Pharmacist-led feedback workshops increase appropriate prescribing of antimicrobials

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Abstract

Objectives

To investigate whether and how structured feedback sessions can increase rates of appropriate antimicrobial prescribing by junior doctors.

Methods

This was a mixed methods study, with a conceptual orientation towards complexity and systems thinking. Fourteen junior doctors, in their first year of training, were randomised to intervention (feedback) and 21 to control (routine practice) groups in a single UK teaching hospital. Feedback on their antimicrobial prescribing was given, in writing and via group sessions. Pharmacists assessed the appropriateness of all new antimicrobial prescriptions two days per week for six months (46 days). The mean normalised prescribing rates of suboptimal to all prescribing were compared between groups using the t-test. Thematic analysis of qualitative interviews with 10 participants investigated whether and how the intervention had impact.

Results

Data were collected on 204 prescriptions for 166 patients. For the intervention group, the mean normalised rate of suboptimal to all prescribing was 0.32±0.36; for the control group, it was 0.68±0.36. The normalised rate of suboptimal prescribing was significantly different between the groups (p-value=0.0005). The qualitative data showed that individuals' prescribing behaviour was influenced by a complex series of dynamic interactions between individual and social variables, such as interplay between personal knowledge and the expectations of others.

Conclusions

The feedback intervention increased appropriate prescribing by acting as a positive stimulus within a complex network of behavioural influences. Prescribing behaviour is adaptive and can be positively influenced by structured feedback. Changing doctors' perceptions of acceptable, typical and best practice could reduce suboptimal antimicrobial prescribing.

Introduction

Inappropriate or otherwise suboptimal antimicrobial prescribing is a common cause of increased patient morbidity and mortality in hospitals.[1] In addition to having detrimental effects on individual patients, such suboptimal prescribing also contributes to antimicrobial resistance, which is a global public health concern[2] that is referred to by some as a "super wicked challenge".[3, 4] In response to the potential consequences of this problem, a UK Five Year Antimicrobial Resistance (AMR) Strategy[5] has recently been introduced, calling for increased understanding of, and response to, this issue. Strategies designed to improve the quality of antimicrobial prescribing have been implemented widely throughout the UK. One such example is the nationwide antimicrobial stewardship program, 'Start Smart – then Focus".[6] This approach advocates 'Right Drug, Right Dose, Right Time, Right Duration, Every Patient'.[7]

Research has shown that the majority of hospital prescriptions are written by junior doctors, who are in the first two years after qualification.[8] Prescribing errors occur in approximately 10% of these prescriptions and a substantial proportion of those errors involve antimicrobials.[9] This suggests that initiatives targeted at improving junior doctors' prescribing behaviour may significantly improve antimicrobial prescribing in the UK.

Despite recognition that structured, regular feedback is an important factor in developing expertise[10] and could facilitate changes in prescribing behaviours,[11, 12] several studies have highlighted that junior doctors get little feedback.[13-15] Ivers and colleagues found, in their systematic review, that feedback was most effective when it was accompanied by clear targets and an action plan, in addition to performance data.[16] Bertels and colleagues recently

reported that junior doctors are eager to receive both individual and general feedback about prescribing errors.[14] Furthermore, they found pharmacists willing to enhance the quality and quantity of the feedback they provided if time was made available. It has been suggested, therefore, that research should focus on developing and evaluating structured methods of providing such feedback that are feasible for pharmacists to deliver and beneficial for junior doctors to receive.[14] In particular, reflection as to what to do with feedback, in order to change future behaviour, is known to be as important as receiving feedback.[17] Self-generated plans have been shown to improve the effectiveness of feedback.[18] To date, there is a scarcity of literature reporting research that combines feedback and supporting future behaviour change with regard to prescribing.

Study aim and research question

Our aim was to conduct and evaluate a pharmacist-led feedback intervention for junior doctors. The research question was: how could structured feedback affect the rate of appropriate antimicrobial prescribing amongst junior doctors, in comparison to normal practice? We addressed this question using mixed quantitative and qualitative methods, assessing appropriate antimicrobial prescribing rates and exploring how both the intervention and normal feedback practice influenced prescribers' behaviour. Quantitative data assessed whether the intervention had an impact, whilst the qualitative data explored perceptions about what worked, when and where. It was important to include both methods because the social world is a complex one and we would not, therefore, be able to explain how or why our intervention had an effect on the basis of numeric data alone.[19, 20]

Methods

Study design

This was a multi-method study, incorporating a qualitative process evaluation within a quantitative intervention study. A single-blinded, randomised controlled trial compared the impact of a feedback intervention with normal practice on rates of junior doctors' appropriate antimicrobial prescribing. Qualitative interviews investigated how and why the intervention influenced prescribers' behaviour within the context of clinical practice.

Investigations as to the impact of complex interventions requires a good theoretical understanding as to the mechanisms by which change could occur.[19] This is not least because lack of impact could reflect problems in implementation, rather than genuine ineffectiveness. Therefore we chose to interview participants in both the intervention and control groups, to explore the whole system of antimicrobial prescribing and the influence of both intervention and normal feedback practice, especially as doctors in the intervention group received both types of feedback, as described below.

Governance approvals

The study was approved by the University of Manchester Senate Ethics Committee and the University Hospital of South Manchester Research and Development Department. All participants gave informed consent to either quantitative data collection alone, or in combination with a qualitative interview.

Setting and participants

The study site was a 900-bed teaching hospital in England. All 36 first year junior doctors were sent information about the study by the Foundation Programme Director. Initially, 29 agreed to participate and were randomly assigned (using computer-generated random numbers) to either intervention or control group. At a later stage, a further six doctors

expressed an interest in joining the study and, as the first intervention had already taken place, they were assigned to the control group (the rationale for allowing participants to join at a later stage is explained under 'Results'). Only they, some members of the research team, and the pharmacist facilitating the feedback intervention knew the group allocation. Ward pharmacists and staff on the validation panel did not know.

