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Research Paper

Improving the visualization of strategic information for public health

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Abstract. This article presents the results of a project carried out to improve the visualization of strategic information in the Strategic Management Support Room (SAGE) of the Ministry of Health based on the user experience. Using participatory methodology and aspects of the agile cycle, the project started by recognizing the needs of public health managers in the three spheres of government, using Infovis design techniques and user experience evaluation, to develop prototypes of information visualization appropriate to the needs and demands of the user managers. The prototypes were prioritized and elaborated: installed capacity, monitoring results, arbovirosis risk map, mobile emergency care service, crossing indicators, interfederative pacting indicators, and covid-19 projection. The project enhances improvements in access and understanding of strategic information needed for decision making in health, essential for the qualification of the management of the Unified Health System.

Keywords: Information and Communication Technology Projects; Use of Scientific Information in Health Decision Making; Information Management; Managerial Decision Making; Public Health Administration

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1 Introduction

Information has become an essential requirement for managerial decision-making, especially in the current social, economic and technological context, in which the production and transmission of information occurs quickly and voluminously. In the context of health, information acquires a fundamental character for making clinical or even managerial decisions, capable of promoting or not the health of individuals.

More recently, in the context of the covid-19 pandemic, the world found the coexistence of an infodemic, a term used to describe the excessive amount of information related to health, accurate or not, with a high potential for multiplication, arousing the interest of health authorities about the aspects related to health information, especially in order to avoid impacts resulting from misinformation [Haraki, 2021].

It should be noted that in the context of public health, the damage caused by misinformation can be alarming, since in the face of untrue or manipulated information, this can lead to wrong health decisions, causing riots. rely on adequate, relevant and timely information, capable of being transformed into knowledge and providing managers with the improvement of the scope and quality of the decisions taken [Tamaki *et al*., 2012].

The decision-making process is something that has been studied in depth over decades, given its relevance to organizations, whether public or private. Making the right choices is important for the lives of organizations and people. Several authors [Pacheco Júnior and Gomes, 2016; Pinheiro *et al*., 2016] propose conceptualizations for the decision-making procedure, mostly associating it with the course of thought and action that starts from the delimitation of the problem and leads to the analysis of alternatives and choice between them.

Although technical rationality is the main basis for decision-making, several factors act as interveners, especially related to the context (financial, organizational, subjective and/or relational issues, among others) and that need to be considered in the analysis [Pacheco Júnior and Gomes, 2016]. Since decision-making is a daily action in health management, it is imperative that managers base their decisions on the best available information and that the system itself is able to produce them based on service operation data, situations epidemiological and related external factors, conditions and/or determinants of health.

In addition to the availability, access and quality of information, the challenges related to 'information visualization', a term routinely abbreviated to Infovis, characterized as the use of interactive and computerized visual representations of abstract data with the aim of expanding the cognition and understanding of these [Card *et al*., 1999].

In the context of health, the visualization of information is still an incipient issue, especially challenging in the context

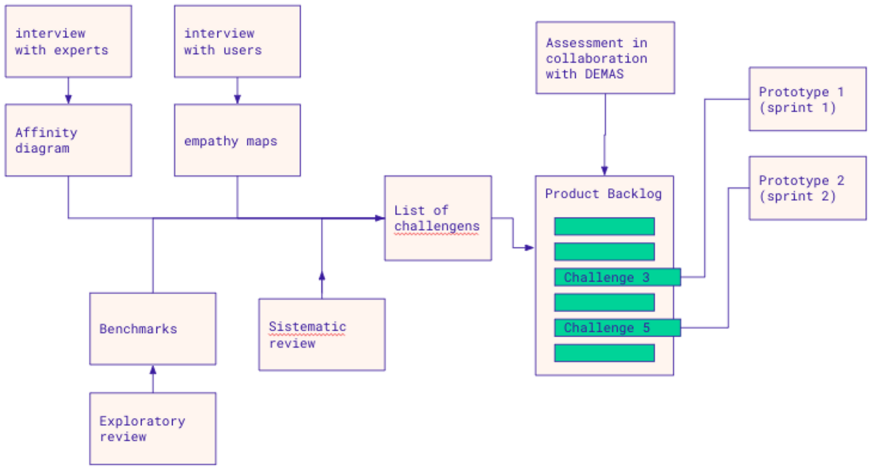


Figure 1. Summary of the project's methodological trajectory

of public health. More than obtaining the correct visual representation of health data, the Infovis for Public Health area must provide adequate presentation instruments, panels that consolidate the necessary information for monitoring and that support the necessary narrative for the evaluation and consequent management decision-making [Filgueiras and Velloso, 2020].

