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Factors affecting prescriber implementation of computer-generated medication recommendations in the SENATOR trial – a qualitative study

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ABSTRACT

Background

The SENATOR trial intervention included the provision of computer-generated medication recommendations to physician prescribers caring for hospitalised older adults (≥65 years), with the aim of reducing in-hospital adverse drug reactions. Interim data analysis during the trial revealed that the prescriber implementation rates of the computer-generated STOPP/START recommendations were lower than expected across all six trial sites.

Aim

The aim of this qualitative study was to identify the factors affecting prescriber implementation of the medication recommendations in the SENATOR trial.

Methods

Semi-structured interviews were conducted with trial researchers and physician prescribers who were provided with SENATOR recommendations. Content analysis was used to identify the most relevant domains from the Theoretical Domains Framework (TDF) that affected recommendation uptake.

Results

Ten trial researchers and fourteen prescribers were interviewed across the six trial sites. Eight TDF domains were found to be most relevant in affecting prescriber implementation: 'environmental context and resources', 'goals', 'intentions', 'knowledge', 'beliefs about consequences', 'memory, attention and decision processes', 'social/professional role and identity', and 'social influences'. Interviewees felt that there was often a disconnect between the time prescribers were reviewing the patient and the point at which the recommendations were provided. However, when recommendations were reviewed, prescriber inertia was highly pervasive, with a particular reluctance to make pharmacotherapy changes outside their own specialty. Implementation was facilitated by recommendations reaching a '*decision-maker*', but this was often not possible as the software could

not evaluate the entire clinical context of patients, and thus frequently produced recommendations of low clinical relevance.

Conclusion

This study has demonstrated that the clinical relevance of the SENATOR prescribing recommendations was a significant factor affecting their implementation. Whilst software refinement will be necessary to improve the quality of recommendations, future interventions will need to be multifaceted to overcome the complex prescriber specialty culture within the acute hospital environment.

Key words

Qualitative, Interview, Theoretical Domains Framework, Prescribing, Aged, Hospital.

Key points

- Qualitative research alongside the SENATOR randomised controlled trial has been very useful in reviewing prescriber implementation issues with the intervention and exploring reasons behind trial findings.
- Many of the computer-generated medication recommendations were deemed to be of low clinical relevance, which limited their uptake and contributed to prescriber fatigue with the SENATOR intervention.
- Future interventions should aim to identify the right person to receive the prescribing recommendations and the right time for the intervention to occur, with appropriate integration into prescriber workflow.

1. INTRODUCTION

A recent systematic review and meta-analysis has demonstrated that computerised interventions can significantly reduce potentially inappropriate prescribing (PIP) in hospitalised older adults, but with limited benefits for patient outcomes [1]. The SENATOR (Software ENgine for the Assessment & optimisation of drug and non-drug Therapy in Older peRsons) project included a multi-centre randomised controlled trial (RCT) whereby the intervention involved the provision of computer-generated pharmacological and non-pharmacological recommendations to attending physician prescribers providing care to older adults in the hospital setting, with the trial's primary aim being to reduce in-hospital adverse drug reactions (ADRs) in this patient cohort (https://www.senator-project.eu/). The pharmacological recommendations were based on version 2 of the Screening Tool of Older Persons' potentially inappropriate Prescriptions (STOPP) and the Screening Tool of to Alert to Right Treatment (START) criteria [2], as well as drug-drug and drug-disease interactions identified by approved electronic databases.

An RCT by O'Connor *et al*. had previously demonstrated that relatively high prescriber implementation rates of STOPP and START recommendations were associated with a clinically significant reduction in the proportion of older patients experiencing in-hospital ADRs when comparing the intervention and control groups (21% versus 11.7%) [3]. However, interim data analysis from the SENATOR trial after 12 months of patient recruitment showed that the prescriber implementation rates of the STOPP and START recommendations were lower than expected across all six trial sites (approximately 17%). A qualitative study alongside the SENATOR RCT was not planned from the outset, but it was deemed of utmost importance to investigate the possible reasons for the observed low implementation rates as this may impact on the primary outcome of the trial (i.e. hospital-acquired ADRs). Qualitative studies conducted in conjunction with RCTs have been shown to be important in the evaluation of complex interventions, and are especially important in multi-centre trials, where the '*same*' intervention may be delivered in different ways [4, 5].

Thus, the aim of this qualitative study was to identify the factors affecting prescriber implementation of the computer-generated STOPP/START recommendations in the SENATOR trial intervention, with a view to informing the design of future studies aiming to optimise pharmacotherapy in hospitalised older adults.

2. METHODS

2.1 Context and Study Setting

This qualitative study was undertaken in conjunction with a larger European research project: the SENATOR study, which included an RCT that was conducted in six large acute teaching hospitals in six European countries (**Table 1**). Briefly, as part of the SENATOR intervention, computer-generated pharmacological and non-pharmacological recommendations were provided to physicians caring for the intervention patient group, with the primary aim of reducing in-hospital ADRs. All patients randomised were multimorbid older adults (≥65 years) with an expected length of hospital stay >48 hours. Primary researchers working with the trial were involved with patient recruitment, data collection, data entry into the SENATOR software engine, patient randomisation, and contacting the attending team of physicians (via telephone or face-to-face, a written note in the patient's clinical record, and email) to inform them that the patient was randomised to the trial intervention arm, and that computer-generated recommendations were available to be reviewed in the patient's clinical record (either paper-based or electronic record depending on the hospital site). For more information about the RCT, the trial methods have been published in detail elsewhere [6].

2.2 Study Design and Recruitment

Semi-structured interviews were conducted with primary researchers working with the trial and prescribers (medical or surgical) who were provided with the SENATOR recommendations. Semi-structured interviews were chosen as the preferred method of data collection as they tend to elicit more in-depth descriptions of participants' experiences and perspectives [7]. The Consolidated

Criteria for Reporting Qualitative Research (COREQ) checklist was used to guide reporting in this study (**Supplementary Table 1**) [8].

Interview participants were eligible to be recruited from any of the six hospitals involved with the SENATOR trial (Table 1). The authors planned to interview i) two medical prescribers per site, ii) one surgical prescriber per site, and iii) two primary researchers per site where possible (as some sites only had one primary researcher still working with the trial). The primary researchers involved with the SENATOR trial were recruited using purposive sampling as there were limited numbers of primary researchers at each site. Snowball sampling was used to recruit prescribers, whereby the SENATOR primary researchers and their colleagues referred the interviewer to prescribers in their site who would participate in the study. Participants were contacted via email and provided with an information sheet and consent form in their native language in advance of the interview.

2.3 Data Collection

Two separate topic guides comprising a similar line of questioning were formulated for both prescribers and primary researchers, and these were based on a review of the literature, the Theoretical Domains Framework (TDF) [9], and the authors' practical knowledge of the RCT and research area (see supplementary material). Careful consideration was given to the language used, knowing that English would not be the first language for all participants. The topic guide for interviewing prescribers was piloted with a prescriber who had received SENATOR recommendations in the lead trial site, and this interview was included in our data analysis. The topic guide for interviewing primary researchers was piloted with a primary researcher working with a similar RCT (OPERAM study - https://operam-2020.eu/index.php?id=1488), who was very familiar with the SENATOR trial procedures. The topic guides were iteratively refined during the study to ensure that emerging themes were explored in subsequent interviews.

