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Spoorenberg, Sophie L W; Reijneveld, Sijmen A; Uittenbroek, Ronald J; Kremer, Hubertus P H; Wynia, Klaske

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# Accepted Manuscript

Health-related problems and changes after one year as assessed with the Geriatric ICF Core Set (GeriatrICS) in community-dwelling frail older adults receiving person-centred and integrated care from Embrace

Sophie L.W. Spoorenberg, PhD, Sijmen A. Reijneveld, MD PhD, Ronald J. Uittenbroek, PhD, Hubertus P.H. Kremer, MD PhD, Klaske Wynia, PhD

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**Running head:** GeriatrICS assessment in frail elderly

**Health-related problems and changes after one year as assessed with the Geriatric ICF Core Set (GeriatrICS) in community-living frail older adults receiving person-centred and integrated care from Embrace**

Sophie L.W. Spoorenberg PhD,<sup>1</sup> Sijmen A. Reijneveld MD PhD,<sup>1</sup> Ronald J. Uittenbroek PhD,<sup>1</sup> Hubertus P.H. Kremer MD PhD,<sup>2</sup> Klaske Wynia PhD<sup>1,2</sup>

<sup>1</sup> University of Groningen, University Medical Center Groningen, Department of Health Sciences, Community and Occupational Medicine, Groningen, the Netherlands

<sup>2</sup> University of Groningen, University Medical Center Groningen, Department of Neurology, Groningen, the Netherlands

**Corresponding author:**

Klaske Wynia PhD

Associate professor Person-centred and Integrated Care

University Medical Center Groningen – UMCG

Departments of Health Sciences and Neurology

De Brug | Room 4.04 | Internal mailbox FA 10 | Antonius Deusinglaan 1

P.O. Box 196 | 9700 AD Groningen | The Netherlands

+31 (6) 256 468 29

k.wynia@umcg.nl

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**Declaration of interests**

We certify that no party having a direct interest in the results of the research supporting this article has or will confer a benefit on us or on any organization with which we are associated and we certify that all financial support for this research and work are clearly identified in the title page of the manuscript.

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1 **Health-related problems and changes after one year as assessed with the**  
2 **Geriatric ICF Core Set (GeriatrICS) in community-dwelling frail older adults**  
3 **receiving person-centred and integrated care from Embrace**

4  
5 **Abstract**

6 **Objective:** To assess the prevalence, severity and change in health-related problems in a sample of  
7 older adults who received individual care and support from Embrace, for the whole sample, per  
8 subgroup based on complexity of care needs and frailty, and for those who had at baseline a health-  
9 related problem.

10 **Design:** A pretest-posttest study with assessments at baseline and after twelve months.

11 **Setting:** Community.

12 **Participants:** Older adults aged 75+ who are frail (n=56) or with complex care needs (n=80).

13 **Intervention:** Participants received care and support by Embrace, a person-centred and integrated  
14 care service for community-living older adults supporting them to age in place. A multidisciplinary  
15 team provided care and support, with intensity depending on the older adults' risk profile.

16 **Main outcome measure:** Health-related problems as perceived by older adults and measured with  
17 the Geriatric ICF Core Set (GeriatrICS).

18 **Results:** Health-related problems were related to six coherent clusters: 'Mental Functions', 'Physical  
19 Health', 'Mobility', 'Personal Care', 'Nutrition' and 'Support'. The most prevalent and most severe  
20 problems at baseline were related to Mental Functions and Mobility. Changes in the prevalence of  
21 problems after twelve months varied. Severity scores decreased or remained stable, except for  
22 Mobility items which showed a varying changing pattern in participants with complex care needs.  
23 Prevalence and severity of problems for those with a problem at baseline decreased after twelve  
24 months. Frail participants with a problem had higher baseline severity scores than those with

25 complex care needs experiencing a problem, but differences in changes between frail individuals and  
26 those with complex care needs were small.

27 **Conclusions:** The results are encouraging and may indicate that individual, person-centred and  
28 integrated care and support from Embrace offers a route to counteracting the decline in physical,  
29 cognitive and social functioning associated with ageing.