It should be noted that in the context of Brazilian public health, the federal authority managing the system, the Ministry of Health (MS), has featured on its official website, since 2012, the platform Sala de Apoio à Gestão Estratégica (SAGE), designed to be a virtual space of information of interest to health managers, with the aim of assisting them in decision-making by obtaining and systematizing data and information: socioeconomic, financial, epidemiological, operational, among others, as well as providing agility in interventions of the SUS [Oliveira *et al*., 2020].

Over time, SAGE has experienced variations in interest and access, especially due to competition with other fast and up-to-date information portals, and even though there is no data related to the users' perception of its usefulness and usability, despite being an official visual repository of the Ministry of Health's monitoring and evaluation indicators and data, was failing to fulfill its role with public managers due to the presentation of fragmented and outdated, albeit diversified, information. In this perspective, the Department of Monitoring and Evaluation of the SUS (DEMAS/SE-MS), responsible for SAGE, outlined Infovis challenges related to the improvement of the User Experience (UX) through the improvement in the visualization of the information contained in the SAGE, which became the focus of the project that originates this report.

2 Methods

This manuscript presents a technical report of a Research and Development (R&D) project carried out through an agreement between the University of São Paulo (USP) and the Ministry of Health through a project entitled: "Improvement of User Experience and Interventions to Improve Visualization of Big Data by SAGE/Ministry of Health (Br)".

Its execution took place between April 2020 and January 2021, during the first wave of the Covid-19 pandemic. The collaborative nature of the methodological framework, represented in Figure 1, used – User-Centered Design [Lowdermilk, 2013] – required the team to adapt to the remote work model due to isolation measures. The research had its operationalization anchored in the SCRUM method [Schwaber and Sutherland, 2020] delimited from the following perspectives and respective activities:

A) User experience (UX):

- Immersion of the team in the context of public health and recognition of the profile and role of health managers through a bibliographic study and semi-structured interviews with stakeholders and key participants;
- Infovis prototyping evaluation and codesign sprints.

B) Infovis design:

- Bibliographic study regarding the representation of multivariate, temporal and georeferenced information;
- Analysis and diagnosis of necessary interventions in SAGE;
- Infovis prototyping sprints, with the creation of panels suitable for SAGE.

C) Dissemination of results:

- Conducting seminars for knowledge transfer;
- Elaboration of didactic material.CD-ROMs and Printed Proceedings.

In some conferences, the papers are published on CD-ROM while only the abstract is published in the printed Proceedings. In this case, authors are invited to prepare two final versions of the paper. One, complete, to be published on the CD and the other, containing only the first page, with abstract, "resumo" and "resumen".

The project results materialized in technical reports and built visualization prototypes, in addition to dissemination events for the transfer of knowledge between the project team and the interested area in the Ministry of Health. As a first

