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Clinical decision support systems for antimicrobial management: a systematic review of interventions in primary and secondary care

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Introduction

Clinical decision support systems (CDSS) for antimicrobial management can support healthcare professionals to optimise antimicrobial therapy. A systematic review of qualitative and quantitative studies describing CDSS in primary and secondary care was undertaken to create a pragmatic picture of the field and produce recommendations for future research.

Methods

PRISMA guidelines were followed. Medline, EMBASE, HMIC Health and Management, and Global Health databases were searched from 1st January 1980 to 31st October 2015. All primary research studies describing CDSS for antimicrobial management in adults in primary or secondary care were included. Critical care orientated CDSS were excluded. Two researchers independently screened abstracts and extracted data against a framework adapted from the Stage Model of Behaviour Intervention Development and the Medical Research Council's developing and evaluating complex interventions guidance. For qualitative studies, thematic synthesis was performed. Quality was assessed using Integrated quality Criteria for the Review Of Multiple Study designs (ICROMS) criteria. Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria was used to rate the overall level of evidence for individual outcome measures at either patient, prescriber, or hospital unit level.

Domain 1: Development	Domain 2: Feasibility & 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	*A 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 of 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*

Table 1. Framework for evaluation of clinical decision support systems reported in the literature

Results

Fifty-eight articles were included describing 38 CDSS. CDSS included were defined as conventional systems (incorporating guidelines, algorithms, and prompts) integrated with electronic medical records (24/38; 63%), intelligent (machine learning) systems (3/38; 8%), web based guidelines (3/38; 8%), pharmacokinetic tools (2/38; 5%), and other systems (6/38;16%). 11/38 (19%) CDSS were deployed in primary care and 27/38 (71%) in secondary care. Primary care CDSS tended to focus on single conditions, such as acute respiratory tract infections, whereas secondary care CDSS focused on empirical antimicrobial selection and prophylaxis in surgery.

CDSS studies failed to report consideration of the non-infection expert, end-user workflow, or routine decision making pathways. They focused on narrow aspects, such as antimicrobial selection, using proxy outcome measures that demonstrate significant outcomes at a hospital or prescriber level, whilst failing to demonstrate direct benefit to the patient. Engagement with CDSS by clinicians was poor.

CDSS characteristics		n = (%)
Types of decision support	Antibiotic prescribing	29 (76)
	Physician feedback	1 (3)
	Alerts / prompts	7 (18)
	Dose optimisation	3 (8)
	De-escalation	2 (5)
	Surveillance	2 (5)
CDSS Platform	Integrated into EMR	28 (74)
	On PDA device	3 (8)
	Web-based application	5 (13)
	Standalone software	2 (5)
System Attributes	Rule based*	29 (76)
	Causal Probabilistic Networks	1 (3)
	Drug-bug logic	1 (3)
	Pharmacokinetic modelling*	2 (5)
	Fuzzy cognitive mapping	1 (3)
	Guidelines	2 (5)
	Predictive models	1 (3)
	N/A	2 (5)

Table 2. Summary of clinical decision support system characteristics

	PRIMARY OUTCOME MEASURE	Total number	No achieving outcome	Quality of evidence
UNIT LEVEL	Disease specific antimicrobial prescribing rate (e.g. in total ARI visits)	6	3	H
	Rate of antimicrobial prescribing (drug e.g. DDD/1000 patient bed days)	3	3	M
	Economic benefit of CDSS	3	1	M
PATIENT	Mortality (e.g. 30 & 180 days)	1	1	L
	Patient specific complications (SSI's / ADE's / HCAI)	1	1	L
	Diagnostic accuracy e.g. Infection type (e.g. ARI / UTI), Predicting probability of blood stream infection, or predict causative organism	3	3	L
	Individualised dose optimisation	1	1	L
PRESCRIBER	Appropriate empirical prescribing – against subsequent bug sensitivity	3	3	H
	Individual changes in prescribing behaviour (including de-escalation)	4	4	M
	Adherence to local guidelines	9	7	M
	Appropriate prescribing – duration / timing of therapy	2	2	M
	Acceptance of CDSS	2	1	L
	Compliance with dosing guidance	2	0	-

Table 3. Summary of primary outcome measures reported in the literature

Discussion

The design of CDSS interventions must consider the factors influencing non-expert decision-making to ensure integration into routine workflow and promote engagement with these interventions. Future work must expand CDSS beyond simply selecting appropriate antimicrobials, instead integrating this aspect with dose optimisation, patient engagement, and surveillance mechanisms to provide personalised decision support. Developing clear and systematic reporting frameworks for CDSS interventions would address the identified gaps in the reporting of evidence for current CDSS.

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