Development of a model on factors affecting instrumental activities of daily living in people with mild cognitive impairment – a Delphi study

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Abstract

The level of functioning in instrumental activities of daily living (IADL) is crucial for a person’s autonomy. A clear understanding of the nature of IADL and its limitations in people with mild cognitive impairment (MCI) is lacking. Literature suggests numerous possible influencing factors, e.g. cognitive function, however, without considering other domains of human functioning, e.g. environmental factors. Therefore, we aimed to propose a comprehensive model for IADL functioning that pictures relevant influencing factors. Methods We conducted a four-round online Delphi study in a sample of international IADL experts (N=69). In the first round, panelists were asked to mention all possible relevant cognitive and physical function factors as well as environmental and personal factors influencing IADL functioning. In the subsequent rounds panelists rated the relevance of these factors. Consensus was defined as: 1) ≥70% agreement between panelists on a factor and 2) stability between two succeeding rounds. Results Response rates of the four rounds were high (83% to 100%). In the first round, 229 influencing factors were mentioned, whereof thirteen factors reached consensus in the subsequent rounds and were used to build a model for IADL functioning. The final model includes five cognitive function factors (i.e. memory, attention, executive function, executive function subdomains (problem solving / reasoning and organization / planning), five physical function factors (i.e. seeing functions, hearing functions, balance, gait / mobility functions and functional mobility functions), two environmental factors (i.e. social network / environment and support of social network / environment) and one personal factor (i.e. education). Conclusions This study proposes a comprehensive model on IADL functioning in people with MCI. The
results from this Delphi suggest that IADL functioning is not merely affected by cognitive function factors, but also by physical function, environmental and personal factors. The numerousness of mentioned factors in the first round also underlines the individuality of IADL functioning in people with MCI. The model may serve as ground for future research in IADL functioning in people with MCI.

Introduction

Instrumental activities of daily living (IADL) are complex tasks such as managing finances or performing a shopping task[1]. Within the context of cognitive decline IADLs have been defined as ‘intentional and complex everyday activities for which multiple cognitive processes are necessary, particularly high-level controlled processes[2]. Preserved IADL abilities allow to live independently, to keep autonomy and are crucial on the individual and the societal level[3]. Performance in IADL is also related to an appropriate physical health[4] and cognitive function[3], whereas IADL limitations are associated with reduced wellbeing[5], increased caregiver burden, supervision time and total societal costs[6]. Furthermore, cognitive impairment affects IADL performance[7-9].

Mild cognitive impairment (MCI) is defined as a transient state between normal cognitive ageing and early dementia and is primarily characterized by loss in cognitive function one or more cognitive domains with preserved functional abilities[10]. However, IADL limitations might be present at the MCI state[9, 11, 12]. A recent meta-analysis demonstrated that people with MCI had greater IADL limitations compared to healthy controls, with an effect size of $g = 0.76[12]$. Furthermore, IADL limitations were found to discriminate people with MCI from people with normal cognition[13] and predict conversion to dementia[14, 15]. These
findings may have led to the incorporation of IADL difficulties into the current
diagnostic criteria of mild neurocognitive disorder (incorporating MCI)[16].
IADL limitations in people with MCI are associated with cognitive impairment[5, 12]Empirical data[7] and a meta-analysis[17] estimated that 20% and 23% respectively of IADL variability were due to cognition. Therefore, other factors seem important in influencing IADL performance. Several studies reported that people with MCI have difficulties in motor function[18-20] and clinical measures incorporating muscular strength, cardiovascular function and physical activity predicted decrease in cognitive function after one year[21]. Thus, a clear understanding of the nature of IADL limitations in people with MCI is lacking.
The international classification of functioning, disability and health (ICF) provides a framework for the description of human functioning[22]. The framework considers functioning and disability as outcomes resulting from a health condition, as well as environmental and personal factors and therefore, may allow a mapping of IADL performance in people with MCI. To date, evidence suggests that there are several physical and cognitive function factors, as well as personal and environmental factors influencing IADL performance in people with MCI. However, to our knowledge previous studies investigated a limited number of possible influencing factors, e.g. the association between factors of cognitive function and IADL performance, without or with limited consideration of factors from other domains of the ICF, i.e. factors of physical function, environmental and personal factors. We, therefore, took another approach to model the complexity of factors influencing IADL performance.
Accordingly, the aim of this study was to develop a model on the contributing physical and cognitive function factors as well as environmental and personal factors on IADL performance in people with MCI by means of a multiple round Delphi
study to reach consensus from an expert panel.

Methods

Study design

Between October 2018 and April 2019 we conducted a Delphi study with an international sample of IADL experts (panelists). This design aims to seek consensus of opinion of a group of panelists through series of structured questionnaires, i.e. rounds with controlled feedback; anonymity between panelists is another key element[23]. Two different concepts of consensus were assessed: agreement and stability[24]. Agreement was defined twofold: ≥70% or ≤10% of all panelists rated a factor as relevant. Stability determines the consistency of responses, defined as <15% difference in percent-agreement between two succeeding rounds[25] and was used as a measure to stop the Delphi study[26]. The maximum of rounds has been set to four, including the option to omit the fourth round when stability between the second and third round is achieved[26].

Selection of panelists

A selective sampling procedure defined the panel[27]. International researchers with authorship of relevant research articles[28] were identified based on a literature search performed in Medline and Web of Science, resulting in a total of 163 possible panelists. The sample for the panel was complemented with researchers from personal networks (SAMS, TM) and to achieve a broad view of the panel[27], clinicians, neuropsychologists and health professionals working with people with MCI on daily basis in Memory Clinics in the eastern part of Switzerland were invited by email. Panelists were free to spread the invitation email to
whomever else considered as relevant (snowball sampling)[28]. Sixty-nine panelists (N = 69) agreed to participate in the Delphi study.

Procedure

Online questionnaires were pretested and implemented in EFS survey (Version 18.3 Questback / Unipark) and distributed by email. In each round, non-responders received a first reminder after two weeks and a second reminder another two weeks later. Questionnaires in each round were sent to all panelists responding the questionnaire of the preceding round. Missing data in questionnaires were excluded from data analysis.

First-round questionnaire and analysis

In the first round, personal details of panelists (i.e. country of residence, professional background, current occupation / position and years of experience) were collected.

The questionnaire included the aim of the Delphi study, a short summary of the current knowledge and the definition of IADL in accordance to Sikkes and Rotrou[2]. The ICF framework[22] was provided as a model for further discussion. The first-round questionnaire asked one open-ended question: What are the relevant factors of physical and cognitive function as well as, personal and environmental factors influencing IADL functioning in people with MCI? Panelists were prompted to list all relevant factors for each domain separately (i.e. physical function, cognitive function, environmental factors and personal factors).

