

Development and validation of web software to support prenatal care management

Desenvolvimento e validação de software web de apoio à gestão da assistência pré-natal

Desarrollo y validación de software web de apoyo a la gestión de la atención prenatal

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Abstract

Objective: To describe the development and validation process of a web software to support the management of prenatal care.

Methods: Technological development research, carried out between March and August 2022, based on principles and techniques of the Scrum method. The functionalities of the web software, with access and specific functions for three different users (Administrator, Manager and Visitor), were developed jointly by developers, researchers, managers and health professionals, based on practical needs related to the management of prenatal care.

Results: The web software is a tool to support the management of prenatal care, with the potential to generate infographics that denote gestational interurrences and that allow, in an agile and safe way, the making of local-regional strategic decisions.

Conclusion: The process of development and validation of the web software to support the management of prenatal care was carried out jointly by developers, researchers, managers and health professionals, based on practical needs related to the management of prenatal care. The tool was developed in order to allow access and specific functions to three different users (Administrator, Manager and Visitor), with a view to making quick and safe decisions.

Resumo

Objetivo: Descrever o processo de desenvolvimento e validação de um *software web* de apoio à gestão da assistência pré-natal.

Métodos: Pesquisa de produção tecnológica, realizada entre março e agosto de 2022, com base em princípios e técnicas do método Scrum. As funcionalidades do *software web*, com acesso e funções específicas a três diferentes usuários (Administrador, Gestor e Visitante), foram desenvolvidas de forma colegiada entre desenvolvedores, pesquisadores, gestores e profissionais da saúde, a partir de necessidades práticas relacionadas à gestão da assistência pré-natal.

Resultados: O *software web* é uma ferramenta de apoio à gestão da assistência pré-natal, com potencial para gerar infográficos que denotem intercorrências gestacionais e que permitem, de forma ágil e segura, a tomada de decisões estratégicas loco-regionais.

Conclusão: O processo de desenvolvimento e validação do *software web* de apoio à gestão da assistência pré-natal deu-se de forma colegiada entre desenvolvedores, pesquisadores, gestores e profissionais da saúde, a partir de necessidades práticas relacionadas à gestão da assistência pré-natal. A ferramenta foi desenvolvida de modo a possibilitar acesso e funções específicas a três diferentes usuários (Administrador, Gestor e Visitante), com vistas à tomada de decisões rápidas e seguras.

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Conflicts of interest: Nothing to declare.

Resumen

Objetivo: Describir el proceso de desarrollo y validación de un *software web* de apoyo a la gestión de la atención prenatal.

Métodos: Investigación de producción tecnológica, realizada entre marzo y agosto de 2022, con base en principios y técnicas de la metodología Scrum. Las funcionalidades del *software web*, con acceso y funciones específicas para tres usuarios (administrador, gestor y visitante), se desarrollaron de forma colegiada entre desarrolladores, investigadores, gestores y profesionales de la salud, a partir de necesidades prácticas relacionadas con la gestión de la atención prenatal.

Resultados: El *software web* es una herramienta de apoyo a la gestión de la atención prenatal, con potencial para generar infográficos que indiquen complicaciones gestacionales y que permitan tomar decisiones estratégicas locorregionales de forma ágil y segura.

Conclusión: El proceso de desarrollo y validación del *software web* de apoyo a la gestión de la atención prenatal se realizó de forma colegiada entre desarrolladores, investigadores, gestores y profesionales de la salud, a partir de necesidades prácticas relacionadas con la gestión de la atención prenatal. La herramienta se desarrolló a fin de permitir el acceso y funciones específicas para tres diferentes usuarios (administrador, gestor y visitante), con el objetivo de tomar decisiones rápidas y seguras.

Introduction

Prenatal care is one of the main pillars responsible for reducing maternal and child morbidity and mortality. Quality prenatal care implies the development of prospective and resolute actions for pregnant women in the context of Primary Health Care.^(1,2) Among the challenges are improving the quality of prenatal care, agile methods of monitoring and evaluating indicators based on technologies to support health management.

