



ELSEVIER

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin



Investigating clinicians' determinants of antimicrobial prescribing behaviour using the Theoretical Domains Framework

H. Talkhan^a, D. Stewart^b, T. McIntosh^a, H. Ziglam^c, P.V. Abdulrouf^d,
M. Al-Hail^d, M. Diab^b, S. Cunningham^{a,*}

^a School of Pharmacy and Life Sciences, Robert Gordon University, Aberdeen, UK

^b College of Pharmacy, QU Health, Qatar University, Doha, Qatar

^c Infectious Diseases Department, Hamad General Hospital, Hamad Medical Corporation, Doha, Qatar

^d Pharmacy Department, Women's Wellness and Research Center, Hamad Medical Corporation, Doha, Qatar

ARTICLE INFO

Article history:

Received 24 November 2021

Accepted 13 January 2022

Available online 22 January 2022

Keywords:

Anti-bacterial agents

Anti-infective agents

Inappropriate prescribing

Therapeutics

Behavior

Theory



SUMMARY

Aim: To identify and quantify potential determinants of antimicrobial prescribing behaviour, using the Theoretical Domains Framework (TDF).

Methods: A cross-sectional survey involving doctors (~4000) and pharmacists (~400) working within Hamad Medical Corporation (HMC), Qatar. An online questionnaire, developed with reference to the TDF, included: personal and practice demographics, and Likert statements on potential determinants of antimicrobial prescribing practice. Analysis included principal component analysis (PCA), descriptive and inferential statistics.

Results: In total, 535 responses were received, 339 (63.4%) from doctors. Respondents were predominantly male, 346 (64.7%). Just over half ($N = 285$, 53.3%) had ≤ 5 years' experience. PCA showed a three-component (C) solution: 'Guidelines compliance' (C1), 'Influences on practice' (C2) and 'Self-efficacy' (C3). The scales derived for each component had high internal consistency (Cronbach's alphas > 0.7), indicating statistical appropriateness for developing scales. Respondents generally scored highly for 'Guidelines compliance' and 'Self-efficacy'. The lowest levels of positive scores were in relation to the items within the 'Influences on practice' component, with particular focus on TDF domains, environmental context and resources, and social influences. Inferential analysis comparing component scores across demographic characteristics showed that doctors, the more qualified and those with greater experience, were more likely to be positive in responses.

Conclusions: This study has identified that environmental context and resources, and social influences, with an emphasis on pharmacists and early career clinicians, may be useful targets for behaviour change interventions to improve clinicians' antimicrobial prescribing, thereby reducing antimicrobial resistance rates. Such interventions should focus on appropriate linked behaviour-change techniques.

© 2022 The Healthcare Infection Society. Published by Elsevier Ltd. All rights reserved.

* Corresponding author. Address: School of Pharmacy and Life Sciences, Robert Gordon University, Aberdeen, AB107GJ, UK. Tel.: +44 1224 262533.

E-mail address: s.cunningham@rgu.ac.uk (S. Cunningham).

Introduction

Antimicrobial resistance (AMR) is a global threat to public health, with many countries implementing antimicrobial stewardship (AMS) interventions [1–4]. Although AMS can be effective, interventions often fail to consider the determinants of antimicrobial prescribing behaviour (APB) [5,6] which vary within and across countries, practice settings and professions [7,8]. Systematic reviews in different practice settings [9–15] provide evidence that APB is influenced by determinants, such as uncertainty over diagnosis, indication or management [9–11], pressure by patients or carers [9,10,12,15], clinicians' underlying emotions and beliefs [12–14], and social norms [5,10,13,14]. However, these systematic reviews show a lack of consideration of behavioural science.

Behavioural science shows that theories provide a useful basis for developing and evaluating interventions which aim to change human behaviour [16,17]. Theories can be used to understand behavioural determinants and so select behaviour change interventions (BCIs) [18]. Theories also offer an efficient way of generalizing research findings across different types of participants and settings [20] and help frame research aims/questions, identify the methodological stance, design data collection/generation tools and consider frameworks for data analysis/interpretation [19]. Specific criteria for theory selection have been proposed and this has helped promote more consistent and appropriate use of theory [21]. In view of this, the UK Medical Research Council (MRC) guidance on 'Developing and implementing complex interventions' includes the need to establish a theoretical basis for interventions [22].

Despite this, a systematic review by Talkhan *et al.* [23] demonstrated that there is no optimal use of theory to inform the design and choice of interventions in antimicrobial prescribing. It yielded only 10 peer-reviewed studies to October 2018 [23]. Given this, it is challenging to interpret why interventions have had positive or negative outcomes. A key limitation reported is that the majority of studies originated from Western primary care ($N = 9$), targeting respiratory tract infections ($N = 8$). The findings of these studies cannot necessarily be generalized or translated to other settings due to the differences in healthcare systems, processes and cultures. Another limitation reported is that the main profession targeted was medical doctors ($N = 10$), despite the role of other healthcare professionals in prescribing for respiratory conditions and infections [24]. There is, therefore, a need to systematically research determinants of antimicrobial prescribing, using a robust theoretical approach.

The 2030 National Vision by the Qatari government aims for 'a comprehensive world-class healthcare system, designed to meet the needs of the State's fast-growing population' [25,26]. The National Health Strategy targets for 2022 include decreasing AMR [27]. An AMS programme has been implemented across Qatar including Hamad Medical Corporation (HMC) [28–30]. This aims to improve antimicrobial prescribing practice and AMR. An infectious disease (ID) doctor and pharmacist are responsible for the programme at each hospital [29]

and local antimicrobial prescribing guidelines have been available on HMC's intranet since 2006. Yet, research shows that there are some challenges relating to AMS implementation in Qatar, including clinicians' APB [29,31–35].

To ensure a better understanding of APB and to improve the quality of interventions in this area, emphasis should be placed on systematically using theory to identify behavioural determinants of prescribing before/implementing new interventions [5,36]. The aim of this study was, therefore, to identify and quantify potential determinants of APB in HMC, Qatar using the Theoretical Domains Framework (TDF).

Methods

Study design

The design was a cross-sectional survey using an online questionnaire.

Setting

The research was conducted across all 12 hospital settings of HMC, Qatar.

Eligibility criteria

All medical doctors and pharmacists who prescribe/recommend antimicrobials as an integral part of their role were invited to participate, with no exclusions.

Questionnaire development

A questionnaire tool was drafted based on a systematic review [23] with contextualization for Qatari practice. This was reviewed for face and content validity by six experienced academics, researchers and practitioners in Qatar and the UK. It was piloted with 15 doctors and 15 pharmacists in HMC with minor modifications. SurveyMonkey® was used and tested for compatibility with different platforms, browsers and HMC filters.

