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Application of the intervention Complexity Assessment Tool for Systematic Reviews within a Cochrane review: an illustrative case study [version 1; peer review: 3 approved]

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Abstract

Background: The intervention Complexity Assessment Tool for Systematic Reviews (iCAT_SR) has been developed to facilitate detailed assessments of intervention complexity in systematic reviews. Worked examples of the tool’s application are needed to promote its use and refinement. The aim of this case study was to apply the iCAT_SR to a subset of 20 studies included in a Cochrane review of interventions aimed at improving appropriate polypharmacy in older people.

Methods: Interventions were assessed independently by two authors using the six core iCAT_SR dimensions: (1) ‘Target organisational levels/categories’; (2) ‘Target behaviour/actions’; (3) ‘Active intervention components’; (4) ‘Degree of tailoring’; (5) ‘Level of skill required by intervention deliverers’; (6) ‘Level of skill required by intervention recipients’. Attempts were made to apply four optional dimensions: ‘Interaction between intervention components’; ‘Context/setting’; ‘Recipient/provider factors’; ‘Nature of causal pathway’. Inter-rater reliability was assessed using Cohen’s Kappa coefficient. Disagreements were resolved by consensus discussion. The findings are presented narratively.

Results: Assessments involving the core iCAT_SR dimensions showed limited consistency in intervention complexity across included studies, even when categorised according to clinical setting. Interventions were delivered across various organisational levels and categories (i.e. healthcare professionals and patients) and typically comprised multiple components. Intermediate skill levels were required by those delivering and receiving the interventions across all studies. A lack of detail in study reports precluded application of the iCAT_SR’s optional dimensions. The inter-rater reliability was substantial (Cohen’s Kappa = 0.75)

Conclusions: This study describes the application of the iCAT_SR to studies included in a Cochrane systematic review. Future intervention studies need to ensure more detailed reporting of interventions, context and the causal pathways underlying intervention effects to allow a more holistic

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Any reports and responses or comments on the article can be found at the end of the article.
understanding of intervention complexity and facilitate replication in other settings. The experience gained has helped to refine the original guidance document relating to the application of iCAT_SR.

**Keywords**
intervention complexity, intervention complexity assessment tool, iCAT_SR, systematic review, evidence synthesis, complex interventions, polypharmacy, older people

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Introduction
Several definitions of the term ‘complex intervention’ exist in the literature. For example, the UK Medical Research Council has defined ‘complex interventions’ as “interventions that contain several interacting components” while recognising that there are multiple dimensions of complexity (e.g. the number of intervention components, interactions between components, target behaviours, target groups or organisational levels, outcomes and degree of tailoring permitted). It is recognised that a broader understanding of the term ‘complex intervention’ is required. For example, Moore et al. contend that “all interventions are complex, but some are more complex than others” and that “rather than an absolute property of new components, intervention complexity can therefore be understood as a relative construct, linked to usual practice within the system, and encompassing challenges associated with disrupting and replacing often entrenched ways of working”. Petticrew has hypothesised that there is in fact no true categorisation of interventions as ‘simple’ or ‘complex’, and that the concepts of simplicity and complexity are instead pragmatic perspectives adopted by researchers to help describe and understand the interventions being evaluated.

Interventions targeting key healthcare issues, such as multimorbidity and the use of multiple medications (i.e. polypharmacy) in older people, are often complex in that the interventions typically involve multiple components. However, this broad categorisation of interventions based on their components limits our potential to systematically compare interventions and their effects. Without a more detailed exploration of intervention complexity, it is difficult to determine if varying degrees of complexity impact on intervention effectiveness. The Intervention Complexity Assessment Tool for Systematic Reviews (iCAT_SR) has been developed to facilitate a more detailed and systematic assessment of intervention complexity in systematic reviews. The tool’s development process involved a series of steps which included: drafting a list of possible intervention complexity dimensions based on a review of relevant literature; development of provisional definitions for these dimensions; discussion and consensus workshops with trialists and implementation scientists to refine and agree on the tool’s core dimensions and definitions; preliminary testing of draft versions of the tool against published intervention reports; development of a finalised version of the tool and guidance document to assist with its application following further testing and refinement. Rather than providing a definitive definition of intervention complexity, the tool focuses on dimensions of complexity that can be assessed when evaluating interventions as part of a systematic review. The first version of the tool (iCAT_SR version 1.0) comprises six core dimensions and four additional dimensions that are considered to be optional, as they may not be relevant to all interventions (Table 1). Within each dimension, there are different levels of complexity assessments. A detailed elaboration on the tool’s dimensions is available from Lewin et al. and the accompanying guidance document.

Application of iCAT_SR in the context of systematic reviews may ultimately help researchers to consider dimensions of intervention complexity that have previously been overlooked so as to guide the pooling of studies for analysis and enhance the interpretation of review findings. Worked examples of the tool’s application are needed to promote its use and refinement. However, to date, references to the application of iCAT_SR primarily relate to protocols of ongoing systematic reviews.

This case study is a proof-of-concept of the potential application of iCAT_SR to studies included in a Cochrane review. The aim was to apply the intervention Complexity Assessment Tool for Systematic Reviews (iCAT_SR) to a subset of interventions included in a Cochrane systematic review of interventions aimed at improving appropriate polypharmacy in older people. In this paper, we report on our experiences of applying iCAT_SR to included studies and outline potential refinements to the tool to facilitate its future application as part of systematic reviews.

Methods
A convenience sample of intervention studies included in a recent update of a Cochrane review of interventions to improve appropriate polypharmacy in older people was assessed using the iCAT_SR. The sample comprised all 20 included studies following the first round of database searches conducted as part of the review’s update. The review followed the Cochrane Collaboration’s methodology for updates of reviews. Key information relating to the review’s PICO (Population, Intervention, Comparison, Outcomes) is summarised in Table 2 and detailed information on all aspects of the methods used is available in the published review.