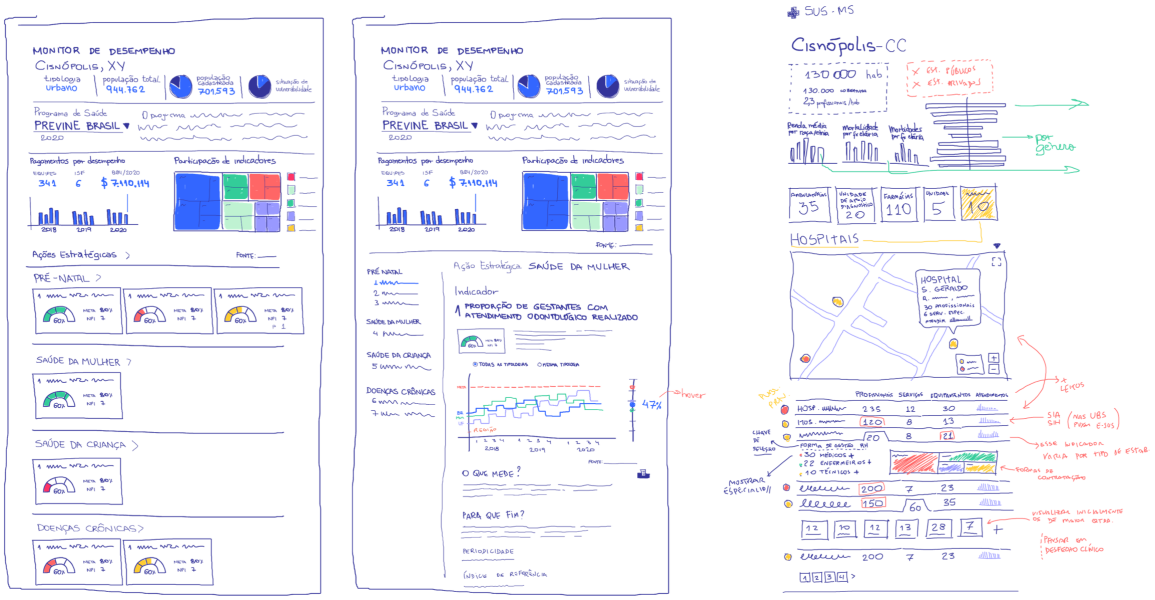


Figure 2. Sketches elaborated in sprints in backlog for prototypes

activity, the participating team immersed itself in the context of public health in Brazil, since to propose any work or adjustments, however small, involving the public health environment, it is necessary first to know it. For this, exploratory research of the literature was developed, where it was possible to understand the organizational structure of the SUS and the role of public managers (municipal, state and federal) in this system. Also, as a way of understanding aspects of the work process of managers, we sought to characterize strategic decision-making based on data, public health management and the formulation of health policies.

The field study took place through semi-structured interviews with public health managers from the three spheres of management, in order to better understand the tripartite structure of the health system, the tasks performed by managers and identify their main pains and desires related to form and content. information needed for the decision-making process.

Based on the information collected in the field study, the systematization of management profiles regarding access to information and the influences that impact these managers in the decision-making process took place through the elaboration of a model of personas [Nielsen, 2018], a design tool that allows capturing the daily experiences and needs of users and customers, enabling innovation and suitability in the design ideation process and in the area of information and communication technology.

Through the personas, it was possible to represent the managers' ways of acting due to the size of the population, financial resources and professional qualification in the field of health management and, considering ethical issues, communicate the findings to the design team. With this and other information, it was possible to guide the treatment of the complexity of the visualizations of the information to be developed and, consequently, facilitate the understanding of the information, by the managers, for decision making.

From the identification of pain points, needs and opportunities for improvement expressed by managers, a set of more than 300 requirements was created, which were classified and grouped into 10 design challenges. Each challenge includes the development of a prototype that serves as a visualization model for a type of problem, presenting a proposal for representing variables, grouping and refining information and interactive tools to support decision-making.

Faced with the identified challenges, together with SAGE administrators, the prototypes to be built within the scope of the project were defined. Challenges were prioritized; Proposals were then prepared for seven of these challenges in agile development cycles based on the SCRUM method.

Following the User-Centered Design principles, successive refinements were worked on, in three-week sprints. Each week of the sprint had a clear objective: the first resulted in a sketch that meets the set of requirements (conceptual model); the second resulted in a low-fidelity navigable prototype, illustrated in Figure 2. The third stage culminated in the creation of a functional prototype integrated with a data interface, as shown in Figure 3.

The validation of the intervention, materialized in the prototypes, took place through additional rounds of interviews, in which the managers appreciated and communicated to the designers the meaning they attributed to the visualization instruments, in their perspective of use. Users' opinions were welcomed and transferred to the design team who made changes to the views if necessary.

Care was taken to ensure that the interviewees represented the different personas of the model. In this way, the aim was to guarantee fidelity to the ideas initially expressed by the health managers, providing more appropriate views for understanding the information and, consequently, better decision-making.

3 Results

The participation of health managers in the construction process of new ways of viewing health information is of vital importance, as it favors engagement and effective use of the proposed solutions. On this premise, seven prototypes were developed, described in the table below based on their purpose