30

31

### 32 **Keywords**

33 Functioning; health; disability; ICF; ageing; chronic care model; integrated care; person-centred care;  
34 community-dwelling; older adults

35

36

### 37 **List of abbreviations**

38 CCM = Chronic Care Model

39 GeriatrICS = Geriatric ICF Core Set

40 GFI = Groningen Frailty Indicator

41 GP = general practitioner

42 ICF = International Classification of Functioning, Disability and Health

43 INTERMED-E-SA = INTERMED for the Elderly Self-Assessment

44 WHO = World Health Organization

45 Worldwide, current healthcare systems are insufficiently well equipped to provide appropriate care  
46 and support to older adults with healthcare needs [1]. Up to two-thirds of the global population  
47 aged 75 and older suffers from multimorbidity [1-4]. These individuals present a wide variety of  
48 health-related problems [5, 6], with great variability in health and health-related functional ability  
49 [7-9]. However, healthcare systems focus on treating single diseases. This results in inefficient,  
50 ineffective and fragmented care for this growing older population [10, 11] – and consequently  
51 misunderstanding by the patient, low treatment participation and even treatment errors [12, 13].  
52 Therefore, these healthcare systems have to deal with the complexity of treating multimorbidity and  
53 the changing and diverse healthcare needs of older adults, which calls for a worldwide system  
54 change [10, 11, 14, 15].

55 Person-centred and integrated care services could encourage comprehensive care for older  
56 adults [11], as acknowledged by the European Union [16], the World Health Organization (WHO) [14,  
57 15] and older adults themselves [17]. According to the WHO, person-centred care is ‘organized  
58 around the health needs and expectations of people rather than diseases’. Integrated care services  
59 provide a continuum of care and support and address the needs of the individual [15].

60 An example of such a new person-centred and integrated care service for older adults is  
61 ‘Embrace’ [18]. Embrace is based on the increasingly popular Chronic Care Model (CCM) [19, 20],  
62 which integrates community resources with healthcare services, and the Kaiser Permanente triangle  
63 [21], a Population Health Management model which segments the population into risk profiles. The  
64 aim of Embrace is to prolong ageing in place by addressing the needs of the individual older adult  
65 living in the community. A multidisciplinary Elderly Care Team organises person-centred care and  
66 support in consultation with the older adults. The focus and intensity of this care depends on a  
67 person’s risk profile, which is based on the self-reported complexity of care needs and level of frailty  
68 (‘Complex care needs’, ‘Frail’, ‘Robust’). Embrace has been implemented extensively in the North of  
69 the Netherlands. The effectiveness of the original Embrace study regarding patient outcomes,

70 service use, costs and quality of care was investigated in a randomized controlled trial [18, 22, 23].

71 The current study was embedded in that trial.

72 As the impact of ageing on health and functioning differs between individuals [24, 25], insight  
73 into the health-related problems and accompanying needs of the individual older adult is needed to  
74 guide the delivery of person-centred and integrated care and support. The Geriatric ICF Core Set  
75 (GeriatrICS) has been developed to provide such insight. It reflects the most relevant health-related  
76 problems of community-dwelling older adults without a dementia diagnosis and is based on the  
77 International Classification of Functioning, Disability and Health (ICF) [26]. Within Embrace, the  
78 GeriatrICS was used for history taking from frail older adults and those with complex care needs  
79 receiving individual care and support by a case manager. Based on this history, care and support was  
80 adapted to the needs of the older adult. Follow-up evaluations using the GeriatrICS were performed  
81 to assess whether problems were solved or to identify newly arisen problems.

82 Therefore, the first objective of this study was to assess the prevalence and severity of health-  
83 related problems and the change after receiving individual care and support from 'Embrace' for the  
84 whole sample and for subgroups based on the risk profiles 'Frail' and 'Complex care needs'. The  
85 second objective was to assess the above for those who had a health-related problem at baseline as  
86 a consequence of ageing.



