Development of Rules and Algorithms for an Intelligent and Integrated Older Care Model

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Abstract. To break through the current bottleneck in home-based older care globally, we developed an intelligent and integrated older care model (SMART model) to facilitate integrated care for home-dwelling older people. As a knowledge-based clinical decision support system, the SMART model relies on rules and algorithms to ensure its transparent and well-supported decision-making process with clear rationales. Therefore, we conducted a mixed study combining qualitative research, literature review of the latest literature and guidelines, and expert consultation. Following the intervention mapping framework and nursing process, we determined 138 care problems along with their diagnostic criteria and care goals. Building upon this, we curated 450 evidence-informed methods, each accompanied by at least one implementation approach. Two sets of IF-THEN rules and algorithms including diagnostic rules and method trigger rules were employed to trigger appropriate care problems and customized methods and implementation approaches.

Keywords. Older care, clinical decision support system, rules and algorithms

1. Introduction

The increasing number of older people and their growing care needs present a significant challenge to the current health and social care systems globally [1]. Despite a preference among older people to be cared for at home, the current fragmented older care model fails to meet their needs. Therefore, integrated care by using mobile health (mHealth) technology has been proposed as a promising solution [2].

Nevertheless, the effectiveness of the mHealth Apps for older care was impeded by several limitations. Primarily, the diverse characteristics and intricate conditions of older people necessitate customized methods, yet most Apps were designed to provide generic methods with diminished usefulness [3]. Additionally, without a rigorous framework, the underlying evidence for the methods involved in the current Apps was less-grounded [4].

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Clinical Decision Support Systems (CDSSs) allow an opportunity to provide customized decision-making support tailored to older people's unique conditions through the knowledge base and inference engine [5]. In contrast to the data-driven CDSSs, the knowledge-based CDSSs incorporate professional expertise as well as rules and algorithms to furnish decisions accompanied by detailed explanations, thereby enhancing transparency and trust in the decision-making process.

The intervention Mapping (IM) framework can assist in identifying methods with ample support evidence [6], while the nursing process serves as a scientific problem-solving approach to satisfying individual needs [7]. The organic combination of the IM framework and nursing process can guide the comprehensive identification of care problems and increase the likelihood of selecting effective evidence-informed methods.

Therefore, we developed an Intelligent and Integrated Older Care Model (SMART model), a knowledge-based CDSS to facilitate integrated care for older people residing at home. This article aimed to describe the development process and results of the rules and algorithms involved in the SMART model by following the IM framework and nursing process.

2.   Methods

Our study is a mixed study that amalgamates qualitative research, literature review, and expert consultation. The development process was steered by the IM framework and nursing process. The study was approved by the Capital Medical University review committee (No.2015SY49).

2.1 Formulation of Care Problems, Diagnostic Criteria, and Care Goals

2.1.1 Generation of Care Problems and Diagnostic Criteria
A qualitative interview was conducted to understand the care needs of older people living at home. Based on the needs assessment findings, we determined the care problems and their corresponding diagnostic criteria with reference to the pertinent guidelines and consensus.

2.1.2 Determination of Care Goals
Per the IM framework, we determined both long-term and short-term care goals for each of the identified care problem.

2.2 Development of Evidence-informed Methods and Implementation Approaches

2.2.1 Selection of the Evidence-informed Methods
To gather a comprehensive set of evidence-informed methods, we systematically searched the PubMed database. Subsequently, a quality evaluation of the retrieved literature was performed for effectiveness ascertainment of these methods. The effective methods were finally selected by the predefined general and desirable criteria and expert consultations.

2.2.2 Translation of the Implementation Approaches

To ensure that the delivered methods were customized and feasible, the methods were translated into implementation approaches by describing when (time of delivery), what (content of delivery), how often (frequency), how many (dose), to whom (individual who will implement the intervention), and presentation formats.