Assessment of intervention complexity using the iCAT_SR
Assessment of intervention complexity was performed independently by two reviewers (CC, AR) using the iCAT_SR (Table 1). Both reviewers are experienced health services researchers who led on the most recent update of the Cochrane review and, therefore, had in-depth knowledge of the included studies. In order to mitigate against a lack of detailed reporting in published study reports, study authors were emailed to request further information (e.g. intervention protocols).

For each intervention, key information was extracted using a purposefully developed data extraction form (Extended data File 1). In completing the assessments, the iCAT_SR guidance document was used as the coding manual. For each complexity dimension, the assessment level and criteria detailed in the guidance document were applied. The coders identified relevant information from the description of the intervention under each assessment dimension, assigned a complexity rating and provided support for their assessments. Notes were taken during the coding process on any issues with applying the iCAT_SR based on the assessment levels/criteria and any refinements that were needed for the guidance document.

To aid graphical presentation of results, assessment levels across each dimension were categorised as ‘high’, ‘intermediate’, ‘low’ or ‘unclear’ using the definitions in the published tool (Table 1). Cohen’s Kappa coefficient was used to assess inter-rater agreement during the assessment process. Both reviewers are experienced health services researchers who led on the most recent update of the Cochrane review and, therefore, had in-depth knowledge of the included studies.
reliability between the two reviewers (≤0.2 = poor agreement, 0.21–0.40 = fair agreement, 0.51–0.6 = moderate agreement, 0.61–0.8 = substantial agreement, 0.81–1.00 = good agreement)\textsuperscript{14}. Any disagreements were resolved by discussion with another member of the research team (SL) who led on the development of iCAT_SR\textsuperscript{8}.

### Results
The characteristics of the subset of 20 studies\textsuperscript{15–34} to which the iCAT_SR was applied are summarised in Extended data File 2\textsuperscript{33}. Briefly, these studies consisted of 12 randomised controlled trials (RCTs), six cluster RCTs and two controlled before-after studies. In total, 25,674 older patients were

| Core dimensions                                                                 | Assessment categories*                                                                 |
|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 1. Organisational levels and categories targeted by the intervention           | I. Multi-level<br>II. Multi-category<br>III. Single category                           |
| 2. Behaviour or actions of intervention recipients or participants to which the intervention is directed | I. Multi-target<br>II. Dual target<br>III. Single target<br>IV. Varies                  |
| 3. Active components included in the intervention, in relation to the comparison | I. More than one component and delivered as a bundle<br>II. More than one component<br>III. One component<br>IV. Varies |
| 4. The degree of tailoring intended or flexibility permitted across sites or individuals in applying or implementing the intervention | I. Highly tailored/flexible<br>II. Moderately tailored/flexible<br>III. Inflexible<br>IV. Varies |
| 5. The level of skill required by those delivering the intervention in order to meet the intervention objectives | I. High level skills<br>II. Intermediate level skills<br>III. Basic skills<br>IV. Varies |
| 6. The level of skill required for the targeted behaviour when entering the included studies by those receiving the intervention, in order to meet the intervention objectives | I. High level skills<br>II. Intermediate level skills<br>III. Basic skills<br>IV. Varies |

| Optional dimensions                                                                 | Assessment categories*                                                                 |
|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 7. The degree of interaction between intervention components, including the independence/interdependence of intervention components | I. High level interaction<br>II. Moderate interaction<br>III. Independent<br>IV. Varies<br>V. Unclear/unable to assess |
| 8. The degree to which the effects of the intervention are dependent on the context or setting in which it is implemented | I. Highly context dependent<br>II. Moderately context dependent<br>III. Independent of context<br>IV. Varies<br>V. Unclear/unable to assess |
| 9. The degree to which the effects of the intervention are changed by recipient or provider factors | I. Highly dependent on individual-level factors<br>II. Moderately dependent on individual-level factors<br>III. Largely independent of individual-level factors<br>IV. Varies<br>V. Unclear/unable to assess |
| 10. The nature of the causal pathway between the intervention and the outcome it is intended to effect | I. Pathway variable, long<br>II. Pathway linear, long<br>III. Pathway linear, short<br>IV. Varies<br>V. Unclear/unable to assess |

*Categorisation of assessment levels: I = high; II = intermediate; III = low; IV = varies; V = unclear/unable to assess.
Interventions in the form of computerised decision support that was provided by pharmacists in collaboration with physicians, patients and appropriate indications. It typically involves medication reviews patients receive the correct medication, at appropriate doses, for a systematic approach to the provision of care that ensures interventions across various settings. Pharmaceutical care reflects overall, 19 studies examined pharmaceutical care-based interventions (five studies).

The included studies reported on the interaction between interventions components and outcomes. However, a lack of detailed information in the study reports made it difficult to apply the iCAT_SR’s optional dimensions consistently across the included studies. For example, none of the included studies reported on the interaction between intervention components or the nature of the causal pathway between intervention components and outcomes.

