one organization contributes to building more robust business continuity strategies. In fact, to evaluate the business implications of being out of service, most companies begin with a business impact study. This initial step does not offer any recovery implementations; it is only an expression of a business need that will be used as input for later phases that will evaluate IT-related circumstances. The following tasks are completed in order to qualify the business consequences: (a) identify the essential business processes, (b) estimate the

effect of a loss or degradation, (c) estimate the risk and vulnerability and (d) identify the IT procedures that support the mission-critical applications with the possibility to articulate potential outage reasons and risk mitigation scenarios. [15]

Another key point while evaluating the performance, when it comes to business continuity, is to consider all the available data, especially the societal figures. In fact, risk analysis in connection to economic, social, and environmental issues is an essential component that companies should consider when developing a BCP. The surveyed firms in [16] consider economic, environmental, and social factors while developing their strategy. The most significant factors were found as economic/market characteristics (92.1% of organizations rated this feature as important). Environmental issues received 67.8% of the vote, followed by social issues with 65.8%.

Hence, the next subsection explains the contribution within this paper which, like others, seeks to measure the influence of different factors on an organization's operation. Distinguishing data types and sources and processing its outcomes makes it possible to predict the behavior of individual and collective in the case of a threatening situation such as a pandemic. Therefore, in terms of societal factors, this work is concerned with the study of a real use case (a public healthcare organization) during the COVID-19 pandemic and its alteration regarding the absence of the staff and patients.

C. The scientific contribution

Based on these two previous subsections, our contribution consists mainly of assessing the Business Continuity strategy by establishing a data model which segregates the data and considers its types, domains and sources within the organization. This model aligns as well with the data's interpretation flow and provides outcomes based on the mentioned phases (raw data, aggregate data, information, knowledge, decisions) for each data cluster.

The model suggested by this research work combines the Business Continuity evaluation key points with the relative datastore that can be at disposal at an organization, along with respecting a standard flow for interpreting the three-dimensional data (Fig. 1). In this model, the data are entitled to three attributes which are its type, source and significance at the level of a BCP and the interpretation flow which results in the decision-making process. In fact, it is essential to anticipate individual and group behavior in the case of a hazardous situation.

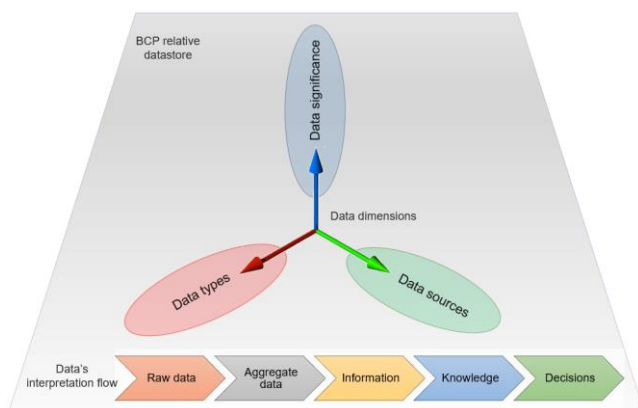


Figure 1. Our model's dimensions and perspectives

Processing segregated data categories and sources helps anticipating these conducts and thus taking preferable decisions and eliminating any possible harmful effects. In addition, a BCP must ensure that the vital activities of the firm are all maintained and protected. Referring to that, this model collects this data and interprets it in order to particularly assess the BCP comprehensiveness. In the following section, the model's dimensions (sources, types and significance) along with the general architecture are explained.

III. THE METHODOLOGY AND SYSTEM OVERVIEWS

This proposal's main feature is its ability to successfully integrate many sorts of data at once, such as societal data, financial data, and physical data (sensors and IoT devices), and utilize them to build a comprehensive data analysis of the organization's environment. This methodology will allow for an integral and multidimensional review of the BCP, resulting in improved risk and business continuity management outcomes.

A. The model's data sources

The data sources of the established 3-dimensional model consist of the following (Fig. 2). Basically, clustered in definite natures, the data can have different origins in one main type. For example, the physical data can be provided through multiple sources such as analog or digital sensors, Hall-effect sensors, wireless objects or geolocation modules.