Items were grouped into sections on demographics, and three aspects of antimicrobial practice, namely: prescribing/recommending antimicrobials, review/amending, and monitoring for efficacy/toxicity. Question types included: closed, five-point Likert scales, and open to allow free text comments. Items on potential determinants of prescribing were based on the Determinants of Implementation Behaviour Questionnaire (DIBQ) [37]. The DIBQ is a 100-item generic questionnaire derived from the 14 theoretical domains of the TDF which is a framework of behavioural theories [38]. TDF meets the criteria of a 'good theory' and can be used in healthcare-related research for intervention targeting [39]. The DIBQ is a valid and reliable tool, and can be adapted and applied to any behaviour of interest [37,40]. In the demographics section, clinicians classified themselves as 'innovators', 'early adopters', 'early majority', 'late majority' and 'laggards' based on receptivity to change [41].

Table 1
Participants' personal and practice demographics (N = 535)

Characteristic		% (N)
Profession	Doctor	63.4 (339)
	Pharmacist	36.6 (196)
Main practice setting (N = 12)	Secondary care (N = 5)	65.8 (352)
	Tertiary care (N = 7)	33 (176)
	Other	1.2 (7)
Gender	Male	64.7 (346)
	Female	34.6 (185)
	Prefer not to say	0.7 (4)
Highest academic qualification	Undergraduate	33.3 (178)
	Postgraduate taught	43.4 (232)
	Doctorate	22.8 (122)
	Other	0.5 (3)
Experience as health professional	≤5 years	53.3 (285)
	6–10 years	34.6 (185)
	≥11 years	12.1 (65)
Characteristics of the Innovation	I resist new ways of working	2 (1)
	I am cautious in relation to new ways of working: I tend to change once	7 (4)
	I think for some time before adopting new ways of working	35.5 (190)
	I serve as a role model for others in relation to new ways of working	3.9 (21)
	I am innovative with new ways of working	59.6 (319)

Recruitment and data collection

An e-mail with a link to the participant information sheet and online questionnaire was sent by the HMC's Corporate Communications to all doctors (~4000) and pharmacists (~400) working within HMC hospitals. Given that the hospitals were unable to provide specific numbers of those with antimicrobial prescribing/recommending roles, the e-mail specified that only those who prescribe/recommend antimicrobials as an integral part of their role were eligible. The following evidence-based measures were adopted to maximize survey response rate: two follow-up e-mail reminders, an information sheet giving full details of the study, potential benefits of participation and confidentiality, a visually attractive questionnaire, an announcement via the official HMC website, and highlighting the study via ward communications [42]. In addition, the doctoral researcher (H.T.) promoted the work at a continuing professional development (CPD) event. The information sheet ensured participants were fully informed about the study and it was indicated to them that completion and submission of the questionnaire constituted consent. Data collection took place from January to May 2020.

Data analysis and statistical methods

Data were analysed using descriptive and inferential statistics using the Statistical Package for the Social Sciences SPSS® Statistics version 25. Descriptive analysis was undertaken for personal and practice demographics, including profession, academic qualification, practice setting, gender, experience and characteristics of the innovation [41].

Statements relating to the five-point Likert scale were subjected to principal component analysis (PCA) to reduce the large number of statements to a smaller number of components [43]. The correlation matrix for coefficients (≥ 0.3), the

Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy (≥ 0.6) and the Bartlett's Test of Sphericity (≤ 0.05) were used to assess data suitability for PCA [43]. The number of components retained was determined based on the Kaiser criterion (Eigenvalues > 1) and visual assessment of the scree plot. Varimax rotation was performed to aid in the component interpretation, and the results were compared with Promax rotation [44]. Final scales did not include items that were stand-alone, cross-loaded or resulted in a reduction of internal reliability, and that did not show acceptable communalities with factor structure coefficients above 0.4. Internal consistencies of the resulting components were tested using Cronbach's alpha aiming for values ≥ 0.7 [43]. Following determination of internal consistencies, total component scores were calculated by assigning scores of 5 (strongly agree) to 1 (strongly disagree) to each of the Likert responses and producing a summed score for statements in each component.

Inferential analysis (Mann–Whitney U for two groups or Kruskal–Wallis for more than two groups) was used to explore any relationships between demographic characteristics and PCA component scores. *Post hoc* analysis (i.e., pairwise comparison) was used to explore the difference between three or more group means when the *P*-value was statistically significant ($P \leq 0.05$).

Thematic analysis was independently performed by two researchers on the free text comments looking for patterns/themes, similarities and differences across data set [45].

Ethics

This study was approved by the Ethical Review Panel of the School of Pharmacy and Life Sciences at Robert Gordon University, UK (S181); Qatar University Institutional Review Board (QU-IRB 1171-EA/19); and the Medical Research Centre (MRC) at HMC, Qatar (MRC-01-19-219).

Table II

Aspect 1: prescribing/recommending antimicrobials in relation to principal component analysis components (N = 535, missing = 16)