Table 2. Summary of key inclusion criteria for Cochrane review of interventions to improve appropriate polypharmacy in older people.

| Study features | Key inclusion criteria |
|----------------|------------------------|
| **Population** | Older people (≥65 years) in any healthcare setting with more than one long-term medical condition and receiving polypharmacy (≥4 medications) |
| **Intervention** | All types of interventions that aimed to improve appropriate polypharmacy in older people in any healthcare setting were eligible for inclusion provided that a validated tool was used to assess the appropriateness of prescribing |
| **Comparison** | Studies using expert opinion alone to assess the appropriateness of prescribing were excluded |
| **Outcomes** | Interventions had to be compared against usual care as defined by the study (except for interrupted time series studies) |

| Study designs | Randomised controlled trials (RCTs), cluster RCTs, non-randomised trials, controlled before-and-after studies and interrupted time series |

involved, the majority of whom were female (65.8% in intervention groups, 65.6% in control groups). On average, patients were 77.2 years old and receiving nine medicines at baseline. The studies were conducted in three types of settings: hospitals (outpatient clinics, hospital/care home interface, inpatient settings), primary care and nursing homes/residential care settings. The studies were carried out in ten countries: Australia (three studies), Belgium (two studies), Canada (two studies), Finland (one study), Germany (two studies), Ireland (two studies), Israel (one study), Italy (one study), Spain (one study) and the USA (five studies).

Interventions
Overall, 19 studies examined pharmaceutical care-based interventions across various settings. Pharmaceutical care reflects a systematic approach to the provision of care that ensures patients receive the correct medication, at appropriate doses, for appropriate indications. It typically involves medication reviews by pharmacists in collaboration with physicians, patients and carers. One study evaluated a single component intervention in the form of computerised decision support that was provided to general practitioners (GPs) in their own practices. Further details about the interventions are summarised in Extended data File 2.

iCAT_SR complexity assessments
Overview of the intervention complexity assessments across the six core dimensions for the 20 studies are displayed in Table 3. A brief outline of the assessments under each of the iCAT_SR dimensions is provided in the subsections below. A detailed breakdown of individual iCAT_SR assessments for each study (including justifications for assigned ratings) is provided in Extended data File 3. The inter-rater reliability was substantial (Cohen’s Kappa = 0.75).

Efforts were made to apply the iCAT_SR optional dimensions. However, a lack of detailed information in the study reports made it difficult to apply the iCAT_SR’s optional dimensions consistently across the included studies. For example, none of the included studies reported on the interaction between intervention components or the nature of the causal pathway between intervention components and outcomes.
### Table 3. Assessments of core iCAT_SR dimensions for individual studies of interventions aimed at improving appropriate polypharmacy in older people.

| Study ID grouped by setting | iCAT_SR assessment dimension | Organisational levels/categories | Behaviour or actions | Active components | Level of tailoring | Skill level required by those delivering intervention | Skill level required by those receiving intervention |
|-----------------------------|-----------------------------|----------------------------------|---------------------|------------------|-------------------|---------------------------------|---------------------------------|
| **Community**               |                             |                                   |                     |                  |                   |                                 |                                 |
| Clyne 2015                  |                             | High                              | High                | High             | Intermediate       | Intermediate                    | Intermediate                    |
| Tamblyn 2003                |                             | Low                               | High                | Low              | Intermediate       | Intermediate                    | Intermediate                    |
| Taylor 2003                 |                             | High                              | High                | High             | Intermediate       | Intermediate                    | Intermediate                    |
| **Hospital**                |                             |                                   |                     |                  |                   |                                 |                                 |
| Basger 2015                 |                             | High                              | High                | High             | Intermediate       | Intermediate                    | Intermediate                    |
| Bucci 2003                  |                             | High                              | High                | Intermediate     | High              | Intermediate                    | Intermediate                    |
| Crotty 2004b                |                             | Intermediate                      | High                | High             | High              | Intermediate                    | Intermediate                    |
| Dalleur 2014                |                             | Low                               | High                | High             | Intermediate       | Intermediate                    | Intermediate                    |
| Franchi 2016                |                             | Low                               | High                | High             | Low               | Intermediate                    | Intermediate                    |
| Gallagher 2011              |                             | Low                               | High                | High             | Intermediate       | Intermediate                    | Intermediate                    |
| Hanlon 1996                 |                             | High                              | High                | High             | High              | Intermediate                    | Intermediate                    |
| Michalek 2014               |                             | Low                               | High                | High             | High              | Intermediate                    | Intermediate                    |
| Schnader 2004               |                             | High                              | High                | High             | High              | Intermediate                    | Intermediate                    |
| Spinewine 2007              |                             | High                              | High                | High             | High              | Intermediate                    | Intermediate                    |
| Wehling 2016                |                             | Low                               | High                | High             | High              | Intermediate                    | Intermediate                    |
| **Residential care**        |                             |                                   |                     |                  |                   |                                 |                                 |
| Crotty 2004a                |                             | Intermediate                      | High                | High             | High              | Intermediate                    | Intermediate                    |
| Frankenthal 2014            |                             | Low                               | High                | High             | Intermediate       | Intermediate                    | Intermediate                    |
| Garcia-Gollarte 2014        |                             | Low                               | High                | High             | Low               | Intermediate                    | Intermediate                    |
| Pitkala 2014                |                             | Intermediate                      | High                | High             | Low               | Intermediate                    | Intermediate                    |
| Trygstad 2005               |                             | Low                               | High                | High             | Intermediate       | Intermediate                    | Intermediate                    |
| Trygstad 2009               |                             | Low                               | High                | Intermediate     | Intermediate       | Intermediate                    | Intermediate                    |

**Organisational levels/categories**

Half of the interventions targeted a single category of individuals (n=10, low level complexity rating), comprising healthcare professionals or patients. In the other studies, interventions were categorised as multi-level (n=7, high level complexity rating) when the interventions typically targeted both patients and healthcare professionals, or multi-category (n=3, intermediate level complexity rating), where multiple groups of healthcare professionals (i.e. GPs, pharmacists, nurses) within the same setting were targeted.

**Target behaviours/actions and active components**

All of the interventions were deemed to be multi-target (high level complexity rating) in that they involved multiple target behaviours/actions. In all studies, this included appropriate prescribing for older patients receiving polypharmacy and the component behaviours/actions (e.g. reviewing prescriptions, implementing prescribing changes).