Control feedback practice

Participants in both the intervention and control groups received normal feedback practice from the ward pharmacist. This involved pharmacists initially detecting any suboptimal antimicrobial prescribing and prescribing errors as part of their normal duties. They then corrected minor issues themselves and discussed issues that were more significant with the doctor on duty at that time, who may not have been the original prescriber.

Intervention feedback practice

The intervention was designed to provide individualised, formal feedback on the appropriateness of foundation trainees' prescribing of antimicrobials. Confidential written feedback of the quantitative data described below was given privately to each participant at the beginning of feedback workshops by a senior pharmacist with medical education experience and training in facilitating group feedback discussions. Each participant received data about their own antimicrobial prescribing (both appropriate and suboptimal) and, for comparison, collated information about antimicrobial prescribing in the whole intervention group.

The feedback workshops were designed to increase participants' ability to prescribe appropriately by addressing knowledge gaps, discussing social and behavioural aspects of

prescribing, and encouraging reflection. Before attending, intervention group participants were asked to reflect on their individual prescribing behaviour and any problems they had experienced. Figure 1 presents the activities that occurred during the workshops after the participants had received the feedback information. Rather than just giving "the right answer", the pharmacist facilitator supported and guided participants' reflective processes. The doctors then set individual objectives as to how they were going to change their behaviour when faced with the same prescribing situations in the future. In the follow-up workshop, participants repeated this process with further feedback information and discussed how they had acted on their earlier objectives.

Quantitative data collection

Ward pharmacists were asked to identify new antimicrobial prescriptions written by junior doctors on weekly census days. The following data were collected from the prescription chart or from the medical notes by a member of the research team:

- Antimicrobial prescription(s) (drug, dose, frequency, route, duration, prescriber)
- Any concomitant condition that would impact on the prescription (e.g. renal/hepatic function impacting on the dose or drug choice)
- Any documented allergies to antimicrobials which would impact on the choice of agent
- Documented indication for each prescription or whether no indication was documented

In addition, the following information was collected, to understand the context of the prescribing and to allow decisions to be made as to whether the prescription was appropriate:

- Whether the drug was prescribed on a ward round (consultant or registrar) or on call

- Whether the infection was community or hospital acquired
- Whether the prescription was for prophylaxis or treatment
- Which specialty the junior doctor was working in
- Whether any recommendations had been documented in the notes (e.g. from microbiologists or infectious diseases specialists)
- Whether the hospital's antimicrobial guidelines had recently been updated
- Any other comments

Prescriptions were categorised as "independent" if there was no evidence that they were in response to instructions from a senior or a specialist in microbiology or infectious diseases. Prescriptions that took place as a result of such instructions were termed "dependent" prescribing.

Categorisation of prescribing appropriateness

A validation panel, which consisted of two hospital clinicians and two clinical pharmacists with specific expertise in infection and antimicrobial prescribing, evaluated all data and judged whether treatments were appropriate or suboptimal. Appropriateness was judged in relation to the Trust's antimicrobial guidelines using a development of a validated algorithm developed by Willemsen and colleagues (see Table S1 (available as Supplementary data at JAC Online).[21] Antimicrobial prescriptions (either for treatment or prophylaxis) were categorised using one of the following: appropriate decision, suboptimal antimicrobial choice, suboptimal prescription writing, or insufficient data to judge appropriateness. If a prescription was suboptimal because of both choice and writing faults, it was classified in the first group, as suboptimal antimicrobial choice. Prescriptions that were written using a non-

approved name (e.g. Augmentin®), rather than the generic name (according to the Trust's guidelines) were noted for feedback to the doctor. If that was the only issue, however, it was not classed as a suboptimal prescription.

Quantitative data analysis

The number of appropriate and suboptimal prescriptions were categorised by type by the panel, who were blinded to the identity of the doctor and whether they were in the intervention or the control group. The prescribing rates, both for appropriate and suboptimal prescribing, were normalised for each participant, to account for variations in prescribing activity. Student's t-test was used to compare these normalised prescribing rates for the participants in the two groups.

Qualitative data collection

Participants from the control and intervention groups were recruited for interview by email. All who agreed to participate were asked about their views on antimicrobial prescribing and normal feedback practices. Ten participating doctors were interviewed; five from the intervention group and five from the control group. Semi-structured qualitative interviews explored participants' experiences of antimicrobial prescribing in their working practice. Participants in both groups were asked about potential influences on changes to their antimicrobial prescribing practice over their first year as a junior doctor. Questions and prompts covered their prescribing practices and asked about their knowledge and skills, their beliefs as to how they could change their practice and their motivation to do so. In total, 233 minutes of audio data were gathered, with individual interviews lasting between 14 and 35 minutes.

For those participants in the intervention group, we also explored their perspectives on the intervention process and outcomes, and any positive or negative views of their experiences. They were asked about the perceived impact of the intervention, such as how the feedback affected participants' daily work practices.

Qualitative data analysis

The interviews were audio-recorded and transcribed verbatim. The data were analysed using a constant comparative method. Two members of the research team (LM and MT) independently identified core themes relating to the intervention and antimicrobial prescribing in general and reached a consensus. The themes within the data led us to examine the interrelationship between individual and social determinants of prescribing behaviour. This interpretation was discussed with a third member of the team (TD), who is an expert qualitative researcher and had remained naïve to the data. This independent opinion of the analysis encouraged reflexivity, enabled the interpretation to be refined further, and contributed to the validity of the final interpretation. The final interpretation is presented as a diagrammatic model, supported by illustrative cases and quotations from the data. Participants are identified by number, indicating the order in which they were interviewed. Unrelated text has been removed from the quotes, as indicated by ellipses (…).

Results

Twenty-nine doctors were initially recruited to the study; 14 were randomised to the intervention group and 15 to the control group. Six more doctors expressed an interest in joining the study after the first workshop had taken place and were added to the control group, which totalled 21 participants. The decision to add these participants at a later stage was based upon the fact that data on their prescribing had already been collected and,

therefore, denying them the opportunity to participate would have been unethical. It was judged that their inclusion would be unlikely to have a confounding effect if they were added to the control group. Three of the participants randomised to the intervention group attended one workshop session, while 11 attended both workshops.

