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Value Stream Mapping applied to information management in infection control

Mapeamento de Fluxo de Valor aplicado ao gerenciamento de informações no controle de infecções

Mapa de la Cadena de Valor aplicado a la gestión de la información en el control de infecciones

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Abstract
Infection control teams collect and produce information on epidemiologic surveillance for prevention of Healthcare Associated Infections (HAIs). Value Stream Mapping (VSM) is a Lean method for developing process through flow efficiency. The aim of the study was to use VSM to identify opportunities for improvement in the infection control department. Flow of information and infection control activities were reviewed using VSM and a questionnaire, where time required for each task was measured. The actual VSM went through multidisciplinary analysis and an ideal VSM was created without considering resource limits. The ideal VSM was reviewed to identify the improvements easily implemented and the ones that would require more time or resources. The actual VSM analysis addressed work overload for Key Performance Indicators (KPI) production, data management (fragmentation, access and redundant work, storage, time between tasks, time typing) and tasks performed retrospectively, when less information is available and with no opportunity to correct protocol deviation. The implementation of the ideal VSM provided a faster and more efficient HAIs analysis, London protocol for HAI cases and surgical prophylaxis evaluation became real time tasks, and all surgical surveillance was improved. A mobile app was proposed as an intervention and became a long-term project. If completely implemented, the ideal VSM would result in 15.7 less work hours/month, having the working time optimized for patient care. VSM is an important tool for epidemiologic surveillance in infection control allowing better data management, continuous workflow, and new information production with potentially fewer work hours.
Keywords: Value stream mapping; Infection control; Process mapping; Lean healthcare.

Resumo
Equipes de controle de infecção coletam e produzem informações sobre vigilância epidemiológica para a prevenção de Infecções Relacionadas à Assistência em Saúde (IRAS). Mapeamento de Fluxo de Valor (MFV) é um método Lean para desenvolver processos através da eficiência do fluxo. O objetivo do estudo foi utilizar MFV para identificar

oportunidades de melhoria em um departamento de controle de infecção. O fluxo de informações e as atividades de controle de infecção foram revisadas utilizando MFV e um questionário, onde o tempo necessário para cada tarefa foi medido. O MFV real passou por análise multidisciplinar e um MFV ideal foi criado sem considerar os limites de recursos. O MFV ideal foi revisado para identificar as melhorias facilmente implementáveis e as que exigiriam mais tempo ou recursos. A análise do MFV real abordou a sobrecarga de trabalho para a produção de indicadores de desempenho (ID), gerenciamento de dados (fragmentação, acesso e trabalho redundante, armazenamento, tempo entre tarefas, tempo de digitação) e tarefas executadas retrospectivamente, quando menos informação está disponível e não há oportunidade de corrigir desvios de protocolo. A implementação do MFV ideal proporcionou uma análise mais rápida e eficiente das IRAS, o protocolo de Londres para casos de IRAS e a avaliação da profilaxia cirúrgica tornaram-se tarefas de tempo real, e toda a vigilância cirúrgica foi melhorada. Um aplicativo móvel foi proposto como intervenção e se tornou um projeto de longo prazo. Se completamente implementado, o MFV ideal resultaria em menos 15,7 horas de trabalho/mês, tendo o tempo de trabalho otimizado para o atendimento ao paciente. MFV é uma importante ferramenta para vigilância epidemiológica no controle de infecção, permitindo um melhor gerenciamento de dados, fluxo de trabalho contínuo e produção de novas informações com potencialmente menos horas de trabalho.
Palavras-chave: Mapeamento do fluxo de valor; Controle de infecção; Mapeamento de processos; Lean para saúde.

