Imperial College London

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

Timothy M Rawson¹, Luke SP Moore^{1,2}, Bernard Hernandez¹, Esmita Charani¹, Enrique Castro-Sanchez¹, Pau Herrero¹, Benedict Hayhoe¹, William Hope³,

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	E
Literature describing a system should	Literature describing a system should	Literature describing a system	L
demonstrate:	outline:	should demonstrate:	S
A definition of stakeholder behaviours	How pilot testing was performed and	Efficacy testing in a "real world"	Ŀ
that are being targeted and how stakeholders have been engaged with	the findings of this	setting	и
during the development phase	A understanding of the mechanism of behaviour change witnessed and how	High levels of control maintained to confirm internal validity of	S a
A rationale for how the intervention	the intervention may be having its	intervention	u
may influence these behaviours	effect		iı
		Confirm how the intervention	
An outline of how the system was		changes practice and quantify its	P
developed		impact	s
			s

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

Pantelis Georgiou¹, Alison H Holmes^{1,2}

UK: 2. Imperial College Healthcare NHS Trust, London, UK; 3. University of Liverpool, Liverpool, UK

Results

ain 4: Implementation Literature describing a system hould outline:

low it was tested in the real world with real-world providers

rategies for implementation ar option of intervention that we ed and how these may of npacted on observations

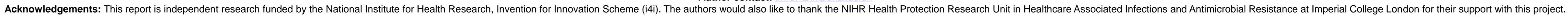
Plans for (or evidence of) long te surveillance / follow up of the

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	н
	Rate of antimicrobial prescribing (drug e.g. DDD/1000 patient bed days)	3	3	М
5	Economic benefit of CDSS	3	1	М
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	3	3	н
	sensitivity Individual changes in prescribing behaviour (including de- escalation)	4	4	М
	Adherence to local guidelines	9	7	М
	Appropriate prescribing – duration/timing of therapy	2	2	М
	Acceptance of CDSS	2	1	L
	Compliance with dosing guidance	2	0	-

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

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.

wson TM, Moore LS, Hernandez B, Charani E, Castro-Sanchez E, Herrero P, Hayhoe B, Hope W, Georgiou P, Holmes AH, A systematic review of clinical decisior port systems for antimicrobial management: Are we failing to investigate these interventions appropriately?, Clinical Microbiology and Infection (2017), doi: ecision support systems in improving antibiotic prescribing by primary care providers: a systematic Lehnbom EC, Li L, Hargreaves A, Day RO, Westbrook JI. The effectiveness of information technology to improve antimicrobial prescribing in hospitals: A matic review and meta-analysis. Int J Med Inform 2016;92:15–34. doi:10.1016/j.ijmedinf.2016.04.008



Discussion