All semi-structured interviews were conducted in English by KD, a research pharmacist with training in qualitative research and a primary researcher with the SENATOR trial. All but one of the interviews were conducted in person. One interview was conducted face to face via Skype® as the

primary researcher was not available at the time the interviewer visited the trial site. The interviewer had established a rapport with some of the primary researchers prior to the qualitative study during trial meetings and teleconferences, but no relationship between the interviewer and prescriber participants was established prior to study commencement.

The interviews were conducted in a private area at the participant's workplace from November 2017 to May 2018. Participants were briefed about the study and reassured that all interviews would be anonymised. All interviewees provided written informed consent for participation, and had the opportunity to withdraw from the study at any time. Interviewees were provided with a sample of a SENATOR report in their native language during the interview as a reminder of the report design and the types of recommendations provided. Field notes were recorded after each interview, and were used to refine topic guides and inform data analysis. Interviews were audio-recorded and transcribed verbatim. Data analysis coincided with data collection, and we sampled until no new themes emerged. An additional three interviews were conducted without any new themes appearing to confirm that data saturation had been reached [10].

2.4 Data Analysis

All transcripts were entered into QSR NVivo® Version 11 to facilitate analysis. The data were analysed in four phases. Phase 1 was a familiarisation phase, which involved reading and re-reading of the transcripts. Phase 2 involved conventional content analysis [11], which comprised open coding to inductively create initial, non-hierarchical codes. These initial codes were subsequently categorised to generate the evolving themes and subthemes. In Phase 3, directed content analysis was employed whereby the transcripts were deductively coded using the TDF to identify the domains present [11]. To ensure validity of the findings, a co-author (SC) independently identified the conventional themes and TDF domains from a sample of ten interview transcripts, with the most relevant domains identified through consensus discussion between two researchers (KD and SC). Three factors were considered when identifying the most relevant domains: the frequency of the beliefs (in each domain), the presence of conflicting beliefs, and perceived strengths of the beliefs impacting implementation [12]. Lastly, the evolving themes (from phase 2) were categorised under each of the TDF domains

identified in phase 3, and were reviewed further by all authors in order to refine the main themes and domains which reflected the key factors affecting implementation of the SENATOR recommendations.

3. RESULTS

A total of 24 interviews were conducted (with 12 medical prescribers, 2 surgical prescribers, and 10 primary researchers) across all six SENATOR RCT sites. The median interview length was 24 minutes (range 18-64 minutes). Demographic details of the interviewees are shown in **Table 2**.

Eight domains were found to be most relevant in influencing prescriber implementation of the SENATOR recommendations, namely 'environmental context and resources', 'beliefs about consequences', 'memory, attention and decision processes', 'social/professional role and identity', 'goals', 'intentions', 'knowledge', and 'social influences'. We have displayed themes and quotations under each domain to help explain the findings, but it should be noted that some of the quotations may illustrate more than one TDF domain due to overlap between the constructs.

Environmental context and resources

Right setting for the intervention?

Participants questioned whether the acute hospital environment was the best setting to conduct this intervention. Some highlighted that making changes in hospital allows for prescribers to monitor patients afterwards. However, many interviewees recognised that the intervention patients were acutely unwell, and that prescribers were more likely to make pharmacotherapy changes when patients were more stable in a non-acute setting.

"I think an outpatient setting or a GP setting is a more appropriate place to change a patient's long-term medications - that really you should be making changes when somebody is well". [Primary Researcher 7]

Busy hospital environment

Prescribers had multiple concurrent work commitments, which did not always permit them to take the time to review the report and implement the recommendations from an unfamiliar source.

"But I think I don't use it enough to immediately be able to read it through quickly which…when you're working under pressure and time constraints in a hospital - if something isn't easy and intuitive to read quickly in less than 30 seconds, you don't have time, you just move on". [Medical Prescriber 8]

Timing and location of the recommendations

Participants strongly felt that the timing of the intervention was a key factor affecting implementation. There was no clear consensus on when the recommendations should be provided - some participants suggested they were provided too early as the patient was still at an acute point in their hospital stay to make pharmacotherapy changes, whilst others stated they may have been provided too late as prescribers may have preferred them immediately when reviewing patients on admission. However, what was clear was that the recommendations were usually not provided at the time the patients' medications were being reviewed by the prescriber.

"…there was a disconnect between when I saw the report and when I saw the patient, which kind of made it hard maybe to implement any changes that may have seemed reasonable". [Medical Prescriber 1]

The location of the report may also have been an important factor. Interviewees stated that prescribers simply may not have seen the recommendations and could easily go unnoticed in the medical notes or in an email inbox.

"*Well it could be because people didn't look at it…if the information doesn't get to them, they probably don't accept anything*…" [Medical Prescriber 10]

Many suggested that provision of the recommendations at the point of prescribing or integration of the recommendations with an electronic prescription record would increase their visibility and potentially increase their implementation rate.

Beliefs about consequences

Clinical relevance of the recommendations

The general consensus from interviewees was that the software generated a high proportion of recommendations that were of low clinical relevance for the given patient, and that this was one of the main factors why the recommendations were not implemented. It was pointed out that a small proportion of recommendations could cause patient harm if implemented.

"I had recommendations that were irrelevant and even, even dangerous". [Medical Prescriber 4]

If, however, the recommendations were related to the reason for admission, then this would increase their relevance, facilitating recommendation review and implementation.

"…if it's related, if someone's come in with a fall and then it's related to the admission, I'd be much more likely to look at the SENATOR recommendations in detail". [Medical Prescriber 6]

Risk versus benefit to the patient

It was noted that some prescribers would not implement the recommendations unless there was a clear risk or benefit to the patient.

"I'm not gonna start interfering with somebody's medications unless there's a glaring danger in them or I see something that's absolutely contraindicated…". [Surgical Prescriber 2]

Memory, attention, and decision processes

Recommendations of low relevance contributing to prescriber fatigue

When prescribers initially saw reports that contained recommendations that were of low relevance, this would have resulted in their devaluation of the perceived benefits of future reports, contributing to decreased engagement with the SENATOR reports and non-implementation of the recommendations.

> *"I think when people have seen these reports and they've seen recommendations that are inappropriate or irrelevant, I think that can sort of change their perception of the study and of these SENATOR reports, and it can sort of devalue them as well. So, I think maybe…when they see a report the next time that they pay less attention, that they have less trust in it".* [Primary Researcher 7]

Attention to recommendation details

The majority of interviewees liked the design of the report. However, many pointed out that whilst the colours on the report would have grabbed the attention of prescribers, the overall length of the report and the large amount of writing would have been off-putting to readers.

> *"It's a little bit lengthy maybe because it takes a couple of minutes to read through this and…it's colourful but it's rather dull…in continuous text"* [Medical Prescriber 12]

Forgetting about an unfamiliar intervention

Even though prescribers may have intended on reviewing or implementing the recommendations, they may have simply forgot about the intervention as it was not ubiquitous for all older patients within the hospital sites.