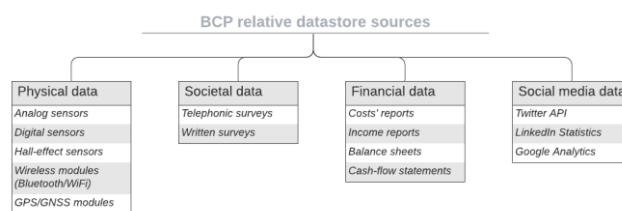


Figure 2. The model's data sources

B. The model's data types and significance

According to each source, the data could have different types and a specific significance. For example, the physical data can be either analog or digital and represent basically the technical environment. Whereas, the societal data can reflect for example fear as a result of alarmist information (through evaluating social networks), rumors, and a desire to copy others' behavior [17]. Organizations that already have some degree of distress (absence, burnout, increased turnover) are different from other organizations. Hospital workers for example are more stressed in the workplace and familiar with workarounds [18]. On the internet, we may try to gauge the intensity of collective terror. This would necessitate the gathering of phrases that encourage individuals to take time off work, limit their movements, flee to the countryside, and purchase essential supplies.

C. The data-gathering approaches

For implementing a β -version of our model, only the technical and societal data were considered since in most cases these data can be essential enough to build strategies for the business continuity as the guidelines given by the norms [4,5] revolves mostly around that. Another reason is that the rest of the data clusters (financial and social media data) will be gathered using other different approaches that will be formalized in the next steps of this research project

after completely finishing all the proceedings with the two first main batches.

This implementation was held within the pediatric ward of a public middle-sized health-care organization in a city of approximately 50000 inhabitants in the southwest of France.

In fact, non-Covid-19 patients had limited access to health care during the initial wave of the COVID-19 pandemic [19]. This was exactly the case in France, especially in our use case. Therefore, this survey was created. In a pandemic crisis (such as the COVID-19 pandemic), the hospital is forced to manage a "crisis within a crisis" situation. It must comprehend the causes behind the hospital's personnel and patients' absences (renunciation of care). Individual and group human factors must be included in the business continuity plan: the reasons for absence as well as collective mental representations of threat and risk (fear of exposure to a viral threat, panic and panic under the effect of rumors). Sociological investigations (surveys of patients and employees) allow that the profile of those who are most concerned to be captured (age, education level, distance to the hospital, type of profession, etc.).

- **The physical (technical) data**

For the physical data, a top-down approach was adapted. It consists mainly of the following steps: (a) formalizing the data to be collected, (b) classifying the data into categories, (c) implementing the sensor-based solution, (d) proposal of data exploitation solutions (Backup, real sequences of fixed durations, display in "Dashboard" gauges), (e) finalizing the generic model, (f) study of the needs in terms of technical data in the organization, (g) extracting a sub-model and sub-features and (h) finishing the "customized" model.

- **The societal data**

For the societal data, a bottom-up approach was adapted. It consists mainly of the following steps: (a) start of the investigation, (b) final acceptance from the organization, (c) CNIL (Commission Nationale de l'Informatique et des Libertés) declaration, (d) update of the survey, (e) discussion and modifications, (f) development of the survey, (g) first confirmation with the concerned organization, and (h) definition of the sociological survey.

- **The model's double-hybridity**

As shown below (Fig. 3), the established model proposed by this research work represents a double-hybridity; in terms of the data's nature and the collecting approaches, making it possible to collect and process data agilely along with considering two different data types.

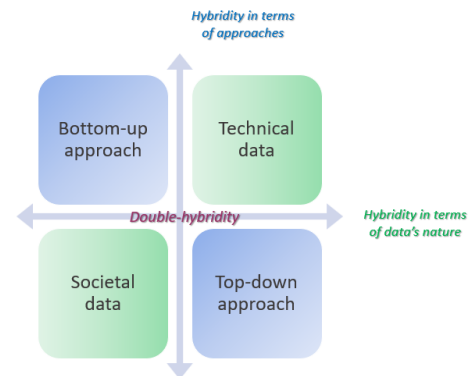


Figure 3. The model's double-hybridity

IV. PRELIMINARY RESULTS BASED ON THE CONSIDERED CASE STUDY: THE "PROOF OF CONCEPT"

To test the proposed approach and implement its POC (Proof of Concept), according to the considered healthcare organization, a hardware architecture and implementation was developed for processing the technical data following the steps proposed in the previous section. For the societal data, a telephonic survey was held with parents of patients in the pediatric ward of the same organization. The preliminary results based on this case study and the status of the processing regarding each type of data are explained in the following subsections.