With the exception of one study, all of the interventions involved more than one component. Tamblyn et al. evaluated an inter-
vention comprising computerised decision support which was
categorised as a single component intervention (low level com-
plexity rating)\textsuperscript{39}. The interventions involving more than one
component were further subcategorised according to whether there
was a defined order to the delivery of intervention components.
There were 17 interventions delivered as a bundle (as opposed
to an intervention package) as there was an order/sequence to
the delivery of the interventions components (high level complex-
ity rating). This was evident in a number of the hospital-based
studies that involved the application of prescribing criteria to
identify potentially inappropriate medications, which were then
communicated to relevant members of a patient’s medical team
and prescribing changes subsequently implemented\textsuperscript{19,22}.

In two studies\textsuperscript{16,32}, there was no apparent order to the delivery
of intervention components and the interventions were there-
fore categorised as packages as opposed to intervention bundles
(intermediate level complexity rating). For example, the multi-
level intervention evaluated by Bucci \textit{et al}.\textsuperscript{16} targeted both patients
and prescribers. Directive guidance was provided to patients
with the intention of improving medication adherence, while
prescribers were targeted by the pharmacist-led intervention to
improve the appropriateness of medication prescribing. How-
ever, the order in which the intervention components were
delivered was not explicitly stated and it was not clear if the
patient-targeted component came, or needed to come, before or
after the prescriber-targeted component.

**Level of tailoring**

Eight interventions were categorised as highly tailored/flex-
ible (high level complexity rating). These interventions typically
involved the application of implicit tools (e.g. Medication Approp-
riateness Index\textsuperscript{37}) in assessing the appropriateness of patients’
medications. Given the judgement-based nature of these types
of tools, a higher degree of tailoring/flexibility would have
been permitted when being applied at the individual patient level.

Nine interventions were categorised as moderately tailored/flex-
ible (intermediate level complexity rating). These interventions
typically involved the application of explicit tools in assessing
the appropriateness of patients’ medications (e.g. STOPP/
START\textsuperscript{49}, Beers’ criteria\textsuperscript{48}). The rationale for rating explicit tools
as moderately flexible was that while they consist of criteria
relating to potentially inappropriate prescribing in older people,
it is at clinicians’ discretion as to whether the criteria are
applicable to individual patients. Therefore, although these tools
consist of pre-specified criteria, there is a degree of flexibility
in terms of their application at the individual patient level.

The three interventions categorised as inflexible (low level com-
plexity rating) involved education and training for health-
care professionals\textsuperscript{20,23,26}. In contrast to the studies involving
prescribing tools, the intention with these interventions would be
to deliver a defined and clearly specified learning activity
which would have arguably less flexibility once it had been
developed.

Skill level required by those delivering and receiving
interventions

For all 20 studies, assessments of the level of skill for those
delivering and receiving interventions were rated as intermedi-
ate (intermediate level complexity rating). In both instances, the
target behaviours/actions related to appropriate prescrib-
ing for older people. This was considered to be within the
scope of normal practice of those involved in delivering and/or
receiving the interventions (e.g. physicians working in geriatric
hospital wards reviewing older patients’ medications), such
that no specialisation was deemed to have been required.

**Discussion**

This study provides the first detailed overview of the appli-
cation of the iCAT_SR\textsuperscript{4}. The experience gained (discussed
below) may assist with the tool’s use in systematic reviews in
other clinical areas. The findings also demonstrate that interven-
tions categorised as ‘multifaceted’ (comprising two or more
components) in previous iterations of this review\textsuperscript{4,39} varied in
complexity using the tool’s core assessment dimensions. This
highlights how broad terms, such as uni-faceted and multi-
faceted, do not adequately describe the scope of intervention
complexity and further illustrates the importance of consider-
ing a range of dimensions of complexity using a tool such as
iCAT_SR.

**Experience in applying iCAT_SR**

Despite detailed available guidance on the tool’s application\textsuperscript{4},
this work was not without challenges. For example, time
needed to be allocated to upskilling the review team on the
iCAT_SR and then applying it to the interventions. Hence, this
initial coding exercise focused on a subset of studies identified
following the initial round of searches for the most recent update
of this Cochrane review\textsuperscript{12}. Therefore, this work is not intended
as a definitive assessment of intervention complexity in this
field of research but as proof of concept of the iCAT_SR’s
application.

The inter-rater reliability was substantial. Most of the observed
variation between the individual rater assessments was primarily
attributable to differences in the interpretation of the two skill-
related dimensions (i.e. skill level required by those deliv-
ering or receiving the intervention) between the coders and
whether they represented intermediate or high level skills. In
assessing these dimensions, it is important to consider the base-
line level of skill that would be expected of the individual(s) deliv-
ering or receiving the intervention and to note whether the study
reports on the skill level required or possessed. For instance,
if a study reports that individuals delivering an intervention
were highly skilled and qualified/experienced, this does not
necessarily mean that this level of skill/experience was required
to deliver the intervention. Assessments based on the reported
level of skill/experience as opposed to the required skill level
could result in the complexity level assessment for this dimension
being overestimated.
For the purpose of this coding exercise, appropriate prescribing for older people was deemed to be within the scope of practice of those involved in delivering and/or receiving the interventions (e.g. physicians working in geriatric hospital wards reviewing older patients’ medications), such that no specialisation was considered necessary. Consequently, all skills-related assessments were rated as intermediate. Assessments of skill level requirements should ideally be based on details of prior training. However, this may not always be explicitly outlined in study reports, in which case a judgement is required based on expected baseline skill level. In such cases, we recommend specifying a priori how decisions will be made between each of the assessments levels.