Quantitative findings

Data were collected on 46 census days, one day per week for eight weeks (January-February 2013) and on two consecutive days per week for 20 weeks thereafter (March-July 2013). Data on antimicrobial prescribing were collected for 166 patients, 104 from medical and 62 from surgical wards. For these patients, 204 antimicrobial prescriptions were identified as having been written by junior doctors. Seventy-five prescriptions were written by participants in the intervention group and 129 written by those in the control group.

Ninety-four (46%) prescriptions were written independently (i.e. apparently based on a junior doctor's own decision) and 110 (54%) dependently, i.e. based on instructions given by a microbiology/infectious diseases doctor or senior colleague on a ward round (Table 1). In total, eighty-eight prescriptions (43.1%) were written appropriately and 116 (56.9%) were written suboptimally (Table 2). Fifteen otherwise appropriate prescriptions and 15 suboptimal prescriptions used a non-approved name.

For the intervention group, there were 37 appropriate and 38 suboptimal prescriptions (mean normalised prescribing rate (±SD) of suboptimal to all prescribing = 0.32±0.36); for the control group, there were 51 appropriate and 78 suboptimal prescriptions (mean normalised suboptimal prescribing rate = 0.68±0.36). The mean normalised prescribing rate of suboptimal prescribing was significantly different between the groups (*p*-value=0.0005).

This was mostly due to differences in suboptimal prescription writing, rather than differences in suboptimal choice of antimicrobials (Table 2).

Qualitative Findings

In order to understand how our intervention affected participants' behaviour, we identified other influences on the participants' antimicrobial prescribing, shown in Coding Template 1 (Table 3). Coding Template 2 (also Table 3) shows themes that related specifically to the structured feedback sessions, i.e. the intervention. Following a thematic analysis, we were able to suggest a theory of prescribing behaviour and propose some mechanisms of change. Throughout this discussion of our findings, themes represented by third-level codes are highlighted in bold.

Prescribing behaviour

Antimicrobial prescribing behaviour had three major components: motivation, process and evaluation (Coding Template 1, second-level codes). Each of these aspects was influenced by a complex network of individual and social variables (Coding Template 1, third-level codes). Some of these influences were primarily individual (indicated by I), whilst others were predominantly social (indicated by S). However, they were interdependent and, therefore, prescribing outcomes (i.e. written prescriptions) could not be accounted for by a purely individual or social view of behavioural determinants. This is illustrated by two case examples. One participant (Participant 04) identified lack of personal knowledge (individual factor) and conflict between colleagues (others' expectations) and guidelines (social factors) as being barriers to optimal prescribing (Table 4, Q01). He went on to explain, in Q02, how the media and his seniors had increased his awareness of antimicrobial resistance (social

influence), which motivated him to be self-aware when he was prescribing (individual factor). He perceived the benefits of careful prescribing as being both social (patient safety) and individual (personal benefit), as described in Q03. This participant went on to discuss how workplace culture had influenced him to prescribe suboptimally in certain circumstances. Although he was aware of how it should be done, the social environment made suboptimal prescribing acceptable (Table 5, Q10).

A second participant (Table 4, Participant 06) described why, even though she was aware that she should complete all the details on a drug chart and ask if she was unsure (self-awareness), it was not always possible to do so. This was due to a mixture of social factors (affordances, others' expectations) and personal factors (avoiding embarrassment/emotions, Table 4, Q04). Even when she was prescribing individually there was a strong social influence, as she relied upon guidelines. An affordance refers to the capabilities or support that an environment or situation offers. When this doctor was by herself, she was afforded the time to look up the information she needed. In contrast, on ward rounds she simply wrote down what she was told to (division of labour, others' expectations, Table 4, Q05): This doctor went on to talk about how her own prescribing practice changed over time, due to increased awareness of why optimal prescribing could benefit her and her peers (self-awareness, personal benefit, workplace etiquette, Table 4, Q06).

Prescribing outcomes

Participants' perceptions of prescribing outcomes could be divided into error, suboptimal or optimal prescribing. Generally speaking, doctors viewed error as being synonymous with potential to cause direct and immediate harm to a patient rather than merely writing a prescription suboptimally (Table 5). One participant explained that avoiding harm to patients

was a strong motivator for good prescribing. She described the difference between forgetting to check a patient's allergy status (an individual responsibility) and poor drug monitoring (a collective responsibility, Table 6, Q12). In doing so, she suggested that the desire to avoid personal responsibility for harming a patient had a strong influence on prescribing behaviour (Table 6, Q13). She also emphasised that prescribing errors cause patients to suffer, implying that a suboptimal prescription that does not cause direct harm to a patient would not be a "true" error (Table 6, Q14). Another doctor put this more explicitly, stating that some of the prescribing we identified as suboptimal was not a true error from her perspective. She recognised the importance of avoiding dangerous prescribing but was less certain about why suboptimal prescribing was important if it didn't cause direct harm to patients. One participant (Table 5, Q11) rejected feedback about an error, based on the fact that she did not perceive it as such. From this, we concluded that junior doctors have their own system of significance regarding errors.

The junior doctors acknowledged that suboptimal prescribing occurred and that they were aware of some aspects of their suboptimal behaviour but unaware of others (Table 5). They perceived suboptimal prescribing differently from error and it was clear that their perceptions of suboptimal prescribing were not aligned with the criteria we had used to categorise suboptimal prescriptions (Table 2). Several participants stated that their suboptimal antimicrobial prescribing behaviour was something they were aware of but they considered it to be *inevitable*, *acceptable* or, in some cases, *necessary*. Due to lack of personal knowledge, some suboptimal prescribing went *unrecognised* prior to feedback (Table 5, Q07). Participants stated that some suboptimal prescribing was *inevitable*, either due to lack of knowledge about prescribing (Table 5, Q08) or due to the social environment (Table 5, Q09). Some suboptimal prescribing was thought to be *acceptable* within workplace culture. One

participant explained that despite being highly motivated to prescribe appropriately and having the personal knowledge to do so, on occasions he chose not to because of social influences, such as senior colleagues, nurses' reactions, the guidelines and lack of feedback on his suboptimal prescriptions (Table 5, Q10). Sometimes suboptimal prescribing was viewed as being *necessary*, due to prioritising patient safety, rather than strictly following the best practice guidelines (Table 5, Q11).