Los equipos de control de infecciones recopilan y producen información sobre vigilancia epidemiológica para la prevención de las Infecciones Asociadas a la Atención de la Salud (IRAS). Mapa de la Cadena de Valor (MCV) es un método Lean para desarrollar procesos a través de la eficiencia del flujo. El objetivo del estudio fue utilizar MCV para identificar oportunidades de mejora en el departamento de control de infecciones. El flujo de información y las actividades de control de infecciones se revisaron mediante MCV y un cuestionario, donde se midió el tiempo requerido para cada tarea. MCV real pasó por un análisis multidisciplinario y se creó un MCV ideal sin considerar los límites de recursos. Se revisó el MCV ideal para identificar las mejoras fáciles de implementar y las que requerirían más tiempo o recursos. El análisis MCV actual abordó la sobrecarga de trabajo para la producción de indicadores de desempeño (ID), la gestión de datos (fragmentación, acceso y trabajo redundante, almacenamiento, tiempo entre tareas, tipeo de tiempo) y tareas realizadas retrospectivamente, cuando hay menos información disponible y sin oportunidad de desviación del protocolo. La implementación del MCV ideal proporcionó un análisis de IRAS más rápido y eficiente, el protocolo de Londres para los casos de IRAS y la evaluación de la profilaxis quirúrgica se convirtieron en tareas en tiempo real, y se mejoró toda la vigilancia quirúrgica. Se planteó una aplicación móvil como intervención y se convirtió en un proyecto a largo plazo. Si se implementara completamente, el MCV ideal resultaría en 15,7 horas menos de trabajo/mes, teniendo el tiempo de trabajo optimizado para la atención del paciente. MCV es una herramienta importante para la vigilancia epidemiológica en el control de infecciones que permite una mejor gestión de datos, flujo de trabajo continuo y nueva producción de información con potencialmente menos horas de trabajo.
Palabras clave: Mapa de la cadena de valor; Control de infecciones; Mapeo de procesos; Lean en la salud.

1. Introduction

Value Stream Mapping (VSM) is a tool that allows understanding a process flow through graphic elements and timelines (Marin-Garcia et al., 2021). VSM originates from Lean, a management philosophy from Toyota Motors Company that values flow efficiency in its processes (Teich & Faddoul, 2013). Lean prioritizes flow efficiency by searching for wastes and reducing any unnecessary work in each step of a process. Lean is also about not compromising flow efficiency by only optimizing resource efficiency (Shah & Ward, 2007; Modig, & Åhlström, 2014). For example, resource efficiency is to plan how many exams can be made by computed tomography based on the time it takes for the machine to complete them. Flow efficiency is to plan the exams based on the steps the patients pass through to undergo the exam, simply and fast.

To implement VSM it is necessary to have practical knowledge during every step of the process, which usually requires not only the participation of all the staff involved, but the empowerment of ideas from those who experience the process where it happens. The graphic representation of the process is done from the point of view of the flow unit (in healthcare it is usually the patient) in a timeline of events, exposing the steps where it is transformed toward the final product (gains value) and where it is waiting for some next step (waste) (Lee et al., 2014). A common approach to VSM is to map the process as it is at the time (actual VSM process) and, after extensive discussion, build a new one (ideal VSM process) (Morell-Santandreu et al., 2021).

Lean is frequently present in business companies and industries and have also been used to increase quality and efficiency of medical services in what is today known as Lean Healthcare (D'Andreamatteo et al., 2015). It can be applied to diagnostics (Vandborg et al., 2012), radiology (Kruskal et al., 2012), surgery (McLaughlin et al., 2014), infection control

(Forrester et al., 2018), emergency care (Breen et al., 2020) and other healthcare departments. Processes may gain from Lean/VSM by increasing profitability through cost reduction, or by the added value of a simpler/faster process for the patient (Ahmed, 2019). Also, time reduction in a process involving a patient may improve the disease outcome allowing faster diagnosis or treatment. It may have intangible benefits as more time is dedicated to the patient by the health professional, less waiting time, early hospital discharge and personal satisfaction. There are some concerns about Lean strategies in healthcare as review articles are published with controversial results (Mazzocato et al., 2010; Poksinska, 2010; D'Andreamatteo et al., 2015), since the methods, definitions and applications in the different studies are very heterogenous.