In Brazil, the maternal mortality ratio is around 62 deaths per 100,000 live births. Approximately 80% of these maternal deaths result from preventable obstetric causes, such as hemorrhages and hypertensive crises, which are related, in most cases, to the low quality and limited monitoring of prenatal care.⁽³⁻⁵⁾ At the same time, it is necessary to consider that 32% of pregnant women in the Unified Health System (SUS) have less than six recommended prenatal consultations for the period.⁽⁶⁾

Investing in the qualification of prenatal care constitutes, in prospective terms, a strategy that induces better practices in maternal and child health. In addition to local initiatives, countries need to make efforts to achieve the goals of the 2030 Agenda, advocated by the United Nations, especially with regard to the reduction of preventable deaths of newborns and children under 5 years of age; as well as the reduction of maternal and neonatal mortality rates.^(7,8)

As a form of encouragement and monitoring, health managers rely on information systems provided by the Brazilian Ministry of Health, more specifically by the Department of Informatics of the Unified Health System (DATASUS). This tool

is capable of enabling the collection, processing, storage and dissemination of data in order to generate local information in different regions of Brazil.⁽⁹⁾

Digital technologies have a growing impact on health care. This is due to the influence of telehealth and other virtual care models, especially in response to the COVID-19 pandemic.⁽¹⁰⁾ Despite substantial advances to date, challenges associated with the use of digital technologies by nursing professionals persist, especially with regard to rapid changes and their impact on health care.⁽¹¹⁾ To respond to these challenges and prepare for the future, nursing needs to be skilled in the development and use of digital tools in order to respond to the complex global challenges faced by health systems and society.⁽¹²⁾

However, it is not enough to provide tools capable of storing and processing health information. In addition to this goal, it is necessary to provide managers with agile methods of handling and analyzing relevant and pertinent local information.⁽¹³⁾ In this direction, there is a study that demonstrates the lack of agile monitoring tools and solutions for strategic decision-making in the context of prenatal care.⁽¹⁴⁾

Thus, in order to contribute to the availability of management tools specific to the monitoring and analysis of predictive local variables, the present study aims to describe the process of development and validation of a web software to support the management of prenatal care.

Methods

Technological development research,⁽¹⁵⁾ in web software format, developed between March and August

2022, in cooperation with an interdisciplinary team, which includes managers, health professionals, information systems professionals, biomedical engineering professionals and nursing researchers.

The development of the web software was anchored in principles and techniques of the scrum method,⁽¹⁶⁾ as shown in figure 1. Scrum is recognized as a framework that prescribes a set of light and agile practices, which are capable of assisting in the management of complex projects that consider that individuals and interactions are more important than processes and tools; in addition to considering that working software is more than comprehensive documentation; that customer collaboration is above contract negotiation; and, finally, that responding to changes cannot be reduced to the procedural linearity of a plan.^(17,18)

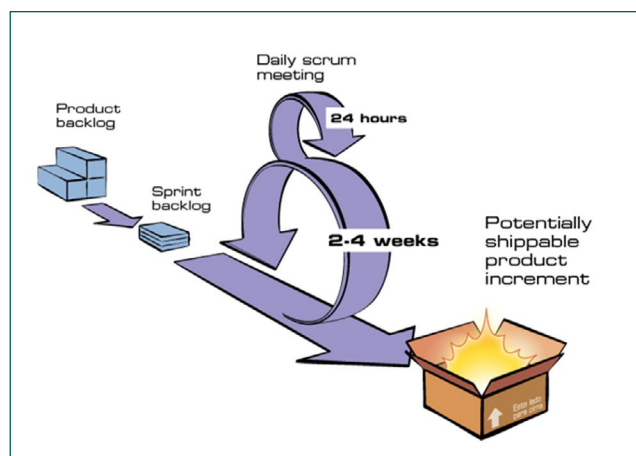


Figure 1. Agile methodologies for software development⁽¹⁸⁾

Based on the principles and techniques of the scrum method, the functionalities of the web software, that is, the product backlog, were collectively defined. In the first meeting, in addition to the developers and researchers, four managers and two health professionals with experience in prenatal care and who are part of regional coordination and municipal health secretariat services participated. Space was opened for managers and professionals to express their perceptions and expectations regarding the weaknesses they saw in prenatal care, within the scope of regional and local Primary Health Care. A sprint backlog was carried out in one of the meet-

ings, in which weaknesses and prospective strategies for improving the quality of prenatal care previously discussed were resumed. At that same meeting, the managers highlighted the need to develop a technology capable of analyzing and monitoring, in an agile and prospective way, the variables related to the mother's age and weight, number of prenatal consultations, type of delivery, weeks of gestation, reference unit, number of live children, number of dead children, number of pregnancies, mother's education, father's age, demographic data, comorbidities, among other variables. Thus, a better understanding of the path was developed, a diagram of use cases of the software, in order to demonstrate the interaction between the user and the system under development, as detailed in figure 2. This process allowed for greater interactivity and an expanded understanding of the functioning of the web software.