2.3 Design of Rules and Algorithms

To enhance the accuracy and usefulness of the care problems and implementation approaches identified through the SMART model, we devised two sets of forward IF-THEN rules and algorithms by using logical combinations of AND, OR, and NOT: diagnostic rules and method trigger rules. The diagnostic rules involved the logical integration of the established diagnostic criteria to identify the existing or potential care problems based on anomalies observed in older individuals. After diagnosing care problems, a set of method trigger rules were created to align customized methods and implementation approaches by considering older individuals' multifaceted characteristics. By establishing connections between abnormal conditions of older people, care problems, and customized methods and implementation approaches, these rules and algorithms ensure that decisions made at each stage were transparent and well-founded by rationale, thus enhancing the usefulness and effectiveness of the implementation approaches and the satisfaction of older people and their main caregivers.

3.   Results

3.1 Care Problems, Diagnostic Criteria, and Care Goals

Based on older people's care needs on daily life, healthcare, external support, and social participation, we established 138 care problems and their corresponding diagnostic criteria, 138 long-term care goals, and 195 short-term care goals, respectively.

3.2 Evidence-informed Methods and Implementation Approaches

After a thorough review of the PubMed database and quality evaluation, 446 evidence-informed methods were identified. The consultation with experts resulted in an additional 4 methods, bringing a total number of 450. The research team then proceeded to devise at least one implementation approach for each evidence-informed method and confirm their feasibility through expert consultations.

3.3 Rules and Algorithms to Trigger Personalized Care

Using diagnostic rules and method trigger rules, the SMART model could diagnose care problems and match customized methods and implementation approaches based on individual characteristics (e.g., functional status, and living arrangements). An example was presented in Table 1.

Table 1 Example of care problems, diagnostic and method trigger rules, methods, and implementation approaches

Care problems	Diagnostic rules	Method trigger rules	Evidence-informed methods	Implementation approaches					
				To whom	What	How many	How often	When	Presentation formats
Risk for falls: related to poor vision	(Older people's near visual acuity is less than 0.3) **AND** (Older people do not stay in bed or rely on a wheelchair for long periods)	Older people suffer from cataracts	Recommendation for medical treatment	Older people	Your cataracts seem to be getting worse, which is very dangerous. You should go see a doctor. There are highly effective treatments available for cataracts nowadays!	/	/	Once the care problem is diagnosed	Text and voice
		The home environment is dark, and the ground is slippery	Reminder	Family members or main caregivers	You can place gentle reminders in areas that are prone to falls, such as stairs, corners, and bathroom walls: Be careful on the floor!	/	/	Once the care problem is diagnosed	Text with images

4. Discussion

Adhering to the IM framework and nursing process, we crafted two sets of rules and algorithms (diagnostic rules and method trigger rules) for our SMART model, to facilitate customized and integrated care for older people dwelling at home. This study represents a pioneering exploration into the realm of CDSS and its rules and algorithms within the domain of integrated care for older people living at home.

A key strength of this study is developing evidence-informed methods in alignment with the nursing process and IM framework. We also drew inspiration from an extensive review of high-quality literature and pertinent guidelines. Expert consultations were also instrumental in refining the determined evidence-informed methods.

The second notable strength is translating evidence-informed methods into practical implementation approaches tailored to individual attributes. Additionally, the formulation of diagnostic and method trigger rules allowed for accurate diagnoses of care problems and customized methods and implementation approaches tailored to older individuals' diverse characteristics [8].

Several limitations are inherent in this study. Firstly, we only searched the PubMed database for evidence-informed methods, which could lead to overlooking certain useful information. Secondly, although we meticulously developed the rules and algorithms through the logical combinations of AND, OR, and NOT, the complexity of older individuals' conditions may lead to a proliferation of rules and algorithms, increasing the likelihood of rule conflicts and contradictions that could compromise the accuracy and reliability of recommendations. We intend to construct a knowledge graph to replace the current IF-THEN rules. Finally, the effectiveness of methods and rules and algorithms in the SMART model has not been validated yet. Future plans include a randomized controlled trial for validation.

5.   Conclusions

The paper details the development and outcomes of the rules and algorithms in the SMART model. Our study laid methodological support for future advancements in developing rules and algorithms for CDSS in the sphere of integrated older care.

Acknowledgements

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