Relationship between prescribing behaviour and outcomes.

Based on our findings from the thematic analysis, we developed a model representing the behaviour of a prescriber whose written prescriptions occur within a spectrum of prescribing outcomes, from A to E (Figure 2). A is a prescription that is unequivocally wrong, whilst E is an optimal prescription (according to our evaluation criteria). The area between A and E represents suboptimal prescribing. The data show that each junior doctor aims to prescribe within certain parameters, based on their own perception of a minimum acceptable standard (B) and their personal maximum capability, which is what they perceive to be best practice (D). Somewhere between these extremes is their typical, or habitual, prescribing behaviour (C). Whilst A and E are fixed points, the positions of B, C and D are flexible, and are determined by interactions between the individual and the social variables mentioned above.

The lower limit of acceptable prescribing (B) is strongly motivated by avoidance of immediate harm to patients (Table 6). The doctors also have a personal standard of typical prescribing, which does not necessarily refer to the best prescription that the prescriber is capable of. Instead, it refers to what an individual prescriber perceives to be an acceptable compromise between the many social and individual variables outlined above in Coding Template 1 (Table 3) and throughout the thematic analysis. The individual's perception of

best practice (D) refers to their current maximum capability, which could be achieved if the individual was strongly motivated to achieve their best standard and if contextual conditions were optimal. This may or may not equate to best practice, depending on whether doctors' perception of an optimal prescription is aligned with our evaluation criteria or falls below actual best practice. In summary, therefore, a prescription that occurred in the space between A and B would represent genuine error and one between B and C represents recognised suboptimal prescribing.

Feedback intervention

The feedback workshops enabled participants to relate to others and feel reassured that they were not the only junior doctor who struggled with antimicrobial prescribing (Table 7, Q15). It also gave them access to specific, personalized feedback that helped them to identify their strengths and weaknesses and learn from errors (Table 7, Q16). Importantly, participants valued having time to reflect on how to improve their prescribing behaviour, as the social context did not usually afford them the opportunity to do this (Table 7, Q17).

Impact of the feedback intervention

The qualitative data show that feedback workshops changed the parameters of an individual's perception of optimal and adequate prescribing, which may have influenced prescribing behaviour. Referring to the model, two main mechanisms were responsible for this, occurring singly or together. The first is by increasing participants' perceptions of best practice (D), thereby improving their maximum capability and reducing the gap between D and E. The second is by increasing the standard of their typical prescribing practice (C), thereby reducing the gap between C and D (Table 8). The intervention enabled participants to become aware of previously unrecognised areas for improvement in their practice, which expanded their scope

for development (Table 8, Q18 and Q19). In addition, by highlighting the importance of improving prescribing behaviour, the intervention seemed to increase doctors' motivation to change (Table 8, Q20).

In summary, our qualitative data showed that a pharmacist-run feedback intervention influenced the complex web of interconnected influences on junior doctors' behaviour. This is explained and explored further in Discussion.

Discussion

The normalised rate of suboptimal antimicrobial prescribing to all antimicrobial prescribing was significantly lower for the intervention group. For both groups, there were few prescriptions categorised as "not needed" and no allergy-related suboptimal prescribing was detected. The difference between the two groups was largely due to differences in suboptimally written prescriptions rather than the choice of antimicrobial agent. Suboptimal prescribing that may have had a direct adverse effect on patient care was infrequent.

Our thematic analysis of the qualitative data showed that individuals' prescribing behaviour was influenced by a complex series of dynamic interactions between individual and social factors. Our interpretation of these findings (summarised in Figure 2) is that junior doctors' prescribing behaviour is part of a complex adaptive social system. When we refer to a system as adaptive, we mean that the system and its agents will co-evolve in response to change. In viewing the system as complex, we accept that we cannot predetermine the precise influences and outcomes of any given situation, so the system eludes prospective analysis. Prescribing behaviour and outcomes (i.e. prescriptions) are the result of a negotiation, or compromise,

between different influences and variables, which will be different for varying situations, contexts and individuals. The parameters relating to doctors' personal perceptions of prescribing standards, identified in our model, represent loose but flexible boundaries, in that they are individually and socially negotiated and are thus changeable. However, it is possible to identify attractors, or states, towards which the system may evolve. We suggest that feedback workshops can act as a positive attractor within this complex system by expanding the doctors' potential for optimal prescribing. Change can occur by influencing doctors' perceptions of acceptable, typical and best practice, which are the socially and individually constructed cognitive parameters by which they judge their own prescriptions.

In light of the complexity of interactions between different influences on junior doctors' perceptions and behaviour, it would be unrealistic to assume that our intervention could have consistent and predictable effects on prescribing practice. In addition, it is possible that unfailingly prescribing according to what is defined as 'best practice' could influence the system in negative ways. Imagine, for example, a junior doctor who is determined to complete all the boxes on the prescription chart during a busy ward round, at the expense of holding up the rest of the team, reducing the amount of time available to review other patients, angering the consultant and causing themselves embarrassment (see Table 4, Q04). Would we prefer a junior doctor to prioritise best practice, designed with the hypothetical average patient in mind, over safe practice for the unique patient they must treat in the immediate social context (Table 5, Q11)?