A deductive content analysis was performed on all responses[29]: two researchers (MB and a research fellow) independently grouped the mentioned factors into the
domains of the ICF framework[22]. Accordingly, environmental factors were defined as factors that are not within the scope of the person and personal factors as possible influencing factors independent of MCI. Depending on personal preference, some factors can be seen as "personal" as well as "environmental factors", e.g. socio-cultural factors. If appropriate, these factors were included in both domains. Answers describing the same factor in a slightly different manner were merged into one factor[28], whereas specifically named factors were not comprised into broader functions, e.g. "planning" into "executive function". Factors were formulated neutrally, without using qualifiers[22], e.g. “impaired vision” was formulated as “seeing function”. Differences in categorization were resolved by discussion with a third researcher (KN)[28].

Second-round questionnaire and analysis
The questionnaire included all factors mentioned in the first round, including their frequency and were presented for each domain separately. Panelists were then asked to state whether the presented factors were relevant or not. Percent-agreement on the factors was calculated. Factors reaching ≥70% or ≤10% agreement were excluded from the third round in accordance to the Delphi methodology[28]. Factors reaching ≥70% percent-agreement were included in the model.

Third-round questionnaire and analysis
The questionnaire included all factors with a percent-agreement of ≥10% and ≤70%, including their frequency and percent-agreement and a first draft of the model was presented. Panelists were asked to rerate the relevance of these factors.
Agreement on the factors was calculated and stability between the second and third round was assessed. Additionally, the questionnaire contained the first draft of the model.

**Fourth-round questionnaire and analysis**

The second draft of the model was presented. Panelists were asked to provide their feedback on the model and to state whether the model is consistent with their conception of IADL performance in people with MCI. Panelists were further asked to rerate on the ten factors not reaching consensus or stability in the third round[23].

The feedbacks on the model were analyzed using inductive content analysis[29]. Accordingly, one researcher (MB) coded all individual panelists’ responses into categories using a stepwise procedure; frequencies of categories were counted. Percent-agreement on the model was calculated, as well as stability and consensus on the remaining factors. If one factor reached stability and consensus, this factor was included in the final model.

**Results**

**Results first round**

Sixty panelists (87% response rate) completed the first-round questionnaire.

Panelists (64% female) were from Europe (62%), North and South America (32%) and Australia (6%). Half of the panelists were currently working in academics or research and half clinically. Details on professional background and current occupation / position are presented in Table 1. Of all panelists, 20 (34%) had more than 20 years of experience within their respective field, 15 (25%) between 11 and 20 years, 21 (36%) five to ten years and 3 (5%) less than five years; one panelist
did not respond to this question.

Table 1 – Panel professional background and experience

| Professional background     | Specialization                      | n  |
|----------------------------|-------------------------------------|----|
| Physician                  | 17                                  |    |
| Psychologist               | 9                                   |    |
| Neuropsychologist          | 5                                   |    |
| Psychopharmacologist       | 1                                   |    |
| Epidemiologist             | 1                                   |    |
| Physical therapist         | 7                                   |    |
| Occupational therapist     | 9                                   |    |
| Nurse                      | 9                                   |    |
| Not stated                 | 2                                   |    |
| Geriatrics / Gerontology   | 6                                   |    |
| Neurology                  | 4                                   |    |
| (Geriatric) Psychiatry     | 6                                   |    |
| Epidemiology               | 2                                   |    |
| Anthropology               | 1                                   |    |
| Research (i.e. PhD)        | 12                                  |    |

Current occupation

| Chair / Dean               | 3                                   |    |
| Professor (assoc. / asst.) | 10                                  |    |
| Lecturer                   | 4                                   |    |
| Researcher                 | 13                                  |    |
| Head of department (i.e. memory clinic) | 7 | |
| Practicing physician       | 8                                   |    |
| Clinical (neuro) - psychologist | 10 | |
| Dementia specialist        | 2                                   |    |
| Physical therapist         | 3                                   |    |
| Occupational therapist     | 4                                   |    |
| Nursing                    | 7                                   |    |
| Professor emeritus / retired | 2 | |
| Not stated                 | 1                                   |    |

Current occupation multiple naming possible; n = absolute frequency

A total of 229 factors were mentioned in the first round, of which 42 (18%) physical function factors, 48 (21%) cognitive function factors, 57 (25%) environmental factors and 82 (36%) personal factors with frequencies ranging from one to twenty-four (Table 2).

