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Intervention planning for Antibiotic Review Kit (ARK): a digital and behavioural intervention to safely review and reduce antibiotic prescriptions in acute and general medicine

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Publication date

30-11-2019

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Document Version

Published version

Citation for this work (American Psychological Association 7th edition)

Santillo, M., Sivyer, K., Krusche, A., Mowbray, F., Jones, N., Peto, T. E. A., Walker, A. S., Llewelyn, M., & Yardley, L. (2019). *Intervention planning for Antibiotic Review Kit (ARK): a digital and behavioural intervention to safely review and reduce antibiotic prescriptions in acute and general medicine* (Version 2). University of Sussex. <https://hdl.handle.net/10779/uos.23306519.v2>

Published in

Journal of Antimicrobial Chemotherapy

Link to external publisher version

<https://doi.org/10.1093/jac/dkz333>

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SUPPLEMENTARY MATERIAL FOR

Intervention planning for the ARK (Antibiotic Review Kit) intervention: a digital and behavioural intervention to safely review and reduce antibiotic prescriptions in acute and general medicine.

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Supplementary Material

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Supplement 1 – Full description of the ARK (Antibiotic Review Kit) Intervention in accordance with the Template for Intervention Description and Replication (TIDieR) framework.

- 1. BRIEF NAME: ARK (Antibiotic Review Kit) Intervention
- 2. WHY: Reducing unnecessary antibiotic use is vital to protect patients from antibiotic resistant infections. At the same time, it is essential that patients with life-threatening infections get early and effective antibiotic treatment. UK Department of Health guidance “Start Smart then Focus” balances these priorities by recommending regular “review and revise” of all antibiotic prescriptions 48-72 hours after they are first written, with five actions: stop, continue, change (narrow/broaden), move from intravenous to oral formulations, or move to outpatient parental antimicrobial therapy (OPAT). Stopping unnecessary antibiotics at “review and revise” is one mechanism of reducing antibiotic exposure. Although hospital antibiotic stewardship programmes usually recommend “review and revise”, this has not always been well-implemented [1]. Where “review and revise” is not done well, many patients may stay on antibiotics after they cease to need them [1]. Barriers to “review and revise” are both behavioural and organisational. The goal of ARK is to safely reduce inappropriate use of antibiotics in order to reduce the risk of antimicrobial resistance through behavioural and organisational change. ARK focuses on the ‘*Then Focus*’ aspect of Antimicrobial Stewardship, with the aim of stopping unnecessary antibiotics early on.
- 3 & 4. WHAT: ARK is a complex behaviour change intervention that incorporates behavioural and organisational components. See Table S1 for an overview of the key intervention components of the ARK intervention. For more detail about specific intervention techniques, see the behavioural analysis in supplement 2. For an overview of the implementation plan of the intervention, see supplementary data 3.

Table S1: Overview of the key intervention components of the ARK intervention

Intervention components	Description
<i>For all staff</i>	
ARK online tool	<ul style="list-style-type: none"> • Evidence-based education and messages to increase motivation and competence to change or stop antibiotics <ul style="list-style-type: none"> ▪ Evidence on lack of harm from shorter antibiotic courses ▪ Evidence on harms from receiving longer antibiotic durations than necessary ▪ “Start Smart then Focus” and “review & revise” ▪ The roles of prescribers and non-prescribers in “review and revise” ▪ Summary of tools within the ARK intervention ▪ Definition, explanation and training in the use of the ARK decision-aid categories. This is a system for categorising antibiotic prescriptions based on risk of infection. Initial antibiotic prescriptions are

	<p>categorised as either ‘possible’ risk from infection (infection is less likely but antibiotics are being prescribed as a precaution) or ‘probable’ risk from infection (infection is likely but more information is required before finalising the diagnosis/treatment). At review, prescriptions are either stopped (no evidence of a continued need for antibiotics) or ‘finalised’ (decision made about final agent, route and duration).</p>
ARK Decision Aid	<ul style="list-style-type: none"> • Application of the ARK Decision Aid categories in clinical practice at initial prescription (included on the drug chart or e-prescribing)
Data collection and regular and supportive discussions with clinical teams	<ul style="list-style-type: none"> • Regular and supportive team-based audit and feedback around levels of “review and revise”, use of the decision aid, rates of stopping antibiotics and any problems with implementing these procedures to support staff to maintain implementation
ARK patient leaflet (included on online training, evidence, and resources website)	<ul style="list-style-type: none"> • A leaflet for patients explaining the risks of antibiotics (i.e. side effects, antibiotic resistance), the rationale for “review and revise”, the fact that their antibiotics may be stopped, and safety-netting advice (to alert clinician/re-consult if symptoms worsen)
<i>For the implementation team</i>	
Implementation guidance	<ul style="list-style-type: none"> • Detailed documentation to support the implementation of ARK, with information about the 7 implementation phases (with the last phase focusing on sustainability) and main steps to take
ARK data collection tool	<ul style="list-style-type: none"> • An excel spreadsheet tool to collect audit data on rates of review, use of the decision aid, rates of stopping antibiotics that automatically produces summary tables and graphs
ARK resources website	<ul style="list-style-type: none"> • Examples of implementation, and example materials and templates to support local implementation
ARK champion email list and teleconferences	<ul style="list-style-type: none"> • Peer-to-peer teleconferences /email list for ARK Champions (site leads) and implementation teams at different sites to share progress and solve any planning/ongoing implementation issues
<ul style="list-style-type: none"> • 5. WHO PROVIDED: ARK will be supplied to hospitals by the ARK Research Team. Hospital sites will then be responsible for the local implementation of ARK. This process will be led by a local ARK Champion with their local implementation team (the ‘ARK implementation team’), comprising existing Antimicrobial Stewardship (AMS) leads and AMS committee members, and other relevant members of the clinical staff team (e.g. consultant and trainee physicians, microbiologists or infection specialists, antimicrobial pharmacists, senior members of nursing staff). Implementation targets are primarily physicians (senior and junior) but also include pharmacists and nurses. 	