TDF domain	Statement	Strongly agree	Agree	Unsure	Disagree	Strongly disagree	Not applicable
		% (N)	% (N)	% (N)	% (N)	% (N)	% (N)
With respect to appropriate and timely prescribing/recommending antimicrobials (i.e. right medication, right dose, right patient, right time and right route)							
Component 1: guidelines compliance							
Beliefs of consequences	If I prescribe/recommend antimicrobials according to the guidelines, I believe that there will be less antimicrobial resistance	11.2 (60)	84.1 (450)	0.6 (3)	1.1 (6)	0	0
	If I prescribe/recommend antimicrobials according to the guidelines, I believe that patients will be treated more cost effectively	13.6 (73)	80 (428)	1.5 (8)	1.3 (7)	0.4 (2)	0.2 (1)
	If I prescribe/recommend antimicrobials according to the guidelines, I believe that patients will be treated more effectively	13.5 (72)	81.7 (437)	0.9 (5)	0.9 (5)	0	0
	If I prescribe/recommend antimicrobials according to the guidelines, I believe that patients will have fewer adverse effects	11.6 (62)	81.1 (434)	2.4 (13)	1.7 (9)	0	0.2 (1)
Goals	I have clear goals for prescribing/recommending antimicrobials according to the guidelines	8.6 (46)	85.8 (459)	1.1 (6)	1.5 (8)	0	0
	Prescribing/recommending antimicrobials according to the guidelines is a high priority for me	12.9 (69)	81.7 (437)	0.7 (4)	1.5 (8)	0	0.2 (1)
Intentions	I intend to follow the guidelines on prescribing/recommending antimicrobials	12.7 (68)	80.6 (431)	2.2 (12)	1.5 (8)	0	0
	I intend to encourage others to follow the guidelines on prescribing/recommending antimicrobials	12 (64)	80 (432)	3 (16)	1.3 (7)	0	0
Component statistics: Cronbach's alpha 0.889, range 8–40, midpoint 24, median 32, IQR 32–33							
Component 2: influences on practice							
Environmental context and resources	I have sufficient support from specialists to enable me to prescribe/recommend antimicrobials according to the guidelines	7.3 (39)	80 (428)	5.8 (31)	3.2 (17)	0.6 (3)	0.2 (1)
	I have undertaken sufficient continuing professional development to prescribe/recommend antimicrobials according to the guidelines	17.6 (94)	60.4 (323)	7.5 (40)	11 (59)	0.4 (2)	0.2 (1)
Social influences	Members of the multidisciplinary team prescribe/recommend antimicrobials according to the guidelines	6.2 (33)	78.7 (421)	9 (48)	2.4 (13)	0.6 (3)	0.2 (1)
	Prescribing/recommending antimicrobials according to the guidelines is encouraged by my peers	6.9 (37)	73.5 (393)	13.3 (71)	3 (16)	0.2 (1)	0.2 (1)
	Prescribing/recommending antimicrobials according to the guidelines is encouraged by superiors	9.2 (49)	72.5 (388)	12 (64)	3 (16)	0.4 (2)	0
	Patients put me under pressure to prescribe/recommend antimicrobials outside the guidelines	4.5 (24)	36.1 (193)	9.3 (50)	31.8 (170)	13.6 (73)	1.7 (9)
Behavioural regulation	I have ways of monitoring the quality of my prescribing/recommending of antimicrobials	2.1 (11)	78.5 (420)	12.3 (66)	3 (16)	0.6 (3)	0.6 (3)
Component statistics: Cronbach's alpha 0.700, range 7–35, midpoint 21, median 26, IQR 25–28							
Component 3: self-efficacy							

(continued on next page)

Table II (continued)

TDF domain	Statement	Strongly agree % (N)	Agree % (N)	Unsure % (N)	Disagree % (N)	Strongly disagree % (N)	Not applicable % (N)
	With respect to appropriate and timely prescribing/recommending antimicrobials (i.e. right medication, right dose, right patient, right time and right route)						
Knowledge	I have sufficient knowledge to prescribe/recommend antimicrobials according to the guidelines	6.7 (36)	86.9 (465)	2.6 (14)	0.7 (4)	0	0
Skills	I am sufficiently skilled to prescribe/recommend antimicrobials according to the guidelines	5.4 (29)	87.9 (470)	3 (16)	0.7 (4)	0	0
Social/professional role and identity	It is my responsibility to prescribe/recommend antimicrobials according to the guidelines	8.6 (46)	84.1 (450)	3 (16)	0.9 (5)	0	0.4 (2)
Optimism	I am confident in my ability to prescribe/recommend antimicrobials according to the guidelines	6.4 (34)	86.4 (462)	3.2 (17)	1.1 (6)	0	0
Belief of capabilities	I am competent to prescribe/recommend antimicrobials according to the guidelines	5.2 (28)	80.7 (432)	8.8 (47)	2.2 (12)	0	0
Component statistics: Cronbach's alpha 0.867, range 5–25, midpoint 15, median 20, IQR 20–20							

Antimicrobials, all antimicrobial agents that act against all types of microbes including bacteria, viruses, fungi and parasites; IQR, interquartile range; TDF, Theoretical Domains Framework.

Results

Study participants

In total, 535 responses were received, 339 (63.4%) from doctors and 196 (36.6%) from pharmacists with a wide range of specialties and expertise. An overall response rate could not be calculated as the total number of clinicians who prescribe/recommend antimicrobials as an integral part of their role, was unknown.

Personal and practice demographics

Table I summarizes demographics of the study participants. Respondents were 346 (64.7%) males. A majority were practicing in secondary care setting as their main job sector ($N = 352$, 65.8 %) with 33% ($N = 176$) in tertiary care. Around half ($N = 285$, 53.3%) had five or fewer years' experience as health professionals. More than half of respondents ($N = 319$, 59.6%) rated themselves as 'innovators' (i.e., eager to try new ideas), 21 (3.9%) as 'early adopters' (i.e. integrate into the local social system more than innovators) and only one (2%) as 'laggards' (i.e. traditionalists and the last to adopt an innovation) [41].

Factor analysis

Respondents completed all statements relating to the three aspects of antimicrobial prescribing practice. When these statements were subjected to PCA, the correlation matrix contained multiple coefficients >0.3 . In addition, the KMO measure of sampling adequacy (0.88) and Bartlett's Test of Sphericity confirmed the factorability of the statements (significance <0.001). For each of the three aspects, there was a three-component solution which had Eigenvalues exceeding 1.0, the three-factor solutions explained cumulative variance of greater than 50% for each aspect. The three components for each aspect of antimicrobial practice were labelled: 'Guidelines compliance' (C1), 'Influences on practice' (C2) and 'Self-efficacy' (C3).

Responses to statements of these aspects and components are given in Tables II–IV. The Cronbach's alpha values for each of the components within Aspects 1 to 3 are also given. In view of these values being greater than the generally accepted value for reliability of 0.7 [43], they were accepted as scales and subjected to further analysis. Of note, two statements in Aspects 2 and 3 did not load to any component: 'Patients put me under pressure to review/monitor outside the guidelines', and 'Reviewing/monitoring antimicrobials according to the guidelines is encouraged by superiors'. The Cronbach's alpha values for these were low and, thus, they were excluded.

Aspect 1: prescribing/recommending antimicrobials

In general, the component scores all indicated positive responses with the median and interquartile range (IQR) values all exceeding the scale midpoints (C1: median 32, IQR 32–33, midpoint 24; C2: median 26, IQR 25–28, midpoint 21; C3: median 20, IQR 20–20, midpoint 15) and all item median responses being 'agree' (Table II). There were, however, less positive responses in Component 2's items relating to determinants of behaviour around influences on practice in prescribing/recommending antimicrobials including items focused

Table III

Aspect 2: review/amendment of antimicrobials in relation to principal component analysis components (N = 535, missing = 16)