Traditional difficulties found in Lean projects are lack of financial resources, poor communication, compartmentalization, data collection and measurement, human resources (lack of leadership, skepticism, lack of knowledge about Lean), terminology, local momentum and governmental policy (Walley et al., 2006; de Souza & Pidd, 2011). There is limited data on Lean in developing countries and challenges to implementation. A study in five sectors of two Brazilian hospitals found that organizational structure, outsourcing a hospital sector, limited knowledge of Lean concept and implementation continuity/sustainability are the major barriers to Lean improvement projects (Costa et al., 2017).

Healthcare Associated Infections (HAIs) are a worldwide public concern. The Centers for Disease Control and Prevention (CDC) estimate 1.7 million HAIs and 99,000 deaths per year in the United States (Stone et al., 2005) and their cost to be 28-45 billion of dollars (Scott, 2009). The Hospital Infection Control Committee (HICC) is responsible for prevention and treatment of healthcare associated infections (HAIs). Epidemiologic surveillance is the most important activity of the HICC and requires the collection and management of a big amount of data. Most of these data are already established worldwide by organizations such as World Health Organization and CDC (Sehulster, Chinn, & HICPAC, 2003; World Health Organization, 2016). Paper records, electronic sheets, databases, and other technologies are used simultaneously to achieve this objective in daily practice (Dhar et al., 2016). Given the volume of data, different professionals need to be involved, and since some hospitals lack ideal Information Technology (IT) resources, the working process can become very complex.

Infection control studies with VSM and other Lean methods are not unusual, showing improvement in hand hygiene (O'Reilly et al., 2016), isolation (Ankrum et al., 2019), surgical infection prevention (Forrester et al., 2018), bloodstream infection prevention (Russell et al., 2018; Ferrari & Taylor, 2020), sterilization processes (Blackmore et al., 2013; Zeferino et al., 2019) and even managing a *Clostridioides difficile* outbreak (Kuenzli et al., 2020). Considering HICC has different professional categories collecting and managing high quality and complete sets of data through different tools and instruments, we hypothesized that the VSM approach could result in opportunities for process improvement in the hospital epidemiologic surveillance.

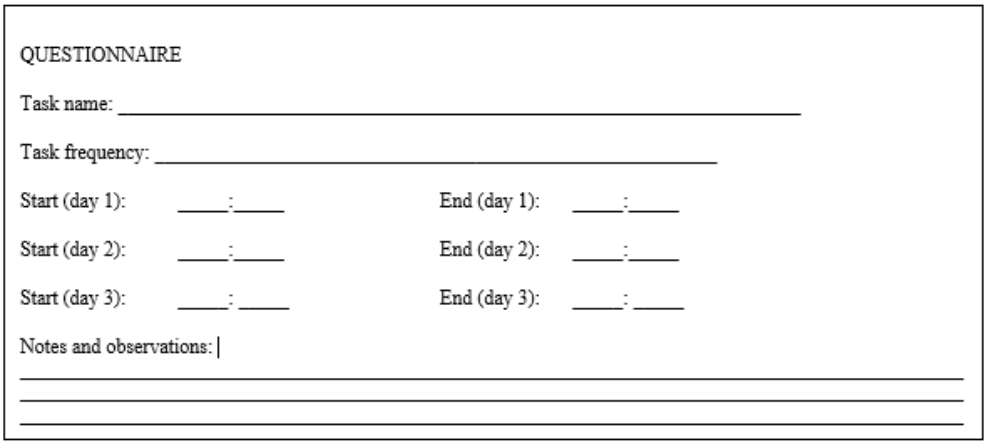
2. Methodology

The study was approved by the Ethics Committee and has full support from the board of directors of a 260-bed (40 intensive care unit beds) private tertiary hospital. It is a case study mixing qualitative (interviews and questionnaires) and quantitative (time measurement) methods to fully describe the infection control work process. VSM falls into this methodology, as described by Yin (2015) and Estrela (2018). The study was carried out during September 2021 focused on the infection control team's activities using VSM in the context of Lean thinking with information as the flow unit.