## 87 **Methods**

### 88 **Study design**

89 We conducted a twelve-month single-group pretest-posttest study on a group of older adults aged  
90 75 and older who were allocated to the intervention group of a randomized controlled trial on the  
91 effectiveness of the person-centred and integrated care service 'Embrace' [18]. The study had been  
92 registered in the Netherlands National Trial Register (NTR3039, <http://www.trialregister.nl>). The  
93 Medical Ethical Committee of the University Medical Center Groningen assessed the Embrace study  
94 proposal, including the analyses as reported here, and concluded that approval was not required  
95 (Reference METc2011.108). The STROBE-guidelines are used for reporting in this paper [27]. All  
96 participants provided written informed consent prior to the start of the Embrace study.

### 98 **Sample**

99 This pretest-posttest study examined a subsample of participants from the Embrace study receiving  
100 individual care and support and classified in the risk profiles 'Complex care needs' and 'Frail'.  
101 Embrace included people aged 75 and older who were registered with a participating general  
102 practitioner (GP) (n=1456, response rate 48.7%). Participants were classified into three risk profiles  
103 using their level of complexity of care needs – as measured with the INTERMED for the Elderly Self-  
104 Assessment (INTERMED-E-SA) [28] – and the level of frailty – as measured with the Groningen Frailty  
105 Indicator (GFI) [29, 30]. The resulting risk profiles are: 'Complex care needs' for participants with  
106 complex care needs at risk for assignment to a hospital or nursing home (INTERMED-E-SA  $\geq 16$ ), 'Frail'  
107 for participants at risk of complex care needs (INTERMED-E-SA  $< 16$  and a GFI  $\geq 5$ ) and 'Robust' for  
108 participants at risk for the consequences of ageing (INTERMED-E-SA  $< 16$  and GFI  $< 5$ ). Participants  
109 were then randomized into the control or intervention groups. A more detailed description of the  
110 Embrace study has been published elsewhere [18].

111 Those identified as frail or having complex care needs, who had been assigned to the  
112 intervention group of the Embrace study and who had completed baseline history-taking with the

113 GeriatrICS [26] within six months of the start were eligible for the current study. Actual inclusion  
114 comprised those who completed follow-up assessments twelve months after baseline assessment.

115

## 116 **Embrace**

117 Embrace is a person-centred and integrated care service for community-dwelling older adults, which  
118 has been implemented in the North of the Netherlands. A multidisciplinary Elderly Care Team  
119 consisting of a GP, a nursing home physician [31] and two case managers – a district nurse and a  
120 social worker for the participants with complex care needs and frail participants, respectively –  
121 organised care and support for older adults. The intensity, focus and individual or group approach of  
122 care and support depended on the participant's risk profile. Frail people and those with complex  
123 care needs received individual support from a case manager. The participant and case manager  
124 jointly developed an individual care and support plan which targeted all health-related problems  
125 identified during history taking using the GeriatrICS [26]. Case managers organised the care and  
126 support as decided on in the care and support plan. They monitored changes and navigated the  
127 plan's delivery. Participants were also invited to follow a self-management support and prevention  
128 programme – including regular Embrace community meetings – which focused on staying healthy  
129 and independent for as long as possible. Details of the implementation of Embrace have been  
130 published in the study protocol [18].

131

## 132 **Data collection and procedure**

133 Data for this study were collected at baseline (T0: January-June 2012) and after twelve months (T1:  
134 January-June 2013). Baseline assessments were performed during home visits. During these visits,  
135 case managers took a history using the GeriatrICS [26], which was integrated into the web-based  
136 electronic record system of Embrace. Follow-up assessments were performed either by the relevant  
137 case manager or by the participant completing a mailed, paper version of the GeriatrICS him or  
138 herself once individual care and support had ended. Self-report questionnaires from the Embrace

139 study (October-December 2011) provided data for assignment to the risk profiles at start, as well as  
140 data on background characteristics.

141

#### 142 **Assessment tool**

143 Health-related problems were evaluated using the GeriatricS, a validated ICF Core Set for  
144 community-dwelling older adults without dementia which includes 29 items covering fourteen Body  
145 Functions, nine Activities and Participation, and six Environmental Factor categories [26]. During the  
146 assessment, participants had to indicate whether they experienced problems in functioning and  
147 whether they experienced lack of support in relation to the Environmental Factors items.  
148 Participants had to rate all the items on a visual analogue scale ranging from 0 (no problem) to 10  
149 (very severe problem). In the paper version of the GeriatricS, each ICF item from the GeriatricS was  
150 translated into a single question.