- 6. HOW: The ARK intervention includes both online and face-to-face components, together with implementation guidance which details 7 phases of implementing and sustaining ARK. The implementation team will be given access to all the online components by the ARK Research Team. Other staff will be given access to the relevant online elements by their implementation team, who will also provide them with information about how ARK will be implemented locally. The latter will be delivered face-to-face, but likely will be supported with written information (depending on local implementation). Staff will be supported on an ongoing basis through face-to-face meetings by their implementation team.
- 7. WHERE: ARK is intended for implementation in acute/general medical inpatients in hospitals (secondary care), but particularly in wards that prescribe anything other than stat (one-off) doses of antibiotics (e.g. acute medical units, elderly medicine/gastroenterology/respiratory wards). The online components will be accessed via computers and phones.
- 8. WHEN and HOW MUCH: The implementation team will be given access to all the online components of the intervention three months prior to their implementation start date to enable them to plan their local implementation of ARK following the implementation guidance. Other staff will be given access to the relevant online elements by their implementation team approximately two weeks before implementation starts, along with information about how ARK will be implemented locally. Application of the ARK decision aid categories should occur at initial prescription of antibiotics, with “review and revise” occurring within 48-72 hours of initial prescription. Team discussions around ARK should occur on a weekly basis in the first month of implementation, changing to fortnightly in the second month, and monthly thereafter during the 12 weeks over which implementation is planned. Subsequently this should occur at least quarterly, but can be less frequent if ARK is going well, or more frequent if it is going less well.
- 9. TAILORING: Whilst the implementation behavioural/organisational elements of ARK will be implemented in all hospitals, the exact manner of their implementation will be decided by the hospital’s implementation team so that it is adapted in a way that best fits local needs. For example, the Decision Aid will be implemented differently in hospitals with e-prescribing compared to paper drug charts.
- 10. MODIFICATIONS: Minor modifications were made to the implementation guidance following qualitative feedback from a feasibility study. Additional example materials are added to the resources website as new sites implement ARK but this is driven by the hospitals themselves, not the research team.
- 11. HOW WELL: The intervention has already been tested in a feasibility trial and piloted in three other hospitals. It is currently being tested in a randomised controlled trial of an additional 33 hospitals. Information about the results of these trials, including both quantitative and qualitative data, will be presented in future publications.

References

- 1 Llewelyn MJ, Hand K, Hopkins S, *et al.* Antibiotic policies in acute English NHS trusts: Implementation of ‘Start Smart-Then Focus’ and relationship with *Clostridium difficile* infection rates. *J Antimicrob Chemother* 2014;70:1230–5.
doi:10.1093/jac/dku515

Supplement 2: Full behavioural analysis of the ARK Intervention using the Behaviour Change Wheel (BCW) and Behaviour Change Techniques Taxonomy (BCTv1)

Overall, the intervention targeted five out of six BCW target constructs (psychological capability, reflective motivation, automatic motivation, physical opportunity, social opportunity), six out of nine intervention functions (training, enablement, environmental restructuring, persuasion, education, incentivisation), and used 10 out of 19 different types behaviour change techniques (goals and planning, feedback and monitoring, social support, shaping knowledge, natural consequences, comparison of behaviour, associations, and reward and threat). See Table S2.