Table 2 – Mentioned factors

| Physical function factors |  |
|                          | First round | Second round | %  | Third round | %  | % diff. | Fourth round |
|--------------------------|-------------|--------------|----|-------------|----|---------|--------------|
| *vision / seeing functions |             |              |    |             |    |         |              |
| vision                   | 13          | 39           | 75 |             |    |         |              |
| acuity                   | 4           | 6            | 11.5 | 6          | 6  | 11.8    | 0.2          |
| eye                      | 1           | 0            |     |             |    |         |              |
| movement functions       |             |              |    |             |    |         |              |
| *hearing functions       |             |              |    |             |    |         |              |
| sensory functions        | 18          | 37           | 71.2 |           |    |         |              |
| functions                | 2           | 7            | 13.5 | 7          | 7  | 13.7    | 0.3          |
| proprioceptive functions | 1           | 6            | 11.5 | 5          | 9.8|         | -1.7         |
| touch                    | 3           | 6            | 11.5 | 3          | 5.88|        | -5.7         |
| functions                | 1           | 1            | 1.9 |            |    |         |              |
| smell                    |             |              |    |             |    |         |              |
| functions                | 5           | 19           | 36.5 | 24         | 47.1|        | 10.5         |
| pain                     | 3           | 8            | 15.4 | 8          | 15.7|         | 0.3          |
| vestibular functions     | 1           | 2            | 3.8 |            |    |         |              |
| function of balance      | 2           | 3            | 5.8 |            |    |         |              |
| stability                | 20          | 37           | 71.2 |           |    |         |              |
| *balance                 | 17          | 38           | 73.1 |           |    |         |              |
| *mobility / gait functions |           |              |    |             |    |         |              |
| fall risk / fall experience |           |              |    |             |    |         |              |
| walking speed            | 3           | 4            | 7.7 |            |    |         |              |
| ***function al mobility (e.g. stair) | 4 | 22 | 42.3 | 32 | 62.7| 20.4 | 31 |
| Function                              | Score 1 | Score 2 | Score 3 | Score 4 | Score 5 | Score 6 |
|---------------------------------------|---------|---------|---------|---------|---------|---------|
| Ability to travel                     | 3       | 4       | 7.7     |         |         |         |
| General physical endurance functions  | 16      | 26      | 50      | 19      | 37.3    | -12.7   |
| Aerobic capacity                     | 1       | 1       | 1.9     |         |         |         |
| Fatigability                          | 3       | 10      | 19.2    | 7       | 13.7    | -5.5    |
| Muscle power functions                | 15      | 30      | 57.7    | 33      | 64.7    | 7       |
| Lower limb power functions            | 4       | 2       | 3.8     |         |         |         |
| Grip strength                         | 5       | 7       | 13.5    | 11      | 21.6    | 8.1     |
| Upper extremity strength              | 1       | 1       | 1.9     |         |         |         |
| Manual dexterity                      | 9       | 25      | 48.1    | 27      | 52.9    | 4.9     |
| Fine motor dexterity (fine motor skills) | 5   | 12      | 23.1    | 15      | 29.4    | 6.3     |
| Fine motor coordination               | 4       | 9       | 17.3    | 11      | 21.6    | 4.3     |
| Coordination                           | 1       | 2       | 3.8     |         |         |         |
| Function                         | First round | Second round | %  | Third round | %  | % diff. | Fourth round |
|---------------------------------|-------------|--------------|----|-------------|----|---------|--------------|
| visuo-motor coordination capacity | 1           | 8            | 15.4 | 16          | 31.4 | 16      | 13           |
| tremor                          | 1           | 0            |      |             |     |         |              |
| mobility of joints              | 13          | 18           | 34.6 | 8           | 15.7 | -18.9   | 6            |
| (e.g. range of motion) mobility of the spine and cervical spine | 1           | 0            |      |             |     |         |              |
| gross motor function            | 3           | 6            | 11.5 | 3           | 5.88 | -5.7    |              |
| motor speed                     | 5           | 11           | 21.2 | 14          | 27.5 | 6.3     |              |
| agility                         | 1           | 0            |      |             |     |         |              |
| functional reach                | 1           | 4            | 7.7  |             |     |         |              |
| functions of the cardiovascular system | 2           | 5            | 9.6  |             |     |         |              |
| cardiorespiratory reserve       | 1           | 1            | 1.9  |             |     |         |              |
| blood pressure                  | 1           | 1            | 1.9  |             |     |         |              |
| cholesterol values              | 1           | 1            | 1.9  |             |     |         |              |
| Respiratory functions           | 2           | 2            | 3.8  |             |     |         |              |
| Cognitive function factors      |             |              |      |             |     |         |              |
| *attention functions            | 23          | 39           | 78   |             |     |         |              |
|                          | 9   | 2   | 4   |
|--------------------------|-----|-----|-----|
| Sustaining attention     |     |     |     |
| Shifting attention       | 5   | 4   | 8   |
| Dividing attention       | 6   | 7   | 14  |
| Sharing attention        | 2   | 2   | 4   |
| Processing speed         | 7   | 19  | 38  |
| Functions               |     |     |     |
| Reaction time            | 2   | 4   | 8   |
| *Executive functions     | 24  | 39  | 78  |
| Sequencing               | 4   | 2   | 4   |
| **Organization and planning | 11  | 27  | 54  |
| Cognitive / mental flexibility | 7   | 22  | 44  |
| Insight                  | 9   | 2   | 4   |
| Judgement / decision making | 5   | 14  | 28  |
| **Problem solving / reasoning | 8   | 27  | 54  |
| Inhibition               | 3   | 2   | 4   |
| Initiation               | 1   | 1   | 2   |
| *Memory functions        | 25  | 42  | 84  |
| Learning                 | 4   | 3   | 6   |
| Short-term memory        | 5   | 3   | 6   |
| Long-term memory         | 3   | 0   |     |
| Function                              | 3   | 2   | 4   | 7   | 9   | 18  | 18  | 35.3 | 17.3 |
|--------------------------------------|-----|-----|-----|-----|-----|-----|-----|------|------|
| Episodic memory                      |     |     |     |     |     |     |     |      |      |
| Semantic memory                      | 1   | 0   |     |     |     |     |     |      |      |
| Working memory                       | 7   | 9   | 18  | 18  |     |     |     | 35.3 | 17.3 |
| Prospective memory                   | 2   | 3   | 6   |     |     |     |     |      |      |
| Retrieval and processing of memory  | 7   | 4   | 8   |     |     |     |     |      |      |
| Language functions                   | 13  | 33  | 66  | 25  |     |     |     | 49.0 | -17  |
| Language comprehension (written and spoken) | 7   | 11  | 22  | 10  |     |     |     | 19.6 | -2.4 |
| Semantic fluency                     | 4   | 1   | 2   |     |     |     |     |      |      |
| Semantic knowledge                   | 1   | 0   |     |     |     |     |     |      |      |
| Language execution                   | 3   | 1   | 2   |     |     |     |     |      |      |
| Word finding                         | 3   | 3   | 6   |     |     |     |     |      |      |
| Calculation functions                | 9   | 4   | 8   |     |     |     |     |      |      |
| Abstraction                           | 1   | 0   |     |     |     |     |     |      |      |
| Perceptual functions                 | 8   | 12  | 24  | 7   |     |     |     | 13.7 | -10.3|
| Perceptual-motor functions           | 1   | 1   | 2   |     |     |     |     |      |      |
| Visuo-spatial functions              | 9   | 21  | 42  | 22  |     |     |     | 43.1 | 1.1  |
| Function                        | First round | Second round | % | Third round | % | % diff. | Fourth round |
|---------------------------------|-------------|--------------|---|-------------|---|--------|--------------|
| **visuo-perceptual functions**  | 5           | 2            | 4 |             |   |        |              |
| **psychomotor functions**       | 5           | 6            | 12| 6           | 11.8| -0.2  |              |
| **orientation**                 | 5           | 11           | 22| 17          | 33.3| 11.3  |              |
| **energy and drive / stamina**  | 2           | 3            | 6 |             |   |        |              |
| **metacognition**               | 3           | 3            | 6 |             |   |        |              |
| **motivation**                  | 16          | 29           | 58| 28          | 54.9| -3.1  |              |
| **mood**                        | 9           | 12           | 24| 13          | 25.5| 1.5   |              |
| **alertness / vigilance**       | 5           | 7            | 14| 12          | 23.5| 9.5   |              |
| **awareness**                   | 1           | 3            | 6 |             |   |        |              |
| **intelligence**                | 3           | 1            | 2 |             |   |        |              |
| **social cognition**            | 8           | 15           | 30| 15          | 29.4| -0.6  |              |
| **emotional functions**         | 8           | 13           | 26| 10          | 19.6| -6.4  |              |

