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Systematic review

A systematic review of clinical decision support systems for antimicrobial management: are we failing to investigate these interventions appropriately?

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ABSTRACT

Objectives: Clinical decision support systems (CDSS) for antimicrobial management can support clinicians to optimize antimicrobial therapy. We reviewed all original literature (qualitative and quantitative) to understand the current scope of CDSS for antimicrobial management and analyse existing methods used to evaluate and report such systems.

Method: PRISMA guidelines were followed. *Medline*, *EMBASE*, *HMIC Health and Management* and *Global Health* databases were searched from 1 January 1980 to 31 October 2015. All primary research studies describing CDSS for antimicrobial management in adults in primary or secondary care were included. For qualitative studies, thematic synthesis was performed. Quality was assessed using Integrated quality Criteria for the Review Of Multiple Study designs (ICROMS) criteria. CDSS reporting was assessed against a reporting framework for behaviour change intervention implementation.

Results: Fifty-eight original articles were included describing 38 independent CDSS. The majority of systems target antimicrobial prescribing (29/38;76%), are platforms integrated with electronic medical records (28/38;74%), and have a rules-based infrastructure providing decision support (29/38;76%). On evaluation against the intervention reporting framework, CDSS studies fail to report consideration of the non-expert, end-user workflow. They have narrow focus, such as antimicrobial selection, and use proxy outcome measures. Engagement with CDSS by clinicians was poor.

Conclusion: Greater consideration of the factors that drive non-expert decision making must be considered when designing CDSS interventions. Future work must aim to expand CDSS beyond simply selecting appropriate antimicrobials with clear and systematic reporting frameworks for CDSS interventions developed to address current gaps identified in the reporting of evidence. **T.M. Rawson, Clin Microbiol Infect 2017;23:524**

Introduction

In response to the global threat of antimicrobial resistance [1], a range of antimicrobial stewardship programmes have been developed that tend to focus on reducing high rates of inappropriate antimicrobial use described widely across care pathways and clinical specialties [2–5]. An important facet of this approach has been the development of decision support mechanisms for those who prescribe antimicrobials. These interventions are based on evidence that the majority of antimicrobial prescribing is done by individuals who are not experts in infection management and therefore, may have a limited understanding of antimicrobials and the evidence on antimicrobial resistance [6–9]. To address this challenge, electronic clinical decision support systems (CDSS) have

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been devised with the aim of providing the prescriber with easy and rapid access to information, which is required to make therapeutic decisions at the point-of-prescription [10,11]. With the expanding use of electronic medical records and developments in information technology, the role of CDSS has become an area of great interest with a wide variety of interventions now labelled as such.

In medicine, CDSS have been demonstrated to reduce medical errors and improve the quality of health care provided by promoting the practice of evidence-based medicine [12]. Therefore, it seems logical that in a field where we have a need to improve the practice of evidence-based antimicrobial management CDSS may be an effective avenue to promote this. CDSS were first developed to support antimicrobial management in the 1980s and since then several systematic reviews of experimental and quasi-experimental studies have explored the potential of CDSS to improve antimicrobial management at different levels of care [11,13,14]. However, these reviews have only tended to focus on single care pathways, such as the hospital setting or primary care and fail to include qualitative studies evaluating CDSS. Through these reviews, a minor to moderate benefit of CDSS for optimizing antimicrobial management has been demonstrated with a number of gaps in knowledge remaining to be answered [11,13,14]. We performed a systematic review of original literature (qualitative and quantitative) to try to understand the current scope of CDSS for antimicrobial management and analyse existing methods used to evaluate and report such systems. This will be used to create a pragmatic picture of CDSS for antimicrobial management and produce recommendations for future research and interventions, which may optimize the effectiveness of CDSS reporting within this field.

Materials and method

Search strategy

This systematic review was performed following PRISMA guidelines [15]. The Medline, EMBASE, HMIC Health and Management, and Global Health databases were searched from 1 January 1980 to 31 October 2015 using the search criteria described in the Supplementary material (Table S1). Search criteria were broad and intended to capture all information technology products that have been labelled as 'clinical decision support systems' for antimicrobial management.

Study selection

Prospective and retrospective articles in English that reported original research on clinical patient or product outcomes of CDSS for antimicrobial management in primary and secondary care were included. Randomized (including cluster), observational (including case–control, cross-sectional, cohort, before–after and interrupted time series), diagnostic, development reports (including data), mixed-methods, and qualitative (survey, semi-structured interview or ethnographic) studies were all included. Interventions focusing predominantly on critical care were excluded as these CDSS are often used by doctors in a controlled setting, where close working relationships with infection specialists have been demonstrated to significantly improve patient outcomes [16–20]. Therefore, these CDSS interventions may not be used in a similar way to other areas, where they are often used to supplement this expert support. Moreover, CDSS designed specifically for paediatric antimicrobial management were excluded given the differences in prescribing compared with adult antimicrobial management. If studies did not present original data, they were not carried forward. Two authors (TMR plus either LSPM, EC or ECS) independently screened study titles and abstracts against the inclusion and exclusion criteria described above and extracted data (described below). On completion of this process, inter-rater reliability was assessed by calculating Cohen's κ statistic. Where there was disparity between opinions, the authors discussed these to reach a consensus.

Decision support system grouping and data extraction

Following study selection, two authors (TMR plus either LSPM, EC or ECS) independently reviewed each study, grouping those for each CDSS described and extracting data. Data recorded included the characteristics of the CDSS (decision support provided, platform, and system infrastructure), the study design(s) used to evaluate the CDSS, and any comparator used. Primary and secondary outcomes were recorded when presented in the manuscript, as was the outcome of these. Qualitative studies were analysed using a thematic synthesis approach [21]. Qualitative studies were synthesized using an inductive approach with line by line coding of the text to draw out descriptive themes (carried out by one author, TMR). Manuscripts were then re-coded and discussed by the researchers (TMR, LSPM, EC, ECS) to agree upon analytical themes from within the text [21]. Finally, the CDSS systems were evaluated against an analytical framework adapted from the Stage Model of Behaviour Intervention Development [22] and the Medical Research Council's Developing and Evaluating complex interventions guidance [23]. The framework is outlined in Table 1. The four domains of the framework used to evaluate the CDSS were (a) development; (b) feasibility and piloting; (c) evaluation of the system; and (d) implementation. When included within reporting of such systems these criteria will allow the reader to understand holistically the rationale for why and how a CDSS was developed and how its effectiveness was evaluated [22,23].

Table 1
Analytical framework for the assessment of clinical decision support systems applied to the studies in this review

Domain 1: Development	Domain 2: Feasibility and Piloting	Domain 3: Evaluation	Domain 4: Implementation
Literature describing a system should demonstrate:	**Literature describing a system should outline:**	**Literature describing a system should demonstrate:**	**Literature describing a system should outline:**
A definition of stakeholder behaviours that are being targeted and how stakeholders have been engaged with during the development phase	How pilot testing was performed and the findings of this	Efficacy testing in a 'real-world' setting	How it was tested in the real world with real-world providers
A rationale for how the intervention may influence these behaviours	An understanding of the mechanism of behaviour change witnessed and how the intervention may be having its effect	High levels of control maintained to confirm internal validity of intervention	Strategies for implementation and adoption of intervention that were used and how these may have impacted on observations
An outline of how the system was developed		Confirm how the intervention changes practice and quantify its impact	Plans for (or evidence of) long-term surveillance / follow up of the system

Analytical framework adapted from Stage Model of Behaviour Intervention Development [22] and the Medical Research Council's Developing and Evaluating complex interventions guidance [23].