HAITooL: An innovative antibiotic stewardship decision-supporting system to improve antibiotic prescription effectiveness

HAITooL: Um sistema inovador de monitorização e de suporte à decisão na prescrição antibiótica

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Resumo

O sistema de gestão de informação HAITooL é uma ferramenta de monitorização e de apoio à decisão para médicos, a equipa de controlo de infeção (GCL-PPCIRA), a farmácia e o laboratório de microbiologia, em benefício da segurança e bem-estar do doente. O sistema disponibiliza a efetiva monitorização da resistência aos antibióticos, a prescrição e utilização de antibióticos, para além de apresentar informação de suporte à decisão para a prescrição de antibióticos, uma vez que integra os dados do doente, os resultados da microbiologia e os consumos da farmácia, provenientes dos múltiplos sistemas de cada hospital. O quadro lógico Design Science Research Methodology, permitiu projetar e implementar o sistema de informação HAITooL, assegurando uma ação participatória e contando com a colaboração ativa e multidisciplinar entre investigadores e os profissionais de saúde de cada hospital participante. O compromisso da Administração de cada Hospital, a constituição de uma Equipa Multidisciplinar e, principalmente, o envolvimento dos Informáticos foram etapas essenciais no processo de implementação. Todo o processo de co-design, desenvolvimento e implementação foi vantajoso ao nível organizacional, em prol da mudança de comportamento.

Abstract

HAITooL is a surveillance and decision-support tool for physicians, the Infection and Prevention Control Team, pharmacists, and microbiologists. It integrates patients, microbiology and pharmacy data, from multiple sources, enabling effective monitoring of antibiotic resistance, antibiotic use and provides an antibiotic prescription decision-supporting system by clinicians, strengthening patient safety. HAITooL information system design and implementation, based on Design Science Research Methodology, ensured full participation, in close collaboration of a multidisciplinary team of researchers and healthcare professionals. Leadership commitment, multidisciplinary team and mainly informaticians engagement was crucial to the implementation process. The design, development and implementation process reveals benefits in organizational and behavior change with success.

Palavras Chave:
Resistência antimicrobiana, gestão de antibióticos, co-design, implementação, suporte à decisão.

Key Words:
Antimicrobial resistance, antibiotic stewardship, co-design, implementation, decision-support system.

Introduction

The global health capacity to sustainably tackle infectious diseases is at risk, by the rising of antibiotic resistance (AR) [1]. HAITooL (Healthcare-associated Infections Tool) is a surveillance and decision-support system for effective antibiotic stewardship programs (ASP). Its design, development and implementation, under a participatory process, reveals benefits in organizational and behavior change, despite some inherent barriers. At the end, it leverages the healthcare professionals (HP) work. Healthcare-associated Infections (HAI) are an important cause of morbidity and mortality [2], worldwide. HAI and Antibiotic Resistance (AR) impact populations, weakening their health, socially and economically, with human losses of thousands of people per year [2]. As a global public health priority, it overloads the systems with direct and indirect costs [3].

The general high consumption of antibiotics suggests that one of the issue to address is at the doctor's office, the inappropriate prescription. It leads to the development of multidrug resistance mechanisms. In general, we can address the problem by tackling one or both antibiotic-resistant HAI and AR dissemination and antibiotics consumption reduction. Several strategies such as hand hygiene, surveillance, decision-support information systems or ASP development are frequently indicated for a prevention and control program [4].

The HAI and AR control essentially lies on human behavior, for the patients' health and safety. Human behavior is a driver with significant association to control system's performance key-indicators [5]. Epidemiological differences throughout Europe indicate cultural conditioning factors of human behavior, such as perceptions and values among the HP community [6]. Combining the socio-cultural, political and organizational dimensions, we can conduct a HAI and AR control program, through behavior change at individual and organizational levels. Organizational aspects in infection control, human and other resources, professionals' workload, education and training, the need for multimodal and multidisciplinary programs, individual and team motivation, engagement and commitment to the programs, among others, are key for a positive organizational culture [7].

Technological innovation solutions can leverage the HP work and help address their organizational needs. The prevention, management and control of HAI and AR require readiness for response and action, with the immediate and clear communication between all the ASP key-actors. Computerized surveillance and decision support systems, with interactive and integrated data visualization technology-based features can effectively help address the issue, improving the HP performance and work quality [8,9].