TDF domain	Statement	Strongly agree	Agree	Unsure	Disagree	Strongly disagree	Not applicable
		% (N)	% (N)	% (N)	% (N)	% (N)	% (N)
With respect to appropriate and timely review/amendment of antimicrobials – for example from broad spectrum to narrow spectrum, intravenous-to-oral and/or discontinuation where appropriate:							
Component 1: guidelines compliance							
Beliefs of consequences	If I review/amend antimicrobials according to the guidelines, I believe that there will be less antimicrobial resistance	10.5 (56)	83.9 (449)	0.9 (5)	1.7 (9)	0	0
	If I review/amend antimicrobials according to the guidelines, I believe that patients will be treated more effectively	13.1 (70)	82.2 (440)	0.4 (2)	1.3 (7)	0	0
	If I review/amend antimicrobials according to the guidelines, I believe that patients will have fewer adverse effects	12.5 (67)	81.3 (435)	1.3 (7)	1.7 (9)	0	0.2 (1)
	If I review/amend antimicrobials according to the guidelines, I believe that patients will be treated more cost effectively	12 (64)	81.1 (434)	2.4 (13)	1.3 (7)	0.2 (1)	0
Goals	I have clear goals for reviewing/amending antimicrobials according to the guidelines	10.5 (56)	83.6 (447)	1.5 (8)	1.5 (8)	0	0
	Reviewing/amending antimicrobials according to the guidelines is a high priority for me	10.7 (57)	83.2 (445)	1.3 (7)	1.9 (10)	0	0
Intentions	I intend to follow the guidelines on reviewing/amending antimicrobials	9.3 (50)	82.2 (440)	3.9 (21)	1.5 (8)	0	0
	I intend to encourage others to follow the guidelines on reviewing/amending antimicrobials	10.1 (54)	81.1 (434)	4.3 (23)	1.5 (8)	0	0
Component statistics: Cronbach's alpha 0.896, range 8–40, midpoint 24, median 32, IQR 32–33							
Component 2: influences on practice							
Environmental context and resources	I have sufficient support from specialists to enable me to review/amend antimicrobials according to the guidelines	8.4 (45)	80.2 (429)	5 (27)	3 (16)	0.2 (1)	0.2 (1)
	I have undertaken sufficient continuing professional development to review/amend antimicrobials according to the guidelines	18.9 (101)	59.4 (318)	7.5 (40)	10.7 (57)	0.6 (3)	0
Social influences	Members of the multidisciplinary team review/amend antimicrobials according to the guidelines	6.7 (36)	76.1 (407)	11.2 (60)	2.6 (14)	0.2 (1)	0.2 (1)
	Reviewing/amending antimicrobials according to the guidelines is encouraged by my peers	6.7 (36)	73.5 (393)	13.8 (74)	2.6 (14)	0	4 (2)
Behavioural regulation	I have ways of monitoring the quality of my reviewing/amending of antimicrobials	3 (16)	78.7 (421)	12 (64)	2.4 (13)	0.4 (2)	0.6 (3)
Component statistics: Cronbach's alpha 0.775, range 5–25 midpoint 15, median 20, IQR 20–21							
Component 3: self-efficacy							
Knowledge	I have sufficient knowledge to review/amend antimicrobials according to the guidelines	4.3 (23)	88.4 (473)	3.2 (17)	1.1 (6)	0	0
Skills	I am sufficiently skilled to review/amend antimicrobials according to the guidelines	5.6 (30)	87.9 (470)	2.8 (15)	0.7 (4)	0	0
Social/professional role and identity	It is my responsibility to review/amend antimicrobials according to the guidelines	9.5 (51)	80.6 (431)	4.9 (26)	1.7 (9)	0.2 (1)	0.2 (1)
Optimism	I am confident in my ability to review/amend antimicrobials according to the guidelines	7.9 (42)	85 (455)	3.2 (17)	0.9 (5)	0	0
Belief of capabilities	I am competent to review/amend antimicrobials according to the guidelines	6.7 (36)	79.8 (427)	9.3 (50)	0.9 (5)	0.2 (1)	0
Component statistics: Cronbach's alpha 0.829, range 5–25, midpoint 15, median 20, IQR 20–20							

Antimicrobials, all antimicrobial agents that act against all types of microbes including bacteria, viruses, fungi and parasites; IQR, interquartile range; TDF, Theoretical Domains Framework.

Table IV

Aspect 3: monitoring for efficacy/toxicity of antimicrobials in relation to principal component analysis components (N = 535, missing=16)

TDF domain	Statement	Strongly agree	Agree	Unsure	Disagree	Strongly disagree	Not applicable
With respect to appropriate and timely monitor for efficacy/toxicity of antimicrobials:		% (N)	% (N)	% (N)	% (N)	% (N)	% (N)
Component 1: guidelines compliance							
Beliefs of consequences	If I monitor for efficacy/toxicity of antimicrobials according to the guidelines, I believe that there will be less antimicrobial resistance	9.2 (49)	84.1 (450)	1.7 (9)	1.9 (10)	0.2 (1)	0
	If I monitor for efficacy/toxicity of antimicrobials according to the guidelines, I believe that patients will be treated more effectively	11.2 (60)	84.1 (450)	0.4 (2)	1.3 (7)	0	0
Goals	If I monitor for efficacy/toxicity of antimicrobials according to the guidelines, I believe that patients will have fewer adverse effects	11.2 (60)	82.6 (442)	1.3 (7)	1.5 (8)	0.2 (1)	0.2 (1)
	If I monitor for efficacy/toxicity of antimicrobials according to the guidelines, believe that patients will be treated more cost effectively	12.9 (69)	80.9 (433)	0.9 (5)	2.1 (11)	0.2 (1)	0
	Monitoring for efficacy/toxicity of antimicrobials according to the guidelines is a high priority for me	10.7 (57)	83 (444)	1.9 (10)	1.3 (7)	0	0.2 (1)
	I have clear goals for monitoring efficacy/toxicity of antimicrobials according to the guidelines	10.1 (54)	84.5 (452)	0.7 (4)	1.5 (8)	0	0.2 (1)
Intentions	I intend to follow the guidelines on monitoring efficacy/toxicity of antimicrobials	8.8 (47)	82.1 (439)	4.5 (34)	1.5 (8)	0	0.2 (1)
	I intend to encourage others to follow the guidelines on monitoring efficacy/toxicity of antimicrobials	10.1 (54)	80.6 (431)	4.3 (23)	1.9 (10)	0	0.2 (1)
Component statistics: Cronbach's alpha 0.891, range 8–40, midpoint 24, median 32, IQR 32–33							
Component 2: influences on practice							
Environmental context and resources	I have sufficient support from specialists to monitor for efficacy/toxicity of antimicrobials according to the guidelines	6 (32)	82.2 (440)	5.4 (29)	3.2 (17)	0	0.2 (1)
	I have undertaken sufficient continuing professional development to monitor for efficacy/toxicity of antimicrobials according to the guidelines	18.5 (99)	59.6 (319)	8.2 (44)	10.3 (55)	0.4 (2)	0
Social influences	Members of the multidisciplinary team monitor for efficacy/toxicity of antimicrobials according to the guidelines	7.7 (41)	73.5 (393)	12.3 (66)	3.4 (18)	0	0.2 (1)
	Monitoring for efficacy/toxicity of antimicrobials according to the guidelines is encouraged by my peers	6 (32)	74 (396)	14.4 (77)	2.2 (12)	0	0.4 (2)
Behavioural regulation	I have ways of monitoring the quality of my monitoring for efficacy/toxicity of antimicrobials	2.2 (12)	79.4 (425)	11.8 (63)	2.2 (12)	0.6 (3)	0.7 (4)
Component statistics: Cronbach's alpha 0.789, range 5–25, midpoint 15, median 20, IQR 20–21							
Component 3: self-efficacy							
Knowledge	I have sufficient knowledge to monitor for efficacy/toxicity of antimicrobials according to the guidelines	5.2 (28)	87.3 (467)	3.2 (17)	1.3 (7)	0	0
Skills	I am sufficiently skilled to monitor for efficacy/toxicity of antimicrobials according to the guidelines	5 (27)	87.5 (468)	3.4 (18)	1.1 (6)	0	0
Social/professional role and identity	It is my responsibility to monitor for efficacy/toxicity of antimicrobials according to the guidelines	9.5 (51)	79.8 (427)	6.2 (33)	1.1 (6)	0	0.4 (2)
Optimism	I am confident in my ability to monitor for efficacy/toxicity of antimicrobials according to the guidelines	7.3 (39)	85.6 (458)	2.8 (15)	1.3 (7)	0	0