After the initial sketch of the web software, new meetings were held with health professionals and managers, active participants throughout the development process. The sprints were shared and discussed in order to broaden perspectives and provide access to the digital tool under development. In these meetings, a total of three variables that should integrate the software were validated and practical aspects related to the operation and appearance of the tool under development were discussed. The tool/software, as shown in figure 2, allows access to three different users, with specific functions, namely: Administrator, Manager and Visitor. The Administrator (nurse or any other executive professional) is responsible for registering the new data analysis algorithms, based on the inclusion of test bases and the systematization of the results generated from the analyses. The Manager associates the already imported databases with existing algorithms in the system, in addition to executing the data analysis process. The Visitor visualizes the results generated by the administrator and manager, in the format of management charts or rules created by the algorithms for the formation of these charts. The three different users with specific access and roles in the Software's operation are recruited by local health managers. It is essential that the Nurse administrator or another professional has experience in health management, as well as it is crucial that the

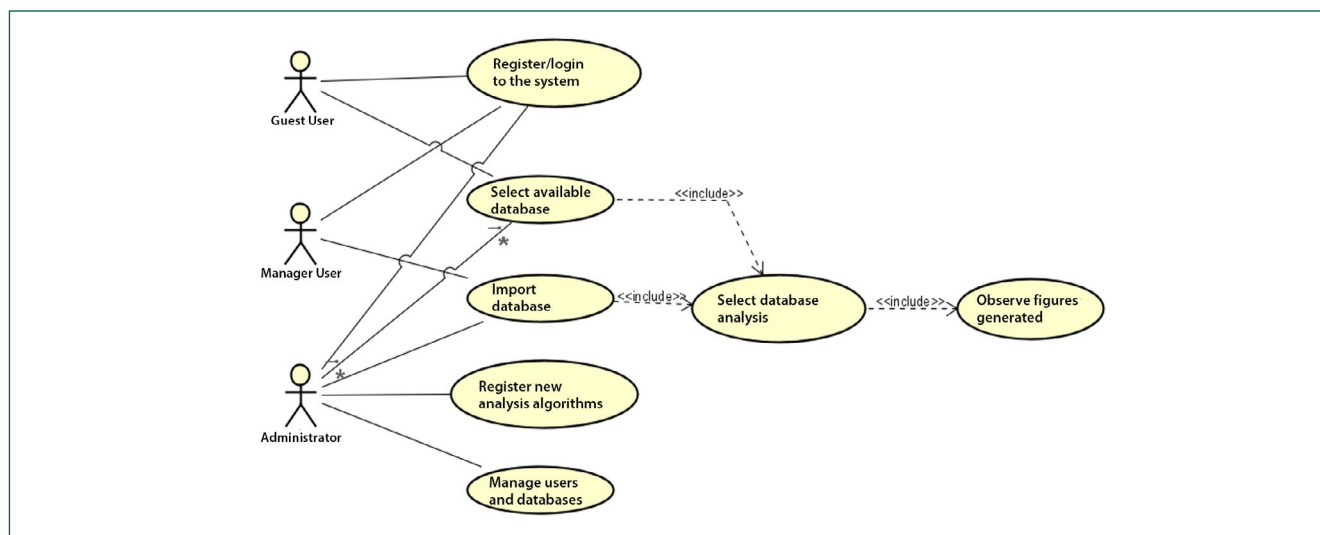


Figure 2. Software use case diagram

user manager has experience with technological tools in the health area.

The sprint backlog phase continued (Figure 1), in which the functionalities associated with prenatal care were selected, which allow access and daily monitoring of the pregnant woman's personal historical data, such as the mother's age and weight, number of prenatal consultations, type of delivery (vaginal or cesarean section), weeks of gestation, reference unit, number of live children, number of losses or miscarriages, amount of gestation period in months, types of pregnancy (single, twins or more children), mother's schooling and father's age. Because it is a regionalized survey, demographic data were not considered, only anomalies related to birth.