Broom and colleagues[22] and Mattick and colleagues[23] have recently proposed that suboptimal prescribing can be logical and realistic when we consider the social context of clinical workplaces. This supports our finding that junior doctors often perceive suboptimal

prescribing as being acceptable or necessary within the context of workplaces. Charani and colleagues also stressed the limitations of best practice by pointing out that, whilst it applies to the 'average' scenario, patients and prescribing situations are more often unique than average.[24]

Our model emphasises the reciprocity between individual and social influences on behaviour, which interact to determine junior doctors' perspectives and subsequent actions. Our findings suggest that junior doctors' individual development is an ongoing, dynamic process of adapting to their social experiences; this view is confirmed by Billett's work on relational interdependence.[25]

Charani and colleagues pointed out that interventions aimed at junior doctors are likely to be limited due to the dichotomy between organisational expectation and social norms.[24] Although we have increased doctors' awareness of how and why they could improve their prescribing behaviour (according to criteria determined by organisational expectation), we have not directly altered the social and cultural rules that exist within workplaces. However, if prescribing is a complex system of practice, then learning can be viewed as the process by which this system, and the individuals within it, adapt and evolve. We propose that, as members of the social group that is responsible for the majority of hospital prescribing,[8] junior doctors could be in a position to facilitate system adaptation if they are adequately supported to do so by academic and clinical advisors. Giving this responsibility to the most junior members of the medical workforce may be innovative but our research has shown that their insights offer a valuable perspective on practice, which can identify long-standing traditions and workplace cultures that should be challenged and addressed.

Strengths and limitations

This was a multi method study that evaluated the efficacy of an intervention designed to improve antimicrobial prescribing amongst junior doctors, as well as exploring what influences behaviour and how structured feedback may change it. The use of quantitative assessment and a qualitative process evaluation is the main strength of this study. Brennan and Mattick recently stated that there is "an urgent need to create educational interventions that support the development of desirable behaviours in junior doctors" and that "future research needs to enhance our understanding of what underpins observed behaviour changes, for example, by including a qualitative process evaluation within quantitative study designs".[20] To our knowledge, our study is the first example of such research in this field.

The numbers of new antimicrobial prescriptions identified on census days were surprisingly low, despite strenuous efforts to maximise data collection. After the study had been completed, a point prevalence audit was conducted on a sample of ten wards (five surgical and five medical), recording the grade of person who had written all prescriptions on that day or the previous one. In this audit, we identified 77 antimicrobial prescriptions. Of these, 22 would have met the inclusion criteria for our study. In contrast, pharmacists identified a mean of 4.4 prescriptions (range 1-15) on the census days. Ward based pharmacists stated that this was due to time pressures, difficulties identifying junior doctors' signatures, 'audit fatigue' and lack of incentive to participate. Our audit confirmed that unidentifiable prescribers were an important barrier to data collection, affecting 13 of the 77 prescriptions, as found by others.[26] Another limitation of the data collection was that it was not always possible to be sure whether a prescription had been written independently, as this is not something that is routinely documented. Given that the intervention is dependent upon ward based pharmacists being willing and able to collect data that can be fed back to prescribers, further work is

needed to develop a system that is sustainable in the current busy NHS, outside the context of a research study.

The interviews provided sufficient data for an informative qualitative analysis. However, due to the complexity of prescribing behaviour and the way in which it is influenced by so many individual and social variables, including feedback, we cannot assume that the prescribing behaviour illustrated here would be similar elsewhere or at a different time within the same setting. It is also possible that participants in the intervention group may have spoken to, and influenced, those in the control group, although interviews with control group participants did not indicate this. We feel that our primary conclusions are valid, as they are based on a conceptualisation of behaviour that could apply to many different workplace tasks, settings and social groups.

Future work

The participants and the pharmacist facilitator in this study suggested that future work should aim to increase the quantity of feedback and provide it closer to the time of the prescription being completed. Further studies could also involve senior doctors and staff from other disciplines, in order to address aspects of workplace culture and etiquette that appeared to have a prominent influence on junior doctors' behaviour. The model that we have suggested could provide a valuable tool for investigating how junior doctors' perceptions of prescribing change for different drugs, different settings or how these perceptions evolve over time. Furthermore, it provides a framework for considering how practice occurs in relation to cognitive parameters that are constructed based on complex interactions between individual and social factors. This could be applicable to aspects of work and workplace learning in many different fields of study.

Conclusion

The normalised rate of appropriate prescribing was significantly better in the intervention group, particularly for prescription writing. Our qualitative analysis showed that the intervention increased junior doctors' awareness of how they could improve and appeared to raise the standard of their habitual prescribing behaviour. We conceptualised junior doctors' prescribing behaviour as part of a complex adaptive social system and view the feedback intervention as a positive attractor within a complex network of behavioural influences. Interventions that address other factors within the system, such as senior colleagues' attitudes and behaviour, may further enhance the potential for better prescribing amongst junior doctors.

The data show that suboptimal prescribing is often perceived as being acceptable or necessary within the complexity of medical practice, by junior doctors and their senior colleagues. An important question that our analysis raises is: does optimal prescribing, as perceived by junior doctors, always indicate true best practice? Our data suggest that it could be time to reconsider our reliance on a narrow view of best practice, which implies that there is a simple, correct way of doing something, and, instead, focus on teaching junior doctors to aim for well-informed, thoughtful practice. Such an approach would take account of the complexity of individuals and the social milieu in which they work and learn.

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None to declare.

Author contributions: MT was the principal investigator and oversaw the project from beginning to end. The whole team contributed to the design of the study, the grant proposal, the ethics approval, the final report and this paper. PL was responsible for the development of the data collection and feedback forms and for setting up the validation panel. PN was responsible for part of the recruitment and was also part of the validation panel. SW managed the pharmacists' participation and managed the validation panel. LM gathered data that had not been collected by the ward

pharmacists and entered data into a database prior to the quantitative analysis, which was carried out by DS. LM also recruited participants for the qualitative interviews, conducted those interviews and led the qualitative data analysis. MT and TD reviewed the qualitative data and contributed significantly to the analysis and the final interpretation. LM carried out the point prevalence audit and was responsible for this manuscript. All authors contributed to, and approved, the final manuscript.