Table S2: Overview of the key intervention components of the ARK intervention

Key: HCP=Health Care Professional; * = Applicable to implementation team only; EO = Barrier emerged from expert opinion; SW=Barriers emerged from stakeholder workshop (#indicates which workshop); + = intervention components and BCTs identified through deductive analysis

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
Target behaviour: Effective “Review and Revise” (stopping unnecessary antibiotics)						
HCPs have contrasting Trust priorities for antibiotic prescriptions based on national and local guidelines [EO; SW1]	Online tool; kick-off meetings	<ul style="list-style-type: none"> Acknowledge that there are contrasting priorities when prescribing antibiotics (e.g. the need to reduce antibiotic use vs. the need to ensure all patients with life-threatening conditions receive the antibiotics they need quickly) Provide a rationale for doing “review and revise” and stopping antibiotics at “review and revise”, including information about existing guidelines for “review and revise” and how they complement different guidelines (e.g. surviving sepsis, start smart and focus) 	↑ Knowledge	Psychological capability; Reflective motivation	Education; Persuasion	5.1. Information about health consequences 5.3. Information about social and environmental consequences

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
<p>HCPs do not know how to perform “review and revise”: There isn’t a system in place in every hospital about how to review and what there is differs [EO; SW1]</p> <p><i>It would be helpful to have clinical scenarios on the online tool to practice using the decision aid</i> [SW3]</p>	Online tool	<ul style="list-style-type: none"> Provide guidelines for when “review and revise” should take place (48-72 hours) based on ‘start smart, then focus’, including information about need for senior input into decisions to stop antibiotics and how different HCP groups can support safe and effective stopping of antibiotics at “review and revise” 	↑ Knowledge	Psychological capability	Education	4.1. Instructions on how to perform a behaviour
	Online tool; kick-off meetings; discussion meetings	<ul style="list-style-type: none"> Provide a decision aid tool that will support prescribers to manage different priorities and guidelines by recording why each prescription was made initially Provide instructions for how to use the decision aid Provide and discuss clinical examples for how to use decision aid Provide interactive quiz to practice using decision aid Identify and discuss potential barriers and solutions to “review and revise” 	↑ Skills	Psychological capability	Training; Enablement	1.2. Problem solving 4.1. Instructions on how to perform the behaviour 6.1. Demonstration of the behaviour 8.1. Behavioural practice/rehearsal
	Implementation guidance*; resources website*	<ul style="list-style-type: none"> Prompt use of decision aid tool categories at initial prescription and review (e.g. in drug chart) Provide materials (e.g. posters, drug charts) that can be used to support “review and revise” 	↑ Environmental constructs and resources	Physical opportunity; Automatic motivation	Environmental restructuring; Persuasion; Enablement;	7.1. Prompts/cues 8.1. Behavioural practice / rehearsal 8.3. Habit formation 12.5. Adding objects to the environment
	Kick-off meetings; discussion meetings	<ul style="list-style-type: none"> Provide kick-off meetings and ongoing discussion meetings to discuss “review and revise” and using the decision aid, including identifying potential barriers and solutions 	↑ Social influences (social support)	Social opportunity	Environmental restructuring; Enablement	3.1. Social support (unspecified)

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
HCPS are not sure if they are allowed to change the prescriptions or are concerned about changing prescriptions when they do not know why they were prescribed initially (lack of confidence) [EO; SW1]	Kick-off meetings; discussion meetings	<ul style="list-style-type: none"> • Provide a rationale for stopping antibiotics at “review and revise”, including information about existing guidelines for “review and revise” and how they complement different guidelines (e.g. surviving sepsis, start smart and focus) • Provide a rationale acknowledging the presence of diagnostic uncertainty in the initial antibiotic prescription and how this relates to stopping antibiotics at review and revise • Explain ARK targets for “review and revise”, rates of stopping, and ARK decision aid, linking to relevant targets (e.g. Commissioning for Quality and Innovation (CQUIN) national goals 	↑ Knowledge	Psychological capability	Education; Enablement	1.1. Goal setting (behaviour) 1.3. Goal setting (outcome) 5.1. Information about health consequences 5.3. Information about social and environmental consequences

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
	Online tool; kick-off meetings; discussion meetings	<ul style="list-style-type: none"> • Provide Decision Aid tool categories to support antibiotic prescribing decisions that acknowledges and documents the presence of diagnostic uncertainty at initial prescription and explains how this might relate to changing or stopping antibiotics at review • Provide examples for when an antibiotic should be changed or stopped • Provide meetings to discuss “review and revise” and use of the decision aid, including case studies • Discuss potential barriers and solutions to implementing them effectively 	↑ Skills	Psychological capability	Training	1.2. Problem solving 4.1. Instructions on how to perform a behaviour
	Kick-off meetings; discussion meetings	<ul style="list-style-type: none"> • Provide meetings to discuss “review and revise” and how it is being implemented locally 	↑ Social influences (social support)	Social opportunity	Environmental restructuring; Enablement	3.1. Social support (unspecified)
	Resources website*	<ul style="list-style-type: none"> • Provide example materials (e.g. posters, information sheets) to ensure ARK is well publicised across a range of staff groups and grades 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	7.1. Prompts / cues
Senior colleagues may not support HCPs to do the review, do not perform the review, or perform it in a different way	Online tool; kick-off meetings	<ul style="list-style-type: none"> • Provide guidance on how senior colleagues (e.g. consultants, ST3+) should be involved in decisions to stop antibiotics at “review and revise” 	↑ Skills	Psychological capability; Reflective motivation	Education; Training	4.1. Instructions on how to perform a behaviour