> *"…it's all about reminders. I think people are well-intentioned, I think they just forget".* [Medical Prescriber 11]

Social/professional role and identity

Responsibility

Participants acknowledged that prescribers must take ownership of the medications prescribed for patients under their care in hospital. Whilst most prescribers were happy to review the SENATOR recommendations, some attending prescribers showed a reluctance to act on the recommendations in the hospital environment or to take sole responsibility for older patients' pharmacotherapy.

> *"…whose role it is to actually do it? At the moment, I'd say it's nobody's role. Nobody really takes it upon themselves, I would say, to actively review patients' medication like this".* [Primary Researcher 2]

Prescriber specialty

Some recommendations were not implemented as prescribers tended to confine prescription changes to those within the professional boundaries of their specialty. In particular, interviewees stated that surgical prescribers were much less likely to implement the SENATOR recommendations than medical prescribers.

> *"It looks like instead of holistic treatment of the patient, each consultant is treating their part".* [Primary Researcher 9]

Prescriber experience and the need for a 'decision-maker'

Interviewees recognised that junior prescribers may be more reluctant to change patients' medications than their more experienced colleagues. However, several participants felt that many junior prescribers have the knowledge and skills required to implement these recommendations, but lack the authority to adjust patients' medications without consulting a more senior colleague.

> *"…they are not in a position to change the medication. They have to discuss with the senior person, either registrar or consultant".* [Primary Researcher 9]

Participants indicated that whilst prescriber experience may be influential, it was more important that the recommendations were reviewed by a '*decision-maker*' in the prescribing team, whereby participants most commonly considered the '*decision-maker*' to be a more senior prescriber.

> *"I think it's helpful, or more helpful, to speak with the senior doctor, who is a decision-maker. I think the senior person on a medical team would be more likely to implement changes".* [Primary Researcher 7]

Goals and Intentions

Priority is managing the acute issues

Interviewees pointed out that many of the recommendations were focused on the patient's chronic disease management, whereas the prescribers were primarily focused on the acute issues.

> *"…the clinical team only deals with the acute problem. They are not interested in looking into the other medications…".* [Primary Researcher 9]

Intrinsic motivation and prescriber outlook toward research studies

Some of the prescriber inertia was due to individuals' lack of motivation to review pharmacotherapy – unwavering in their intentions despite the SENATOR intervention.

> *"…the doctors that don't want to make a change, they're not going to make a change…".* [Primary Researcher 4]

It was highlighted that some prescribers who were more open-minded towards research studies were more likely to engage with the intervention and act on the recommendations, whilst others may have appeared less interested and were less likely to implement the recommendations.

> *"…there are clearly two groups – the doctors who are very enthusiastic and the doctors who think 'ugh just another study'…".* [Primary Researcher 6]

Knowledge

Prescriber knowledge

It was clear from the interviews that prescribers were much less comfortable in acting on recommendations that were outside their field of specialist knowledge.

> *"They have conditions that are out of my range of knowledge, and their treatment often…their treatment of one condition might collide with another condition that I'm not an expert in".* [Medical Prescriber 12]

Aid to prescribing, but knowing it cannot be trusted blindly

Overall, participants expressed positivity toward the concept of the intervention, and would welcome computerised interventions like SENATOR to be an aid to prescribing in multimorbid older adults. However, most participants recognised that the computerised recommendations could not be trusted without careful consideration, and that appropriate clinical knowledge is required to judge if recommendations should be implemented or not.

> *"I would not trust them blindly. I have gotten bad and good recommendations, and that's just because the computer programme can't know the whole story".* [Medical Prescriber 3]

Knowing the patient

Whilst some prescribers emphasised that they were happy to review the SENATOR recommendations as they knew about the patients under their care, interviewees also described that hospital prescribers were often reluctant to act on the recommendations as they did not know enough about these complex multimorbid patients (who were only recently admitted to hospital), or their pharmacotherapy.

> *"I don't know whether that's appropriate or not because I don't know what the decision was to put them on it in the first place".* [Surgical Prescriber 2]

Social influences

Patient preference

Some interviewees stated that the patient's preference was a factor in whether the recommendations were implemented, and that patients would be resistant to deprescribing of certain medications.

> *"Of course, also patients' will. Like it always suggested to stop the sleep medication but most of the people we try to stop the sleeping medication, they will shoot you".* [Medical Prescriber 4]

Prescriber encroachment

Prescribers expressed reluctance in making changes that might encroach on other prescribers' decisions (e.g. the patient's GP or other hospital specialists).

> *"…you're not the only person involved in their care so you may be reluctant to stop a medication that somebody else started".* [Medical Prescriber 1]

Report provision by primary researcher

Many prescribers appreciated the face-to-face delivery of the report from the primary researcher as it allowed for discussion on the rationale for the recommendations – to optimise prescribing in older adults – and facilitated their review. However, some primary researchers felt that the status of the person communicating the presence of the recommendations was a factor affecting their implementation.

> *"I think because I'm not a doctor, it's sometimes difficult to discuss it with them because yeah you can always see you're not on the same level…"* [Primary Researcher 1]

Suggestions for future interventions

Some suggestions made by interviewees for future interventions included:

- Having a pilot phase prior to full intervention rollout.
- Integrating the recommendations with electronic prescribing.
- Providing an informed rationale on how each recommendation was generated.
- Adjusting the algorithms to avoid unnecessary recommendations being produced.
- Streamlining the number of recommendations to focus on the most relevant PIP issues only.

4. DISCUSSION

We have generated a deeper understanding of the key factors that affected prescriber implementation of the computer-generated medication recommendations in the SENATOR RCT. Significantly, many of the SENATOR software-generated recommendations were considered of no clinical relevance or inappropriate for the individual patient during the acute care setting, and thus were unlikely to be implemented ('beliefs about consequences'). The SENATOR intervention targeted a wide range of PIP instances on the basis of STOPP/START criteria version 2. Previous researchers have encountered difficulties computerising these criteria [13], which were not designed specifically to be put into computerised algorithms, and this may be a reason for the difficulty with routinely providing recommendations of high clinical relevance tailored for each patient. Pilot testing the SENATOR software intervention might have identified opportunities for software modification early on in order to reduce the number of irrelevant recommendations produced, as well as to overcome some of the issues identified with delivery of the recommendations to prescribers. Pilot testing did not take place in the SENATOR trial because of time constraints within the project that arose because of unforeseen difficulties with completion of the software construction and challenges with interfacing the software with the electronic case report form (eCRF). By the time these issues were resolved, there was no time left within the project timeline in which pilot testing of SENATOR software-generated prescribing advice reports could be accommodated given the practical imperative to complete the substantive clinical trial. Given the low prescriber implementation rates observed in the SENATOR trial, this emphasises the importance in conducting pilot testing for future studies of this kind involving complex interventions [14].

In the aforementioned O'Connor *et al.* intervention, a physician provided 1.94 recommendations per patient on average for the 233 patients where a report was provided (based on STOPP/START criteria version 1), with an implementation rate of 83.4% [3]. Contrastingly in the SENATOR intervention, an average of 5.48 recommendations per patient was provided (based on STOPP/START criteria version 2, excluding the two vaccine-related START recommendations provided to all patients), with only 15% of the recommendations implemented [15]. The high proportion of irrelevant SENATOR

recommendations may have overwhelmed prescribers and thereby incurred user fatigue with the intervention, such that clinically important recommendations may also have been ignored ('memory, attention, and decision processes') [16]. A systematic review indicated that computerised interventions which target fewer PIP instances in hospitalised older adults may have greater recommendation implementation rates than those targeting a wider range of PIP issues [1]. Future interventions of this kind may need to consider producing a smaller number of recommendations that are of high clinical relevance, which are tailored to the specific needs of individual patients in order to increase prescriber implementation rates and reduce PIP.