Table 1. Description of the prototypes

Prototype	Relevance
Installed capacity Information panel on professionals, health establishments, beds, equipment and services offered	Overview of the installed capacity of health services, allowing the identification of the potential for action in health in a given location/territory. Aggregator dashboards, which group various information needed for management tasks. Demographic information and registration data. Displays the distance between health units on the map, making it possible to optimize the distribution of units. It allows the physical location of a health service anywhere in the country. Features a dashboard-supported user communication mechanism.
Monitoring of Municipality Results Panel to display information about the transfer of financial resources in the Previne Brasil program	Exemplifies the presentation of indicators related to public policies. Enhances the understanding of municipal managers regarding indicators. Supports financial management with historical series and performance composition. Allows simulation of indicator performance and transfers. Provides narrative visualization.
Risk Map for Arboviruses Panel to display risk maps of contamination by arboviruses with an emphasis on dengue	Allows viewing data on infestation and disease incidence. Projection based on epidemiological control diagram. Combines multiple data sources for tactical actions. Introduces collaboration mechanisms. Uses automatically generated texts and multiple smalls technique.
SAMU 192: Mobile Emergency Service Panel for viewing information from the Mobile Emergency Care Service (SAMU)	Supports operational decision-making. Consolidates information about resources and performance. Allows multi-level navigation. Enables geographic coverage analysis. Uses road network maps. Aggregates semi-structured data.
Indicator Crossing Toolbox Panel for displaying crossings of two health indicators	Enables comparison between indicators. Provides multiple visualization types. Supports temporal and geographic correlation analysis. Uses scatter plots. Supports narrative visualization for literacy.
Interfederative Agreement Indicators Panel to display information about health indicators agreed by states and municipalities	Innovative visualization for overall understanding. Shows time series of results and goals. Integrates metadata and APIs. Supports planning and evaluation processes.
Covid-19 projection Panel to display pandemic data	Shows ICU availability, case numbers and projections. Helps understand uncertainty representation. Developed under agile methodology. Strengthened collaboration and remote work dynamics.

and relevance.

Considering that the design process must be guided so that, at all times, it does not deviate from what was reported by health managers, alternative proposals were proposed to contemplate this premise after its release to the public. Thus, in addition to the established evaluation process to judge the quality of the proposed visualizations, once the Infovis prototypes are implemented and the information is available for access in digital media, it is necessary to have continuous feedback from your audience, especially automated [Holmlund *et al.*, 2020]. To this end, an architecture integrated to the panels involving tools for quantitative analysis of access has become necessary, implemented through the free Google Analytics platform, which can generate subsidies for the improvement of views based on the analysis of access and use.

Access to adequate, quality and timely information is essential to the processes of monitoring and evaluating public policies, an essential public health function highlighted by the Pan American Public Health Organization [National Council of State Health Secretaries, 2007]. Such a premise implies a process of planning and organizing the system so that the services can produce relevant information, adequately represented and easily accessible. In an increasingly technological and globalized world, high performance has been demanded from health organizations in relation to the resources made available to them, and in this context, the existence of quality information is essential.

In the context of the work process of public health policy managers, Monitoring and Evaluation (M&E) are an essential function at all levels. In the SUS, M&A still lacks advances for its consolidation, even though recent advances have been made for its institutionalization [Tanaka *et al.*, 2018; Sousa, 2018]. Nowadays, information has become a supporting factor in the process of coping with the Covid-19 pandemic, when, in addition to the search for treatment, cure and rehabilitation strategies, information has become a strategic tool in the context of collective health measures and taking of individual decisions.

Information visualization panels are support tools widely used in managerial decision-making processes, gathering a compilation of data and strategic information through indicators and strategic information visualization tools [Odqvist, 2020]. However, in the context of public management, these tools may be difficult to create, implement and use, related both to the bureaucratic organizational profile of public institutions, and to the difficulties related to the technical, cognitive and human-computer relationship aspects present in the profile of information consumers.

The panels previously contained in SAGE presented data and indicators in time series and isolated maps. Other information systems of the Ministry of Health also present data,