**Environmental factors**

| Factor                          | First round | Second round | % | Third round | % | % diff. | Fourth round |
|---------------------------------|-------------|--------------|---|-------------|---|--------|--------------|
| parental beliefs                | 2           | 0            | 0 |             |   |        |              |
| societal attitudes              | 4           | 6            | 12| 3           | 5.9| -6.1  |              |
| social expectations             | 3           | 5            | 10| 3           | 5.9| -4.1  |              |
| social norms                    | 4           | 11           | 22| 3           | 5.9| -16.1 |              |
| socio-cultural factors          | 4           | 19           | 38| 22          | 43.1| 5.1   |              |
| widowed / changes in            | 3           | 7            | 14| 7           | 13.7| -0.3  |              |
| Category                                      | N1 | N2 | N3 | N4 | Mean (SD) |
|-----------------------------------------------|----|----|----|----|-----------|
| Personal network family support               | 3  | 11 | 22 | 16 | 31.4 (9.4) |
| *Social network / social environment          | 13 | 35 | 70 |    |           |
| ***Network / social support                   | 11 | 16 | 32 | 31 | 60.8 (28.8) |
| Loneliness / isolation personal               | 5  | 20 | 40 | 25 | 49.0 (9)   |
| Personal assistance available immediate       | 3  | 4  | 8  |    |           |
| Family (e.g. children, siblings) extended     | 6  | 9  | 18 | 8  | 15.7 (-2.3) |
| Family (e.g. spouse) weather                  | 1  | 1  | 2  |    |           |
| Climate                                      | 3  | 0  |    |    |           |
| Extreme temperatures                          | 1  | 0  |    |    |           |
| Noise                                         | 3  | 3  | 6  |    |           |
| Adequate light                                | 1  | 2  | 4  |    |           |
| Air quality / pollution                       | 3  | 1  | 2  |    |           |
| Place of residence (rural versus urban)       | 7  | 31 | 62 | 25 | 49.0 (-13) |
| Factor                                      | 1 | 7 | 14 | 9 | 17.6 | 3.6 |
|---------------------------------------------|---|----|----|---|------|-----|
| Neighborhood age-friendliness of environment| 4 | 7  | 14 | 9 | 17.6 | 3.6 |
| Environmental demands                       | 1 | 8  | 16 | 11| 21.6 | 5.6 |
| Familiarity with environment                | 3 | 6  | 12 | 3 | 5.9  | -6.1|
| Challenging environment                     | 3 | 0  | 0  |   |      |     |
| Physical environment / living environment   | 6 | 0  | 0  |   |      |     |
| Presence of gangs                           | 1 | 0  | 0  |   |      |     |
| Type of house / apartment                   | 3 | 3  | 6  |   |      |     |
| Adaptation / age-friendliness / safety of home environment | 7 | 13 | 26 | 10| 19.6 | -6.4|
| Housing / immediate home                    | 9 | 19 | 38 | 21| 41.2 | 3.2 |
| Environment accessibility of the house / apartment | 1 | 4 | 8 |
|--------------------------------------------------|---|---|---|
| Living form                                      | 5 | 6 | 12 | 5 | 9.8 | -2.2 |
| Living with family / family nearby living        | 3 | 5 | 10 | 7 | 13.7 | 3.7 |
| Living situation (independent / dependent)        | 1 | 5 | 10 | 8 | 15.7 | 5.7 |
| Financial situation / resources                   | 13 | 32 | 64 | 21 | 41.2 | -22.8 |
| Financial resources for dental care living        | 1 | 0 |
| Living condition access to ICT products           | 4 | 4 | 8 |
| Communication technology for personal use in daily living | 2 | 6 | 12 | 10 | 19.6 | 7.6 |
| Personal devices                                  | 2 | 1 | 2 |
|                                                     | 1 | 0 |
|                          |       |     |     |     |      |     |
|--------------------------|-------|-----|-----|-----|------|-----|
| (apps) technologic aids / means means for physical impairments / access to assistive devices | 2     | 2   | 4   |     |      |     |
| mobility aids access to cognitive protheses access to information and use of different channels quality of instructions (easy to understand for MCI) access to and dependence on transportation accessibility / distance to public transport accessibility / distance to (social) | 2     | 1   | 2   |     |      |     |
|                          | 1     | 2   | 4   |     |      |     |
|                          | 2     | 1   | 2   |     |      |     |
|                          |       |     |     |     |      |     |
|                          | 1     | 0   |     |     |      |     |
|                          |       |     |     |     |      |     |
|                          | 3     | 8   | 16  | 9   | 17.6 | 1.6 |
|                          |       |     |     |     |      |     |
|                          | 6     | 16  | 32  | 15  | 29.4 | -2.6|
|                          |       |     |     |     |      |     |
|                          | 4     | 10  | 20  | 9   | 17.6 | -2.4|
| activities accessibility / distance to facilities | 7 | 12 | 24 | 14 | 27.5 | 3.5 |
| country of residence | 1 | 5 | 10 | 2 | 3.9 | -6.1 |
| insurance policy of a country | 1 | 1 | 2 |
| official structured support / possibilities (e.g. home care) | 4 | 11 | 22 | 10 | 19.6 | -2.4 |
| educational opportunity | 1 | 2 | 4 |
| availability and access to health care policy | 3 | 12 | 24 | 12 | 23.5 | -0.5 |

