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ABSTRACT

Delivery of future healthcare information systems requires systems to support patients with multi-morbidity. Current approaches to computer interoperable guidelines typically consider only a single clinical guideline for a single condition. There is a need to establish a robust protocolized approach to the development of holistic consensus computer interoperable guidelines in the context of multi-morbidity. The presence of mild cognitive impairment (MCI) and dementia adds an additional challenge to the delivery of effective digital health solutions. CAREPATH proposes an ICT-based solution for the optimization of clinical practice in the treatment and management of multi-morbid older adults with mild cognitive impairment or mild dementia. In this manuscript, we present an evidence-based protocol for the development of a single computer

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interoperable holistic guideline for a collection of multi-morbid conditions. To the best of our knowledge, this is the first published protocol for the production of a consensus interoperable clinical guideline for people with multi-morbidity, with special focus on older adults with MCI or mild dementia. This addresses a still unmet need for such processes which are expected to play a central role for future integrated healthcare information systems.

CCS CONCEPTS

• **Applied computing → Health care information systems**.

KEYWORDS

Computer interoperable guidelines, Multi-morbidity, CAREPATH

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1 INTRODUCTION

Computer interoperable clinical guidelines are a key step in the development of future healthcare information systems and the digitization of healthcare [5]. They introduce the potential to implement intelligent clinical decision support (CDS) systems for healthcare professionals to easily follow complex clinical protocols in a personalized manner for an individual patient. However, advances in computing ability must be fully exploited with the changing healthcare landscape. Clinicians are managing an increased population prevalence of multi-morbidity, where individual patients have multiple interacting diagnosed clinical conditions. This is partly an inevitable consequence of population ageing [6]. This increasing presence of multi-morbidity means that individual clinical guidelines for an individual health condition may conflict with each other due to the different management requirements between conditions. Currently, this is reconciled by clinicians experienced in the management of such multi-morbid conditions. Notably, certain combinations of conditions in the context of multi-morbidity are more common than others. Indeed, in parallel to the population ageing, cognitive impairment and dementia are becoming increasingly present as co-morbid conditions alongside other chronic health conditions. The presence of such multi-morbidity means that the development of a single interoperable clinical guideline is no longer fit for purpose as health information systems will be unable to manage the interacting and potentially conflicting guidelines creating a potential adverse safety environment [2]. Where there have been some early successes in the development of computer interoperable guidelines, these frequently fail to take account of an end user with cognitive impairment. In this context, the fluctuating, varying and individual approaches to cognitive impairment and, therefore, a varying impact on underlying interoperable guidelines over time, create and urgent need for a new protocolized approach to developing digitally interoperable clinical guidelines that can be readily utilized for CDS systems.

1.1 CAREPATH Project

The EU-funded CAREPATH project proposes an ICT-based solution for the optimization of clinical practice in the treatment and management of patients of older age with MCI and mild dementia and multi-morbidity. Specifically, the project is developing a patient-centered integrated care approach aiming to deliver a best care, adapted framework for increasing the independence and quality of life of multi-morbid older patients with mild cognitive impairment or mild dementia. Overall, CAREPATH will elaborate on a methodology for computer-interpretable clinical guidelines. The findings are expected to have major benefits in terms of improving treatment outcomes for such patients. CAREPATH proposes an ICT-based integrated care solution for the optimization of clinical practice in the treatment and management of these patients. As such, this solution is targeting a more complex multi-morbidity scenario and follows an integrated patient-centered approach, instead of a routine disease centered approach. In order to develop a flexible and modular system to deliver a best care, adapted framework for increasing the independence and Quality of Life (QoL) of patients with such multi-morbidity. The proposed solution exploits previous experience from IONIS and C3-Cloud [1] and provides a holistic environment for both healthcare providers and patients, efficiently addressing the joint multi-morbidity and dementia challenges in older adults. To demonstrate and validate its results, CAREPATH will focus on combining multi-morbid conditions, in different levels of complexity, and in combination with dementia. As such, CAREPATH will consider eleven health conditions such as diabetes mellitus, hypertension, heart failure, atrial fibrillation, chronic obstructive pulmonary disease, asthma, or chronic kidney disease, malnutrition and sarcopenia. The CAREPATH pilots will take place in four European countries (Spain, Romania, Germany and UK) with diverse health and social care systems, ICT landscape/digital maturity of healthcare provision, and dementia national programs. These pilots will strengthen the evidence base on associated health outcomes and efficiency gains. CAREPATH will elaborate on a methodology for computer interpretable clinical guidelines and computationally derived best clinical practice for improved management of multi-morbid older patients with dementia. In this article, we present the CAREPATH protocolized approach to the development of consensus interoperable clinical guidelines for these patients. Despite the need for such process in integrated healthcare information systems, to the best of our knowledge, this is the first published protocol to produce a consensus interoperable clinical guideline for people with multi-morbidity.