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
[EO; SW1]	Discussion meetings	<ul style="list-style-type: none"> • Provide ongoing meetings for the whole team to discuss stopping antibiotics at “review and revise” and use of the decision aid to support consistent practice • Promote stopping antibiotics at “review and revise” across a range of staff groups and grades in the wider clinical team 	↑ Social influences	Social opportunity	Environmental restructuring; Enablement	3.1. Social support (unspecified)
HCPS are not formally encouraged to conduct “review and revise”[EO; SW1]	Kick-off meetings; discussion meetings	<ul style="list-style-type: none"> • Set targets for “review and revise”, rates of stopping antibiotics, and use of the decision aid 	↑ Intentions	Reflective motivation	Persuasion; Enablement	1.1. Goal setting (behaviour) 1.3. Goal setting (outcome)
	Kick-off meetings	<ul style="list-style-type: none"> • Provide information about how the Trust is performing at “review and revise” and rates of stopping, and how this compares to other Trusts and national targets+ 	↑ Social influences	Social opportunity	Persuasion Enablement	6.3. Social comparison
	Discussion meetings	<ul style="list-style-type: none"> • Provide tailored advice and encouragement (at a team level) about progress towards targets for “review and revise”, stopping, and use of the decision aid (based on data collection)+ 	↑ Beliefs about capabilities	Reflective motivation	Persuasion; Enablement	1.6. Discrepancy between current behaviour and goal 2.2. Feedback on behaviour 2.7. Feedback on outcome(s) of behaviour 5.3. Information about social and environmental consequences

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
<i>Patients accept the review decision:</i> <i>HCPs will be confident to address any concerns patients may have.</i> [EO; SW1]	Patient leaflet	<ul style="list-style-type: none"> Provide a patient leaflet that HCPs can give to patients or use to facilitate discussion with their patients to explain the “review and revise” process, that this might lead to their antibiotics being stopped, and address any concerns might have about it 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	12.5. Adding objects to the environment
HCPs may believe that “review and revise” could cause more harm than good (e.g. confusion, less effective treatment) [EO; SW1; SW2]	Online tool; Patient leaflet	<ul style="list-style-type: none"> Provide a rationale for stopping antibiotics at “review and revise” Provide information about shorter vs. longer courses of antibiotic for common infections 	↑ Knowledge	Psychological capability; Reflective motivation	Education; Persuasion	5.1. Information about health consequences
	Online tool; kick-off meetings	<ul style="list-style-type: none"> Provide information about negative health consequences of continuing antibiotics longer than necessary Provide evidence for effectiveness of shorter vs. longer antibiotic durations 	↑ Positive beliefs about consequences of ‘review & revise	Psychological capability; Reflective motivation	Persuasion; Education	5.3. Information about social and environmental consequences
	Patient leaflet	<ul style="list-style-type: none"> Provide a patient leaflet that HCPs can give to patients explaining what patients can expect from the “review and revise” process and what to do if their symptoms return (“safety-netting”) 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	12.5. Adding objects to the environment
HCPs may believe that stopping antibiotics before a course is finished could encourage resistance [EO; SW2]	Online tool	<ul style="list-style-type: none"> Provide information about the relationship between antibiotic use and antibiotic resistance 	↑ Knowledge	Psychological capability; Reflective motivation	Education; Persuasion	5.1. Information about health consequences

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
It may be hard to sustain “Review and Revise” as a priority in competition with other ward-round decisions. [EO; SW1; SW2]	Implementation guidance*; resources website*; discussion meetings	<ul style="list-style-type: none"> • Incorporate decision aid categories into local practice (e.g. as options within drug chart or electronic prescribing system) • Provide materials that support and prompt “review and revise” in the short and long-term (e.g. information sheets, posters) 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	12.5. Adding objects to the environment
		<ul style="list-style-type: none"> • Provide feedback and encouragement on progress towards targets for “review and revise”, stopping, and use of the decision aid (based on data collection)+ • Congratulate clinical staff on progress towards targets 	↑ Positive beliefs about consequences of ‘review & revise	Psychological capability; Reflective motivation; Automatic motivation	Persuasion; Incentivisation	1.6. Discrepancy between current behaviour and goal 2.2. Feedback on behaviour 2.7. Feedback on outcome(s) of behaviour 5.3. Information about social and environmental consequences 10.4. Social reward