The acute hospital environment is well-known for being conducive to inappropriate prescribing [17, 18]. The timing of the SENATOR intervention seemed to be inconvenient for some hospital prescribers, who often had several other competing tasks as part of their busy workload ('environmental context and resources' and 'goals'). During the trial, prescribers were commonly informed of the recommendations being present in the patients' medical records at a time when they were not reviewing the patient. Whilst prescribers may have been motivated to examine the SENATOR recommendations ('intentions'), time constraints coupled with their workload may have distracted some prescribers from the intervention. Prescriber implementation rates may be improved if the recommendations are provided simultaneously with the act of prescribing [19]. Although enhancing the environment in which prescribers work is not a simple undertaking, the incorporation of this type of medication optimisation intervention with hospital electronic prescribing systems may aid integration into prescribers' workflow and facilitate review of the prescribing recommendations [20, 21]. Equally, it may be useful to evaluate if there is increased implementation of these recommendations in other care settings, where patients are more stable, and to further assess if there is a greater impact on patient outcomes.

Whilst computerised interventions are often assumed to provide solutions to minimising inappropriate prescribing, this study corroborates previous findings which show that simply providing computer-generated recommendations does not guarantee their uptake [22, 23]. In the present study, even when the computerised output was accurate, and the clinically relevant SENATOR recommendations were

reviewed by prescribers, they were still not always implemented. Our findings have highlighted the importance of targeting interventions like this at the decision-makers on the prescribing team as one way to increase the likelihood of recommendation uptake ('social/professional role and identity) [24]. Prescriber inertia was notably pervasive in our interviews, and was previously found to be the predominant reason for non-implementation of computer-generated guideline-based recommendations in a primary care study [25]. This inertia may be due to fear of negative consequences of changing therapy ('beliefs about consequences') [26], with a particular reluctance to make prescribing changes outside of one's own specialty ('social/professional role and identity) [27]. More education and training on geriatric pharmacotherapy is therefore required at both undergraduate and postgraduate levels to reduce this prescriber inertia and to make all prescribers more confident in routinely optimising older adults' pharmacotherapy [28].

Participants recognised that patients' own beliefs also influenced the implementation of the SENATOR recommendations, particularly as some patients preferred to continue taking certain medicines that may be considered 'potentially inappropriate' ('social influences'). More patient education may be required as previous trials have shown that it can be a significant facilitator in discontinuing PIMs in older adults [29, 30]. In addition, the importance of educating prescribers on non-technical skills, such as eliciting and accounting for patient preferences, to improve patient safety has also been recognised [31]. Therefore, healthcare professionals' training should incorporate guidance on dealing with patients' treatment beliefs so that they are prepared to resist patient requests when necessary, such as in scenarios where patients ask that PIP is continued, increasing the risk of patient harm.

Moreover, being highly familiar with the patient's clinical details was considered an important facilitator in prescribers acting on the SENATOR recommendations. Hospital prescribers stated that they often know much less about the patients, their comorbidities, or their established pharmacotherapy compared to the GP or other hospital specialists ('knowledge') [32, 33]. However, there is evidence that GPs frequently do not receive information on the specific indications of hospital-initiated medicines [34], emphasising the need for better information exchange, particularly

at care transitions points, to facilitate informed prescriber decisions for older adults in all care settings. Future intervention studies of this kind could consider providing the computer-generated recommendations to GPs, geriatricians, and pharmacists in order to enhance the likelihood of their implementation.

We have already established that the person who receives the prescribing recommendations is a significant factor affecting implementation (e.g. based on their level of seniority). However, the person who delivers the prescribing recommendations may also be a factor. A recent study has demonstrated that the type of healthcare professional providing STOPP/START recommendations and the approach taken by that person may substantially influence prescriber implementation rates [35]. Hierarchical differences were implicit in the comments from primary researchers in our study, as they suggested that physician prescribers may have appeared less interested in reviewing the recommendations if they were not provided by a fellow physician ('social influences'). Future interventions must consider the importance of the particular healthcare professional that provides these types of recommendations, and to balance this against other factors such as cost.

Ultimately, the SENATOR trial demonstrated a negative result for its primary outcome, i.e. no significant difference in the proportion of patients experiencing a non-trivial in-hospital ADR between the intervention and control groups, probably attributable to a low implementation rate of the computer-generated STOPP/START recommendations [15]. When complex interventions produce negative results, as in the SENATOR trial, one may reasonably question if the intervention is inherently ineffective, whether it was improperly employed, or applied in an unsuitable clinical context [36]. Qualitative studies are increasingly advocated in such circumstances as they can draw upon the experiences of those involved with the trial to enable a better understanding of the quantitative results [37]. Although this qualitative study was not used to adjust the SENATOR intervention, it should help inform the design of future interventions of a similar kind. Coordinators of future RCTs with complex interventions should strongly consider the inclusion of parallel qualitative study components, with integration of these findings along with the main trial results.

Strengths and Limitations

A robust theoretical framework was used to structure the topic guides, with inductive and deductive approaches both used in data analysis. It has been shown that TDF-based interviews elicit additional themes from participants that would not otherwise be reported compared to studies without a theoretical basis [38, 39]. The relevance of our findings is reinforced by the sampling of participants from six hospitals across Europe. Interestingly, the authors identified no key differences in the relevant domains and factors affecting implementation across the different institutions; the emergence of common themes from a wide spread of geographical locations enhances the transferability of the findings. Furthermore, all interviews were conducted by the same researcher (KD) across all sites, allowing for consistency in both data collection and analysis.

Open coding was performed by two pharmacist researchers; however, extra codes may have been identified with additional researchers from different backgrounds. Another limitation to our study is that the number of eligible interviewees from each site was limited to those who were proficient in English. As it was not the first language of some interviewees, this may have impeded their potential to fully express their exact views. Additionally, the responsibility of selecting prescribers to participate in this study was largely assigned to members of the SENATOR research teams at each site. This delegation of duties, coupled with busy work schedules, may be the main reasons for the small sample size of surgical prescribers interviewed.

Finally, one interview was conducted face-to-face via Skype®; however, this was not perceived to be an issue as the interviewer had previously built a rapport with this primary researcher in person at a trial meeting. Skype® has been shown to be a viable research medium to conduct semi-structured interviews, and could be considered for future qualitative studies alongside multi-centre RCTs where geographical proximity may be an issue in conducting interviews in person [40, 41].

5. CONCLUSION

This study clearly demonstrates the value of qualitative evaluation methods in assessing the delivery of complex interventions within RCTs. Our findings highlight the difficulties associated with optimising prescribing in hospitalised older adults, and that a multifaceted approach will be required to tackle these issues. We have identified the key factors affecting prescriber implementation of computer-generated medication recommendations across six European acute hospital sites in the SENATOR RCT. There is now an opportunity for additional quantitative studies to investigate the relationship between these key factors and prescriber implementation of the SENATOR recommendations.