2 REQUIREMENTS OF AN INTEROPERABLE CONSENSUS GUIDELINE PROTOCOL

Both the CAREPATH project and the future development of interoperable, single consensus clinical guidelines for multi-morbidity requires a process for creating consensus clinical guidelines for

multi-morbidity. Such single consensus guidelines need to ensure that the eventual guideline created covers the entire spectrum of the clinical multi-morbid conditions; however, there is a need to assess the quality of the guidelines presented to ensure that only recommendations with a robust evidence base are included within the clinically interoperable guideline that is created. The CAREPATH project team have identified 10 key requirements that must be developed as part of the protocol. These requirements are stipulated in Table 1.

3 THE CAREPATH CONSENSUS GUIDELINE PROTOCOL

In order to deliver a consensus, holistic and digitally interoperable guideline, we have developed a protocol that addresses all of the key requirements described above. This is a multi-step protocol from guideline identification through to presentation of an agreed computer interoperable flow chart.

3.1 Systematic review for selection of base clinical guidelines

Base clinical guidelines are required as a key input into the development of a consensus, holistic, and digitally interoperable clinical guideline. These are extracted from the literature through a systematic review methodology. In the context of CAREPATH in order to create a guideline encompassing specific multi-morbid conditions and mild cognitive impairment, the following areas of focus are included in the developed protocol:

(1) Specific multi-morbid conditions (in the case of CAREPATH: frailty, sarcopenia, malnutrition, diabetes mellitus, heart failure, chronic obstructive pulmonary disease (COPD), asthma, chronic kidney disease (CKD), stroke, coronary artery disease (CAD) and hypertension)
(2) Multi-morbidity and comorbidity guidelines
(3) Dementia and Alzheimer's disease guidelines
(4) Behavioral guidelines

The applied systematic review specifically focused on study types including guidelines, updates on previous guidelines, systematic reviews and meta-analyses of guidelines. A well-defined PICO approach was used for framing this systematic review, considering the Population, Intervention, Comparison and Outcomes relevant to the consensus clinical guideline under question. This literature search needs to be targeted to databases most likely to cover the relevant guidelines required for the computer interoperable guideline. For all consensus guidelines we recommended Guidelines International Network (g-i-net), PubMed database, UpToDate portal, Cochrane database, World Health Organization (WHO) portal, NICE portal, and SIGN portal. We then propose that the protocol should include an additional 10 websites of the relevant specialist societies including Veterans Affairs/Department of Defense [VA/DoD], American Medical Association, American Academy of Neurology, American Geriatrics Society, British Geriatrics Society, Gerontological Society of America, Alzheimer's Association website, American Psychiatric Association, American Association for Geriatric Psychiatry and American Academy of Home Care Medicine. Senior authors will conservatively screen the title and abstract of identified guidelines according to a two independent author review process, with subsequent full text extraction and review to further narrow down the number of guidelines.

3.2 Screening of selected guidelines

This systematic review of clinical guidelines will generate a larger volume of published content, too great to refine into a single consensus digitally interoperable clinical guideline. Thus, there is also a screening stage to narrow down the selected guidelines. This screening is performed independently by two individuals by confirming that content is a true guideline, assessing its scope, assessing whether it is international, national or regionally approved, publication year and extent of coverage of key content area. Based on this screening, the reviewers should select, for each of the conditions a refined number of clinical guidelines in the order of 5-10 guidelines for each condition that cover the whole scope of clinical practice for that condition. At this stage, there is likely duplication of the content within these guidelines and there may well be a degree of conflict.