The main goal was to design and implement an information system - HAITooL - which could effectively be a tool for the HAI and AR surveillance, being as well a decision-support system for antibiotics prescription. It aims at im-

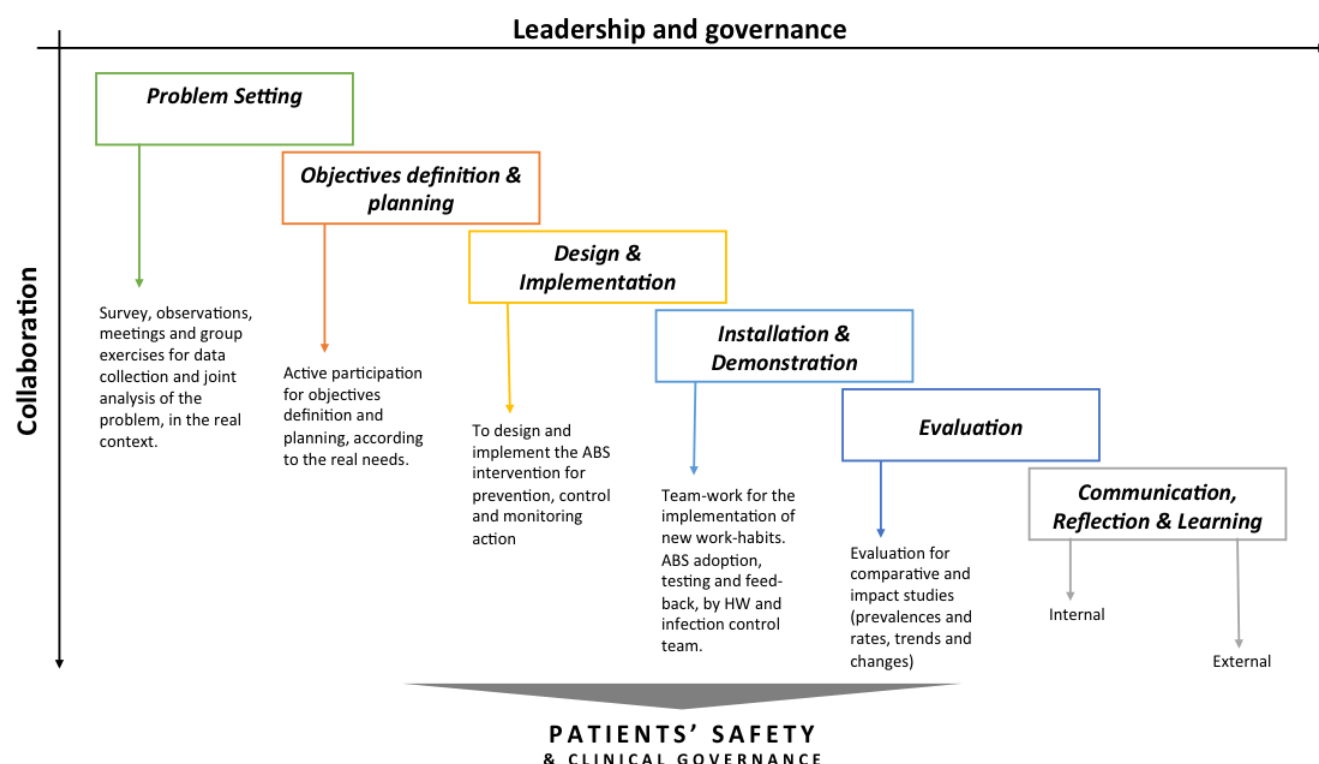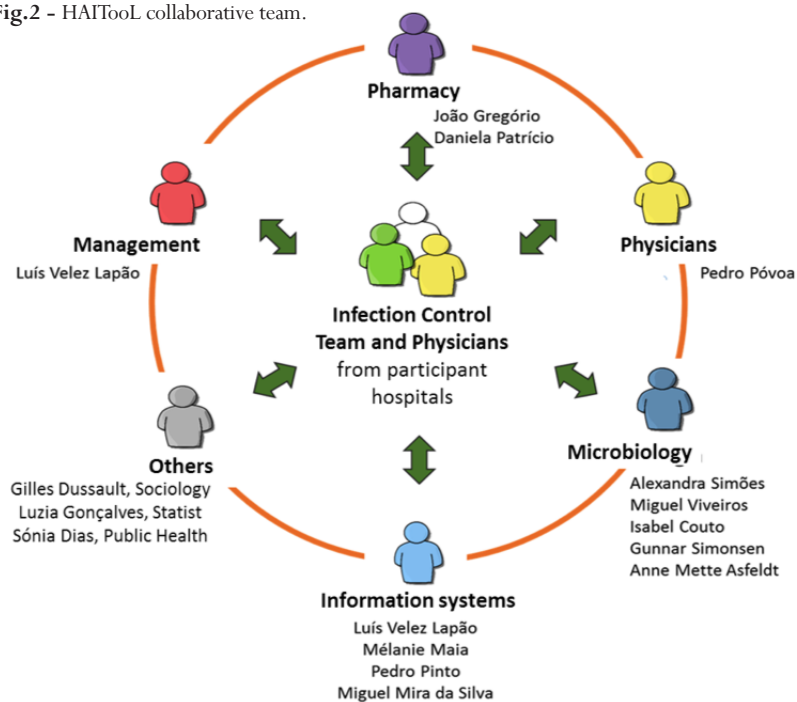**Fig.1 –** HAITooL's Design Science Research Methodology framework.