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
There may be persisting diagnostic uncertainty at 48-72 hours (e.g. test results not available, not clinically clear if a patient is better because they are on antibiotics or because they never had an infection) [EO; SW1; SW2]	Online tool; discussion meetings	<ul style="list-style-type: none"> • Provide case examples on how to do “review and revise” using the decision aid, including examples of both observational and diagnostic information that might be used to inform the decision to stop • Provide interactive quiz to practice using decision aid • Discuss real case examples and how the decision aid could be applied and potential ‘review and revise’ decisions • Provide the opportunity to discuss difficult case examples • Identify and discuss potential barriers and solutions 	↑ Skills	Psychological capability; Reflective motivation	Education; Training	1.2. Problem solving 4.1. Instructions on how to perform a behaviour 6.1. Demonstration of the behaviour 8.1. Behavioural practice/rehearsal
	Kick-off meetings; discussion meetings	<ul style="list-style-type: none"> • Provide kick-off meetings and ongoing discussion meetings to discuss “review and revise” and using the decision aid 	↑ Social influences (social support)	Social opportunity	Education; Environmental restructuring; Enablement	3.1. Social support (unspecified)
Target behaviour: Effective implementation*						
Lack of confidence in ability to implement ARK / Belief that ARK won’t work [EO]	Implementation guidance*; resources website*	<ul style="list-style-type: none"> • Provide empowerment user stories / quotes about how easy HCP have found it to implement ARK processes* • Support action planning for implementation through providing detailed implementation guidance about timing and activities of implementation* 	↑ Beliefs about capabilities	Reflective motivation	Persuasion; Enablement	1.4. Action planning 5.3. Information about social and environmental consequences 9.1. Credible source

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
		<ul style="list-style-type: none"> Provide positive user stories/quotes about the outcomes of ARK* 	↑ Positive beliefs about consequences of 'review & revise'	Psychological capability; Reflective motivation	Persuasion	5.3. Information about social and environmental consequences
Concerns about how new ARK Champions would be trained, how ARK Champions could be updated about new developments in the long-term, and staff turnover [SW2; SW3]	Implementation guidance	<ul style="list-style-type: none"> Support action planning for sustainability of ARK through guidance about how to sustain ARK in the long-term (e.g. planning handover in the event of staff change, embedding ARK in practice)* 	↑ Beliefs about capabilities	Reflective motivation	Persuasion; Enablement	1.4. Action planning
	Resources website	<ul style="list-style-type: none"> Provide 'examples materials' section in resources website where ARK Champions can share resources they developed* 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	12.5. Adding objects to the environment
	ARK Champion Network	<ul style="list-style-type: none"> Provide email list and teleconferences for ongoing peer-to-peer support (including sites at various stages of implementation)* 	↑ Social influences (social support)	Social opportunity	Enablement	3.2 Social support (practical)
Concerns that undertaking the ARK intervention "review and revise" procedures will be too burdensome and hard to sustain [EO; SW1; SW2] <i>Integration into existing</i>	Implementation guidance*	<ul style="list-style-type: none"> Provide instructions for how to integrate ARK into existing processes and practice* Provide instructions about how to embed "review and revise" within the organisation (for example, by obtaining board level support, making the Online tool part of mandatory training)* 	↑ Skills	Psychological capability	Education; Training	4.1. Instructions on how to perform a behaviour

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
<i>practice</i> [EO; SW1] <i>Provide selection of implementation methods / resources</i> [EO; SW1]	Data collection tool*; resources website*	<ul style="list-style-type: none"> • Provide an electronic data collection tool to support monitoring rates of “review and revise” and use of the decision aid to give feedback to staff on progress towards targets* • Provide example materials that can be used to support “review and revise” in the short and long-term (e.g. examples of changes that could be made to drug charts)* 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	12.5. Adding objects to the environment
	ARK Champion Network*	<ul style="list-style-type: none"> • Provide ARK Champion Network for ARK Champions to share their resources and advice about how they could implement ARK* 	↑ Social influences (social support)	Social opportunity	Enablement	3.2 Social support (practical)
Difficulties communicating with different teams about ARK [SW2]	Implementation guidance	<ul style="list-style-type: none"> • Provide more detail about who should be included in the ARK implementation team to maximise access to different staff groups and grades* • Emphasise the role of mapping patient flow to identify which teams need to be targeted in ARK* • Add tips and examples for how to publicise ARK and organise kick-off meetings* 	↑ Skills	Psychological capability	Education; Training	4.1. Instructions on how to perform a behaviour
	Resources website	<ul style="list-style-type: none"> • Provide example materials that can be used to promote ARK (e.g. email templates, posters)* 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	12.5. Adding objects to the environment