3.3 AGREEII Based Quality Assessment of Clinical Guidelines

The next step in this protocol is for two reviewers to assess the quality of the clinical guidelines independently by using the Appraisal of Guidelines for Research and Evaluation (AGREE) II [4], the best current tool for assessing clinical guidelines' quality. AGREE II includes 23 items categorized in six domains, each captur¬ing a separate dimension of clinical quality. These six domains are scope and purpose, stakeholder involvement, rigor of development, clarity and presentation, applicability and editorial independence. The instrument also includes two final overall assessments requiring the appraiser to make overall judgments of the practice clinical guideline and consider how they rated the 23 items. The scores assessed by the two independent reviewers will be added and standardized. The domain scores will be calculated as the percentage of the maximum possible score. Once completed, low scoring clinical guidelines will be removed from the selected list.

3.4 Modified Delphi Consensus Formation of Guideline

The creation of an international consensus clinical guideline then requires agreement between a diverse group of international clinical partners, including all relevant professional groups, with expertise in the guideline area. This is best achieved through a modified Delphi technique [3]. The modified Delphi technique is a particularly suited approach for generating discussion and reaching consensus for addressing multifactorial complex problems. We propose a four-step modified Delphi approach, which includes a whole day summit meeting. In the stage 1 "preparatory" phase, a series of remote questionnaires are sent to clinical partners to identify whether the guidelines presented are felt to cover the whole spectrum of the multi-morbid scenario under question. Participants will rate the completeness of different guidelines, whilst this will also allow free text of problems identified. Individual single specialty guideline statements will be distributed initially with partner review, prior to paired guideline statements being circulated. The stage 2 "summit"

Table 1: Protocol Requirements

#	Requirement
1	Includes guidelines for all the individual multi-morbid conditions
2	Consideration for all international guidelines relevant to the individual multi-morbid conditions
3	Latest version of each clinical guideline
4	Identification of clinical guidelines that span relevant elements of multi-morbid conditions
5	Selection process to reduce the number of clinical guidelines to a manageable number
6	Assessment of quality of selected clinical guidelines and selection on that basis
7	International clinical consensus agreement of selected guidelines
8	International clinical consensus agreement in combining guidelines into a single unified guideline
9	Conversion of clinical guidelines into computer operable flowcharts
10	International clinical consensus agreement on interoperable flowcharts

meeting sees review of this master narrative draft guideline, with specific discussion on the areas of conflict described above and address free text comments. The aim of this meeting is to finalize the structure and content of the clinical guideline through a structured and recorded voting process. This is an important part in the process, and the non-clinical/technical partners are also invited to participate fully in this process so that specific technical feasibility questions required to address the conversation of the narrative guideline into a clinically interoperable digital guideline are posed, voted on and then modified. The stage 3 "review" process sees review of the consensus clinical guidelines with votes on each section of the guideline to assess whether they are complete or whether further modification is needed. This voting continues until there is consensus amongst the clinical partners and a final consensus clinical guideline is created. The strengths and limitations of the body of evidence will be clearly assessed and further described. We will then clearly describe the recommendations, presenting the health benefits, side effects, and risks in the formulation, giving explicit links to the supporting evidence for each recommendation. The different options for the management of the target population will be clearly provided, and key recommendations will be easily identifiable. Although not included in the general methodology, other relevant aspects for these patients like polypharmacy, ethics, gender aspects, quality of life, sustainability, equity, and acceptability of the recommendations will be ascertained. Applicability of the guideline will be presented, including facilitators and barriers to its application, advice and/or tools on how the recommendations might be put into practice, and potential resource implications of applying the recommendations. Finally, the guideline draft will be sent for external review to an expert external panel composed of relevant stakeholders and end-users, that will give advice on the methodology and final recommendations updated. A procedure for monitoring, auditing, and updating the guideline will also be provided.