Belief of capabilities	I am competent to monitor for efficacy/toxicity of antimicrobials according to the guidelines	6.7 (36)	79.8 (427)	8.6 (46)	1.9 (10)	0
Component statistics:	Cronbach's alpha 0.890, range 5–25, midpoint 15, median 20, IQR 20–20					
Antimicrobials, all antimicrobial agents that act against all types of microbes including bacteria, viruses, fungi and parasites; IQR, interquartile range; TDF, Theoretical Domains Framework.						

on the TDF domains: environmental context and resources, social influences and behavioural regulation. The items with the lowest levels of positive responses were: 'Prescribing/recommending antimicrobials according to the guidelines is encouraged by my peers' (agree/strongly agree $N = 430$, 80.4%) and 'I have undertaken sufficient CPD to prescribe/recommend antimicrobials according to the guidelines' (agree/strongly agree $N = 417$, 78%). The item: 'Patients put me under pressure to prescribe/recommend antimicrobials outside the guidelines' had almost an even spread of agree/strongly agree ($N = 217$, 40.6%) and disagree/strongly disagree ($N = 243$, 45.4%).

Inferential statistics showed that there was a statistically significant difference in component scores between doctors and pharmacists for each component (C1: $P < 0.001$; C2: $P < 0.001$; C3: $P = 0.01$), with doctors generally having higher scores. Highest academic qualification showed a significant difference between categories (undergraduate, postgraduate taught or doctorate) for each component (C1: $P < 0.001$; C2: $P < 0.001$; C3: $P = 0.009$), with *post hoc* analysis showing that undergraduate respondents had lower scores than others. Lastly, for the 'Experience as health professional' categories (≤ 5 years, 6–10 years and ≥ 11 years) there was only a difference in C2 ($P < 0.001$), with *post hoc* analysis showing lower scores for less experienced respondents. All other demographic data categories showed no statistically significant relationships ($P > 0.05$).

Aspect 2: reviewing/amending antimicrobials

Similar to Aspect 1, the component scores all indicated generally positive responses with the median and IQR values all exceeding the scale midpoints (C1: median 32, IQR 32–33, midpoint 24; C2: median 20, IQR 20–21, midpoint 15; C3: median 20, IQR 20–20, midpoint 15) and all item median responses being 'agree' (Table III). There were, however, less positive responses in Component 2's items relating to determinants of behaviour around influences on practice in reviewing/amending antimicrobials including items focused on the TDF domains: environmental context and resources, social influences and behavioural regulation. The items with the lowest levels of positive responses were: 'Reviewing/amending antimicrobials according to the guidelines is encouraged by my peers' (agree/strongly agree $N = 429$, 80.2%) and 'I have undertaken sufficient CPD to review/amend antimicrobials according to the guidelines' (agree/strongly agree $N = 419$, 78.3%).

Inferential statistics showed that there was a statistically significant difference in component scores between doctors and pharmacists for each component (C1: $P < 0.001$; C2: $P < 0.001$; C3: $P < 0.001$), with doctors generally having higher scores. Highest academic qualification showed a significant difference between categories (undergraduate, postgraduate taught or doctorate) for each component (C1: $P < 0.001$; C2: $P = 0.008$; C3: $P < 0.001$), with *post hoc* analysis showing that undergraduate respondents had lower scores than others. Lastly, for the 'Experience as health professional' categories (≤ 5 years, 6–10 years and ≥ 11 years) there was only a difference in C2 ($P = 0.003$), with *post hoc* analysis showing lower scores for less experienced respondents.

Aspect 3: monitoring efficacy/toxicity of antimicrobials

Likewise, the component scores all indicated generally positive responses with the median and IQR values all

exceeding the scale midpoints (C1: median 32, IQR 32–33, midpoint 24; C2: median 20, IQR 20–21, midpoint 15; C3: median 20, IQR 20–20, midpoint 15) and all item median responses being 'agree' (Table IV). There were, however, less positive responses in Component 2's items relating to determinants of behaviour around influences on practice in monitoring efficacy/toxicity of antimicrobials including items focused on the TDF domains: environmental context and resources, social influences, and behavioural regulation.

The items with the lowest levels of positive responses were: 'Monitoring for efficacy/toxicity of antimicrobials according to the guidelines is encouraged by my peers' (agree/strongly agree $N = 428$, 80%) and 'I have undertaken sufficient CPD to monitor for efficacy/toxicity of antimicrobials according to the guidelines' (agree/strongly agree $N = 418$, 78.1%).

Inferential statistics showed that there was a statistically significant difference in component scores between doctors and pharmacists for each component (C1: $P < 0.001$; C2: $P < 0.001$; C3: $P < 0.001$), with doctors generally having higher scores. Highest academic qualification showed a significant difference between categories (undergraduate, postgraduate taught or doctorate) for each component (C1: $P < 0.001$; C2: $P = 0.027$; C3: $P = 0.008$), with *post hoc* analysis showing that undergraduate respondents had lower scores than others. Lastly, for the 'Experience as health professional' categories (≤ 5 years, 6–10 years and ≥ 11 years) there was only a difference in C2 ($P = 0.005$), with *post hoc* analysis showing lower scores for less experienced respondents.