As with previous research, our results suggest that prescribers generally welcome computerised interventions, such as SENATOR, in the hospital setting as an aid to prescribing in complex multimorbid older adults [42]. However, future researchers must endeavour to improve the clinical relevance of these computer-generated medication recommendations, as well as identifying the most appropriate person to receive the recommendations, the best time for the intervention to occur, and to develop a greater understanding on how to best integrate these types of interventions into current healthcare systems.

Compliance with ethical standards

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Ethical Approval

Ethical approval for this study was granted by the Clinical Research Ethics Committee of the Cork Teaching Hospitals, Cork, Ireland. On foot of this, local ethical approval was also granted at each RCT site where English was not the first language of participants (sites 3 – 6 in Table 1), with participant information sheets and consent forms also translated into the participants' native language.

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Table 1: Acute hospital sites where the SENATOR randomised controlled trial was conducted.

Number	Hospital
1	Cork University Hospital, Cork, Republic of Ireland.
2	Aberdeen Royal Infirmary, Aberdeen, United Kingdom.
3	Landspitali University Hospital, Reykjavik, Iceland.
4	Ghent University Hospital, Ghent, Belgium.
5	Hospital Universitario Ramón y Cajal, Madrid, Spain.
6	Azienda Ospedaliero-Universitaria, Ospedali Riuniti di Ancona, Ancona, Italy.

Table 2: Characteristics of interview participants.

	Number
Participant type	
Medical Prescriber	12
Surgical Prescriber	2
Primary Researcher	10
Gender	
Male	13
Female	11
Years of post-qualification experience	
< 5 years	6
≥ 5 – ≤ 10 years	6
≥ 10 – ≤ 15 years	3
≥ 15 – ≤ 20 years	4
≥ 20 years	5

Supplementary Material

Supplementary Table 1

Consolidated criteria for reporting qualitative research (COREQ) Checklist

Domain 1: Research Team and Reflexivity			
Personal characteristics			
1.	Interviewer/facilitator	Which author/s conducted the interview or focus group?	KD conducted the interviews.
2.	Credentials	What were the researcher's credentials (e.g. PhD, MD)?	At the time of undertaking the interviews, KD's credentials were BPharm, MPharm, MPSI.
3.	Occupation	What was their occupation at the time of the study?	KD is an Irish registered pharmacist, who was undertaking a PhD in Clinical Pharmacy research when this study was conducted.
4.	Sex	Was the researcher male or female?	Male.
5.	Experience and training	What experience or training did the researcher have?	KD completed training in utilisation of NVivo software, and received training in analysis of qualitative interviews at the University of Oxford, United Kingdom.
Relationship with participants			
6.	Relationship established	Was a relationship established prior to study commencement?	The interviewer had established a rapport with some of the primary researchers prior to the qualitative study due to trial commitments (i.e. annual general meetings, teleconferences, communication via email), but no relationship between the interviewer and prescriber participants was established prior to study commencement.
7.	Participant knowledge of the interviewer	What did the participants know about the researcher (e.g. personal goals, reasons for doing the research)?	KD had disclosed to all participants that he was a pharmacist undertaking this study as part of his PhD, prior to conducting the interviews.
8.	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? (e.g. bias, assumptions, reasons and interests in the research topic)	KD is a registered pharmacist who was working as a primary researcher as part of the SENATOR trial, and was conducting this study as part of his PhD exploring factors affecting prescriber implementation of medication recommendations in hospitalised older adults. This information was disclosed to participants ahead of the interview.
Domain 2: Study Design			
Theoretical framework			
9.	Methodological orientation and Theory	What methodological orientation was stated to underpin the study (e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis)?	Content analysis was used in this study to analyse the data from the interview transcripts. Conventional content analysis was used to identify the conventional themes, which were attributed as factors that influenced implementation of the SENATOR recommendations. The Theoretical Domains Framework (TDF) was used to structure the interview topic guides, and directed content analysis was used to identify the relevant TDF domains.
Participant selection			
10.	Sampling	How were participants selected (e.g. purposive, convenience, consecutive, snowball)?	Primary researchers involved with the SENATOR trial were recruited using purposive sampling as there were limited numbers of primary researchers at each site. Snowball sampling was used to recruit prescribers, whereby the SENATOR primary researchers and their colleagues referred the interviewer to prescribers in their site who would participate in the study.
11.	Method of approach	How were participants approached (e.g. face-to-face, telephone, mail, email)?	Participants were contacted via email, and were provided with an information sheet and consent form in their native language in advance of the interview.

12.	Sample size	How many participants were in the study?	24.
13.	Nonparticipation	How many people refused to participate or dropped out? Reasons?	None.
Setting			
14.	Setting of data collection	Where were the data collected (e.g. home, clinic, workplace)?	All interviews took place in the participant's workplace, or in their workplace when previously working as part of the SENATOR trial.
15.	Presence of nonparticipants	Was anyone else present besides the participants and researchers?	No.
16.	Description of sample	What are the important characteristics of the sample (e.g. demographic data, date)?	Table 1 provides details of where the participants were sampled from, whilst Table 2 provides demographic details of the participants. The interviews took place between November 2017 and May 2018.
Data collection			
17.	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Two separate topic guides comprising a similar line of questioning (with prompts where appropriate) were formulated for both prescribers and primary researchers, and these were based on a review of the literature, the TDF, and the authors' practical knowledge of the randomised controlled trial and research area. Careful consideration was given to the language used, knowing that English would not be the first language for all participants. Interviewees were provided with a sample of a SENATOR report in their native language during the interview as a reminder of the report design and the types of recommendations provided. The topic guide for interviewing prescribers was piloted with a prescriber who had received SENATOR recommendations in the lead trial site, and this interview was included in our data analysis. The topic guide for interviewing primary researchers was piloted with a primary researcher working with a similar RCT (OPERAM study), who was very familiar with the SENATOR trial procedures. The topic guides were iteratively refined during the study to ensure that emerging themes were explored in subsequent interviews.
18.	Repeat interviews	Were repeat interviews carried out? If yes, how many?	No.
19.	Audio/visual recording	Did the research use audio or visual recording to collect the data?	All interviews were audio-recorded.
20.	Field notes	Were field notes made during and/or after the interview or focus group?	Field notes were recorded after each interview, and were used to refine topic guides and inform data analysis.
21.	Duration	What was the duration of the interviews or focus group?	The median interview length was 24 minutes (range 18-64 minutes).
22.	Data saturation	Was data saturation discussed?	Data analysis coincided with data collection, and we sampled until no new themes surfaced. As per the Francis *et al* method, an additional three interviews were conducted without any new themes appearing to confirm that data saturation had been reached.
23.	Transcripts returned	Were transcripts returned to participants for comment and/or correction?	Transcripts were returned to participants who requested their retrieval at the time of obtaining informed consent. This was not for the purpose of commenting and/or correction.