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Figure 1. Outline of activities in feedback workshop

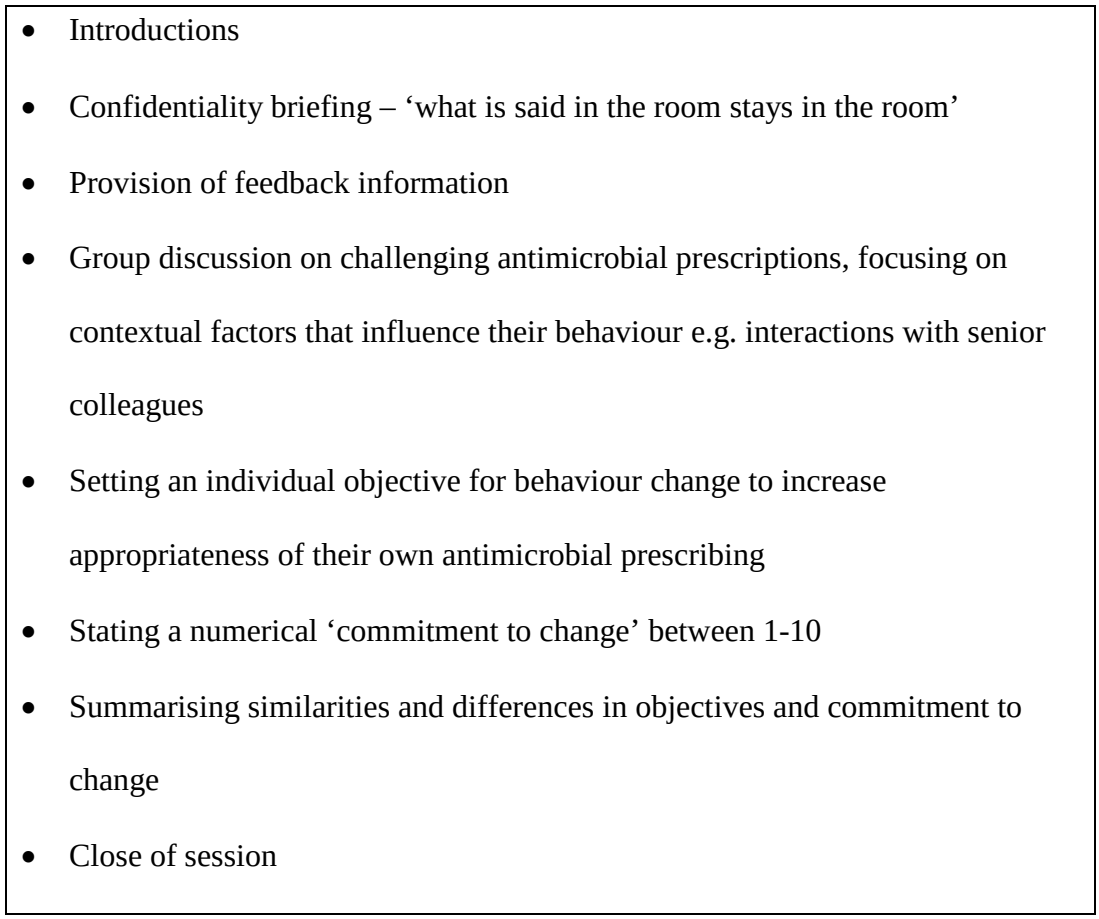

Table 1. Number of appropriate and suboptimal prescriptions, shown as independent or dependent prescriptions, for the intervention and the control group.

	Intervention n (%)	**Control n (%)**	**All n (%)**
Appropriate Independent	20 (26.7%)	18 (13.9%)	38 (18.6%)
Appropriate Dependent	17 (22.7%)	33 (25.6%)	50 (24.5%)
Suboptimal Independent	20 (26.7%)	36 (27.9%)	56 (27.5%)
Suboptimal Dependent	18 (24.0%)	42 (32.6%)	60 (29.4%)
Total	**75**	**129**	**204**

671 **Table 2**. Number of appropriate and suboptimal prescriptions, categorised by type, for the

672 intervention and the control group.

	Intervention	**Control**
Appropriate antimicrobial prescribing		
Choice/use based on recognised best practice	37 (49.3%)	51 (39.5%)
Suboptimal choice of antimicrobial medication		
Not needed	2 (2.7%)	3 (2.3%)
Not followed Trust/other guidance	5 (6.7%)	8 (6.2%)
Suboptimal choice for patient due to age etc	0	1 (0.8%)
Suboptimal writing of prescription		
Sub-optimal regimen	31 (41.3%)	62 (48.1%)
Sub-optimal or no duration	0	4 (3.1%)
Overall total	**75 (100%)**	**129 (100%)**

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674 **Table 3.** Coding Templates 1 and 2.

Coding Template 1: Influences on Prescribing Practice		
First-level code	Second-level code	Third-level code
Prescribing behaviour	Prescribing process	Personal knowledge/experience (I)
		Habits (I)
		Agency (I)
		Self-awareness (I)
		Emotions (I)
		Instructions from others (S)
		Division of labour (S)
		Affordances (S)
		Resources/guidelines (S)
		Workplace culture/etiquette (S)
	Motivation	Personal benefit (I)
		Others' expectations (S)
		Patient safety (S)
		Best practice (S)
	Evaluation	Self-assessment (I)
		Feedback (S)
Prescribing outcome (the written prescription)	Error	
	Suboptimal – recognised or unrecognised	
	Optimal prescribing	
Coding Template 2: Impact of Feedback Intervention		
Feedback intervention	Relating to others	Peer group learning
		Reassurance
	Informed self-assessment	Learning from errors
		Identification of weaknesses

	Reflection on feedback	Rejection of feedback
		Trigger for behaviour change
	Behaviour change	

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676 I=individual influence; S=social influence

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678 **Table 4.** Case examples of prescribing behaviour from the qualitative data.