A. The technical data

A generic sensor-based solution was implemented according to the steps described in section III.C The data model for this generic architecture is given by figure 4 below. However, the "customizing" process is still ongoing based on the needs' study within the use-case organization.

Basically, within this hardware architecture, the most important types of technical-environmental data are collected exhaustively. These data are divided into four main categories as explained below:

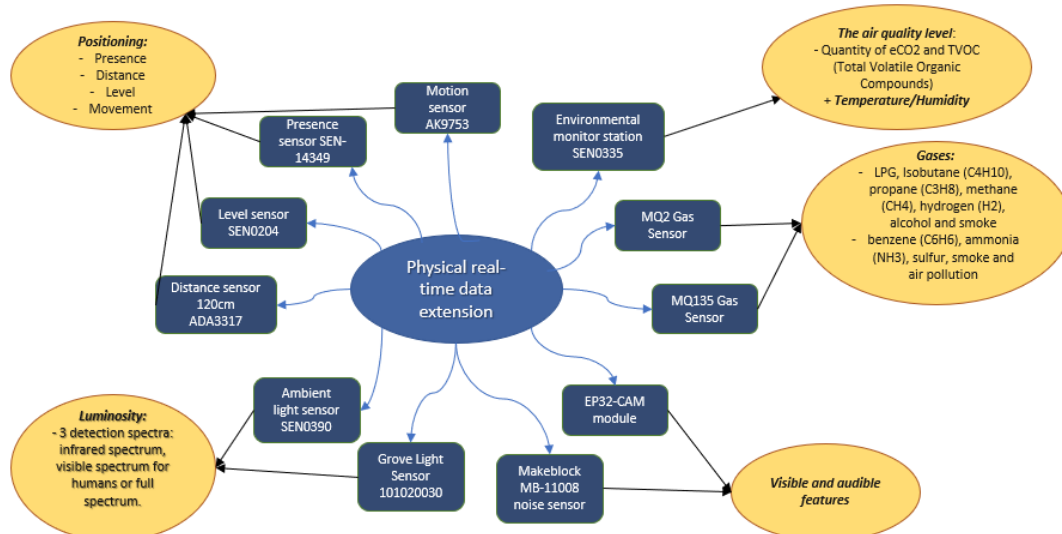


Figure 4. The physical data architecture

Positioning: Presence, distance, level and movement.

Air quality: Quantity of eCO₂ and Quantity of TVOC (Total volatile organic compounds).

Liquefied petroleum gas: Isobutane (C₄H₁₀), Propane (C₃H₈), Methane (CH₄), Hydrogen, etc.

Visible & audible features: Image and noise.

Luminosity: Infrared, human visible and full spectrums.

As mentioned in section III.C, the hardware architecture is being customized through an exchange-review process with the use case organization whereas this β -version implementation includes an exhaustive model with all the possible and important technical-environmental data flows.

These indicators could be used to: (a) describe the technical environment of the organization, (b) measure the likely risks which may cause interruptions to its vital activities and hence (c) assess the BCP.