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
Undertaking weekly discussion meetings will be challenging [SW2; SW3]	Implementation guidance	<ul style="list-style-type: none"> • Provide rationale for ongoing feedback* 	↑ Positive beliefs about consequences of weekly discussion meetings	Psychological capability; Reflective motivation	Persuasion	5.3. Information about social and environmental consequences
		<ul style="list-style-type: none"> • Provide advice for how to integrate feedback meetings into existing practice (e.g. ward rounds)* • Provide information about who might give feedback/organising feedback • Provide information about how to give feedback* 	↑ Skills	Psychological capability	Education; Training	4.1. Instructions on how to perform a behaviour
Belief that staff will not accept the online training, will view it negatively, or will not complete the online training before kick-off meetings (e.g. that it will have little benefit in increasing their skills, will take a long time to do) [EO; SW1]	Online training	<ul style="list-style-type: none"> • Provide updates regarding completion of online training by key members of staff identified by ARK Champion* • Provide a certificate of completion as incentive (with logos of key bodies endorsing ARK e.g. BSAC) 	↑ Positive beliefs about consequences of 'review & revise	Psychological capability; Reflective motivation; Automatic motivation	Persuasion; Incentivisation	1.6. Discrepancy between current behaviour and goal 2.2. Feedback on behaviour 10.1. Material incentive (behaviour) 10.2. Material reward (behaviour)

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
	Implementation guidance*	<ul style="list-style-type: none"> • Provide instructions about how to embed the online training into local development activities (e.g. appraisals, induction, mandatory training)* • Discuss including ARK in local antimicrobial stewardship policies* • Provide instructions about how and when to promote completion of the Online tool with staff, including how long it will take to complete (10 minutes), what clinical organisations recognise/endorse it, and that staff will receive a certificate for completion* • Advise champions to allow time for completing the online training during the kick-off meeting* 	↑ Skills	Psychological capability	Education; Training	4.1. Instructions on how to perform a behaviour
	Resources website*	<ul style="list-style-type: none"> • Provide example materials that can be used to promote the Online tool (e.g. email templates)* 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	12.5. Adding objects to the environment
Difficulties incorporating categories into practice; drug charts can take a long time to change, hospitals are moving to e-prescribing [SW2; SW3]	Implementation guidance	<ul style="list-style-type: none"> • Provide suggestions for how the ARK categories could be incorporated into practice e.g. write categories in notes, stickers, modify drug charts, suggestions for e-prescribing* • Provide a ‘barriers and solutions’ template to identify, discuss, and find potential solutions to barriers, including a couple of examples* • Suggest using other resources prompting using of the Decision Aid (i.e. posters)* • Recommend piloting in phase 2* 	↑ Skills	Psychological capability	Education; Training	4.1. Instructions on how to perform a behaviour 8.1. Behavioural practice/rehearsal

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
	Resources website	<ul style="list-style-type: none"> Provide examples and example materials for how other hospitals have incorporated the Decision Aid categories into practice* 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	12.5. Adding objects to the environment
Senior colleagues may not support HCPs to do the review, do not perform the review, or perform it in a different way [EO; SW1]	Implementation guidance*	<ul style="list-style-type: none"> Provide instructions on who should be a member of the implementing team and key members of staff who should be involved early on in implementation (including both senior and junior level staff from different staff groups e.g. doctors, nurses, pharmacists)* Provide instructions and examples of how to promote “review and revise” across a range of staff groups and grades in the wider clinical team* 	↑ Skills	Psychological capability	Education; Training	4.1. Instructions on how to perform a behaviour
	Resources website*	<ul style="list-style-type: none"> Provide example materials that can be used to promote ARK and its “review and revise” procedures (e.g. introductory email templates, posters, information sheets)* 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	12.5. Adding objects to the environment
Concerns about how to do data collection [SW2]	Implementation guidance	<ul style="list-style-type: none"> Provide a rationale for data collection and emphasise that data collection is to support implementation* 	↑ Positive beliefs about consequences of weekly discussion meetings	Psychological capability; Reflective motivation	Persuasion	5.3. Information about social and environmental consequences
		<ul style="list-style-type: none"> Provide additional information about how to do the audits, including what data should be collected, how, and when* Recommend piloting in phase 2* 	↑ Skills	Psychological capability	Education; Training	4.1. Instructions on how to perform a behaviour 8.1. Behavioural practice/rehearsal

Barriers / <i>facilitators</i> to target behaviours	Intervention Component/s	Intervention ingredient	Theoretical Domains Framework (TDF)	Target construct (BCW)	Intervention function (BCW)	BCT (using 93 BCT taxonomy v1)
	Data collection tool	<ul style="list-style-type: none"> Provide a spreadsheet tool to facilitate data collection, including automatic summary tables and graphs to facilitate comparison to targets and progress since baseline* 	↑ Environmental constructs and resources	Physical opportunity	Environmental restructuring	12.5. Adding objects to the environment

Supplement 3 – Overview of Phases of Implementation

Implementation team

The implementation team is led by a local ‘ARK Champion’, chosen from the antimicrobial stewardship team by its members. The ARK Champion should form an implementation team (8-10 individuals) to support the planning and implementation of ARK. This team should include a range of staff groups (doctors, pharmacists, nurses) and grades (junior and senior staff) to better support implementation throughout the hospital. In addition to the implementation team, ARK Clinical Team Leads should be nominated to support implementation in their own clinical teams once implementation starts.