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Number	Quote
	Case 1 – Participant 04
Q01	*"Sometimes being unaware of how long you should keep somebody on something, because even though the guidelines state so-and-so days, if you phone a microbiologist they may say to go longer or shorter, and then your consultant who's very experienced might say only keep them on that for three days, don't keep them on longer."*
Q02	*"I heard from a consultant before that so much money is being spent on different drugs but hardly anything's been spent on new antibiotics, and we haven't really got a new generation of antibiotics being brought in, so these are the antibiotics that we have now and if we waste them and do get resistances then that's bad news for us.… …Some people have a blasé attitude about that. It's very easy to just fall into being equally blasé. So I suppose I don't like being like that. I like being smart about things.… … You usually have weekly updates on how we're all going to die because of some horrible bug on BBC One. So [I'm] influenced by the media and by my seniors basically"*
Q03	*"I think if someone's on Tazocin too long you always want to review them after 48 hours. If they're apyrexial, take them off. Even if it is just for the reason that you don't want to have to keep on cannulating them, because you should always try and switch them on to orals as quickly as possible for their benefit, but it also benefits you because you don't have to faff around…"*
	Case 2 – Participant 06
Q04	*"I do try to always make sure I write those things [dosage, duration] on, but as an F1 [Foundation Year 1 doctor], sometimes you're just told what to prescribe by whoever, your senior, and it's not always clear what the indication is sometimes, and sometimes you don't want to ask because you look a bit stupid if you don't know, like, why they've chosen that antibiotic…I should probably ask, but sometimes you don't have time, or sometimes you think, maybe I just wasn't listening when he said what it was for, so, I don't want to look stupid and ask him."*
Q05	*"Prescribing by myself is normally… I'll know why I want to give the antibiotics, or if I don't, like, sepsis query source that's fine because I know that there's a guideline for it, the formulary for the hospital, so that makes it much easier. Then I can look up that because I'm by myself and I've got time to, to look up how long it should be and what it should be. So, that's easier if it's by myself, but if I'm on ward round and someone just tells me to write something up, that's probably when less things get filled in, if they're not telling me what to put in it."*

Q06	*"[When I first started] I didn't really see the importance of it [writing the clinical indication on the prescription]. Now, because I've done loads of on calls, I can see the importance of how it's useful… …I think it doesn't really matter to the patient whether clinical indications are written on there if they're getting the right antibiotic. I think it makes it easier for other doctors coming in to look at it."*

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681 **Table 5.** Participants' explanations of suboptimal prescribing.

Number	Quote
Q07	**Participant 10:** *"The first job I was in it [prescribing] wasn't really pointed out as a problem but during the study it was. I got to know that I was prescribing Tazocin."* **Interviewer:** *"So that was something you just hadn't realised you were supposed to do differently?"* **Participant 10:** *"Yeah."*
Q08	**Participant 02:** *"I was always conscious, at the back of my head, of the lack of microbiology teaching that I received in medical school anyway, and based on that, the fact that my knowledge in this area is deficient…It was a bad basis for antimicrobial prescribing, the fact that our microbiology teaching was not sub-optimal, it was absent. It was non-existent.… …That formed the bad basis for antimicrobial prescribing."*
Q09	**Participant 08:** *"Surgical ward rounds post take are so fast you don't even know if you're coming or going and, you know, you're writing in someone else's notes whilst they've gone on to the next patient and you're expected to prescribe the medication. So, yeah, you know, you often...that is tricky so you do...they're those prescriptions that might not be as good as you'd like them to be."*
Q10	**Participant 04:** *"I'll still prescribe Tazocin because someone will just say Tazocin, and all my colleagues just write Tazocin, and it's just Tazocin…everyone else does it so you do it…you actually have that written as Tazocin on the antimicrobial [guidelines]…maybe that's why I've been influenced…I always feel like a bit of a geek when I prescribe it [piperacillin and tazobactam]…It's almost like you're writing it in a very formal way but you don't need to because they all know. It's almost like they [the nurses] look at you as if you're insulting their intelligence…You need to inform the consultants, the registrars to call it piperacillin and tazobactam and encourage it from that point of view so that juniors get into good habits at the start…If you write Tazocin and then nothing comes of it and there's no adverse effects you think wow, well I can just write Tazocin every day."*
Q11	**Participant 01:** *"I think that [prescribing a lower dose] was appropriate anyway because I don't want to give a higher dose risking overdose rather than, you know, I just always think it's safer to give a lower dose in that case ... I think in that situation I would perhaps still prescribe as I wouldn't think it's dangerous or anything like that. If anything I think it's safer than prescribing the higher dose to a renal impaired patient."*

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684 **Table 6.** Participants' perceptions of error.

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Number	Quote
Q12	**Participant 06:** *"[Checking allergies is] such a simple thing to do, and if you get it wrong, like it's…instead of you giving a treatment that's going to help somebody, you've actively made them worse, and that's your prescribing. I think that's…I mean, I'm not…like giving someone C. diff, and giving them antibiotics for 20 days is obviously horrendous as well, but there will have been people that have looked at that every day, not just you, and seen it was going on for 20 days."* ***(patient safety, motivation, emotions****)*
Q13	**Participant 06:** *"The less mistakes I can make, the better, because obviously, it is always the patient that suffers"****(patient safety)***
Q14	**Interviewer**: *"Maybe some of what was classed as inappropriate prescribing wasn't a prescribing error from your point of view?* **Participant 01**: *"Yeah, I think there is a grey area as well a lot of the times in antimicrobials so I think you really need to...yeah, I don't know, I think it depends on the percentage of dangerous prescribing. Hopefully there isn't any."****(patient safety****)*

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690 **Table 7.** Participants' views on the impact of the intervention.