Only a few of the clinicians responded to the open questions. However, when they did, they often acknowledged the key role of ID doctors, clinical microbiologists and pharmacists in AMS practice, with the main limitations being the lack of guidelines regular updates and sufficient staff. Concerns were also expressed about interprofessional conflict and the need for further training relating to appropriate antimicrobial prescribing practice.

Discussion

This study captured quantitative data from doctors and pharmacists across different HMC hospital settings, in relation to the potential determinants of APB. PCA indicated three components of 'Guidelines compliance', 'Influences on practice' and 'Self-efficacy'. While component scores for 'Guidelines compliance' and 'Self-efficacy' indicated positive responses, the other component (i.e., 'Influences on practice') was much less positive. There were low levels of agreement for items relating to undertaking sufficient CPD (environmental context and resources) and peers' encouragement (social influences) to review/monitor antimicrobials according to the guidelines. There were neutral responses around patient pressure to prescribe/recommend antimicrobials outside the guidelines. Comparison of component scores across demographic characteristics identified that, in general, doctors, more qualified individuals and those with greater experience were more likely to be positive in their responses. Scores did not vary significantly between clinicians from different practice settings.

This study adds context to the limited literature on use of theory to inform BCIs to improve antimicrobial prescribing [23]. It was rigorous in the process of questionnaire development and resulted in findings that offer an original contribution to the evidence base around potential determinants of APB within hospitals. Limitations include an indeterminate response rate because the total number of those who prescribe or recommend antimicrobials as an integral part of their role in HMC was unknown. Additionally, data collection took place from January to May 2020 and engagement could have been affected by the COVID-19 pandemic. However, most of the data was collected in January and February 2020 prior to the start of the pandemic in March 2020 with only final reminders sent out in April and May. Despite all strategies to encourage participation, the number of responses could be considered low. This may have introduced response bias. To carry out a robust study,

Table V

Mapping the determinants of antimicrobial prescribing to relevant Behaviour Change Techniques [56,57]

TDF determinant	BCT	
	Label	Definition
Environmental context and resources	Information about environmental consequences	Record/provide information (e.g., written, verbal, visual) about environmental consequences of performing the behaviour
	Prompts/cues	Introduce or define environmental stimulus with the purpose of prompting or cueing the behaviour
	Restructuring the physical environment	Change the physical environment to facilitate, or create barriers to, the target behaviour
Social influences	Adding objects to the environment	Add objects to the environment in order to facilitate performance of the behaviour
	Social support (unspecified)	Advise on, arrange, or provide practical help (e.g., from colleagues, 'buddies' or staff) for performance of the behaviour
	Information about health consequences	Provide information (e.g., written, verbal, visual) about health consequences of performing the behaviour
	Social comparison	Draw attention to others' performance to allow comparison with the person's own performance
	Restructuring the social environment	Change the social environment to facilitate, or create barriers to, the target behaviour

BCTs, behaviour change techniques; TDF, Theoretical Domains Framework.

the questionnaire had to be long which may have affected engagement and completion. Furthermore, there may have been social desirability and acquiescence bias, particularly in relation to Component 1. Guidelines compliance, may have been prevalent and results are all based on self-reported data which could not be confirmed or validated. Lastly, the study was carried out in HMC hospitals only and thus findings may lack generalizability. However, findings of this work seem to indicate differences between settings within HMC but confirmation of this and in different healthcare settings and countries would be recommended.

This study quantified theoretically based behavioural determinants which may support the development of an effective BCI for AMS [46]. Michie *et al.* [47] reported that BCIs are more likely to be effective if they are designed to target the causal determinants of behaviour.

Respondents scored items within the 'Guidelines compliance' component highly, suggesting a general acceptance of the local antimicrobial prescribing guidelines. This is in accordance with previous studies among hospital doctors in other countries [48–50] who had positive attitudes towards local guidelines. Likewise, respondents scored items in the 'Self-efficacy' component highly, demonstrating confidence in caring for patients with infection, consistent with an earlier multidisciplinary study with clinicians who work in long-term care facilities in Ireland [18]. In this study, clinicians conveyed confidence in providing a high quality of care for the patients due to their long work experience and their in-depth knowledge of the patient cases. Another study in the Democratic Republic of Congo revealed a similar result, in which almost 90% of hospital doctors felt confident about their antibiotic prescribing [51].

The lowest levels of positive scores were in relation to the items within the 'Influences on practice' component, with particular focus on the TDF domains, environmental context and resources and social influences. Other studies have also reported these domains as potential influences on antimicrobial prescribing [18,52–54], however, this is the first questionnaire-based survey which has used the TDF in the context of AMS.

Although previous studies reported that clinicians are more likely to prescribe antimicrobials when they feel pressure from their patients [9,10,12,15], in this study respondents generally held neutral views with regard to patient pressure. This could have been influenced by the fact that a high proportion of respondents were ≤5 years qualified and AMS techniques are more likely now to be included in university curricula.

The finding that component scores did not vary significantly between practice settings (i.e., secondary and tertiary care) is in line with previous research into doctors working in two different UK hospitals which found greater differences between specialities than between hospital types [55].

TDF determinants can be mapped to relevant Behaviour Change Techniques (BCTs) [56,57] which in turn can form part of an intervention. An example of this for environmental context and resources, and social influences are outlined in Table V.

This is consistent with a recent systematic review of interventions to improve antibiotic prescribing in long-term care facilities, reporting the BCTs of interventions that were associated with improved outcomes [58]. In this review, similar BCTs were identified, including adding objects to the

environment, providing information about health consequences and restructuring the social environment [58].

Qualitative research exploring the environmental context and resources, and social influence issues around antimicrobial prescribing in more depth is required to developing effective BCIs in the area of AMS. This should follow the UK MRC phases of intervention development, feasibility/pilot testing, evaluation and implementation [22].

In conclusion, this study has demonstrated that clinicians in HMC, Qatar, perceive themselves to be compliant, confident and competent in relation to antimicrobial prescribing practice. There were, however, issues around influences on practice, with particular focus on the behavioural determinants of environmental context and resources, and social influences among pharmacists and early career clinicians. A range of relevant BCTs were identified. The findings may contribute to the development of effective BCIs in this area.

Acknowledgements

The authors would like to acknowledge those involved in questionnaire development and study respondents. The authors are also grateful to the faculty members of the pharmacy school at Robert Gordon University and at Qatar University who helped in reviewing, validating and testing the data-collection tool. Special thanks go to Dr Binny Thomas for his support throughout the data collection phase.

Conflict of Interest statement

None to declare.