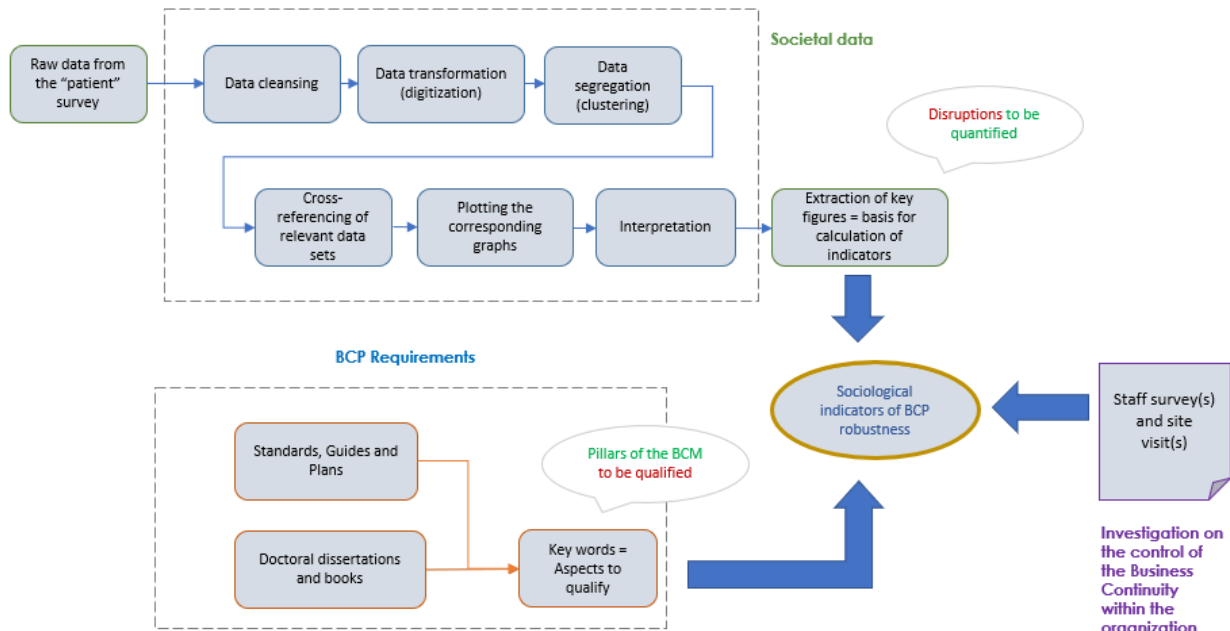


Figure 6. A full overview of the survey's data handling methodology

The data explained below, collected through a sensor-based solution, are forming the RT (Real-Time) data flows which are sent afterwards wirelessly (via Wi-Fi) to the cloud and visualized in RT within an interactive web-based dashboard (Fig. 5) designed using Node-Red and the MQTT protocol for sending the data. The hardware allowing this consists of the sensors, a programming board and a Wi-Fi module. In fact, MQTT (Message Queuing Telemetry Transport) is a Client/Server Publish/Subscribe protocol that allows sending and receiving messages. It's a lightweight and quick protocol that's easy to use in several situations including restricted environments like Machine-to-Machine (M2M) and Internet of Things (IoT) connections. Whereas Node-Red is a web-based flow editor that allows linking flows using a variety of nodes from the palette.



Figure 5. An extract of the dashboard of our "POC" demo

This platform is used to receive the data via MQTT protocol and display it on a RT flow-based Dashboard for our use case. The figure 5 above shows an extract of the dashboard with the measures of temperature (Celsius), humidity (%) and pressure (Pa).

B. The societal data

Technical data alone are not sufficient to fully understand the intricate environment of the organization. For this reason, and as explained at the beginning of section IV, these data are complemented by other data, namely societal data. The main problem that was investigated by this survey is the reasons that are causing parents to not bring their children to the hospital as scheduled. In fact, a telephonic survey was held within the pediatric direction of the use-case. This survey counts around 44 questions and was answered by 673 parents of the children being treated by this department.

Therefore, the parents' answers were noted using LimeSurvey (a statistical survey and polling software) and then processed following this methodology (Fig. 6). In fact, the undertaken survey aims at extracting some key figures from the parents' answers to the survey. These key figures are used in the calculus of the sociological indicators of the BCP's robustness. This in-house methodology for processing the societal data consists basically of:

- **Data clustering**

Since the patients were reluctant to seek care because of a semi-lockdown and due to fear of contracting COVID-19, willingness to preserve health care resources, and unawareness of health services still being available [20], these data are divided mainly into the several categories such as during the first lockdown and the same period for the year 2019, absence due to fear of the pandemic reasons and causes, socio-professional situation (level of education and nature of work: manager, employee, etc.), economic situation (monthly income, work situation: suspended, unemployed, etc.), professional situation during the first lockdown and the residence of the parents.

• **Relevant plots example**

Once the societal data were segregated, the relevant digitized answers were used to plot some key graphs such as the following (Fig. 7). An example of this data consists of displaying the division of appointments during the first lockdown and the parents' refusal according to their employability status.