An additional challenge in applying the tool’s coding manual related to the assessment of the target behaviour (i.e. prescribing of appropriate polypharmacy) across included studies. The more precisely a behaviour is defined, the greater the specificity of the barriers and facilitators identified (e.g. reducing overprescribing of benzodiazepines, a commonly identified class of potentially inappropriate medications in older people); however, cases exist where it is not possible to isolate and target one behaviour for change, particularly where multiple interdependent behaviours exist (e.g. ensuring prescribing of appropriate polypharmacy for older people)\textsuperscript{40,41}. Unless explicitly outlined at the outset for any given intervention, compiling an exhaustive list of these interdependent behaviours (also referred to as sub-behaviours) is practically impossible\textsuperscript{42}. This was the case with regard to the prescribing of appropriate polypharmacy – although these interventions typically involved medication reviews and implementation of prescribing changes, this represented an over-simplification of the key behaviours/actions. As such, the intricacies of the nursing home-based interventions that involved multi-disciplinary case conferences was not adequately captured\textsuperscript{14,34}. Consequently, the target behaviour across all included studies was categorised as multi-target. However, this detracted from the potential of this core complexity dimension to discriminate between interventions. Reporting on the behaviours and actions taken as part of interventions more explicitly in future research may help in discriminating more clearly between interventions. In the interim, future research involving application of iCAT_SR may look to prioritise key expected behaviours or actions across interventions\textsuperscript{40}.

Finally, a lack of detailed reporting and the absence of an explicit theoretical underpinning across the interventions precluded consistent application of the iCAT_SR’s optional dimensions. These are both well recognised issues with the existing literature\textsuperscript{42-47}. Consequently, assessments were largely based on the reported interventions without detailed consideration of the context/settings in which they were delivered, the interaction between intervention components and the nature of the causal pathway between intervention components and outcomes. Addressing these widely recognised issues through application of relevant reporting guidelines and checklists\textsuperscript{48-51}, as well as operationalisation of appropriate theory in future research, would help to ensure more consistent application of the tool’s optional dimensions. This could enhance the tool’s capability of discriminating between interventions and offering plausible explanations for sources of heterogeneity between studies. Reporting on interactions between intervention components and the nature of the causal pathways underlying intervention effects would enhance our understanding of not just what interventions work, but also in understanding what happens when they are implemented\textsuperscript{52}. This could ultimately enable systematic reviews of interventions to extend beyond assessing whether interventions are effective or not, to interrogating the role of different intervention components, and exploring how, why and for whom the intervention works, and under what circumstances\textsuperscript{53}.

Interpreting iCAT_SR assessments
The iCAT_SR assessments for individual studies were consistent across three dimensions which related to behaviour and skills. This was to some extent expected as the interventions focussed on improving appropriate prescribing and were delivered by clinicians involved in the care of older patients. For the remaining dimensions, there was no consistent pattern for intervention complexity assessments across included studies even when categorised according to setting. We had considered the application of a scoring system to the iCAT_SR assessments as part of this work. However, we were unable to establish a firm evidence base on which to base one.

Refinements to iCAT_SR
The experience gained from applying the iCAT_SR has identified two potential refinements to the tool and the associated guidance document\textsuperscript{48}. Firstly, the assessment dimensions in the original tool have been re-ordered to enable a more logical sequence of conceptualisation and application (i.e. starting with ‘Organisational levels/categories’ and progressing to ‘Behaviour or actions’, ‘Active components’, etc.). Secondly, additional examples have been incorporated to supplement the existing ones which were largely directed towards health system and public health interventions\textsuperscript{47}. These may assist with the tool’s application to systematic reviews in other clinical areas. A revised version will be published on the Cochrane Collaboration’s website at a later date.

Relationship to other work in the field
A recent systematic review of interventions to promote active transport to school in children has also applied the iCAT_SR\textsuperscript{54}. The authors assigned arbitrary scores to each assessment dimension to calculate a global complexity score for each study and then assessed if there was a correlation between intervention complexity and effectiveness. Considerable variation was reported in global complexity scores across included studies and no correlation was detected between intervention complexity and effectiveness. However, the review authors noted the need for more robust methods of evaluating the relationship between intervention complexity and effectiveness.

A previous overview of systematic reviews seeking to compare the effectiveness of multifaceted interventions and uni-faceted
interventions in changing healthcare professionals’ behaviour found no compelling evidence that the former were more effective. The current study allowed limited comparison of uni-faceted interventions and multifaceted interventions. The computerised decision support-based intervention evaluated by Tamblyn et al.29 that was previously described in the review as uni-faceted showed comparable assessments across a number of complexity dimensions to other interventions that were categorised as multi-faceted. This simple dichotomy of interventions according to the presence of one component or more than one component may overlook critical dimensions of complexity that impact on effectiveness. This lends support to the view that it is difficult and probably not useful to create a simple definition of a complex intervention.6,46 Therefore, it may be more appropriate to define complexity in terms of intervention characteristics as opposed to the number of intervention components alone. For example, Guise et al.57 have defined complex interventions based on key characteristics that extend beyond the intervention and components and encompass a range of other dimensions including pathway complexity, population complexity, implementation complexity and contextual complexity. It is important to recognise that complexity is not merely a characteristic of the interventions themselves but also a feature of the systems (i.e. context, setting) in which they are delivered.58

Implications for use in future reviews
The application of the iCAT_SR was a useful exercise, as it allowed dimensions of complexity to be assessed systematically across included studies. However, the value of including iCAT_SR assessments in future updates of the review is currently unclear, in relation to the additional work involved. Further work is needed to determine if application of the iCAT_SR can help to interpret whether varying levels of complexity impact on intervention effectiveness. Systematic reviews involving larger numbers of studies with data that can be pooled in meta-analyses may allow more detailed analysis of relationships between iCAT_SR assessments and intervention effect sizes using appropriate statistical techniques such as meta-regression. It is important that other systematic reviews focusing on other intervention areas apply the iCAT_SR and report on both the findings and experiences of using the tool. This will help in continuing to refine the tool and establishing methods for determining whether varying levels of complexity impact on intervention effectiveness.