3.5 Creation of computer interoperable flowcharts

The final step in this process is to convert the consensus holistic multi-morbidity guideline into a computer programmable series of flowchart steps. This is achieved in partnership between the clinical and technical partners and is supported by the presence of technical partners within the modified Delphi process as described above. At this stage, the consensus guidelines with automation potential through CDS services are identified. Potential input parameters for these flowcharts are identified, as patient context variables such as certain lab results, diagnosis, presence of certain medications in the medication plan of the patient. These context variables are then mapped to well-defined clinical concepts that are linked to codes from international clinical code systems and terminologies such as SNOMED CT, LOINC and ICD 10. Then, flowcharts including multiple decision points affecting the recommended clinical therapies are designed. UML activity diagrams are used to represent the flowcharts designed as decision trees. The recommended care plan activity suggestions that are represented as leaf nodes of these flowcharts are also conceptualized in a coded manner as care plan goals, medication plans, referral requests, lab test and control appointment recommendations. The final step is representing these computable parts of these flowcharts as CDS-Hooks enabled CDS service descriptions. The CDS-Hooks standard is an HL7 FHIR based specification that describes the RESTful APIs of CDS. At this step, the input parameters of these flowcharts are represented as CDS-Hooks prefetch data items as well defined HL7 FHIR resources. Similarly, the potential recommendations to be delivered by these CDS services (which corresponds to the leaf nodes of flowcharts), are represented as CDS Hooks cards incorporating the respective FHIR Resources. An accelerated approval process is utilized to seek approval from a clinician consensus group to each of the pathway steps identified.

4 DISCUSSION

The protocol presented here enables the creation of a holistic, consensus computer interoperable guideline in the context of multimorbidity and taking due account of cognitive impairment. This protocol allows the blending of the clinical and technical partners required to deliver such a guideline. To the best of our knowledge, this is the first published protocol to deliver such a guideline, addressing an unmet urgent need to establish a standard approach to the development of computer interoperable guidelines in the context

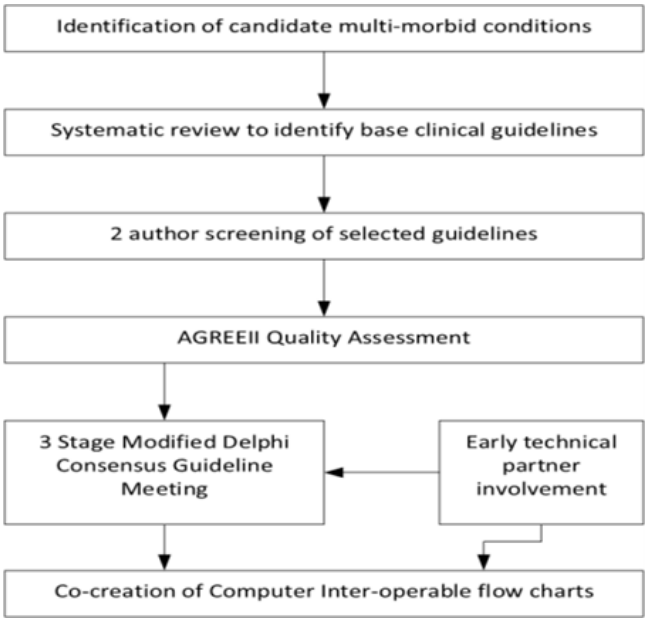

Figure 1: Summary of the applied protocol approach

of multi-morbidity in older adults with mild cognitive impairment or mild dementia. The approach described here, summarized in Figure 1, has several strengths including the incorporation of an industry standard systematic approach for initial screening and robust quality and consensus methodologies incorporated through the AGREEII and Modified Delphi approaches. This protocol supports the delivery of a high-quality service through the inclusion of international multi-stakeholder engagement and the involvement of technical partners and clinical partners. There are potential limitations to the approach described there. The process is time consuming and there is not yet a feasible or pragmatic approach to computer-based automation of the reconciliation. There is also a need to recognize healthcare inequalities when incorporating different guidelines, as this can be confounded in the process of guideline reconciliation. The inclusion of this within the collated guideline process is only achieved through clinical and technical partner input in the modified Delphi approach. An additional step that acts as an Equality Impact Assessment approach within the reconciliation may better incorporate the needs of underserved populations. This protocol and the subsequent guideline form the foundation for the development of the CAREPATH ICT-based solution for the optimization of clinical practice in the treatment and management of multi-morbid patients with mild cognitive impairment or mild dementia. This has the potential to represent a step change in the relevant clinical practice and future health information based clinical system development.

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