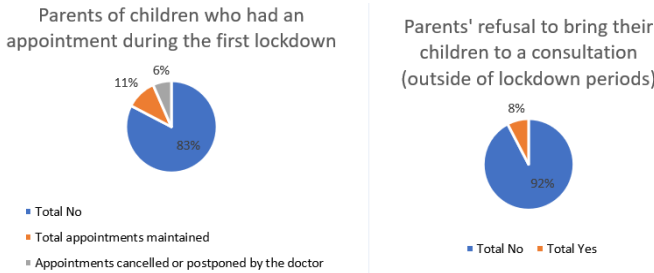


Figure 7. The distribution of appointments during the first lockdown, the parents' refusal and their employability status

• **Key figures extractions**

From several graphs and processing, some key figures were extracted and included into a "Societal Performance Indicators (SPI) dashboard". The figure 8 below shows a part of our β -version SPI dashboard. For example, the graphs in Fig. 8 are essential to obtain the N_{pttA} and N_{pssA} key indicators.

Outside the periods of lockdown				During the periods of lockdown									
$N_p = 673$	$N_{mcH1} = 790$	$N_{mcH2} = 857$	$N_{pjrC} = 473$	$N_p = 673$	$NR_{dvpC} = 116$	$NR_{dVA} = 44$	$NR_{dVR} = 51$	$NR_{dVM} = 72$	$N_{pssp} = 613$	$N_{pipp} = 41$	$NR_{dVRpC} = 7$		
			$N_{pjrCmax} = 128$				$N_{pttA} = 11$	$N_{pssA} = 13$					
			Home address: 81000	Home address: 81230, 81320, 81470									
			$Pt_{pjrCmax} = 94,32\%$	$Pt_{pjrCmin} = 91,59\%$									
			Age range: 18-29	Age range: 30-39									

Appendix:

- N_p = Number of parents surveyed.
- NR_{dvpC} = Number of parents who had an appointment during the first lockdown
- NR_{dVA} = Number of cancelled/rescheduled appointments by hospital physician
- NR_{dVR} = Number of appointments that parents declined to bring their child to
- NR_{dVM} = Number of appointments kept by the hospital
- N_{pssp} = Number of parents satisfied with the hospital's pediatric service during the first lockdown
- N_{pipp} = Number of parents whose child's health was impacted due to difficulties accessing care during the lockdown
- N_{mcH1} = Minimum number of visits to the hospital's pediatric service in 2019-2020
- N_{mcH2} = Minimum number of visits to the hospital's pediatric service between 04/2021 and 04/2020
- NR_{dVRpC} = Number of appointments that parents declined to bring their child to due to fear of becoming infected with COVID-19
- N_{pttA} = Number of telecommuting parents who missed their child's appointment
- N_{pssA} = Number of on-site parents who missed their child's appointment
- N_{pjrC} = Number of parents who never gave up taking their child to a consultation, test or hospitalization outside of lockdown periods
- Pt_{pjrC} = Percentage by age group of parents who never gave up taking their child to a consultation, examination or hospitalization outside of lockdown periods

Figure 8. An extract of the SPI dashboard and its appendix

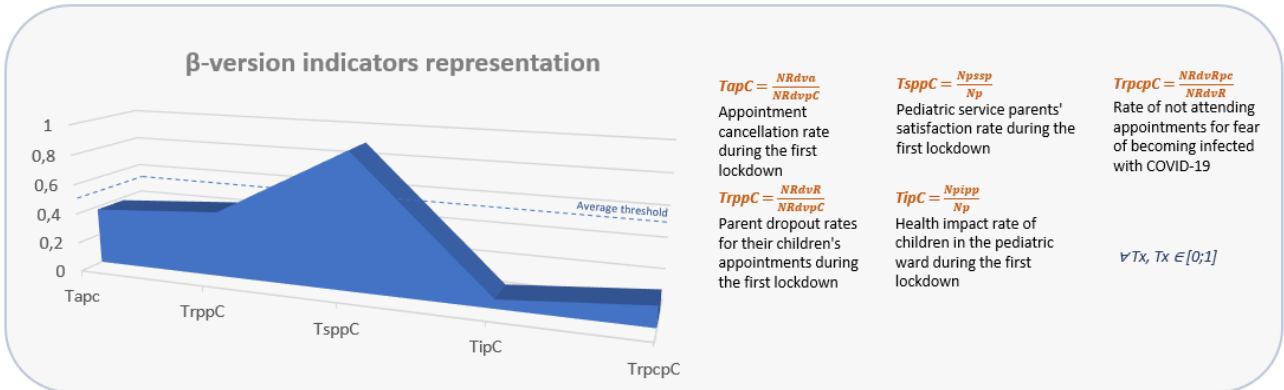


Figure 9. An extract of the indicators' formulas and representation

sensitive services known as vital activities [21]. In addition to these measures, there is the constraint of the provision of specialized and dedicated staff within the establishment to take care of children as regulated in [22].