Funding sources

We would like to thank the Hamad Medical Corporation Medical Research Center (HMC MRC), Doha, Qatar for funding this work (grant number MRC-01-19-219).

References

- [1] Global action plan on antimicrobial resistance. World Health Organization; 2015 Available at: <https://apps.who.int/iris/handle/10665/193736> [last accessed August 2021].
- [2] Political declaration of the high-level meeting of the general assembly on antimicrobial resistance. United Nations Digital Library System; 2016. Available at: <https://digitallibrary.un.org/record/845917> [last accessed August 2021]
- [3] Davey P, Brown E, Charani E, Fenelon L, Gould I, Holmes A, et al. Interventions to improve antibiotic prescribing practices for hospital inpatients. *Cochrane Database of Systematic Reviews* 2013;4:CD003543.
- [4] Schuts E, Hulscher M, Mouton J, Verduin C, Stuart J, Overdiek H, et al. Current evidence on hospital antimicrobial stewardship objectives: a systematic review and meta-analysis. *Lancet Infect Dis* 2016;16:847–56.
- [5] Charani E, Edwards R, Sevdalis N, Alexandrou B, Sibley E, Mullett D, et al. Behavior change strategies to influence antimicrobial prescribing in acute care: a systematic review. *Clin Infect Dis* 2011;53(7):651–62.
- [6] Edwards R, Charani E, Sevdalis N, Alexandrou B, Sibley E, Mullett D, et al. Optimisation of infection prevention and control in acute health care by use of behaviour change: a systematic review. *Lancet Infect Dis* 2012;12:318–29.
- [7] Charani E, Castro-Sanchez E, Sevdalis N, Kyratsis Y, Drumright L, Shah N, et al. Understanding the determinants of antimicrobial

- prescribing within hospitals: the role of "prescribing etiquette. *Clin Infect Dis* 2013;57(2):188–96.
- [8] Lorencatto F, Charani E, Sevdalis N, Tarrant C, Davey P. Driving sustainable change in antimicrobial prescribing practice: how can social and behavioural sciences help? *J Antimicrob Chemother* 2018;73(10):2613–24.
 - [9] Md Rezal R, Hassali M, Alrasheedy A, Saleem F, Md Yusof F, Godman B. Physicians' knowledge, perceptions and behaviour towards antibiotic prescribing: a systematic review of the literature. *Expert Rev Anti Infect Ther* 2015;13(5):665–8.
 - [10] Lucas P, Cabral C, Hay A, Horwood J. A systematic review of parent and clinician views and perceptions that influence prescribing decisions in relation to acute childhood infections in primary care. *Scand J Prim Health Care* 2015;33(1):11–20.
 - [11] Tonkin-Crine S, Yardley L, Little P. Antibiotic prescribing for acute respiratory tract infections in primary care: a systematic review and meta-ethnography. *J Antimicrob Chemother* 2011;66(10):2215–23.
 - [12] Lopez-Vazquez P, Vazquez-Lago J, Figueiras A. Misprescription of antibiotics in primary care: a critical systematic review of its determinants. *J Eval Clin Pract* 2011;18(2):473–84.
 - [13] Köchling A, Löffler C, Reinsch S, Hornung A, Böhmer F, Altiner A, et al. Reduction of antibiotic prescriptions for acute respiratory tract infections in primary care: a systematic review. *Implement Sci* 2018;13:47.
 - [14] Teixeira Rodrigues A, Roque F, Falcão A, Figueiras A, Herdeiro M. Understanding physician antibiotic prescribing behaviour: a systematic review of qualitative studies. *Int J Antimicrob Agents* 2013;41(3):203–12.
 - [15] Fletcher-Lartey S, Yee M, Gaarslev C, Khan R. Why do general practitioners prescribe antibiotics for upper respiratory tract infections to meet patient expectations: a mixed methods study. *BMJ Open* 2016;6(10):e012244.
 - [16] Michie S. Designing and implementing behaviour change interventions to improve population health. *J Health Serv Res Policy* 2008;13(Suppl 3):64–9.
 - [17] Michie S, Fixsen D, Grimshaw J, Eccles M. Specifying and reporting complex behaviour change interventions: the need for a scientific method. *Implement Sci* 2009;4:40.
 - [18] Fleming A, Bradley C, Cullinan S, Byrne S. Antibiotic prescribing in long-term care facilities: a qualitative, multidisciplinary investigation. *BMJ Open* 2014;4(11):e006442.
 - [19] Stewart D, Klein S. The use of theory in research. *Int J Clin Pharmacol* 2016;38:615–9.
 - [20] Foy R, Ovretveit J, Shekelle PG, Pronovost PJ, Taylor SL, Dy S, et al. The role of theory in research to develop and evaluate the implementation of patient safety practices. *BMJ Qual Saf* 2011;20(5):453–9.
 - [21] Birken S, Powell B, Shea C, Haines E, Alexis Kirk M, Leeman J, et al. Criteria for selecting implementation science theories and frameworks: results from an international survey. *Implement Sci* 2017;12(1):124.
 - [22] Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: the new Medical Research Council guidance. *BMJ* 2008;337:a1655.
 - [23] Talkhan H, Stewart D, Mcintosh T, Ziglam H, Abdulrouf P, Al-Hail M, et al. The use of theory in the development and evaluation of behaviour change interventions to improve antimicrobial prescribing: a systematic review. *J Antimicrob Chemother* 2020;75(9):2394–410.
 - [24] Courtenay M, Rowbotham S, Lim R, Deslandes R, Hodson K, MacLure K, et al. Antibiotics for acute respiratory tract infections: a mixed-methods study of patient experiences of non-medical prescriber management. *BMJ Open* 2017;7(3):e013515.
 - [25] Qatar data. [Data.worldbank.org](https://data.worldbank.org/country/qatar). 2016 Available at: <https://data.worldbank.org/country/qatar> [last accessed October 2021].
 - [26] Qatar national health strategy 2011–2016 delivers the foundations for world class healthcare – national health strategy. [Nhsq.info](http://www.nhsq.info). 2016 Available at: <http://www.nhsq.info/news-and-events/in-the-media/qatar-national-health-strategy-2011-2016-delivers-the-foundations-for-world-class-healthcare?back-Art=112> [last accessed August 2021].
 - [27] National health strategy 2018–2022. [Moph.gov.qa](https://www.moph.gov.qa/english/strategies/National-Health-Strategy-2018-2022/Pages/default.aspx). 2018. Available at: <https://www.moph.gov.qa/english/strategies/National-Health-Strategy-2018-2022/Pages/default.aspx> [last accessed August 2021].
 - [28] Alghamdi S, Shebl N, Aslanpour Z, Shibl A, Berrou I. Hospital adoption of antimicrobial stewardship programmes in Gulf Cooperation Council countries: a review of existing evidence. *J Glob Antimicrob Resist* 2018;15:196–209.
 - [29] Nasr Z, Jibril F, Elmekaty E, Sonallah H, Chahine E, AlNajjar A. Assessment of antimicrobial stewardship programs within governmental hospitals in Qatar: a SWOC analysis. *Int J Pharm Pract* 2020;29(1):70–7.
 - [30] Ababneh M, Nasser S, Rababa'h A. A systematic review of Antimicrobial Stewardship Program implementation in Middle Eastern countries. *Int J Infect Dis* 2021;105:746–52.
 - [31] Pawluk S, Black E, El-Awaisi A. Strategies for improving antibiotic use in Qatar: a survey of pharmacists' perceptions and experiences. *Int J Pharm Pract* 2015;23(1):77–9.
 - [32] Butt A, Navasero C, Thomas B, Marri S, Katheeri H, Thani A, et al. Antibiotic prescription patterns for upper respiratory tract infections in the outpatient Qatari population in the private sector. *Int J Infect Dis* 2017;55:20–3.
 - [33] Nasr Z, Babiker A, Elbasheer M, Osman A, Elazzazy S, Wilby K. Practice implications of an antimicrobial stewardship intervention in a tertiary care teaching hospital. *Qatar. East Mediterr Health J* 2019;25(3):172–80.
 - [34] Sid Ahmed M, Hassan A, Abu Jarir S, Abdel Hadi H, Bansal D, Abdul Wahab A, et al. Emergence of multidrug- and pandrug- resistant *Pseudomonas aeruginosa* from five hospitals in Qatar. *Infect Prevent Pract* 2019;1(3–4):100027.
 - [35] Sharaf N, Al-Jayyousi G, Radwan E, Shams Eldin S, Hamdani D, Al-Katheeri H, et al. Barriers of appropriate antibiotic prescription at PHCC in Qatar: perspective of physicians and pharmacists. *Antibiotics* 2021;10(3):317.
 - [36] Arnold S, Straus S. Interventions to improve antibiotic prescribing practices in ambulatory care. *Cochrane Database Syst Rev* 2005;2005:CD003539.
 - [37] Huijg JM, Gebhardt WA, Dusseldorp E, Verheijden MW, van der Zouwe N, Middelkoop BJ, et al. Measuring determinants of implementation behaviour: psychometric properties of a questionnaire based on the theoretical domains framework. *Implement Sci* 2014;9(1):33.
 - [38] Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implement Sci* 2012;7:37.
 - [39] Wacker JG. A definition of theory: research guidelines for different theory-building research methods in operations management. *Journal of Operations Management* 1998;16:361–5.
 - [40] Ris I, Schröder K, Kongsted A, Abbott A, Nilsen P, Hartvigsen J, et al. Adapting the determinants of implementation behavior questionnaire to evaluate implementation of a structured low back pain programme using mixed-methods. *Health Sci Rep* 2021;4(2):e266.
 - [41] Rogers EM. *Diffusion of innovations*. 5th ed. New York: Free Press; 2003.
 - [42] Edwards P, Roberts I, Clarke M, DiGiuseppi C, Wentz R, Kwan I, et al. Methods to increase response to postal and electronic questionnaires. *Cochrane Database Syst Rev* 2009;(3):MR000008.
 - [43] DeVellis R. *Scale development: theory and applications*. 1st ed. California: SAGE Publications; 1991.
 - [44] Pallant J. *SPSS survival manual: a step by step guide to data analysis using IBM SPSS*. 7th ed. Sydney: ALLEN & UNWIN; 2020.