The HICC consists of one physician, two nurses and one pharmacist. They were introduced to the study and Lean principles through training and interviewed concerning epidemiologic surveillance activities. Two of the authors took the role of Lean consultants to coordinate the whole process. A questionnaire was applied to each of the HICC professionals concerning their daily activities. The main topics of the questionnaire were task frequency, task start requirements, time spent between tasks,

estimated task duration, instrument used to record data, detailed description of the task. The questionnaire can be observed in Figure 1.

Figure 1 - Questionnaire.


QUESTIONNAIRE

Task name: _____

Task frequency: _____

Start (day 1): ____:____ End (day 1): ____:____

Start (day 2): ____:____ End (day 2): ____:____

Start (day 3): ____: ____ End (day 3): ____: ____

Notes and observations:

NOTE: The questionnaire was applied to each HICC routine task. Source: Elaborated by the authors (2021).

The activities were reviewed at the workplaces and in different hospital departments since infection control professionals work across the hospital. A graphic representation of the work process focusing on data flow was created using the Bizagi software (version 3.8.0.206). The VSM was designed to view the activities of each professional category on the team, where they took place, what kind of data and where they were recorded. The initial stage was defined as the first day of an inpatient and the last stage was delivery of Key Performance Indicators (KPI) to the hospital director and public healthcare agents.

The time of each step of the process and the intervals between them were measured 3 times, so the average time could be used on the map. When the VSM was finished (actual VSM), a critical review resulted in a new mapping of an ideal information flow (ideal VSM), created without regard to resource limitations to stimulate creativity and to give voice to all good ideas. Actual and ideal VSMs can be observed in figures 2 and 3. The critical review team included personnel from quality office, information technology, laboratory, emergency room, Intensive Care Unit (ICU), the medical director, and the HICC. Both VSMs were compared and the differences in time spent by the team, steps to reach the same goal, number of tools to store data were measured. Data analysis was performed based on time and human resources required to perform tasks. Only descriptive statistics were performed.

At the end of the ideal VSM, the team reviewed the interventions, deciding which could be promptly implemented, which would be made into future goals to be achieved and discard the ones that could not be implemented. Table 1 summarizes the general steps of our team in creating the VSM.