151

#### 152 **Analysis**

153 We first examined baseline data and changes per ICF item for the whole sample and for the  
154 subgroups 'Complex care needs' and 'Frail' (Objective 1). We analysed responses in terms of  
155 whether or not a health-related problem existed (prevalence) and in terms of its severity. Prevalence  
156 scores were dichotomized scores including 'no problem' (score 0) versus 'problem' (scores 1-10),  
157 while severity scores employed the full 0-10 range. Differences in prevalence between the  
158 subgroups ('Complex care needs' and 'Frail') at baseline were tested using difference of proportions  
159 tests and Mann-Whitney U tests to assess differences in severity. Changes in prevalence after twelve  
160 months were analysed using McNemar's tests. Changes in severity were analysed by Wilcoxon  
161 signed rank tests. We considered changes to be statistically significant at  $p < 0.05$  (two-tailed;  
162  $p < 0.0017$  after Bonferroni correction). We calculated Cohen's  $d$  effect sizes to measure the strength  
163 of the effect.

164 We then repeated all analyses for each ICF item, including only those older adults who reported  
165 a health-related problem with that item at baseline (Objective 2). We analysed using SPSS Statistics  
166 version 22.0 and calculated effect sizes using Microsoft Excel 2010.

167

168

## 169 **Results**

170 The flow of participants is presented in Figure 1. Of the 267 eligible participants, 136 (50.9%) were  
171 included in this study because they completed follow-up assessments. Participants mainly dropped  
172 out because of a missing end evaluation when a participant was transferred to the Robust profile  
173 (48.9%), due to death (13.7%), termination of participation (6.9%), moving to another living situation  
174 or city (9.2%) or for unknown reasons (19.8%). No statistically significant differences in the baseline  
175 characteristics and ICF severity scores were found between those included and those lost to follow-  
176 up, except for dropouts scoring worse than participants on 'experienced health today' (EQ-VAS  
177  $p=0.013$ ) but better than participants on *b152 Emotional functions* ( $p=0.024$ ) and *b710 Mobility*  
178 ( $p=0.035$ ).

179

*Figure 1*

180

*Table 1*

181 In general, the health-related problems reported by older adults were pragmatically and  
182 retrospectively grouped into six coherent clusters: 'Mental Functions', 'Physical Health', 'Mobility',  
183 'Personal Care', 'Nutrition' and 'Support' (see Table 2).

184

*Table 2*

185

**186 All older adults in this study**

187 Table 3 provides an overview of the prevalence of the problems reported at baseline, the severity  
188 and change in their prevalence, and the severity in the whole sample. The most prevalent and most  
189 severe problems at baseline were related to Mental Functions (*b152 Emotional functions*) and  
190 Mobility.

191 The changes in prevalence after twelve months varied. The largest decreases were found for  
192 items related to Mental Functions (*b152 Emotional functions*), Nutrition (*d560 Drinking*) and Support  
193 (*e575 General social support services, systems and policies*), whereas the prevalence of the Mobility-  
194 related items increased (*b730 Muscle power functions*). Severity scores decreased or remained  
195 stable after twelve months.

196

**197 'Complex care needs' vs 'Frail' individuals**

198 Baseline differences between subgroups were noticeable, as participants with complex care needs  
199 had higher prevalence and severity scores compared to frail participants regarding Personal Care  
200 items (Table 3). Frail participants, on the other hand, had higher baseline severity scores on Mental  
201 Functions (*b144 Memory functions*) and Physical Health (*b230 Hearing functions*).

202 Participants with complex care needs had varying alterations in prevalence after twelve months.  
203 Severity scores, however, mainly remained stable or decreased, except for the Mobility items which  
204 showed a more varying pattern. Frail participants also showed varying alterations in prevalence, but  
205 the severity in all clusters decreased or remained stable after twelve months.

206

*Table 3*

207

**208 Older adults with problems at baseline**

209 Table 4 shows the number of older adults experiencing a problem at baseline, their baseline severity  
210 scores and the changes in number of participants who still had a problem at follow-up, as well as the  
211 related severity scores. Testing the change in prevalence per ICF item could not be performed in this

212 case, given that at baseline (T0) 100% of the older adults had a health-related problem with that ICF  
213 item. The baseline severity scores of those with a problem at baseline were highest for Mental  
214 Functions and Mobility.