Conclusion
This study reports on the application of the iCAT_SR to a subset of studies included in a Cochrane review of interventions to improve appropriate polypharmacy in older people. The findings show that categorisation of interventions as multi-faceted or unifaceted without a more detailed assessment of other dimensions of complexity is a potential oversimplification as it not necessarily the case that interventions with fewer components are less complex across all relevant complexity dimensions. Future research needs to ensure more detailed reporting of interventions, context and the nature of the causal pathways underlying intervention effects to allow a more holistic understanding of intervention complexity. This could assist in ensuring more informative descriptions of interventions and the context in which they are delivered, and ultimately contribute to both understanding the effects of these interventions and facilitating replication in other settings.

Data availability
Underlying data
All data underlying the results are available as part of the article and no additional source data are required.

Extended data
Open Science Framework: Application of the intervention Complexity Assessment Tool for Systematic Reviews (iCAT_SR) within a Cochrane review. https://doi.org/10.17605/OSF.IO/N3KW2

This project contains the following extended data:
- File 1: Data extraction form
- File 2: Cochrane review summary findings
- File 3: iCAT_SR assessments for individual studies

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

References
1. Medical Research Council: Developing and evaluating complex interventions: new guidance. In: London: United Kingdom: Medical Research Council; 2008; Accessed: 01/05/20. Reference Source
2. Moore G, Evans R, Hawkins J, et al.: All interventions are complex, but some are more complex than others: using iCAT_SR to assess complexity, Cochrane Database Syst Rev 2017; 7: Ed000122. PubMed Abstract | Publisher Full Text
3. Petticrew M: When are complex interventions ‘complex’? When are simple interventions ‘simple’? Eur J Public Health. 2011; 21(4): 397–8. PubMed Abstract | Publisher Full Text
4. Patterson SM, Cadogan CA, Kers, N, et al.: Interventions to improve the appropriate use of polypharmacy for older people. Cochrane Database Syst Rev 2014; (10): CD008165. PubMed Abstract | Publisher Full Text
5. Smith SM, Wallace E, O’Dowd T, et al.: Interventions for improving outcomes in patients with multimorbidity in primary care and community settings. Cochrane Database Syst Rev 2016; 3(3): CD006560. PubMed Abstract | Publisher Full Text | Free Full Text
6. Lewin S, Hendry M, Chandler J, et al.: Assessing the complexity of interventions within systematic reviews: development, content and use of a new tool (iCAT_SR). BMC Med Res Methodol. 2017; 17(1): 76. PubMed Abstract | Publisher Full Text | Free Full Text
7. Lewin S, Hendry M, Chandler J, et al.: Guidance for using the iCAT_SR.
Intervention Complexity Assessment Tool for Systematic Reviews (Version 1.0). Accessed 01.05.20.

Reference Source:

Chung Y, Garden FL, Marks GB, et al.: Non-invasive positive airway pressure therapy for obesity hyperventilation syndrome in adults (Protocol). Cochrane Database Syst Rev. 2018; 3: CD012376. Publisher Full Text | Free Full Text

Ribero DC, Abbott JH, Sharma S, et al.: Process evaluation of complex interventions tested in randomised controlled trials in musculoskeletal disorders: a systematic review and meta-analysis. BMJ Open. 2019; 9(4): e028160. PubMed Abstract | Publisher Full Text | Free Full Text

Alghamdi SM, Janaudis-Ferreira T, Alhasani R, et al.: Acceptance, adherence and dropout rates of individuals with COPD approached in telehealth interventions: a protocol for systematic review and meta-analysis. BMJ Open. 2019; 9(4): e026794. Publisher Full Text | Free Full Text

Rankin A, Cadogan CA, Patterson SM, et al.: Interventions to improve the appropriate use of polypharmacy for older people. Cochrane Database Syst Rev. 2018; 9(9): CD008165. PubMed Abstract | Publisher Full Text | Free Full Text

Rankin A, Cadogan CA, Cooper J, et al.: Interventions to improve the appropriate use of polypharmacy for older people: an updated Cochrane systematic review. International Journal of Pharmacy Practice. 2018; 26(S1): 5–6.

Cadogan CA, Rankin A, Lewin S, et al.: Application of the Intervention Complexity Assessment Tool for Systematic Reviews (CAT_SR) within a Cochrane review. Open Science Framework repository. 2020. http://www.doi.org/10.17605/OSF.IO/N3K2W

Landis JR, Koch GG: The measurement of observer agreement for categorical data. Biometrics. 1977; 33(1): 159–74. Publisher Full Text

Bassler BJ, Moles RJ, Chen TF: Impact of an enhanced pharmacy discharge service on prescribing appropriateness criteria: a randomised controlled trial. Int J Clin Pharm. 2015; 37(6): 1194–205. Publisher Full Text | Free Full Text

Bucci C, Jackievicz C, McFarlane K, et al.: Pharmacist’s contribution in a heart function clinic: patient perception and medication appropriateness. Can J Cardiol. 2003; 19(4): 391–6. PubMed Abstract

Clyne B, Smith SM, Hughes CM, et al.: Effectiveness of a Multicentre Intervention for Potentially Inappropriate Prescribing in Older Patients in Primary Care: A Cluster-Randomized Controlled Trial (OPTI-SCRIPT Study). Ann Fam Med. 2015; 13(6): 545–53. PubMed Abstract | Publisher Full Text | Free Full Text