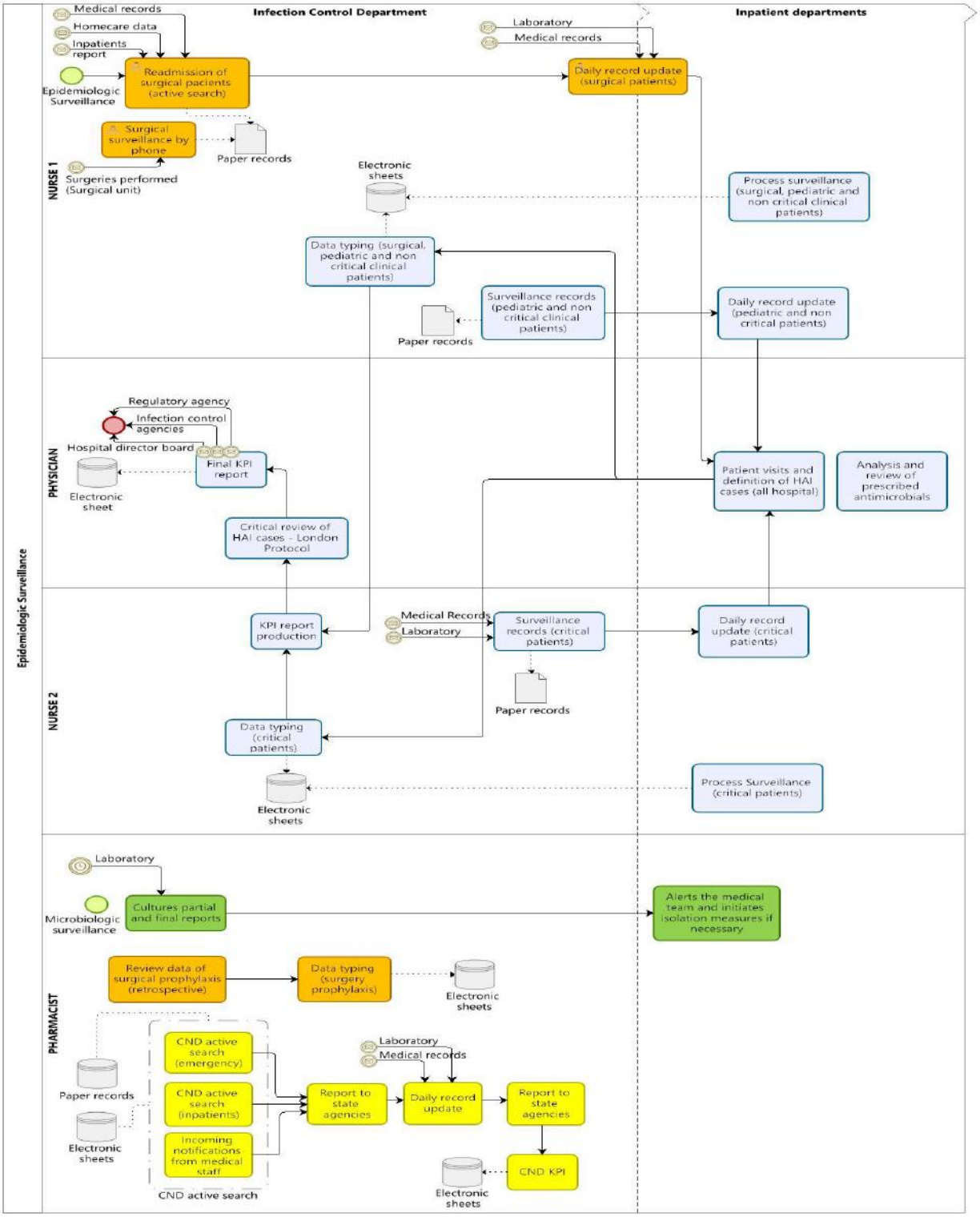
Table 1 - General steps in creating the VSM.

	Steps	Description
1	Create a team	Must have high direction support, be multidisciplinary, have people trained in Lean/VSM, daily involved with the process, motivated and with resources provided.
2	Observe the process and review objectives	Identify the flow unit and other variables of interest such as stages, subprocesses, people involved, beginning and end of mapping, etc. Review the process at the workplace. Identify what adds value from the point of view of the flow unit.
3	Map the actual process	Encourage suggestions from the team, identify the information system used, estimate time spent on each stage, between stages and delays. Identify people involved with each step, communications, triggers, suppliers and clients.
4	Validate the map	At the workplace, take multiple measures of the time each worker takes at each stage, delays and/or interruptions.
5	Analyze the map	Identify the reasons behind the delays, look for waste (process, information, delays, resource and people waste), events that cause delay and/or interruption
6	Map the ideal process	Don't try to rebuild the actual process better, but to create an ideal process. The most efficient process possible and then adapt to your resource limitation.
7	Implementation and continuity	The most difficult part. It may involve a lot of people and modify the organizational culture of the department or even the healthcare unit.

Source: Elaborated by the authors (2022).

Figure 2 is the actual VSM showing the epidemiological surveillance activities performed by each professional in the Infection Control department (ICD). Green squares: microbiological surveillance; orange squares: surgical surveillance; yellow squares: surveillance of notifiable diseases; blue squares: inpatient departments. Solid arrows show the process steps and dotted arrows show where the information is stored. CND: Compulsory Notifiable Disease.