The tool in question enables the generation of loco-regional infographics that point out gestational interurrences and that allow the early detection of adverse events, such as pregnant women who tend not to complete the pregnancy or to lose their child in the first postpartum days. Web software also has the potential to predict the emergence of new outbreaks, such as influenza, toxoplasmosis and others.

A new meeting (sprint) was developed with professionals and health managers, in order to validate the appearance, accessibility and functionality of the tool. The developers presented the operationalization of the tool and, in the sequence, opened space for the participants to weave their considerations and suggestions for improvement. It is evi-

dent that the sprint is iterative and enables dialogue between users. The interoperability of data between health equipment is not feasible, since the system only works with data that were previously selected from health systems, without online interaction. Finally, a pilot test was carried out with the same four managers and two health professionals with experience in prenatal care, in addition to inviting three other nurses who work directly in prenatal care. The web software was considered relevant and pertinent in achieving agile and specific results on prenatal care and with the potential to determine local strategic interventions, according to the needs of each pregnant woman and/or region.

The Python language was used throughout the web software development process, due to its wide interactivity with environments and interlocutors. The Django framework has also been embraced for its focus on web development; the matplotlib and seaborn libraries to enable data visualization in Python; pandas to provide fast and agile data structures and numerical analysis tools; numpy (python core library) to perform scientific computing, perform calculations and facilitate data analysis.⁽¹⁹⁾

Results

The web software was developed in cooperation with health managers and professionals, informa-

tion systems professionals, biomedical engineering and nursing researchers in the area. The average age of the participants was 42 years and males (73%) prevailed over females. The time of experience in the area ranged from 5 to 15 years. After being presented and discussed, in five consecutive meetings, the web software was evaluated by managers and professionals with experience in prenatal care and considered adequate in its functional, apparent form and prospection of local intervention strategies. Thus, this tool proved to be accessible, practical and viable in providing agile, secure and prospective information for strategic decision-making at the local level. Based on this journey, the web software is at maturity level TRL7 (Technology Readiness Level).

For Nurses who work in prenatal care, the web software is capable of generating, in an agile and reliable way, infographics that present a real photograph of each pregnant woman and the region covered. And, based on this information, nurses are able to establish a preventive and educational care plan to meet the specificities of each pregnant woman/family and, in this way, contribute affirmatively and prospectively to favorable outcomes in childbirth, puerperium and the healthy development of the child. The results were organized and systematized according to the use cases diagram shown in Figure 2. The initial screen displays the options

related to the research project for the SUS and the possibility of accessing the system (Figure 3).

Figure 3 illustrates the screen associated with login (A) and user registration in the system, according to specific access guidelines. After identification, each user has their respective functionalities available in the system (B and C). Administrators, as detailed in Figure 3 (A), are responsible for registering users and defining the type of user (Administrator (B)/Manager (B)/Visitor (C)), as well as which routines/processes can be accessed. Administrators are still responsible for importing databases and inserting new classification and analysis algorithms. Manager features will also be available to administrators. The unit managers previously registered by the administrators, as shown in Figure 3 (B), have access to the choice of databases and algorithms, with emphasis on algorithmic correlations of their own interest. These will be able to generate analysis results and promote visualizations through rules presented by the system and through the graphs (Figure 3. E) generated by the processes (Figure 3. D).

Likewise, as shown in figure 3 (C), visitors need to be previously registered by the administrators. However, they will have limited access to viewing the results generated by administrators or unit managers (Figure 3.E), that is, they do not have access to operationalize new data analysis. Their access is