Domain 3: Analysis and Findings			
Data analysis			
24.	Number of data coders	How many data coders coded the data?	Two (KD and SC). SC read and coded ten transcripts to identify the themes and relevant TDF domains, whereas KD did this for all transcripts.
25.	Description of the coding tree	Did authors provide a description of the coding tree?	A description of the process is provided, whereby initial, non-hierarchical codes were categorised, and subsequently developed to generate themes and subthemes as part of conventional content analysis. The TDF was the chosen framework for directed content analysis, and was used as the basis for a coding tree here.
26.	Derivation of themes	Were themes identified in advance or derived from the data?	Conventional content analysis comprised open coding to inductively create initial, non-hierarchical codes. These initial codes were subsequently categorised to generate the evolving themes and subthemes. Directed content analysis was then employed whereby the transcripts were deductively coded using the TDF to identify the domains present. All authors were involved in the refinement of the themes and subthemes according to each of the relevant TDF domains.
27.	Software	What software, if applicable, was used to manage the data?	QSR NVivo® Version 11
28.	Participant checking	Did participants provide feedback on the findings?	Primary researcher participants were provided with an opportunity to provide feedback on the findings at a SENATOR trial annual general meeting.
Reporting			
29.	Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	Yes.
30.	Data and findings consistent	Was there consistency between the data presented and the findings?	Quotes are presented in a manner consistent with findings.
31.	Clarity of major themes	Were major themes clearly presented in the findings?	Major themes (as the relevant TDF domains) are clearly presented in the results section.
32.	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Subthemes are presented under each of the major themes in the results section.

Supplementary Table 2: Illustrative quotations to support the TDF domains identified.

Note: illustrative quotations may reflect more than one TDF domain.

Domain	Descriptor	Illustrative Quotations
Environmental context and resources	Right setting for the intervention?	*"It's the right place to do it, absolutely. Here we are starting a lot of new drugs. Here we have the possibility to monitor the response and the side effects".* **Medical Prescriber 12** *"Hospital is acute setting, and this is overall view of patients with chronic disease, then the setting is the main, for me is the main problem as to why the recommendation rate is low"* **Primary Researcher 3** *"…the inpatient services are very specialty-driven. And probably the only people who've really got a whole overview of the person, to me, is the general practitioners and they're the ones who are having to, who are being asked to, continue prescriptions".* **Medical Prescriber 6** *"The other setting I could think of is primary care physicians, because we are suggesting…the SENATOR is suggesting changes mainly to the medications which are taken long term".* **Primary Researcher 9** *"I think when the SENATOR trial first came out I wondered why it wasn't being targeted in general practice".* **Medical Prescriber 6**
	Busy hospital environment	*"…any trial would probably suffer from similar…you know similar challenges in a really busy hospital where people just are kind of too busy to give an awful lot of time to a research project".* **Primary Researcher 2** *"…this would take you kind of 5/10 minutes to go through, and then go through the notes, and that's, that's time missing. Time is a scarce commodity as I'm sure you realise in terms of, in terms of doing this".* **Medical Prescriber 1** *"It's a very busy ward in there, and there's lots of, lots of noise going on, lots of signals, lots of…demands on your time".* **Medical Prescriber 12** *"…they were rushed, they were busy doing something else, and the recommendations that I would have highlighted to them would not have been seen as a priority, it would have been something that they would have come back to at a later stage".* **Primary Researcher 7**
	Timing and location of the recommendations	*"…certainly from me the big issue was just the timing of getting the report versus when I saw the patient, when I was probably most invested in (you know) their, their care pathway".* **Medical Prescriber 1** *"…if it was present right at the time where they're dealing with the patient, where they're focused on the patient, I think that could absolutely have improved uptake of the recommendations".* **Primary Researcher 7** *"The intervention of getting the information may not have been the best time. The patient isn't on your mind - you're not thinking about the patient, you're not doing a chart review".* **Medical Prescriber 8** *"I'd say it was more the timing and…you know it was hit or miss if you got somebody who was in the middle of doing a hundred things and you're interrupting them to tell them about this report you've placed, they're not going to be very receptive to…to hearing about it".* **Primary Researcher 2** *"I suppose one of the other things is that this came into me by email, and em…it, it, it maybe wasn't immediate enough in terms of the patient interaction to take it on board, you know that you would…probably the best time to get this is actually the first time you see the patient on the ward round".* **Medical Prescriber 1** *"I think it's location. I think simply if we saw it we'd have gone 'oh yeah, that's sensible'. So, putting it physically in where we're writing our notes".* **Medical Prescriber 11** *"If instead having it inside the history, it was em…it appeared with the programme, with the prescription programme, because you have to use it - there's no other way, and probably they would pay more attention".* **Medical Prescriber 10** *"I find the eh, the email a bit better for me personally, because eh if it's filed in the notes it can get lost amongst all the pages and I wouldn't necessary know that the patient would have that type of recommendations."* **Medical Prescriber 9** *"Ill often the time when you'll come, when you'll actually open this email will be a couple of days later after you've gotten it and at that stage the patient is well gone home and that window is kinda missed you know".* **Surgical Prescriber 2**

Beliefs about consequences	Clinical relevance of the recommendations	*"I think absolutely for sure the fact that a lot of the recommendations were simply not relevant or appropriate, I think that's very very very very important, and…obviously explains part…at least partly explains the low uptake".* **Primary Researcher 7** *"None of them were kind of compelling STOPPs I would say. You know they were all kind of…by and large I think they were, were kind of softer, softer STOPPs rather than strong STOPPs".* **Medical Prescriber 1** *"… these recommendations are relevant to the patient, but they're not particularly relevant to a patient in hospital at that particular time".* **Primary Researcher 2** *"…the START recommendation for anticoagulation. That's immediately relevant in a patient who is A fib and if the patient isn't on an anticoagulant".* **Primary Researcher 7** *"I mean there was a couple of recommendations that we got that just didn't make any sense during the SENATOR trial".* **Medical Prescriber 8**
	Risk versus benefit to the patient	*"The benzodiazepine one - again if the patient's unwell and they've been on a long-term sleeping tablet, my impression would be let's sort the acute issue. If they're drowsy or something like that, then that's a different issue".* **Primary Researcher 7** *"When people have come in with something that might be related to their medication, I think then yeah that's fine".* **Medical Prescriber 6** *"While the PPI - my impression would be: well look what harm is it? The patient's unwell at the moment, why rock the boat?".* **Primary Researcher 7** *"…the decision support software says that for a thousand people, that's the right thing to do. It may not be the right thing to do for that person".* **Surgical Prescriber 2**
Memory, attention, and decision processes	Recommendations of low relevance contributing to prescriber fatigue	*"So, I think there's potential for benefit, but you need to make sure it's not information overload and people aren't just getting dismissive of it".* **Medical Prescriber 6** *"…if we could filter out the irrelevant or inappropriate recommendations, I think that the whole value of the report would go upwards very significantly. Because undoubtedly there is a fatigue as well when you get lots and lots of recommendations".* **Primary Researcher 7** *"…it seems that if there's been a negative one then they're not so receptive the next time".* **Primary Researcher 4** *"Well if you have some not very specific recommendations, you can see that they are…the second time you go they are…or the third time they are less interested in the study. So I already had physicians who start laughing when I go there again. So, it's definitely a barrier to the adherence".* **Primary Researcher 1** *"…some consultants were really interested and over time when I repeatedly met the same consultant, they kind of lost interest because some of the recommendations were too broad, too generic. They were not tailored to that particular patient".* **Primary Researcher 9**
	Attention to recommendation details	*"There's a lot of text in it so if people are very busy, they might think it's too big, too big a file. But having this in colour – STOPP and START – this is very good, very clear yeah".* **Primary Researcher 8** *"…if it could be a one-page document I think that would be better because I think we all have short attention spans…".* **Primary Researcher 7** *"…it's probably a little bit too long and a bit too detailed (you know), and that maybe just focusing on the smaller number of maybe significant…significant STOPP or START recommendations might make more sense".* **Medical Prescriber 1**
	Forgetting about an unfamiliar intervention	*"I think the team has to be given a…a real nudge – 'read the STOPP medications!' – not because they won't, because I think we just forget".* **Medical Prescriber 11** *"I think it was usually something that they would put on the long finger, that they would intend to come back to".* **Primary Researcher 7** *"You're like "I'll come back to that", you know but then it's always invariable whether you have enough time to do that at the end of the day, and it slips to the next day, and then before you know it you're kind of three or four days into an admission and the admitting kind of SENATOR stuff is kind of maybe forgotten about".* **Medical Prescriber 8** *"So in order for it to be used in the everyday rounds, it has to become more established so that (you know) it's a part of that, that everyday work, not just something that (you know) you hear about once a week, or every other week, or something like that, then you forget about it".* **Medical Prescriber 12** *"So unless they actually become part of the fabric of a health service, then you're gonna have a situation where you're gonna have a few enthusiastic early uptakers, and then you're gonna have everyone else who kind of (you know) will uptake, take them up for a period of time and then will drift out of consciousness".* **Surgical Prescriber 2** *"I think just by repeating this I think people will get more eh…yeah familiar with this kind of program".* **Medical Prescriber 4**