For this reason, the patients' survey was completed by some investigations done within the staffs' HR department to survey the evolution of absenteeism in the pediatric ward before, during and after the first lockdown in France due to the COVID-19 pandemic. These investigations demonstrate that the staff's collective absence in the pediatric ward was multiplied by 6.25 between the first lockdown's period in France and the same period during the previous year (17/03/2019 to 11/05/2019).

These results and additional investigations, as indicated by the methodology proposed in figure 7, should be finalized by designing all societal indicators based on the main guidelines for business continuity (pillars of the BCM to be qualified) but also other examinations during field visits to the studied ward.

V. DISCUSSION

Because business processes may not always function as planned, using ICT for real-world applications can lead to system failure. Any danger, especially in the healthcare environment, can have a major influence on patient safety and the capacity to provide high-quality care [23].

In this particular context, several challenges were faced during this β -version implementation. In the following subsections the most important challenges are discussed.

A. The technical challenges

Working across an organization's portfolio of risks necessitates a wide range of abilities. In order to be effective, those participating in BCM would require managerial and technical skills [24]. For such reasons, implementing this β -version model was a challenging multi-input process at the following points:

- **Concerning the technical data:**

- Building a model covering several types of data with consideration to their natures and sources. Developing, running then debugging an algorithm collecting data from more than 10 different sensors.
- Sending the gathered data in RT and designing an interactive and user-friendly dashboard using Node-Red and MQTT.

- **Concerning the societal data:**

- Transforming the "descriptive" societal data obtained through the telephonic survey into "digital" data in order to be used for statistical processing and representative graph displaying.
- Designing key indicators throughout the processed societal data and the visualizations performed by these data. Interpreting the data according to the specific situation (first lockdown period in France) of the use case is also a challenging milestone.

The combination of the two challenges mentioned above makes the integration, agility and interoperability of the complete system even a more challenging further milestone.

B. The scientific challenges

The scientific challenges consist basically of the fact that implementing an IS for a healthcare organization is a complex task since the outputs in this case are crucial and can highly impact the structure's business performance. In fact, socio-technical systems are necessary for society to operate properly [25]. Therefore, designing the proposed model wasn't an easy task, particularly for the fact that it should be generic and that its outcomes should be suitable for the majority healthcare organization. At the level of this first implementation, the model isn't widely exploitable since it only considers societal data of the pediatric ward's considered use case and the technical data of an exhaustive form. Refining the model, customizing the technical data extension according to the use case's needs and developing one integral dashboard for all the indicators and their evaluation for the business continuity strategy are mostly the next steps that are expected by this research work. The next section then concludes this research work, evaluates its current state and eventually describes its perspectives.

VI. CONCLUSION

Managing the business continuity has been a topic of interest for many scientists especially with the rise of crisis events. In order to protect the organizations' vital activities from such interruptive threats different approaches were developed. As a result, this data-based approach to evaluate the BCP was developed.

This research work's first main feature is that it goes beyond technical data to fully include other dimensions, particularly social aspects such as the sociological profile of individuals (age, occupation, etc.) and the variables (distance to the hospital, type of pathology, etc.) that are essential to predicting the renunciation of medical care by patients in order to assess the BCPs in similar forms of corporations. By proposing a more efficient BCP and identifying critical components and resources, organizations can mitigate disaster vulnerability. The second important feature is that the output of this work aims at designing a full interactive dashboard for piloting all the business continuity indicators, identifying the at-risk audiences and proposing a vigilance model.

At this stage, the β -version dashboards are built separately, a more agile improved version of this model aims at building a full-integrate BCP robustness indicators dashboard. To reach this goal, the next steps for this research work consider: (a) proposing a BCP robustness model defining clear rules for the assessment methodology, (b) an upgrade of the β -version indicators, (c) a classification of the indicators in the proposed model and (d) a validated technical description of an integration prototype to create the interactive BCP robustness indicators dashboard.

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