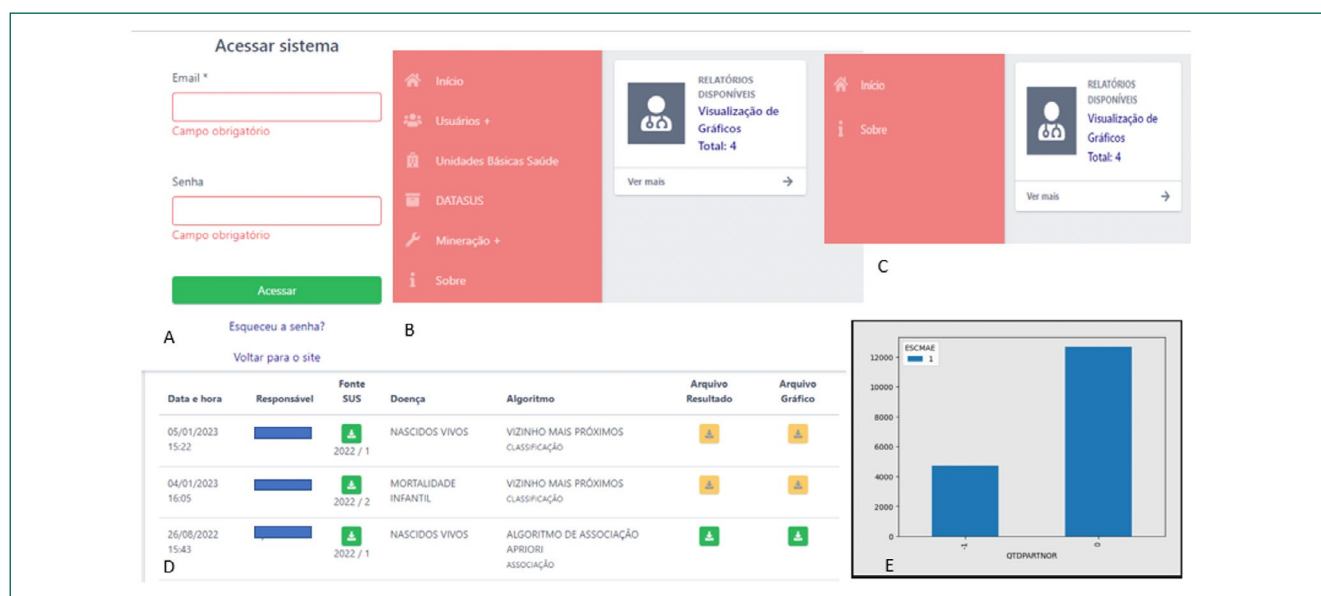


Figure 3. Web software screens

limited to viewing the data generated and analyzed by the administrators. The screens were developed in HTML5, based on the need to serve as an interface between the system and the user. Thus, Screen (3.A) allows the user to present their credentials to access the system and, if validated, will allow access to Screen (3.B and 3.C). Based on the need for access by logged-in users to the results of the processing carried out, a screen (3.D) was developed, which allows access to a list of processes and allows selecting who wants to perform the visualization, exemplified in the screen (3.E).

Based on the results achieved and the expected impacts with the development of the web software, the availability of a two-dimensional spatial visualization platform was made possible by the Matplotlib and Seaborn libraries. The Pandas and Numpy libraries enable the application of algorithms resulting from data analysis and the generation of relevant information to support prospective and strategic decision-making in the context of management and prenatal care in an integrated manner. In turn, visitors registered on the platform are allowed access to information previously made available in the system. Figure 3 shows a brief analytical association of variables. It is noted that there was a strong correlation between the mother's education and the other variables that show that, the greater the access to information, the greater the probability of the mother adhering to normal delivery and the smaller the number of children. In the same correction, mothers with lower levels of education have a greater number of children. Such associations of variables, as demonstrated in the previous example, allow nurses and health managers to access local information quickly and securely to make strategic decisions in the context of prenatal care. These local actions are of fundamental importance for achieving global impact and achieving the goals of the 2030 Agenda, advocated by the United Nations.

Discussion

In the area of health, digital tools have taken on increasing relevance in inducing agile and efficient

processes for strategic decision-making in the field of management. In Brazil, the “Projeto Saúde Brasil 2030” stands out, which aims to intuit a national network for the structuring of an innovation system”, centered on sustainable regional development. Through integration and inter-institutional cooperation and between different areas of knowledge, this proposal aims to determine prospective technological strategies to face regional inequalities in health.^(20,21)

In this same direction, the Digital Health Strategy for Brazil 2020-2028 stands out. Which has the purpose of responding affirmatively and prospectively to the information needs of the Unified Health System (SUS). In order to ensure the quality of health indicators, it is essential that new digital tools guarantee the definition of clear rules for accessing data, broad social participation, security and credibility for users, exchange of information, implementation, evaluation and continuous improvement of processes and products, as well as alignment with current legislation and with the interests of relevant actors, among others.⁽²²⁾