Social/professional role and identity	Responsibility	*"Well I think it's my responsibility to do so as a doctor and I'm the one who has to decide which medicines I give to someone".* **Medical Prescriber 10** *"They don't feel it's their place. They feel it's a GP's job so they don't want to get involved or they're not confident enough to get involved".* **Primary Researcher 4** *"But I'm not the prescribing clinician. You know because a lot of the time, and you can say it well yes you are because they've come into hospital and you've, you or a member of your team have physically prescribed them, but really you're not. You're, you're carrying on a prescription on a decision that's been made by somebody else. You're honouring their decision".* **Surgical Prescriber 2**
	Prescriber specialty	*"So, it's possible that a specialist could think that he has to manage only the drugs of the specialty".* **Medical Prescriber 7** *"…we would kind of just, probably just intervene on the ones that are within our area of specialty. We leave the other ones generally alone".* **Surgical Prescriber 2** *"One thing you'll find I suppose with consultants is their kind of, their particular area is what they would focus on, so if they're admitted under cardiology, they may look at cardiology meds, and you know if they're on a high dose of a PPI it's not something they're really gonna review".* **Primary Researcher 2** *"…we know when they're surgical if it is a…like fracture, the focus is on the fracture, not all the other medication, so they are not willing to change many things".* **Primary Researcher 8** *"…surgeons most of the time don't care about these things, well some of them at least, because they are really focused on the surgery, and it's like this is someone else's job".* **Medical Prescriber 10** *"…a number of the recommendations would be out of my comfort zone of what I manage".* **Surgical Prescriber 1**
	Prescriber experience and the need for a 'decision-maker'	*"…if you're just started as a doctor…I think you're also a bit hesitant to, to stop certain medications than if you've years of experience".* **Medical Prescriber 12** *"…if you have a lot of years of work, it's possible that you tend to consolidate your ideas so SENATOR could be less effective in changing your prescription".* **Medical Prescriber 7** *"I mean it definitely has to be somebody with senior clinical decision-making power. Em…most interns won't really have the kind of experience to go tinkering with people's medications and they shouldn't be".* **Medical Prescriber 8** *"I think it's probably more important that it's targeted at the actual decision-maker".* **Surgical Prescriber 2** *"The junior doctors, like interns – they are maybe…do not have the eh…they're not that independent or they (you know) don't take many decisions without consulting their seniors"* **Medical Prescriber 12**
Goals and Intentions	Priority is managing the acute issues	*"…the priority to that patient may have been focused on, on more acute issues around that you know, you know do I need to operate or not? So that's probably why there's been a slight, a lower em acceptance of some of the recommendations".* **Surgical Prescriber 1** *"The primary reason is I think they are not (the physicians here) are not worried about the chronic medications, they focus on the acute conditions".* **Primary Researcher 5** *"I suppose we're so tied up with fire-fighting at the moment with the problems that we have that it's the now not the future that you're looking at".* **Surgical Prescriber 2** *"I think the mindset on a busy clinical job is to sort out the acute issue and the long-term medications oftentimes I would imagine physicians don't feel that they're the ones that should have to em…em…change or interfere or sort of adjust the long-term medications".* **Primary Researcher 7**
	Intrinsic motivation and prescriber outlook toward research studies	*"I think it depends on the person itself if they are open-minded for studies. Sometimes physicians are not really…they can have the impression that not all the physicians are very open-minded to studies, and others are…eh…open-minded…".* **Primary Researcher 1** *"…so when the doctors are enthusiastic about the study, they will read it, and they will take it…they will see it more as a priority but if the doctor isn't interested in the study, they will not see it as a priority".* **Primary Researcher 6** *"I appreciated the work they did so I was receptive to em…doing this and receiving the information because I think it's important, and I think that before they did it I already thought that we needed something like this so I was very ready to have it and I wanted to see it and I don't know if the rest of the people who participated had the same feeling".* **Medical Prescriber 10** *"…some seemed to be quite positive and I've noticed that they have then gone on to make changes in the kardex".* **Primary Researcher 4**