**Personal factors**

| | First round | Second round | % | Third round | % | % diff. | Fourth round |
|---|---|---|---|---|---|---|---|
| age | 8 | 26 | 52 | 23 | 45.1 | -6.9 |
| sex / gender | 6 | 13 | 26 | 11 | 21.6 | -4.4 |
| race | 1 | 0 |
| *education | 15 | 35 | 70 |
| professional background | 2 | 6 | 12 | 6 | 11.8 | -0.2 |
| professional occupation | 3 | 2 | 4 |
| socio economic | 7 | 24 | 48 | 20 | 39.2 | -8.8 |
| Status                  | 1 | 2 | 4 | 6 | 12 |
|-------------------------|---|---|---|---|----|
| Genetics (e.g. predisposition) |   |   |   |   |    |
| Body composition        |   |   |   |   |    |
| Body mass index         |   |   |   |   |    |
| Weight / obesity (physical) | 8 | 25 | 50 | 28 | 54.9 | 4.9 |
| Condition / fitness predetermed physical capacity |   |   |   |   |    |
| Cognitive health        |   |   |   |   |    |
| Cognitive habits        |   |   |   |   |    |
| Cognitive reserve       |   |   |   |   |    |
| Nutrition / liquid intake |   |   |   |   |    |
| Nutritional state       |   |   |   |   |    |
| Vitamin / vitamin deficiency |   |   |   |   |    |
| Sleep quality           |   |   |   |   |    |
| Circadian rhythm balance between | 1 | 3 | 6 |   |    |
| Category                      | Value 1 | Value 2 | Value 3 | Value 4 | Value 5 | Value 6 | Value 7 |
|-------------------------------|---------|---------|---------|---------|---------|---------|---------|
| Recreation and activity       | 2       | 5       | 10      | 3       | 5.9     | -4.1    |         |
| Beliefs                       | 3       | 4       | 8       |         |         |         |         |
| Religion / Spirituality       | 5       | 5       | 10      | 2       | 3.9     | -6.1    |         |
| Personal attitudes            | 1       | 1       | 2       |         |         |         |         |
| Self-concept                  | 3       | 2       | 4       |         |         |         |         |
| Self-esteem                   | 2       | 2       | 4       |         |         |         |         |
| Self-satisfaction             | 1       | 0       |         |         |         |         |         |
| Self-efficacy                 | 4       | 13      | 26      | 16      | 31.4    | 5.4     |         |
| Perceived stress              | 2       | 2       | 4       |         |         |         |         |
| Stress                        |         |         |         |         |         |         |         |
| Well-being                    | 1       | 0       |         |         |         |         |         |
| Sense of purpose in IADL tasks| 2       | 10      | 20      | 16      | 31.4    | 11.4    |         |
| Personality                   | 10      | 22      | 44      | 20      | 39.2    | -4.8    |         |
| Social skills                 | 7       | 8       | 16      | 10      | 19.6    | 3.6     |         |
| Conation                       | 2       | 0       |         |         |         |         |         |
| Desire for independence       | 2       | 5       | 10      | 9       | 17.6    | 7.6     |         |
| Behavior pattern              | 3       | 0       |         |         |         |         |         |
| General initiative-taking     | 1       | 2       | 4       |         |         |         |         |
| Extraversion                  | 2       | 0       |         |         |         |         |         |
| Being open                    | 3       | 5       | 10      | 3       | 5.9     | -4.1    |         |
| (e.g. willing to learn new things) |         |         |         |         |         |         |         |
| Coping strategies             | 8       | 25      | 50      | 28      | 54.9    | 4.9     |         |
| Factor                                    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------------------------------------------|---|---|---|---|---|---|---|---|---|----|
| frustration tolerance                   | 1 | 0 |   |   |   |   |   |   |   |    |
| willing to ask for and accept someone’s help | 3 | 8 | 16| 13| 25.5| 9.5|
| flexibility / creativity                | 2 | 1 | 2 |   |   |   |   |   |   |    |
| resilience                               | 3 | 8 | 16| 5 | 9.8 | -6.2|
| hobbies                                  | 2 | 1 | 2 |   |   |   |   |   |   |    |
| interests                                | 4 | 5 | 10| 8 | 15.7| 5.7|
| maintenance of habits (e.g. hobbies, interests, sexuality) | 1 | 6 | 12| 8 | 15.7| 3.7|
| personal hygiene                         | 3 | 0 |   |   |   |   |   |   |   |    |
| personal habits (e.g. not have done certain IADL lifelong) | 1 | 8 | 16| 13| 25.5| 9.5|
| personal routine                         | 3 | 3 | 6 |   |   |   |   |   |   |    |
| personal (daily) structure               | 2 | 2 | 4 |   |   |   |   |   |   |    |
| physical activity (past and current)     | 6 | 15| 30| 15| 29.4| -0.6|
| enjoy of physical activity               | 2 | 0 |   |   |   |   |   |   |   |    |
| Category                          | Count 1 | Count 2 | Count 3 | Count 4 | Mean | SD  |
|----------------------------------|---------|---------|---------|---------|------|-----|
| Social activities                | 2       | 3       | 6       |         |      |     |
| Moral conduct                    | 3       | 0       |         |         |      |     |
| Family position                  | 2       | 1       | 2       |         |      |     |
| (gender) roles                   | 4       | 0       |         |         |      |     |
| Social integration/connectedness | 8       | 15      | 30      | 18      | 35.3 | 5.3 |
| Socio-cultural background        | 13      | 10      | 20      | 10      | 19.6 | -0.4|
| Upbringing                       | 3       | 0       |         |         |      |     |
| Literacy/experience              | 1       | 3       | 6       |         |      |     |
| Socio-cultural background        | 7       | 5       | 10      | 4       | 7.8  | -2.2|
| Upbringing experience            | 6       | 10      | 20      | 21      | 41.2 | 21.2|
| Literacy/experience              | 3       | 0       |         |         |      |     |
| Familiarity with certain IADL tasks | 3       | 0       |         |         |      |     |
| Computer literacy                | 6       | 7       | 14      | 8       | 15.7 | 1.7 |
| Physical health                  | 3       | 4       | 8       |         |      |     |
| Neurological medical conditions  | 5       | 3       | 6       |         |      |     |
| Treatment                        | 1       | 0       |         |         |      |     |
Factors mentioned in the first round, frequency, %: percent-agreement between panelists; %-diff: difference in percent-agreement between two succeeding rounds – a positive number indicates more agreement; *factors included after second round; **factors included after third round; ***factors included after fourth round

Results second round

Fifty-three panelists (88%) completed the second-round questionnaire. The panel reached consensus on 126 (55%). Nine of these factors were rated as relevant by
≥70% of panelists and were included in the model, whilst 117 (51%) of factors were rated as relevant by ≤10% and these factors were subsequently excluded from the third round (Table 2). Overall, 103 (45%) factors did not reach consensus in the second round and were included in the third-round questionnaire (Table 2).

Results third round

Fifty-three panelists (100%) completed the third-round questionnaire. Of the remaining 103 factors, two (2%) reached consensus and were included in the model. Stability of responses between the second and third round was ascertained for 93 (90%) factors. Ten factors (10%) did not reach stability and were therefore included in the fourth-round questionnaire.

Results fourth round

Forty-four panelists (83%) responded to the fourth-round questionnaire. Thirty-three (62%) panelists provided feedback on the model and of these 28 (85%) stated that the model met their conception on IADL functioning in people with MCI. Feedback on the model contained: factors not included in the model; lack of weighting and relatedness of the factors; one panelist questioned the method itself (Table 3).

Table 3 - Critique comments on the model

| *Categories                                      | Frequency (percent) |
|-------------------------------------------------|--------------------|
| Same weighting for all factors                  | 4                  |
| Balance as separate factor from mobility        | 4                  |
| Mental health not included                      | 4                  |
| Relatedness of factors not included             | 3                  |
| Problem solving / planning included in executive functions | 3                  |
| Environmental factors - products and technology not included | 3                  |
| Environmental factors - natural environment not included | 2                  |
| Vision / hearing functions not gathered as sensory functions | 2                  |
| Physical function factors (others than balance) not included | 2                  |
| Visuospatial functions not included             | 1                  |
| Language functions not included                 | 1                  |
| Fine motor skills not included                  | 1                  |
| Motivation not included                         | 1                  |
| Method not appropriate                          | 1                  |
*Categories based on qualitative content analysis from the feedback provided on the model

The two additional factors reached consensus and stability between the third and fourth round and were therefore included in the final model (Figure 1). Stability between the third and fourth round was not reached for five factors (50%), i.e. judgment / decision making; working memory; language functions; financial situation and experience / familiarity with certain IADL tasks (Table 2).