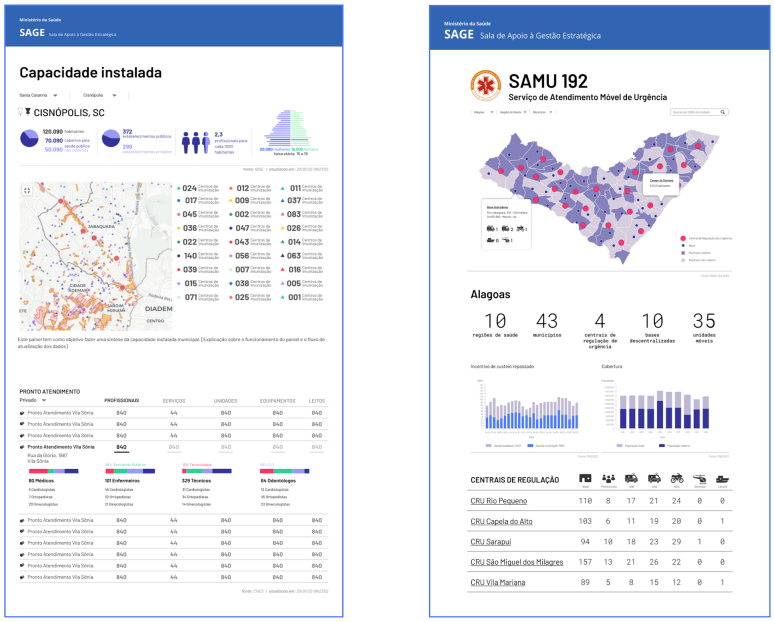


Figure 3. Prototypes of elaborate high fidelity panels

in the same way, presenting isolated information, competing with SAGE. Such an identified perspective is harmful for the understanding of information consumers, especially for managers who, to understand a complex problem in their work context, have to resort to different systems and download data individually from each of them to compose an analysis, albeit punctual.

The process introduced by the project starts from the perspective of manager users, who need a higher level of abstraction, with panels that consolidate information from different sources, and present them in an organized and compiled way so that, at a next level, they can give access to maps and time series of each variable.

The prototypes developed, described in Table 1, are instruments for monitoring and evaluation, gathering information from different systems in panels created around management tasks. It should be noted that SAGE, by achieving the functionality of presenting various panels of strategic health information, adapted to the different profiles of consumption of the information presented, appears as a contributory instrument to carry out the monitoring of policies, programs, strategies and health actions to be starting from the exposition of defined indicators, produced through continuous demand and controlled by quality data, with the presentation of temporality information and timely signaling of changes, in appropriate instruments for decision-making. Thus, it will also be able to subsidize executive evaluation processes, assisting in the decision-making process for the formulation, implementation or analysis of interventions based on analysis tools, consistency and projection of data and health indicators.

It is a fact that managerial decision-making in the SUS is complex and can be/be conditioned or determined by different factors: official regulations, evaluation processes, scientific evidence and/or even the preferences of the community or executives. However, the increasing incorporation of the rationalist model in the decisions of policy makers, and the desire to design public policies based on evidence [Pinheiro, 2020], raise the need for access, quality and adequate visualization of strategic health information, which may have at SAGE its best version.

Thus, the process of preparing the panels within the scope of the project demonstrated the importance of using the user experience design to achieve access results, search, understanding and effectiveness of the produced artifacts, especially in the context of the management of the public health, where managers lack instruments for data analysis, comparison of indicators and formulation of alternatives, ensuring foundation and rationality to the process of making managerial decisions with a high impact on the health of communities. In the absence of these instruments, decision-making strategies can become empirical or heuristic, when not intuitive, and may incur errors or deviation from strategic objectives, wrong referrals or even misuse of resources, so scarce in the public context.

4 Conclusion

The aspects addressed in this study contribute to the qualification of public health management by improving the visualization of strategic information based on the demands and tasks of health managers. In addition to the exploratory research work carried out, capable of providing a compendium of information on various aspects of health information, the greatest contribution of this project is the potential improvement of the managerial work process in the SUS based on decision-making based on information. The prototypes of elaborated panels have perspectives of implementation in SAGE, and through the transfer of knowledge carried out by the project, we can raise possible advances in the visualization of the information made available by the Ministry of Health.

In the scope of research perspectives in this area, there is much to be done in terms of ensuring availability, quality, access, accessibility and adequate visualization of public health information. However, we believe that the information and guidelines elaborated in this project pave the way for the

consolidation of infovis aspects in Brazilian public health.

Declarations

Authors' Contributions

All authors participated in the development of the study. LVLF, LMRV, and MI contributed to the conceptualization, methodological development, and execution of the design and prototyping activities. LSS, LAG, JMJ, GMA, and SMF were involved in the development and implementation of the functional prototypes and data interfaces. TLS, HMF, and MFC participated in the analysis and validation of the developed products. MFC and LVLF drafted the first version of the manuscript. All authors contributed to the critical review of the content, approved the final version of the manuscript, and agree to be accountable for all aspects of the work.

Competing interests

The authors declare that they have no financial or non-financial conflicts of interest related to this study. The authors participated in the development of the prototypes described in this article as part of a project funded by the Pan American Health Organization (PAHO) and conducted in partnership with public institutions, including the Brazilian Ministry of Health and the University of São Paulo.

Availability of data and materials

The prototypes and products developed as part of this study are available for consultation at http://infovisparasaude.fau.usp.br/. Additional materials and supporting information may be made available by the authors upon reasonable request.

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