In this direction, it is expected that educational and health institutions, in general, invest in proposing, developing and implementing innovative technologies that can contribute to the qualification of management and the achievement of better results in health care. As a mediating and transforming agent of health care, nursing and other health professionals cannot be oblivious or on the sidelines of this process. In addition to consuming and importing technologies, it is essential that nurses/health professionals, in cooperation with other areas of knowledge, make them protagonists based on daily demands and references that provide theoretical support for the understanding and critical-reflexive systematization of their outcomes.^(23,24)

In view of the speed of transformations at the global level, especially in the health area, it is not enough to develop new information and management support technologies, it is necessary to consider agile methods of producing and incorporating information, with a view to monitoring and analyzing predictive local variables, indicative of changes and possible risks. Under this approach, the web soft-

ware to support prenatal care management that was developed in this study enabled practicality, agility and identification of functional changes throughout the software development process. This process has become even more agile due to the possibility of it being administered by a professional nurse who is responsible for registering the new data analysis algorithms.

In the present study, the scrum method did not determine specific aspects for the creation of web software. It focused on the planning of the stages, the way each stage was carried out and the induction of autonomous choices by each nurse administrator. Anchored in the scrum method, the web software developed enabled local health managers to deliver information with greater efficiency, quality and in less time, according to regional needs and specificities.

It corroborates with previously carried out studies,⁽²⁵⁻²⁷⁾ by denoting that the scrum method is an excellent resource for aligning processes and making the development environment more democratic, collaborative and agile to new and necessary changes. The same authors also recognize that the scrum method enhances initiatives, favors the identification of failures and, at the same time, favors the design of proactive and prospective health solutions.

Although scrum presents itself as a simple and flexible method for managing projects and large-volume information, it generates the demand for skills and competencies to visualize, critically analyze, prospect and lead changes and behavioral postures on the part of the operational team. In this sense, the role of the scrum leader is related to promoting highly interactive and collaborative environments, conducting meetings, encouraging cooperation, promoting self-management and favoring interdisciplinary action. It is also responsible for managing the backlog, building short, medium and long-term strategic objectives and goals, mediating learning processes and promoting continuous and permanent self-assessment.⁽²⁸⁾

Although promising advances in the health area are evident, information technologies are incipient in the context of Primary Health Care, more specifically with regard to prenatal care. Under this approach, the present study aims to awaken the in-

terest of nurses and other health professionals in the development of agile, efficient and resolute tools for making early decisions in health. Therefore, the present web software proved to be favorable and with the potential to monitor and deliver information with greater efficiency, quality and in a shorter time, based on the loco-regional health needs and specificities. Therefore, the tool will contribute to the improvement of maternal and child morbidity and mortality indicators at the local and national level and, consequently, to the achievement of the Sustainable Development Goals.

The main contribution of this study to nursing/health science is related to the proposition of a new technological tool to support health management, especially in the context of Primary Health Care. It demonstrates, in addition to this technological proposition, the possibility for nurses to articulate knowledge and different areas of knowledge and operate this new tool as a manager/administrator, responsible for registering new data analysis algorithms, based on the inclusion of test bases and the systematization of the results generated from the analyzes.

The limitations of this study are associated with the little expertise of nursing/health researchers in the development of information technologies, although this process has been increasingly encouraged by the Coordination for the Improvement of Higher Education Personnel (CAPES) and the Brazilian health system. From the development of this web software, based on the scrum method, it is recommended that nurses and health professionals adopt this method, which is capable of enabling improvements, overcoming disciplinary barriers and inducing prospective policies from agile, efficient and collaborative tools.

Conclusion

The process of development and validation of the web software to support the management of prenatal care took place jointly between developers, researchers, managers and health professionals, based on practical needs related to the management of

prenatal care. The tool was developed to allow access and specific functions to three different users (Administrator, Manager and Visitor), with a view to making quick and safe strategic decisions. The web software makes it possible to generate loco-regional infographics that point out gestational interurrences and allow the early detection of stormy events, such as pregnant women who tend not to complete their pregnancy or to lose their child in the first postpartum days. Also, the tool has the potential to predict the emergence of new outbreaks, such as influenza, toxoplasmosis and others.

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Collaborations

Pires MO, Vieira SAG, Ferreira CLL and Backes DS collaborated with the project design, data collection, analysis and interpretation, article writing, relevant critical review of the intellectual content and final approval of the version to be published. Lomba ML and Dal Sasso GTM collaborated with the writing of the article and the relevant critical review of the intellectual content, as well as the final approval of the version to be published.

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