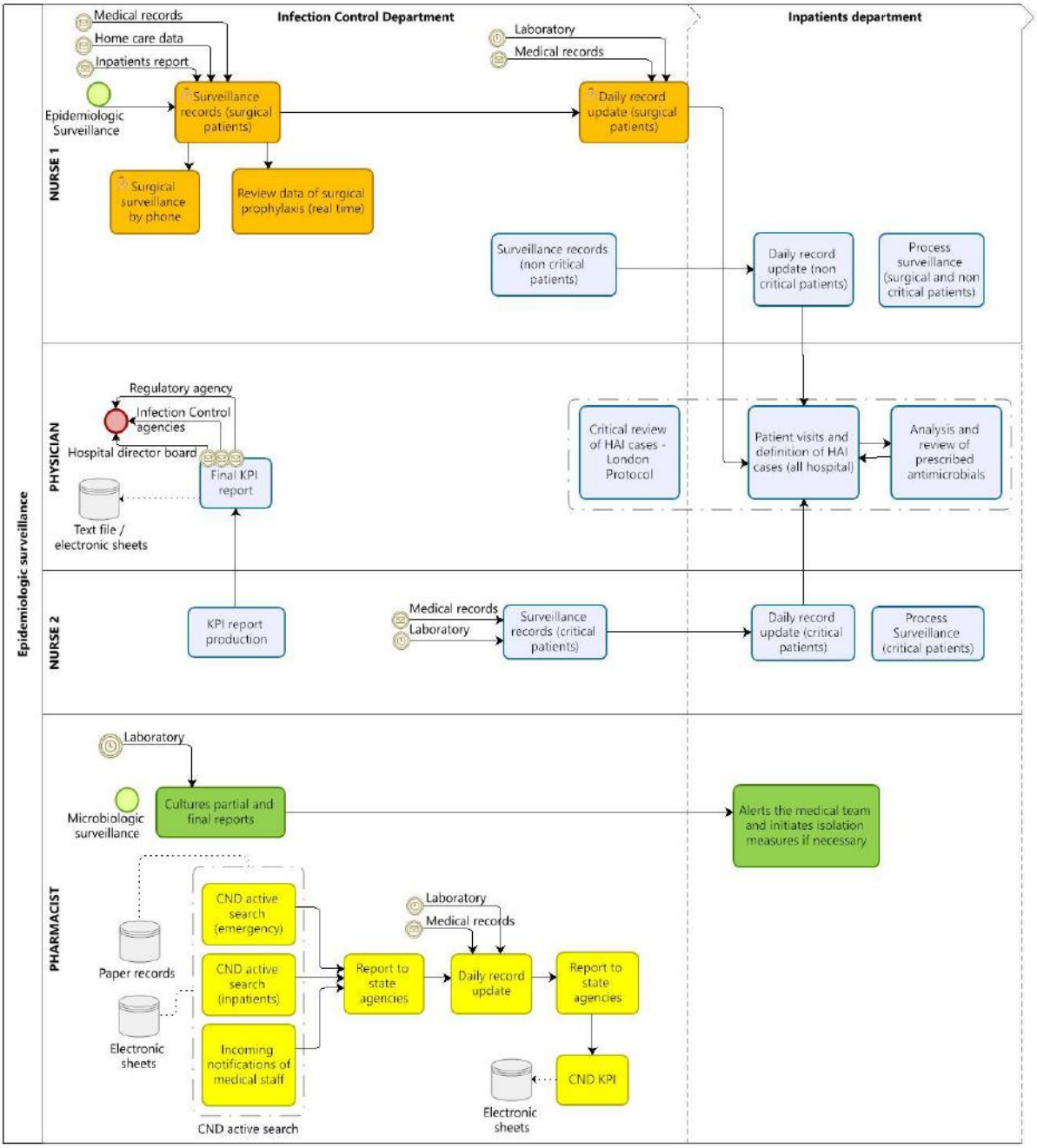
Figure 2 - Actual VSM.