Crotty M, Albert T, Rowett D, et al.: An outreach geriatric medication advisory service in residential aged care: a randomised controlled trial of case conferencing. Age Ageing. 2004; 33(6): 612–7. PubMed Abstract | Publisher Full Text | Free Full Text

Hanlon JT, Schmader KE, Samsa GP, Patterson SM, Hughes C, Kerse N, et al.: STOPP/START criteria for potentially inappropriate prescribing in older people: version 2. Age Ageing. 2015; 44(2): 213–8. PubMed Abstract | Publisher Full Text | Free Full Text

Hepler CD, Strand LM: Opportunities and responsibilities in pharmaceutical care. Am J Hosp Pharm. 1990; 47(3): 533–43. PubMed Abstract

By the 2019 American Geriatrics Society Beers Criteria® Update Expert Panel: American Geriatrics Society 2019 Updated AGS Beers Criteria(R) for Potentially Inappropriate Medication Use in Older Adults. J Am Geriatr Soc. 2019; 67(1): 674–94. PubMed Abstract | Publisher Full Text | Free Full Text

Patterson SM, Hughes C, Kerse N, et al.: Interventions to improve the appropriate use of polypharmacy for older people. Cochrane Database Syst Rev. 2012; (5): CD008165. PubMed Abstract | Publisher Full Text | Free Full Text

Atkins L, Francis J, Islam R, et al.: A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. Implement Sci. 2017; 12(1): 77. PubMed Abstract | Publisher Full Text | Free Full Text

Peters G: A practical guide to effective behavior change: How to identify what to change in the first place. European Health Psychologist. 2014; 16(4): 142–55. Reference Source

Colquhoun HL, Brehaut JC, Sales A, et al.: A systematic review of the use of theory in randomized controlled trials of audit and feedback. Implement Sci. 2013; 8: 65. PubMed Abstract | Publisher Full Text | Free Full Text

Davies P, Walker AE, Grimshaw JM: A systematic review of the use of theory in the design of guideline dissemination and implementation strategies and interpretation of the results of rigor evaluations. Implement Sci. 2010; 5: 14. PubMed Abstract | Publisher Full Text | Free Full Text

Michie S, Fixon D, Grimshaw JM, et al.: Specifying and reporting complex behaviour change interventions: the need for a scientific method. Implement Sci. 2009; 4: 49. PubMed Abstract | Publisher Full Text | Free Full Text

Colquhoun H, Mchiste S, Sales A, et al.: Reporting and design elements of audit and feedback interventions: a secondary review. BMJ Qual Saf. 2017; 26(1): 54–60. PubMed Abstract | Publisher Full Text | Free Full Text

Harper R, Lewin S, Denton C, et al.: Completeness of reporting of setting and health worker cadre among trials on antenatal iron and folic acid supplementation in pregnancy: an assessment based on two Cochrane reviews. Syst Rev. 2013; 2: 42. PubMed Abstract | Publisher Full Text | Free Full Text
47. Shepperd S, Lewin S, Straus S, et al.: Can we systematically review studies that evaluate complex interventions? PLoS Med. 2009; 6(8): e1000086. PubMed Abstract | Publisher Full Text | Free Full Text
48. Möhler R, Köpke S, Meyer G: Criteria for Reporting the Development and Evaluation of Complex Interventions in healthcare: revised guideline (CReDECI 2). Trials. 2015; 16: 204. PubMed Abstract | Publisher Full Text | Free Full Text
49. Hoffmann TC, Glazsiou PP, Boutron I, et al.: Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. BMJ. 2014; 348: g1687. PubMed Abstract | Publisher Full Text
50. Albrecht L, Archibald M, Arseneau D, et al.: Development of a checklist to assess the quality of reporting of knowledge translation interventions using the Workgroup for Intervention Development and Evaluation Research (WIDER) recommendations. Implement Sci. 2013; 8: 52. PubMed Abstract | Publisher Full Text | Free Full Text
51. Guise JM, Butler ME, Chang C, et al.: AHRQ series on complex intervention systematic reviews-paper 6: PRISMA-CI extension statement and checklist. J Clin Epidemiol. 2017; 90: 43–50. PubMed Abstract | Publisher Full Text
52. Petticrew M: Time to rethink the systematic review catechism? Moving from ‘what works’ to ‘what happens’. Syst Rev. 2015; 4: 36. PubMed Abstract | Publisher Full Text | Free Full Text
53. Kelly MP, Noyes J, Kane RL, et al.: AHRQ series on complex intervention systematic reviews-paper 2: defining complexity, formulating scope, and questions. J Clin Epidemiol. 2017; 90: 11–18. PubMed Abstract | Publisher Full Text
54. Jones RA, Blackburn NE, Woods C, et al.: Interventions promoting active transport to school in children: A systematic review and meta-analysis. Prev Med. 2019; 123: 232–41. PubMed Abstract | Publisher Full Text
55. Squires JE, Sullivan K, Eccles MP, et al.: Are multifaceted interventions more effective than single-component interventions in changing health-care professionals’ behaviours? An overview of systematic reviews. Implement Sci. 2014; 9: 152. PubMed Abstract | Publisher Full Text | Free Full Text
56. Petticrew M, Anderson L, Elder R, et al.: Complex interventions and their implications for systematic reviews: a pragmatic approach. J Clin Epidemiol. 2013; 66(11): 1209–14. PubMed Abstract | Publisher Full Text
57. Guise JM, Chang C, Butler M, et al.: AHRQ series on complex intervention systematic reviews-paper 1: an introduction to a series of articles that provide guidance and tools for reviews of complex interventions. J Clin Epidemiol. 2017; 90: 6–10. PubMed Abstract | Publisher Full Text
58. Greenhalgh T, Papoutsi C: Studying complexity in health services research: desperately seeking an overdue paradigm shift. BMC Med. 2018; 16(1): 95. PubMed Abstract | Publisher Full Text | Free Full Text
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Thank you for inviting me to review this interesting case study. The study aimed to apply the iCAT_SR to a subset of studies that were recently included in a Cochrane Review that assessed interventions designed to improve appropriate polypharmacy in the elderly. Authors independently assessed included studies using the iCAT_SR, assessed and reported the inter-rater reliability using the Cohen's Kappa coefficient. The findings suggest limited consistency in intervention complexity across included studies and, importantly, highlight the lack of information within included studies. In the conclusions, the authors highlight the need for more detailed information regarding the interventions tested by original studies, the context and causal pathways through which interventions may work.