Discussion
The results of this Delphi study illustrate how panelists with a perspective from research and clinical practice agreed on several factors of cognitive and physical functions as well as personal and environmental factors that are thought to influence IADL performance in people with MCI.
To our knowledge, this study is the first that proposes such a comprehensive model on the influencing factors on IADL performance in people with MCI incorporating all domains of the ICF framework. IADL performance in people with MCI is highly individual, which was represented by the huge number of factors mentioned in the first round of the Delphi survey. Although the Delphi method included relevant researchers and clinicians, the model might be conclusive. However, a substantial number of the factors reaching consensus are consistent with the findings from empirical data, others have been neglected in the literature so far. Thus, our model might provide better understanding of IADL functioning in people with MCI and serve as ground for future intervention studies and the way IADL functioning is assessed.
Cognitive function factors

Multiple cognitive function factors were included in the model. Consensus was reached for memory, attention and executive function, as well as executive function subdomains organization / planning and problem solving / reasoning. The bulk of literature investigating the question on which cognitive domains account for IADL performance is not consistent. Despite the widely accepted assumption that IADL performance is mainly affected by cognition, Royall et al. suggest that, based on empirical data, less than 8% of IADL variance is explained by cognition[30]. Furthermore, in another study, the same group ascertained in their model based on empirical data that intelligence accounts for at least 50% of variance in IADL performance in people with MCI[31]. Furthermore, the fact that IADL performance is independent from cognitive performance measures and the fraction of intelligence is related to IADL may both serve as a dementia severity metric[31]. However, intelligence did not reach consensus and our results contradict the findings of empirical studies. On the other hand, in their meta-analysis McAlister et al. revealed that cognitive functions accounted for 23% of variability in IADL performance in people with MCI[17]. Among the cognitive domains executive function (37%), attention (33%) and memory (23%) explained a certain amount of variance in IADL performance, while planning / organization and problem solving / reasoning explained a smaller amount of variance[17]. However, this meta-analysis also detected other cognitive domains and executive function subdomains explaining a remarkable amount of variance not included or explicitly mentioned in our model (e.g. switching, judgment / decision making and working memory). Therefore, factors not reaching consensus in our Delphi process, but a remarkable amount of
agreement might still be added to the model in future studies, e.g. language functions (67%).

**Physical function factors**

Certain IADL tasks need appropriate sensory functions. Not surprisingly, visual and hearing functions were included in the model in accordance with the current literature. A longitudinal study indicated that visual and hearing impairments are related to self-reported functional impairments in old people[32]. Furthermore, sensory restrictions are associated with slight IADL changes[33] and the presence of visual and hearing impairment in combination with cognitive decline was associated with impaired IADL performance in older adults[34].

Balance was included in the model, although some panelists suggested balance as a subdomain of gait functions. Impaired balance has an impact on gait functions; however, several IADL tasks require static balance abilities[35]. Therefore, balance was not summarized under gait functions. Literature on balance in people with MCI is sparse, however studies using instrumented assessments did found impaired balance functions in people with MCI[20]. Moreover, studies using clinical assessments of balance, e.g. POMA, revealed an association between IADL performance and balance in people with MCI[36].

Mobility/gait functions were included in the model which is supported by the current literature[20]. Different aspects of gait function were found to be impaired in people with MCI[19, 37-39]. A remarkable number of IADLs require sound gait functions, e.g. doing the shopping or using public transport.

A further factor included in the model was functional mobility, e.g. walking stairs or functional reach, although functional mobility had little attention to date in
literature regarding IADL performance. Therefore, future studies investigating IADL performance in people with MCI should consider functional mobility as a possible influencing factor.

Physical function factors that might affect IADL performance[40], e.g. muscle power functions reached remarkable percent-agreement (65%), but not sufficient consensus to be included in the model. Mobility/gait functions and functional mobility presumes, among others, appropriate muscle power functions. Therefore, this factor might be worth to be considered in studies investigating the influence on physical function factors on IADL performance in people with MCI in the presence of impaired mobility / gait functions and / or functional mobility.

Environmental factors

Based on the panelists’ suggestions “Network / Social Environment” and “Network / Social Environment Support” were included in the model. Intervention studies incorporating study partners reported positive findings on IADL performance in people with MCI[41, 42] and therefore, one might conclude that these factors play an important role.

Several environmental factors have been mentioned in the first round but did not reach consensus. However, some were raised in the feedbacks on the model: natural environment, e.g. place of residence, housing and products and technology, e.g. technical aids. The importance of compensatory strategies and use of technical aids in the performance of IADL in people with MCI has been highlighted in literature[43]. Furthermore, these factors underline the individuality of IADL functioning and therefore, might be considered in the design of future studies or interventions on IADL performance in people with MCI.
Personal factors

The only personal factor included in the model was education. Education and cognitive function might be related in people with MCI and therefore, education is usually included as a possible confounder in empirical studies. However, conclusions from literature are not clear. In a sample of Asian older adults lower education was associated with greater IADL dependence[44] and a higher level of cognitive reserve delayed the onset of cognitive decline in a longitudinal study in elderly people[45]. In contrast a meta-analysis did not find education as a mediator of the relationship of cognitive function and IADL[17].

Literature suggests additional personal factors that might influence IADL performance in MCI[3], however with inconsistent findings. Age was found to be associated with impaired IADL performance in MCI[44, 46], as well as depression[44, 47], frailty[36], physical activity[48] and comorbidities[44, 49]. In contrast, Mariani and colleagues revealed that IADL performance was more strongly related with cognitive function than physical comorbidities[33]. The inconclusive findings in literature, as well as the ratings in the Delphi process underline the individual nature of IADL performance in people with MCI.

Strength and Limitations

One strength of our study is the number of panelists with half of them working in research and academics and the other half in clinical settings. Noteworthy, is the amount of experience of the panelists in the field of MCI and IADL performance. Furthermore, the response rate in the first three rounds of the Delphi survey was very high. Another strength of this study is that it used a different approach to
model IADL functioning in people with MCI with new insights and therefore might provide ground for future research.

This study has several limitations. Results from a Delphi study report only consensus on experts’ opinion on a topic and therefore, might contradict findings from empirical studies[28]. Performing a systematic review would have been a different approach to investigate possible contributing factors on IADL performance in MCI. However, systematic reviews performed in this field faced the same problems: the constructs of interest (i.e. MCI, IADL) were defined and operationalized in different ways[5, 7, 12, 17, 50]. Furthermore, the type and number of assessments used to measure the outcomes of interest were heterogeneous[5, 7, 12, 17, 50]. Moreover, the results are limited to the factors investigated in the included studies and therefore, might not be encompassing. Comparable problems would arise from empirical studies: a retrospective analysis of pre-existing data sets would be limited to the outcomes assessed and in a prospective design it remains unclear so far what factors should be assessed given the huge amount of possibilities, e.g. domains provided by the ICF. Therefore, we suggest our model to be used as a starting point to be validated and further developed based on empirical data.