Number	Quote
Q15	**Participant 02:** *"Just a feeling of relief that most of us junior doctors are pretty much in the same boat, it's not just me that is a bit oblivious to certain aspects of antimicrobial prescribing!...That's one of the things I appreciate the most of this intervention …[I'm] not really different from other junior doctors."*
Q16	**Participant 10:** *"Yeah, I think it's good to see what you're doing well and what you're doing badly like individually, you know, because I think a lot of the time there's a focus on not singling people out on the wards and saying you're doing that wrong. And I think it's a good thing to do really."*
Q17	**Participant 08:** *"When you're on a ward round and you're filling out the form, it was more seen as a chore and obviously it would flag things up in your mind but then you're on to the next thing, whereas this [the intervention] makes you actually sit down and think about it, talk about it and reflect on it."*

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694 **Table 8.** Mechanisms of behaviour change.

Number	Quote
Q18	**Participant 02:** *"I would find out the duration if I'd been asked to prescribe, indication…so yes, and also when I am referring to resources, particularly when I'm discussing the case with the microbiologist, I would ask, for my own learning experience, to address the knowledge deficiency…just say, for my own learning, why this antibiotic and why not the other one."*
Q19	**Participant 10:** *"I suppose it was just interesting to hear what, from a pharmacist's point of view and generally from the records point of view, what was wanted of us when we write an antibiotic prescription in terms of being as specific as you can possibly be about why you're giving it, the duration of it."*
Q20	**Participant 09:** *"[The ward round] goes so fast and you'll often just get told to prescribe something and you're not sure yourself why so you leave that box blank because you don't want to look like an idiot and say, why are we starting this? But I'm just going to question anyway so I can get it right…you might just get a bit of a telling off or a 'you should know', but that's life isn't it."*

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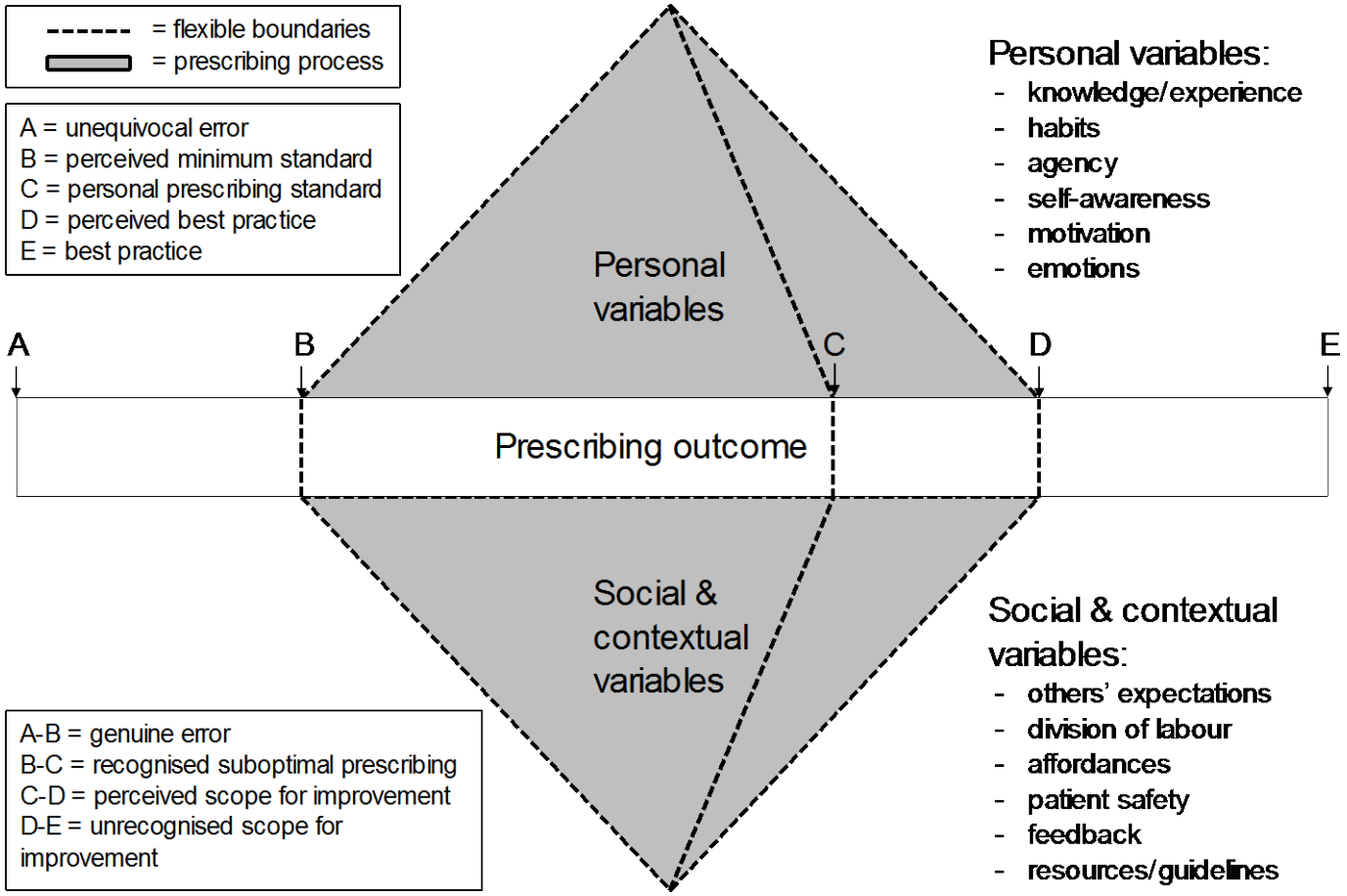
Figure 2. A model of junior doctors' prescribing behaviour


= flexible boundaries
= prescribing process
A = unequivocal error
B = perceived minimum standard
C = personal prescribing standard
D = perceived best practice
E = best practice
Personal variables:
- knowledge/experience
- habits
- agency
- self-awareness
- motivation
- emotions
Personal variables
A
B
C
D
E
Prescribing outcome
Social & contextual variables
Social & contextual variables:
- others' expectations
- division of labour
- affordances
- patient safety
- feedback
- resources/guidelines
A-B = genuine error
B-C = recognised suboptimal prescribing
C-D = perceived scope for improvement
D-E = unrecognised scope for improvement