Phases of Implementation

There are seven phases of implementation, counting down from a period of 3-4 months prior to the start of implementation (see Figure 1), and four key activities, which are identified as being integral to ARK. These are;

- Completion of the ARK online tool by prescribers and other relevant staff involved in managing antibiotics such as pharmacists and nurses, to introduce current guidelines and evidence for shorter vs. longer antibiotic durations, and how and why to implement the ARK decision aid categories
- Application of the ARK decision aid categories at initial prescription to help clarify why antibiotics were initially prescribed, so that prescribers can feel more confident about stopping antibiotics at review when appropriate
- Data collection to check how ARK is being implemented to identify early on any problems with implementation. This includes monitoring use of the decision aid categories at initial prescription and rates of stopping antibiotics at review
- Regular, supportive discussion with the wider clinical team about how ARK is being implemented to help the clinical team implement ARK effectively and address any problems with implementation early on. These discussions are informed by the data collection.

Each phase of implementation is designed to support planning and embedding these activities into clinical practice.

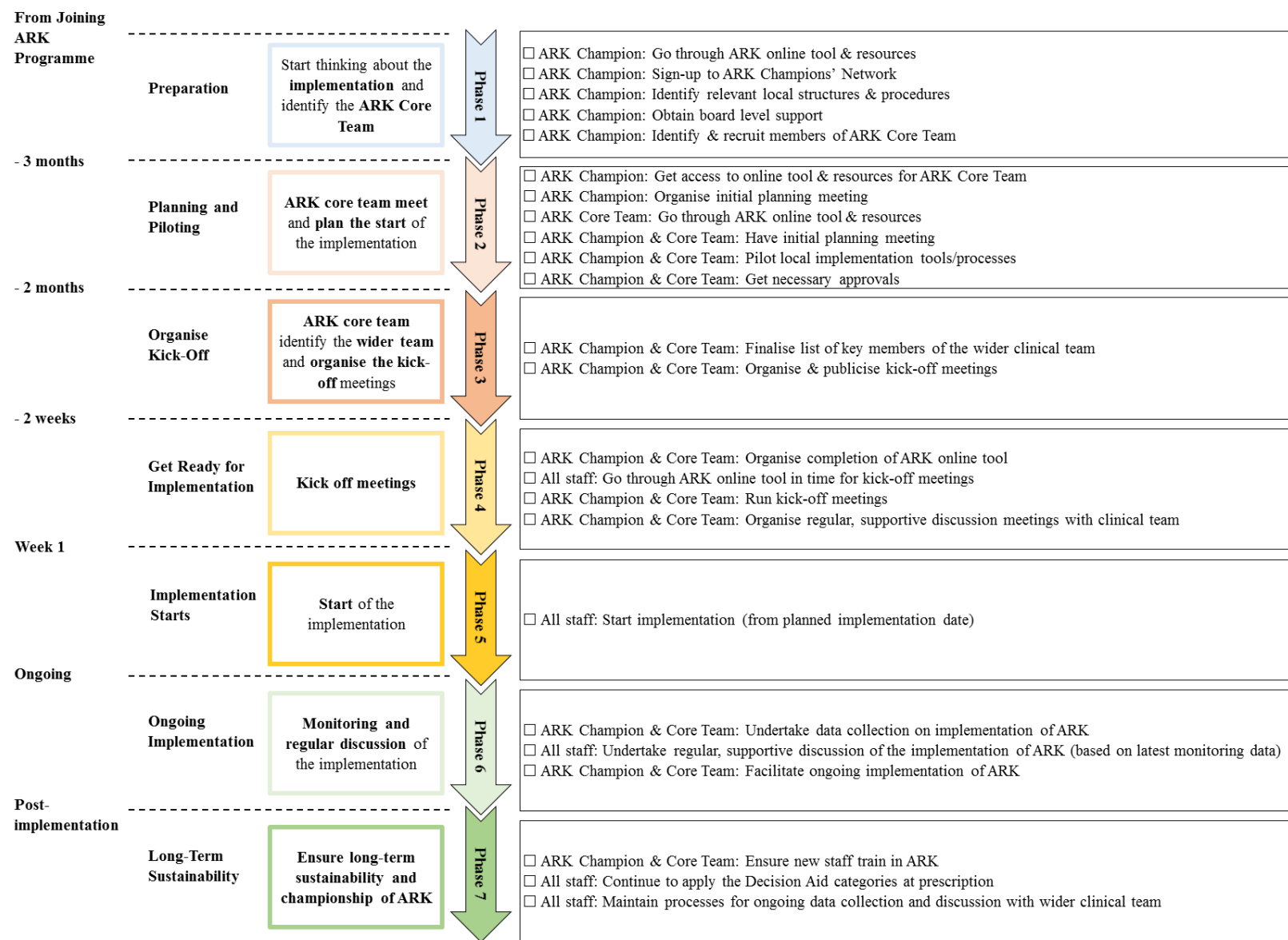


Figure 1: Summary of the ARK intervention phases of implementation

Phase 1: Preparation [From Joining ARK Programme]

Phase 1 involves preparing the ARK Champion for their role in ARK. The key tasks in this phase involve the ARK Champion;

- a) Familiarising themselves with ARK and the resources it provides by completing the online tool, reading the implementation guidance and reviewing the materials on the resources website
- b) Familiarising themselves with relevant local procedures, including identifying; where antibiotic prescribing decisions are made (where, who by, when), what local guidelines are, and current rates of 'review and revise' in the hospital
- c) Starting to consider how ARK might be adapted to fit locally, and what potential barriers and solutions might be
- d) Recruiting the ARK implementation team

Phase 2: Planning and Piloting [3 Months before Implementation]

Phase 2 involves the detailed planning and piloting of how ARK will be adapted locally by the ARK Champion and the ARK implementation team. Key tasks in this phase involve;

- a) Familiarising the ARK implementation team with ARK and the resources it provides by completing the online tool, reading the implementation guidance and reviewing the materials on the resources website
- b) Planning how ARK will be adapted locally, including; promoting the online tool and planning kick-off meetings, discussing how to implement the decision aid, and what potential barriers and solutions might be, planning data collection, and planning regular, discussion with the clinical teams
- c) Testing and finalising local implementation processes
- d) Getting necessary approvals for integrating ARK tools into practice (i.e. the online tool, the ARK decision aid, the patient leaflet)

Phase 3: Organise Kick-Off [2 Months before Implementation]