The definition of consensus in Delphi studies is somehow arbitrary[24]. One might argue, that the predefined cut-off level of ≥70% percent-agreement for factors to be included in the model was too low. However, this study included a heterogeneous sample of panelists and therefore, very high percent-agreements were not anticipated. On the other hand, the cut-off might have been too high and therefore, relevant factors with substantial percent-agreement were not included in the model and might be considered in future studies, as discussed previously.
Finally, due to the design of our study, it was not possible to weight the factors. In the feedback round some panelists pointed out that some factors are more important than others. Therefore, weighting of factors should be incorporated in future studies investigating IADL performance in people with MCI.

Conclusion

The results of this study suggest that IADL performance in people with MCI is affected not only by cognitive function factors but also by various physical function factors as well as personal and environmental factors. Therefore, it is crucial considering all these factors in future studies investigating IADL performance in people with MCI, in the way of assessing IADLs as well as in the design of new interventions to improve IADL performance in people with MCI.

List of Abbreviations

IADL: Instrumental Activities of Daily Living
ICF: International Classification of Functioning, Disability and Health
MCI: Mild cognitive impairment
POMA: Performance Oriented Mobility Assessment

Declarations

Ethics declarations

In accordance to the Swiss regulations on research involving humans this study does not fall within the scope of an ethical approval (Cantonal Ethics Committee Zurich; No: Req-2019-00110). Even though in accordance to the European General Data Protection Regulation all necessary information were provided and all
participants had to explicitly give consent to the use of their data for research purposes.

*Consent for publication*

Not applicable

*Availability of data and materials*

The datasets generated and analyzed during the study are available upon reasonable request to the corresponding authors.

*Competing interests*

All authors disclose any competing interests.

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*Author’s contributions*

MB participated in the study design and conception, data acquisition and analysis, wrote the first draft of the manuscript and revised new drafts. SAMS and TM participated in the study design and conception and manuscript drafting. KN participated in the study design and conception, data analysis and revised new drafts of the manuscript.

All authors read and approved the final manuscript for submission.

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References

1. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969;9(3):179-86.

2. Sikkes SA, Rotrou J. A qualitative review of instrumental activities of daily living in dementia: what's cooking? Neurodegener Dis Manag. 2014;4(5):393-400.

3. Gold DA. An examination of instrumental activities of daily living assessment in older adults and mild cognitive impairment. J Clin Exp Neuropsychol. 2012;34(1):11-34.

4. Heyn PC, Johnson KE, Kramer AF. Endurance and strength training outcomes on cognitively impaired and cognitively intact older adults: a meta-analysis. J Nutr Health Aging. 2008;12(6):401-9.

5. Giebel CM, Challis D, Montaldi D. Understanding the cognitive underpinnings of functional impairments in early dementia: a review. Aging Ment Health. 2015;19(10):859-75.

6. Reed C, Belger M, Vellas B, Andrews JS, Argimon JM, Bruno G, et al. Identifying
factors of activities of daily living important for cost and caregiver outcomes in Alzheimer's disease. Int Psychogeriatr. 2016;28(2):247-59.

7. Royall DR, Lauterbach EC, Kaufer D, Malloy P, Coburn KL, Black KJ, et al. The cognitive correlates of functional status: a review from the Committee on Research of the American Neuropsychiatric Association. J Neuropsychiatry Clin Neurosci. 2007;19(3):249-65.

8. Reppermund S, Sachdev PS, Crawford J, Kochan NA, Slavin MJ, Kang K, et al. The relationship of neuropsychological function to instrumental activities of daily living in mild cognitive impairment. Int J Geriatr Psychiatry. 2011;26(8):843-52.

9. Marshall GA, Amariglio RE, Sperling RA, Rentz DM. Activities of daily living: where do they fit in the diagnosis of Alzheimer's disease? Neurodegener Dis Manag. 2012;2(5):483-91.

10. Winblad B, Palmer K, Kivipelto M, Jelic V, Fratiglioni L, Wahlund LO, et al. Mild cognitive impairment--beyond controversies, towards a consensus: report of the International Working Group on Mild Cognitive Impairment. J Intern Med. 2004;256(3):240-6.

11. Jekel K, Damian M, Wattmo C, Hausner L, Bullock R, Connelly PJ, et al. Mild cognitive impairment and deficits in instrumental activities of daily living: a systematic review. Alzheimers Res Ther. 2015;7(1):17.

12. Lindbergh CA, Dishman RK, Miller LS. Functional Disability in Mild Cognitive Impairment: A Systematic Review and Meta-Analysis. Neuropsychol Rev. 2016;26(2):129-59.

13. Rodakowski J, Skidmore ER, Reynolds CF, 3rd, Dew MA, Butters MA, Holm MB, et al. Can performance on daily activities discriminate between older adults...
with normal cognitive function and those with mild cognitive impairment? J Am Geriatr Soc. 2014;62(7):1347-52.

14. Sikkes SA, Visser PJ, Knol DL, de Lange-de Klerk ES, Tsolaki M, Frisoni GB, et al. Do instrumental activities of daily living predict dementia at 1- and 2-year follow-up? Findings from the Development of Screening guidelines and diagnostic Criteria for Predementia Alzheimer's disease study. J Am Geriatr Soc. 2011;59(12):2273-81.

15. Farias ST, Lau K, Harvey D, Denny KG, Barba C, Mefford AN. Early Functional Limitations in Cognitively Normal Older Adults Predict Diagnostic Conversion to Mild Cognitive Impairment. J Am Geriatr Soc. 2017.

16. Sachdev PS, Blacker D, Blazer DG, Ganguli M,Jeste DV, Paulsen JS, et al. Classifying neurocognitive disorders: the DSM-5 approach. Nat Rev Neurol. 2014;10(11):634-42.

17. McAlister C, Schmitter-Edgecombe M, Lamb R. Examination of Variables That May Affect the Relationship Between Cognition and Functional Status in Individuals with Mild Cognitive Impairment: A Meta-Analysis. Arch Clin Neuropsychol. 2016;31(2):123-47.

18. Beauchet O, Allali G, Montero-Odasso M, Sejdic E, Fantino B, Annweiler C. Motor phenotype of decline in cognitive performance among community-dwellers without dementia: population-based study and meta-analysis. PLoS One. 2014;9(6):e99318.

19. Montero-Odasso M, Oteng-Amoako A, Speechley M, Gopaul K, Beauchet O, Annweiler C, et al. The motor signature of mild cognitive impairment: results from the gait and brain study. J Gerontol A Biol Sci Med Sci. 2014;69(11):1415-21.
20. Bahureksa L, Najafi B, Saleh A, Sabbagh M, Coon D, Mohler MJ, et al. The Impact of Mild Cognitive Impairment on Gait and Balance: A Systematic Review and Meta-Analysis of Studies Using Instrumented Assessment. Gerontology. 2017;63(1):67-83.