Source: Elaborated by the authors (2022).

Figure 3 is the ideal VSM showing the epidemiological surveillance activities performed by each professional in the ICD. Green squares: microbiological surveillance; orange squares: surgical surveillance; yellow squares: surveillance of notifiable diseases; blue squares: inpatient departments. Continuous arrows show the process steps, and dotted arrows show how information from the ICD will be exported to stakeholders. CND: Compulsory Notifiable Disease

Figure 3 - Ideal VSM.



Source: Elaborated by the authors (2022).

3. Results

The actual and ideal VSM can be observed in figures 2 and 3. Reviewing the actual VSM, the barriers regarding data collection and management were:

1. Data fragmentation. Data is collected through different instruments, such as excel sheets, paper records, computerized medical records, etc. And data on those instruments can't be crossed without substantial extra work, severely limiting the generation of useful information.

2. Information stored outside computerized systems. This results in some tasks being done more than once (one professional needs information on paper sheets that is currently being used by another). Also, there is the need to transfer some data from the paper to another tool later.
3. Access to information restricted to the computer and not available on mobile, leading to the need for the professional to be inside the infection control room (and less at the work field supporting the medical staff). Some data, after collection, keep waiting for the beginning of the next month to be used on the KPI or the next professional that is going to use them. One consequence is that there is no way to produce partial KPI's without wasting human resources to produce them. A software informs the infectious diseases physician of the antimicrobial prescriptions in real time for approval. Signaling new data available to the next professional about to make use of it should be employed whenever possible in other situations.
4. Delays in triggers from other sectors were not a problem. Data from the laboratory were very well scheduled.

The ideas to create an ideal work process were:

1. Creation of a mobile data collection tool to make data collection easy, avoid re-writing information on a computer and making information available as soon as recorded.
2. Active signaling new data available to be worked on by the next professional that is going to use it.

In the ideal VSM, the time spent by the infection control team to execute the work was reduced by 15.7 hours/month (from 541,3 to 525,6 hours/month). One of the nurses was the least affected with 0.4 hours/month (from 143,5 to 143,1 hours/month) followed by the second nurse with 4.8 hours/month (from 143,2 to 138,3 hours/month) and the pharmacist with 5.0 hours month (from 138,3 to 133,3 hours/month). The physician was the most affected with 5.4 hours/month (from 116,3 to 110,8 hours/month) because is the one responsible for the production and presentation of the KPI. The production of KPI reports were significantly reduced, since the mobile app would produce reports with graphics and data, and only the analyses consumed some time of the team at the end of the month. The gain in time could be used to develop other projects and activities, like a stewardship or outpatient programs.

The HAI cases were analyzed with the London protocol soon after the case was diagnosed instead of at the end of the month, allowing faster identification of protocol deviation and opportunities for improvement. Also, the team pointed out the potential mindset change in the healthcare professionals outside the infection control unit on filling the forms and analyzing the cases, since this review would now be made with fresh information and by the physician caring for the patient daily (instead of only the unit coordinator at the end of the month).

The main medical work takes place through 3 activities: 1) antimicrobial prescription evaluation; 2) visit and definition of HAI cases; 3) HAI case review at the end of the month. The first two frequently occur at the same time at the bedside. But as the prescription evaluation needs to be transcribed to a form of the electronic chart, the physician called attention to the fact that some prescriptions ended up being reviewed in the infection control room, away from the unit. The ideal VSM would turn all the activities into one, with all the data being collected at the bedside with the patient's attending physician. Evaluation of surgical prophylaxis was turned from a monthly retrospective review into a daily real time activity, allowing any protocol deviation to be corrected. Also, all steps of surgical vigilance were performed by the same professional, who gained a better picture of the process.