Phase 3 involves preparing the clinical team for kick-off. Key tasks include;

- a) Identifying key members of the wider clinical team who need to be involved in ARK. These are the people who will be engaged and willing to help implement ARK in their own clinical teams.
- b) Organising and publicising the kick-off meetings that will tell staff about how ARK will be adapted locally

Phase 4: Get Ready for Implementation [2 Weeks before Implementation]

Phase 4 involves preparing the clinical team to start implementing ARK. Key tasks include;

- a) Promoting the online tool and getting staff to complete it prior to the kick-off meetings
- b) Running the kick-off meetings, including; introducing ARK, checking that staff have completed the online tool, explaining how ARK will be adapted locally, explaining how ARK will be monitored and targets for 'review and revise' / use of the decision aid categories, and discussing potential barriers and solutions
- c) Arranging regular discussion meetings with the clinical team about how ARK is being implemented (based on data collection)

Phase 5: Implementation starts [Week 1]

Phase 5 is the start of the main 12 week implementation phase. All staff should be applying the decision aid as part of routine clinical practice from this point onwards.

Phase 6: Ongoing implementation [Week 1 Onwards]

Phase 6 concerns the ongoing implementation of ARK by the ARK Champion and implementation team. Key tasks during the main 12 week implementation phase include;

- a) Undertaking regular data collection, initially on a weekly basis, and then gradually moving to monthly to monitor; use of decision aid categories, rates of review and stop, progress compared to baseline, progress towards targets
- b) Facilitating regular, supportive discussion with the clinical team about how ARK is being implemented (based on data collection), including what's going well, what could be improved, and example case studies
- c) Holding regular meetings with the ARK implementation team to monitor how ARK is being implemented and address any problems that arise
- d) Ensuring the continuity of ARK (training new staff, managing handover in the event of staff changeover)

Phase 7: Long-term sustainability [Week 13 Onwards]

Phase 7 concerns the long-term sustainability of ARK by the ARK Champion and implementation team to ensure that ARK is embedded in antibiotic prescribing practice in the long-term, so that it becomes a routine part of patient management. Key tasks include;

- a) Ensuring that new staff complete the online tool, ideally as part of ongoing learning and development
- b) Ensuring that staff continue to apply the decision aid at prescription, ideally by getting the ARK decision aid incorporated into the Trust's drug chart / electronic prescribing system
- c) Maintaining processes for ongoing data collection and discussion with the wider clinical team, ideally undertaking data collection at least quarterly and more frequently if ongoing maintenance and use of the ARK intervention is going less well
- d) Ensuring ongoing championship of ARK by the local antimicrobial stewardship team, with an ARK champion as an ongoing role within the team