- [45] Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006;3(2):77–101.
- [46] Warreman E, Lambregts M, Wouters R, Visser L, Staats H, van Dijk E, et al. Determinants of in-hospital antibiotic prescription behaviour: a systematic review and formation of a comprehensive framework. *Clin Microbiol Infect* 2019;25(5):538–45.
- [47] Michie S, Johnston M, Francis J, Hardeman W, Eccles M. From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change techniques. *Appl Psychol* 2008;57(4):660–80.
- [48] Cortoos P, De Witte K, Peetermans W, Simoens S, Laekeman G. Opposing expectations and suboptimal use of a local antibiotic hospital guideline: a qualitative study. *J Antimicrob Chemother* 2008;62(1):189–95.
- [49] Pulcini C, Williams F, Molinari N, Davey P, Nathwani D. Junior doctors' knowledge and perceptions of antibiotic resistance and prescribing: a survey in France and Scotland. *Clin Microbiol Infect* 2011;17(1):80–7.
- [50] Parker H, Mattick K. The determinants of antimicrobial prescribing among hospital doctors in England: a framework to inform tailored stewardship interventions. *Br J Clin Pharmacol* 2016;82(2):431–40.
- [51] Thriemer K, Katuala Y, Batoko B, Alworonga J, Devlieger H, Van Geet C, et al. Antibiotic prescribing in DR Congo: a knowledge, attitude and practice survey among medical doctors and students. *PLoS One* 2013;8(2):e55495.
- [52] Brookes-Howell L, Hood K, Cooper L, Little P, Verheij T, Coenen S, et al. Understanding variation in primary medical care: a nine-country qualitative study of clinicians' accounts of the non-clinical factors that shape antibiotic prescribing decisions for lower respiratory tract infection. *BMJ Open* 2012;2(4):e000796.
- [53] Chater A, Family H, Lim R, Courtenay M. Influences on antibiotic prescribing by non-medical prescribers for respiratory tract infections: a systematic review using the theoretical domains framework. *J Antimicrob Chemother* 2020;75(12):3458–70.
- [54] Moe S, Kan T, Soobiah C, Golian A, Li T, Raybardhan S. Using a behavioural framework to optimize antibiotic prescribing by family medicine residents. *MedEdPublish* 2021;10(1):113.
- [55] Mattick K, Kelly N, Rees C. A window into the lives of junior doctors: narrative interviews exploring antimicrobial prescribing experiences. *J Antimicrob Chemother* 2014;69(8):2274–83.
- [56] Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med* 2013;46(1):81–95.
- [57] Michie S, Wood C, Johnston M, Abraham C, Francis J, Hardeman W. Behaviour change techniques: the development and evaluation of a taxonomic method for reporting and describing behaviour change interventions (a suite of five studies involving consensus methods, randomised controlled trials and analysis of qualitative data). *Health Technol Assess* 2015;19(99):1–188.
- [58] Crayton E, Richardson M, Fuller C, Smith C, Liu S, Forbes G, et al. Interventions to improve appropriate antibiotic prescribing in long-term care facilities: a systematic review. *BMC Geriatr* 2020;20(1):237.