This is an interesting and well-written study. I enjoyed reading it and I have only one minor suggestion for the authors. I hope these are useful for improving the quality of the reporting.

Table 3: suggest adding a caption below the table, for defining what “high, intermediate and low” refer to. This is implied but it is not explicit.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes
Are the conclusions drawn adequately supported by the results?
Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Process evaluation of clinical trials.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

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Marie Gaarder  
International Initiative for Impact Evaluation, Oslo, Norway

The aim of the study was to test the Complexity Assessment Tool for Systematic Reviews (iCAT_SR) in a subset of studies included in a Cochrane review in order to promote its use and refinement. In order to draw the right conclusions and make the right interpretations of review findings, it is important to understand and document the implementation details and the context in which interventions take place. Hence testing the extent to which the tool can be implemented and whether it adds value is important.

Interventions were assessed using the six core iCAT_SR dimensions: (1) ‘Target organisational levels/categories’; (2) ‘Target behaviour/actions’; (3) ‘Active intervention components’; (4) ‘Degree of tailoring’; (5) ‘Level of skill required by intervention deliverers’; (6) ‘Level of skill required by intervention recipients’. Attempts were made to apply four optional dimensions: ‘Interaction between intervention components’; ‘Context/setting’; ‘Recipient/provider factors’; ‘Nature of causal pathway’.

I have three comments:

1. As I have argued elsewhere (blog: www.3ieimpact.org/blogs/misdiagnosis-and-evidence-trap-tale-inadequate-program-design), identifying the root cause or causes of a problem is maybe the most important step to designing the correct interventions to treat it. This may be obvious but is done quite infrequently, certainly in sectors outside of medicine, and I assume the iCAT_SR is meant for wider use. What this means is that you could have two identically designed (complex) interventions focusing on the same issue, in this case aimed at improving appropriate polypharmacy in older people, yet one works and the other does not because the underlying reasons for suboptimal polypharmacy were different. I do not think that the 6 SR dimensions, even if they could be applied easily, would hence be sufficient to make the right interpretations of review findings.

2. The additional four dimensions focused on interaction, context, causal pathway etc are also all key to understanding the underlying factors that drive the current situation and the effectiveness of the
intervention. It is not clear whether they directly incorporate the questions of the existence of
in-depth diagnoses of the problem/root cause(s) but I would strongly recommend that they should
and that this should be elevated to a separate dimension. Also, the study should explain why it was
decided to add the four dimensions. They seem key (from a theoretical perspective) and it is
surprising that they had not been considered among the original dimensions.

3. Given the finding that there was not sufficient information on the additional dimensions to report on
these, and the fact that the first 6 dimensions are necessary but not sufficient to explain differences
in effectiveness, I am surprised at the section on refinements. I would venture that the authors
should go further in indicating that the tool needs to incorporate the spirit behind the additional
dimensions, namely understanding context, root causes, causal pathways etc.

Congratulations to the authors for a very valuable contribution.

Is the work clearly and accurately presented and does it cite the current literature?
Yes
Is the study design appropriate and is the work technically sound?
Yes
Are sufficient details of methods and analysis provided to allow replication by others?
Yes
If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable
Are all the source data underlying the results available to ensure full reproducibility?
Yes
Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: International development - impact evaluations, organizational evaluations and
systematic reviews.

I confirm that I have read this submission and believe that I have an appropriate level of
expertise to confirm that it is of an acceptable scientific standard.
I have reviewed the manuscript titled “Application of the intervention Complexity Assessment Tool for Systematic Reviews within a Cochrane review: an illustrative case study”. The aim of this case study was to apply the iCAT_SR to a subset of 20 studies included in a Cochrane review of interventions aimed at improving appropriate polypharmacy in older people.

My comments are as follows:

- This sample of 20 studies is rather small, and homogeneous in terms of the chosen topic. But this was a case study, so that is acceptable.

- In the abstract, it is unclear what does it mean limited consistency in intervention complexity, and whether this consistency is desired or not.

- It is commendable that there are additional details posted on OSF as supplementary files.

- I am impressed that none of the assessments in Table 3 are “unclear”. I would expect poorer reporting.

- It is acknowledged that this work is not intended as a definitive assessment of intervention complexity in this field of research but as proof of concept of the iCAT_SR’s application.

- It would be interesting to report inter-rater agreement for each individual iCAT_SR dimension.

Is the work clearly and accurately presented and does it cite the current literature?  
Yes

Is the study design appropriate and is the work technically sound?  
Yes

Are sufficient details of methods and analysis provided to allow replication by others?  
Yes

If applicable, is the statistical analysis and its interpretation appropriate?  
Yes

Are all the source data underlying the results available to ensure full reproducibility?  
Yes

Are the conclusions drawn adequately supported by the results?  
Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Research methodology.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.