A mobile app for data collection could be created relatively fast by an experienced IT professional. Its use simply would end all the time spent transcribing information from paper to electronic charts, making all information available in real time, allowing data that were stored in different tools to create useful information and making it possible for the team to spend more

time working in patient care and infection control medical consulting in the other hospital units. The use of this app was considered when creating the ideal VSM, as well as the impact it would have on task times. Compulsive Notification Disorders (CND) are diseases and conditions that must be informed to epidemiology state agencies in 24 hours upon susception. Those were not included in our analysis and data collection through the mobile app idea, since they have specific official paper and/or online forms for notification. Transcribing these data was considered a waste at the ideal VSM.

The execution of monthly activities (HAI diagnosis, London protocol, surgical surveillance by phone) in real time and centralization of surgical surveillance in one professional were implemented. The mobile app was the only intervention that could not be promptly implemented in the daily practice, so the work hours were not reduced. However, the idea was well received by the hospital direction, was made into a future goal and is being developed by some of the authors. No interventions were completely discarded.

4. Discussion

The benefits described in the results as quality improvements in the teamwork were very impressive using the VSM method. The ideal VSM resulted in 15.7 less work hours in a month for the infection control team and it can be viewed as an extra half day of work for each of the four professionals. All VSM papers were reviewed focused on the patient as the flow unit, which makes sense, since healthcare is all about taking good and effective care of them. However, HICC has no direct patient care, mostly except for consults by the physician. We discussed that the way the HICC manages data changed historically, as the specialty became more complex, gaining responsibility over many areas/processes and that the lack of new tools and technology severely hindered good possibilities of data usage and efficacy of the team's work. Problems regarding data management in the HICC are considered almost universal challenges in healthcare and important barriers for the implementation of new technologies are similar, such as artificial intelligence tools (Scardoni et al., 2020; Fitzpatrick et al., 2020).

There is no data about clinical impact of the benefits listed in the ideal VSM. A study on neonatal sepsis used artificial intelligence to recognize sepsis diagnosis by collecting data from different sources in a neonatal unit and observed that there was no difference in mortality (Kalil et al., 2018). We believe that subgroups of high-risk patients could benefit from HICC with high information flux, including antimicrobial prescription review in less than 24 hours. One possible application of VSM is to estimate the ideal number of HICC professionals in the team for the hospital being studied. The only recommendation on the topic in Brazilian Ministry of Health is from 1998 (Brasil, 1998). At that time, the obligations, and activities of the HICC were very different from today.

There are different HAIs reports used by hospitals to measure their results in infection control (El-Saed et al., 2013). Using information as the flow unit in VSM interventions may allow efficient, detailed and reproductible data management, adding in reliability of infection control metrics and practice. One of the strengths of the study is that a complex VSM was performed not only with estimates from the team, but with real time measurements taken to finish each step of the process, showing opportunities for improvement that wouldn't have become apparent otherwise. Also, the meetings for the actual and ideal VSM charts included staff from departments outside infection control, such as microbiology, hospital medical director, ICU staff, surgery department staff and IT.

A limitation to be considered is that the IT staff of the hospital have no experience with mobile app programming, which made the ideal VSM only partially implemented in practice.

This study is the first to our knowledge to use information as the flow unit for a VSM intervention in the HICC processes and activities. Future research on the topic should include solutions to address data fragmentation in healthcare focused on developing countries and studies to quantify if a better flow of information results in improved clinical outcomes.

4. Conclusion

VSM was able to identify many opportunities for improvement and potentially reduce the time required to the HICC to complete their routine tasks with some investment. Data fragmentation, storage, access, and delay in analysis were approached and resulted in less retrospective data use, more time providing patient care and medical staff consulting, ideas for IT resource development and new/better information production for KPI. Also, VSM could be used to estimate human resources in infection control.

Future research may include the VSM/Lean in quality healthcare processes, in addition to infection control and hospital epidemiology, with the possibility of using flow mapping in areas such as antimicrobial stewardship and home care facilities, helping to optimize and improve resources in hospital and outpatient settings.

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