Knowledge	Prescriber knowledge	*"I should have some knowledge around it, but...but eh…I clearly understand that there are certain specialist fields that I'm capable of dealing with…".* **Surgical Prescriber 1** *"I'd know quite a lot about my drugs. But then some of the other drugs, it's harder to keep in your head".* **Medical Prescriber 6** *"…the one area I feel really inadequate, and I suspect I wouldn't be alone, I might be the only one to admit it, is eh, drugs for delirium and drugs for dementia that are very specific to geriatricians but yet we all use them".* **Medical Prescriber 11**
	Aid to prescribing, but knowing it cannot be trusted blindly	*"…essentially what they're doing is giving us guidance and as clinicians it's up to us to decide what we do about it".* **Surgical Prescriber 1** *"I don't think you can look at the advice alone. Em…like I said sometimes there are a bit of errors, which I think is normal. Em…you have to think about it yourself and not just read like the advice and put it into eh…put it into practice, but really think about it as well".* **Medical Prescriber 2** *"I think…the human intelligence, at least as it is today, computers haven't taken that over…that we use them as assisting us but not relying on it completely so if there comes, you know if there's something that we think sounds funny we can always take over and correct that".* **Medical Prescriber 12** *"If it comes out with something that is completely opposed to my views then I would also then be looking into that to find out then, okay, I wouldn't have perceived that as an interaction. Is there other stuff to back it up? I don't think I would be blindly led by a computer".* **Medical Prescriber 6** *"…you cannot trust the programme blindly, i.e. you have to still think about the medication".* **Medical Prescriber 4**
	Knowing the patient	*"…it's more who is in charge of the patient and who knows the patient best".* **Primary Researcher 8** *"I think doctors that meet the patient for the first time at the hospital admission, they don't know…they don't know him so much".* **Primary Researcher 10** *"They don't want to get involved…em…you know making big changes. They think that's a job for the GP that knows the patient better and knows what they've been taking long-term and the reasons why".* **Primary Researcher 4**
Social influences	Patient preference	*"So, eh…and then there's of course patient preference factors. Some of them really prefer to have some drugs".* **Medical Prescriber 3** *"A lot of the recommendations involved taking patients off sleeping tablets and benzos and things, which you're gonna get resistance to".* **Primary Researcher 2** *"I think, again, if a patient is very positive and keen for changes to be made, and speaks to the doctor then that seems to help".* **Primary Researcher 4** *"…because patients should be the centre role. In my experience, patient have in part, a little part in influencing the recommendation".* **Primary Researcher 3**
	Prescriber encroachment	*"In the ward, I'm often just dealing with the acute issues. And I probably don't see it so much as my role to start stopping what other people have done".* **Medical Prescriber 6** *"I think especially if you're meeting a patient for the first time and they're on a number of different medications em…you will not want to interfere with medications that you didn't start…".* **Primary Researcher 7** *"…you're carrying on a prescription on a decision that's been made by somebody else. You're honouring their decision. So, in honouring their decision, you're dishonouring their decision by changing that, and without due regard to them for doing it".* **Surgical Prescriber 2**
	Report provision by primary researcher	*"…if you've had a chance to speak to the researchers, you've get…you've got a better understanding".* **Medical Prescriber 6** *"…she personally handed them, and she told us…em…which patient it concerns…so I think it was a good idea to do it like that".* **Medical Prescriber 2** *"…their interest would be higher if I was a doctor who would give the report to them".* **Primary Researcher 1**

TOPIC GUIDE FOR PRIMARY RESEARCHERS

1. As we know, the SENATOR engine analysed the patient's information and made recommendations to optimise the patient's medicines. Here's an example of a report that was generated. What are your thoughts on the design of the report?
   - Structure, layout, colours, font size, information provided Location of report

2. When a prescriber was looking at a SENATOR report for the first time, what do you think they would've thought of it?
   - Do you think that they knew what the report was asking them to do?

3. What are your thoughts on the quality of the recommendations?
   - Thoughts on the relevance of the recommendations? Would you change anything about the recommendations/report?

4. What are your thoughts on the timing of the intervention?
   - Would it have been better to have the report at another time?

5. What are your thoughts on conducting this intervention in the hospital setting?
   - Do you think there's a more appropriate setting this could take place?

6. Whose role is it to make recommendations to optimise older patients' medicines in your hospital?
   - How would these recommendations be communicated (do you know)?

7. How do you communicate the presence of the report and the recommendations?
   - Were there any facilitators/barriers to this communication?

8. What are your thoughts on the methods of communication of the report's recommendations in this hospital?
   - What method of communication did you find most successful when providing the recommendations to the prescribing team, e.g. face to face or via telephone

9. Given your professional background, how do you feel your role may affect the number of recommendations implemented?
   - The role/status of the primary researcher

10. How do you feel when discussing the report with the prescribing team?

11. Did you have any particular rewarding or negative experiences in your role in carrying out the intervention?

12. What was the reaction of prescribers in your hospital to the SENATOR report/recommendations?
   - Was there a positive or negative reaction?
   - Do you think that prescribers saw it as a priority to review the SENATOR report recommendations?

13. In your opinion, whose role should it be to review computer-generated recommendations like this in the hospital setting?
   - Do you think there should be someone to screen the recommendations before reaching the prescriber?
   - If so, who should this be? Doctor? Pharmacist? Nurse?

14. The prescriber implementation rates for the SENATOR recommendations have been lower than expected – why do you think that may be?

15. How do you think that we could achieve higher implementation rates of the recommendations?

16. Do you foresee any problems for implementing an intervention like this routinely in future?
   - Resources (money, electronic prescribing) Having a defined role for someone to lead/deliver the intervention

17. Do you think there is anything more <u>you</u> could have done to enhance the acceptance rates of the recommendations?
   - Anything more that your PI could have done? e.g. promotion in the hospital Anything more that the lead site (Cork) could have done?

18. How could SENATOR (or a similar intervention) be done better in future?
   - What resources would be required? Different ways of working/communicating?
   - What information would you want to be provided by the computer? How should the information to be provided?

That brings us to the end of the interview

19. Do you have any additional comments that you would like to make, or any points you'd like to expand on?

Thank you very much for giving up your time to talk to me today.

TOPIC GUIDE FOR PRESCRIBERS

The SENATOR trial involves a computer programme analysing older patients' medicines, medical conditions, and other information with the aim of optimising prescribing. The programme then generates a report for the prescribing team to review with recommendations to address potentially inappropriate medications or potential prescribing omissions.

1. Firstly, what are your thoughts on the role that computerised programmes can have on reducing PIP in hospitalised older adults?

2. What is your role in reviewing the appropriateness of medicines an older patient is prescribed during their hospital stay?
   - How would these recommendations be communicated (do you know)?
   - Is this a priority of yours on a daily basis?

3. How confident do you feel in prescribing for this patient group?
   - Do you think that your prescribing decisions would benefit from regular automated support/feedback/advice?
   - How do you feel about trusting recommendations from an automated programme?

As I said, the SENATOR intervention produced a report highlighting potentially inappropriate medicines or potential prescribing omissions. Here's an example of a report generated.

4. When you looked at the SENATOR report for the first time, what did you think of it?
   - Did you understand what the report was aiming to do or what it asked of you?
   - What do you think of the design of the report? Refer to layout, font size, length, colours, data / information contained within the report etc.

5. When looking at the report, how easy or difficult was it for you to identify which of the recommendations were relevant for each patient?
   - Do you think all of the recommendations that you've reviewed have been relevant for your patients' needs?

6. What influence, if any, did the SENATOR report have on your decision-making?

7. How did you receive the report or how were you made aware of the recommendations?
   - What are your thoughts on the method of communication for this intervention?

8. What are your thoughts on conducting this type of intervention in the hospital setting?
   - What about the timing of the intervention?

9. Is there anything that may have prevented you from acting upon the SENATOR recommendations?
   - Patient's acute medical presentation? Lack of information to hand? Work environment/Resources, Time, Your role/role of others

10. Were there any particularly rewarding or negative experiences that you encountered with the SENATOR intervention?

11. In your opinion, whose role should it be to review these computer-generated recommendations in the hospital setting?
    - Do you think someone should screen the recommendations before reaching the prescriber? e.g. doctor, pharmacist, nurse

12. The implementation rate of recommendations by prescribers has been lower than anticipated – what do you think are the reasons for this?
    - How do you think that we could achieve higher implementation rates of the computer-generated recommendations?

13. How well was the trial promoted in the hospital?

14. What problems, if any, do you foresee in implementing this intervention into routine clinical practice?

15. Do you have any suggestions for how we could enhance the implementation of this type of intervention in future?
    - What resources would be required? Electronic prescribing?
    - What information would you want to be provided by the computer? How would you like this information to be provided?

That brings us to the end of the interview.

16. Do you have any additional comments that you would like to make, or any points you'd like to expand on?

Thank you very much for giving up your time to talk to me today.