pacting on antimicrobial resistant HAI and antibiotic use, by leveraging the HP's work.

Methods

HAITooL, a surveillance and decision-support open-sourced information system (IS), was developed and implemented, on the Design Science Research Methodology framework (DSRM) [10].

The study has been conducted in three Portuguese Hospitals. Full participation of the HP was ensured, counting in each case, on the close collaboration of researchers and a multidisciplinary team of HP. The focus was on better adjusting the process to Portuguese and local organizational and socio-cultural context, leading HP to adequate behavioral change.

Six sequential DSRM main steps [8] was planned and accomplished, through a teamwork-based intervention (Figure 1). Several interviews and surveys were performed [11], in addition to the process observation and intervention, under the principles of Österle for abstraction, originality, justification and benefit [12].

Results and discussion

HAITooL is a contextualized and validated information system for surveillance and decision-support [9], underpinning the operationalization of an effective ASP. It was designed to leverage the professionals' role, strengthening their capacity and quality of work. It re-

sults from the collaborative work between researchers and the multiple key-actors in the ASP (Figure 2). The researchers, together with the HP (including clinicians, the Infection and Prevention Control Team, physicians, nurses, pharmacists, microbiologists and ICT technicians), set up what the problem and priorities were, as well as main objectives for the solution. Important and necessary data were pre-selected, for the system co-design, implementation and demonstration. Evaluation and communication, in form of constant profiling, meeting and reporting, was central to understand the problem, engage the team, follow-up and disseminate the solution by communicating results.

The co-design process of HAITooL followed the strategy of well-adjusting with the background where the system was being implemented (e.g. integrating national health directorate antibiotic guidelines and meeting local perceived needs) [13].

The HAITooL decision-support systems proves to be of major importance to best manage patient safety, for medical work quality improvement. The main findings, achievements and milestones, are as following:

1. At an early stage, we understood that the problem was originated on infection control team work overload, with time-consuming tasks, dealing with all the ward organization complexity, and experiencing difficulty in accessing evidence-based information, real-time [9].

2. An initial survey participants, gave major relevance to the need for better access to hospital antibiotic susceptibility patterns and epidemiological data, among other pertinent daily information (e.g. clinical and pharmaceutical data) [11].

3. As learnt from best-practices' benchmark, of the infection control teams of Norway, Switzerland and others, including national ones, surveillance and clinical decision-support systems have the potential to enhance ASP, by improving HP access to validated information [14]. Pharmaceutical, microbiological, and clinical data, integrated all together within one main system, the HAITooL, offer all the participants the possibility of giving their inputs, review clinical and technical information and participate actively throughout the entire process, on the behalf of patient's security and work quality improvement.

4. With web-services or views in place, HAITooL

gather the data into a single database, organized by several pre-selected indicators. HAITooL includes integrated views of patient, microbiology and pharmacy data, displayed in innovative layouts and graphics. Visualization of patient clinical evolution, antibiotic consumption trends, antibiotic resistant infections distribution, and local antimicrobial susceptibility patterns turns to be easy and clear for the professional. The display of alerts, for example in cases of excessive antimicrobial therapy duration and antimicrobial therapy not in accordance with microbiology results, among others, helps the decision-maker.

5. In HAITooL's implementation first steps, it already could provide the HAI's information management for the involved hospitals, with implemented evidence-based practices and teamwork techniques, aligned with the objectives of the National Program for Prevention and Control of Infections and Antimicrobial Resistance, in Portugal.

6. The system architecture and the DSRM framework for intervention, enables its implementation in other settings. HAITooL information system is now being developed in Cape Verde main hospitals.