21. Bolandzadeh N, Kording K, Salowitz N, Davis JC, Hsu L, Chan A, et al. Predicting cognitive function from clinical measures of physical function and health status in older adults. PLoS One. 2015;10(3):e0119075.

22. WorldHealthOrganization. How to use the ICF: A practical manual for using the International Classification of Functioning, Disability and Health (ICF). Exposure draft for comment. Geneva: WHO2013.

23. Hasson F, Keeney S, McKenna H. Research guidelines for the Delphi survey technique. Journal of advanced nursing. 2000;32(4):1008-15.

24. von der Gracht HA. Consensus measurement in Delphi studies. Technological Forecasting and Social Change. 2012;79(8):1525-36.

25. Diamond IR, Grant RC, Feldman BM, Pencharz PB, Ling SC, Moore AM, et al. Defining consensus: a systematic review recommends methodologic criteria for reporting of Delphi studies. J Clin Epidemiol. 2014;67(4):401-9.

26. Trevelyan EG, Robinson PN. Delphi methodology in health research: how to do it? European Journal of Integrative Medicine. 2015;7(4):423-8.

27. Prinsen CA, Vohra S, Rose MR, King-Jones S, Ishaque S, Bhaloo Z, et al. Core Outcome Measures in Effectiveness Trials (COMET) initiative: protocol for an international Delphi study to achieve consensus on how to select outcome measurement instruments for outcomes included in a 'core outcome set'. Trials. 2014;15:247.

28. De Vet E, Brug J, De Nooijer J, Dijkstra A, De Vries NK. Determinants of forward
stage transitions: a Delphi study. Health education research. 2005;20(2):195-205.

29. Mayring P. Qualitative Inhaltsanalyse Grundlagen und Techniken. 7. Auflage ed. Weinheim: Deutscher Studienverlag; 2000. 135 S. p.

30. Royall DR, Palmer RF, O'Bryant SE, Texas Alzheimer's R, Care C. Validation of a latent variable representing the dementing process. J Alzheimers Dis. 2012;30(3):639-49.

31. Royall DR, Palmer RF. Getting Past "g": testing a new model of dementing processes in persons without dementia. J Neuropsychiatry Clin Neurosci. 2012;24(1):37-46.

32. Brennan M, Su YP, Horowitz A. Longitudinal associations between dual sensory impairment and everyday competence among older adults. Journal of rehabilitation research and development. 2006;43(6):777-92.

33. Mariani E, Monastero R, Ercoiani S, Rinaldi P, Mangialasche F, Costanzi E, et al. Influence of comorbidity and cognitive status on instrumental activities of daily living in amnestic mild cognitive impairment: results from the ReGAI project. Int J Geriatr Psychiatry. 2008;23(5):523-30.

34. Guthrie DM, Davidson JGS, Williams N, Campos J, Hunter K, Mick P, et al. Combined impairments in vision, hearing and cognition are associated with greater levels of functional and communication difficulties than cognitive impairment alone: Analysis of interRAI data for home care and long-term care recipients in Ontario. PLoS One. 2018;13(2):e0192971.

35. Horak FB. Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? Age Ageing. 2006;35 Suppl 2:ii7-ii11.
36. Nyunt MSZ, Soh CY, Gao Q, Gwee X, Ling ASL, Lim WS, et al. Characterisation of Physical Frailty and Associated Physical and Functional Impairments in Mild Cognitive Impairment. Front Med (Lausanne). 2017;4:230.

37. Verghese J, Robbins M, Holtzer R, Zimmerman M, Wang C, Xue X, et al. Gait dysfunction in mild cognitive impairment syndromes. J Am Geriatr Soc. 2008;56(7):1244-51.

38. Beauchet O, Allali G, Launay C, Herrmann FR, Annweiler C. Gait variability at fast-pace walking speed: a biomarker of mild cognitive impairment? J Nutr Health Aging. 2013;17(3):235-9.

39. Muir SW, Speechley M, Wells J, Borrie M, Gopaul K, Montero-Odasso M. Gait assessment in mild cognitive impairment and Alzheimer's disease: the effect of dual-task challenges across the cognitive spectrum. Gait Posture. 2012;35(1):96-100.

40. Aggarwal NT, Wilson RS, Beck TL, Bienias JL, Bennett DA. Motor dysfunction in mild cognitive impairment and the risk of incident Alzheimer disease. Arch Neurol. 2006;63(12):1763-9.

41. Schmitter-Edgecombe M, Dyck DG. Cognitive rehabilitation multi-family group intervention for individuals with mild cognitive impairment and their care-partners. Journal of the International Neuropsychological Society. 2014;20(9):897-908.

42. Greenaway M, Duncan N, Smith G. The memory support system for mild cognitive impairment: Randomized trial of a cognitive rehabilitation intervention. International Journal of Geriatric Psychiatry. 2013;28(4):402-9.

43. Schmitter-Edgecombe M, Parsey C, Lamb R. Development and psychometric properties of the instrumental activities of daily living: compensation scale.
Arch Clin Neuropsychol. 2014;29(8):776-92.

44. Ng TP, Niti M, Chiam PC, Kua EH. Physical and cognitive domains of the Instrumental Activities of Daily Living: validation in a multiethnic population of Asian older adults. J Gerontol A Biol Sci Med Sci. 2006;61(7):726-35.

45. Soldan A, Pettigrew C, Cai Q, Wang J, Wang MC, Moghekar A, et al. Cognitive reserve and long-term change in cognition in aging and preclinical Alzheimer's disease. Neurobiol Aging. 2017;60:164-72.

46. Artero S, Touchon J, Ritchie K. Disability and mild cognitive impairment: a longitudinal population-based study. Int J Geriatr Psychiatry. 2001;16(11):1092-7.

47. Cahn DA, Malloy PF, Salloway S, Rogg J, Gillard E, Kohn R, et al. Subcortical hyperintensities on MRI and activities of daily living in geriatric depression. J Neuropsychiatry Clin Neurosci. 1996;8(4):404-11.

48. Storeng SH, Sund ER, Krokstad S. Factors associated with basic and instrumental activities of daily living in elderly participants of a population-based survey: the Nord-Trondelag Health Study, Norway. BMJ open. 2018;8(3):e018942.

49. Wang L, van Belle G, Kukull WB, Larson EB. Predictors of functional change: a longitudinal study of nondemented people aged 65 and older. J Am Geriatr Soc. 2002;50(9):1525-34.

50. Nygard L. Instrumental activities of daily living: a stepping-stone towards Alzheimer's disease diagnosis in subjects with mild cognitive impairment? Acta Neurol Scand Suppl. 2003;179:42-6.
Figures

Figure 1

Model of IADL functioning in people with MCI