The HP's change of work habits, through education and organizational policies and measures is happening by improving HP's confidence in prescribing antibiotics and making control decisions. The surveillance and decision-support system could be an effective anchor to improve their work quality. The implementation of a new information system should have in account the HP relationship either with the information and communication technologies (ICT) and with the decision and prescribing tasks' changing [15].

The information system development has considered the key-elements of an ASP (Figure 3) to be able to: (a) monitor antibiotic consumption; (b) monitor antibiotic resistant bacteria; (c) promote antibiotic prescription based on laws and main guidelines; (d) improve physicians' prescription behavior. All the key-elements are considered to be essential. However, if we cannot ensure continuity of action and participation of the first two - Leadership Commitment and Multidisciplinary Team - all the process stays at risk. The role of informaticians was also of major importance, often the major bottleneck.

During each process of implementation, there were observed important barriers at the different levels of leadership power and collaboration (e.g. the recurrent lack of available time, the lack of human resources within the hospitals, bureaucratic authorizations delays, among others).

The co-design process was a good instrument to maintain everyone engaged, and to find time to work in the system. Those are examples of implementation obstacles often blocking the process of system evolution, threatening the final product delivery, and risking to be a demotivating factor.

It is vital to guarantee multidisciplinary and full engagement at all implementation levels to address all the critical factors, where human variables must be considered. Continuous communication is paramount. Managers are key in promoting the engagement of all participants.

Conclusion

HAITooL is important to enable effective monitoring of antibiotic resistance and antibiotic use, and helps antibiotic prescription, strengthening the HP work capacity.

The design, development, implementation and evaluation process reveals benefits in organizational and behavior change. The close collaboration with clinicians, the Infection and Prevention Control Team, physicians, nurses, pharmacists, microbiologists and ICT technicians, under a participative approach, was the baseline for a successful implementation.

All the key-elements for an ASP are important, but the leadership commitment, multidisciplinary team and mainly informaticians' engagement are crucial to the implementation process.

When overcoming the

Fig.3 - Key-elements for HAITooL ASP [8].

Leadership Commitment

Multidisciplinary Team

Situation Assessment — Real-time monitoring of patient's clinical situation

Interventions to improve antibiotic use — Alerts for antibiotic prescription and real-time access to microbiology results (eg. antimicrobial resistance patterns)

Surveillance — Real-time monitoring of antibiotic consumption and distribution of isolated bacteria

Report — Facilitate results communication (eg. between microbiology laboratory and physicians)

Education — "Educational" alerts on Antimicrobial Prescription

HAITooL Information System

barriers and after all the collaborative process, HAITooL turns to be unquestionably an important step forward to reduce antibiotic misuse and to control and prevent antibiotic-resistant HAI.

Acknowledgement

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Sessions

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15 November | 09h15 – 13h00 | Sala Fraga de Azevedo

First GHTM Antimicrobial Resistance Awareness Day

Schedule	Speaker	Title
9.15h - 9.30h	Zulmira Hartz Isabel Couto	Opening
9.30h - 10.00h	Ana Afonso Univ. São Paulo, Instituto de Química de São Carlos, Brasil	Praziquantel-Resistance in *Schistosoma mansoni*: Role of Efflux Pumps, Phenotypic characteristics and Proteomics Analysis
10.00h - 10.30h	Sofia Santos Costa GHTM, THOP	Antibiotic and biocide resistance in *Staphylococcus epidermidis* colonizing humans in close contact with animals
10.30h - 11.00h	Pedro Póvoa H. São Francisco Xavier (CHLO) NOVA Medical School, CEDOC	Antibiotics at the Ward: The role of physicians
11.00h - 11.30h	Coffee break	
11.30h - 12.00h	Pedro Cravo GHTM, VBD	Genome-wide strategies for rapid discovery of drug resistance-associated mutations
12.00h - 12.30h	Mélanie Maia GHTM, PPS	HAITool: An Innovative Antibiotic Stewardship Decision-Supporting System to Improve Antibiotic Prescription Effectiveness
12.30h - 13.00h	Rita Castro GHTM, THOP	Antimicrobial resistance of *Neisseria gonorrhoeae* isolates from MSM in Lisbon area
	Ben Sobkowiak London School of Hygiene & Tropical Medicine	Genetic variation and transmission events in clinical *Neisseria gonorrhoeae* from Lisbon
13.00h		Final remarks

Host: Isabel Couto, Sofia Santos Costa

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