215 Participants with a problem at baseline generally showed clear positive changes after twelve  
216 months. The largest reductions in the number of participants with persistent problems were in items  
217 related to Personal Care, Nutrition and Support (could not be statistically tested). Severity scores  
218 decreased for all items, with the largest decreases (effect sizes) being related to Nutrition and  
219 Support.

220

221 *'Complex care needs' vs 'Frail' individuals*

222 Comparing the subgroups of participants with a problem at baseline showed similar, positively  
223 changing patterns in prevalence and severity, but baseline severity scores were higher for frail  
224 participants than for those with complex care needs (Table 4).

225 For both subgroups, the numbers of participants who still had a problem at follow-up  
226 decreased, with the largest decreases in items related to Personal Care, Nutrition and Support  
227 (could not be statistically tested). Severity scores decreased for almost all items after twelve months,  
228 with the largest decreases (effect sizes) being related to Nutrition and Support.

229 *Table 4*

230

231

## 232 **Discussion**

233 This is the first study which used the GeriatrICS to obtain detailed insight into the prevalence,  
234 severity and changes in perceived health-related problems of community-dwelling older adults who  
235 received twelve months of individual, person-centred and integrated care and support. We grouped  
236 health-related problems reported by older adults into six clusters: 'Mental Functions', 'Physical  
237 Health', 'Mobility', 'Personal Care', 'Nutrition' and 'Support'. The most prevalent and most severe

238 problems at baseline were related to Mental Functions and Mobility. The changes in prevalence  
239 after twelve months varied, with largest decreases found in the clusters Mental Functions, Nutrition  
240 and Support, whereas the prevalence of Mobility-items increased. Overall, severity scores decreased  
241 or remained stable. This picture was also present in both risk profiles, except for a more varying  
242 pattern in severity scores of Mobility-items in participants with complex care needs. For those with a  
243 problem at baseline, the prevalence and severity of these problems decreased in all clusters after  
244 twelve months. Furthermore, of those reporting a problem at baseline, frail participants reported  
245 higher severity scores than participants with complex care needs.

246 Mobility-related problems were the most frequent and severe problems and showed a varying  
247 change pattern. This was especially the case for older adults with complex care needs. Mobility is  
248 known to constitute an important condition for independent living which often deteriorates during  
249 ageing. It is also a strong indicator of functional decline, health status and frailty [32, 33]. Older  
250 adults were perhaps not sufficiently exposed to lifestyle interventions, such as physical exercise  
251 training or dietary adaptations, or encouraged to participate during the twelve months. Such  
252 lifestyle interventions could prevent or solve mobility problems [32, 34]. Therefore, case managers  
253 and other health care and welfare professionals should pay extra attention to the possible  
254 preventive effect of such interventions for older adults.

255 Frail participants with a problem had higher baseline severity scores than participants with  
256 complex care needs experiencing a problem. However, both groups showed positively changing  
257 patterns after twelve months of person-centred and integrated care and support. The fact that frail  
258 participants had higher baseline severity scores is counterintuitive, as those with complex care needs  
259 usually have a poorer clinical condition. This might be because this latter group may already have  
260 become accustomed to the consequences of ageing and able to apply coping strategies for health  
261 problems, whereas frail older adults still have to adapt to and accept the consequences of ageing  
262 [35, 36]. Professionals should therefore consider the duration of the problems experienced in

263 supporting older adults. Those with relatively 'new' problems may have more difficulty with coping,  
264 whereas those with persistent problems may already have adapted to some extent to their situation.

265 The improvements after twelve months are encouraging, since normal ageing is associated with  
266 decreased physical, cognitive and social functioning [32, 37, 38]. The participants may have learned  
267 about the consequences of ageing and care and support available, as communicated by case  
268 managers and as acquired during Embrace community meetings [18]. This may have strengthened  
269 their self-management abilities and coping strategies, and thus their well-being [39, 40]. Care and  
270 support for older adults should therefore stimulate self-management and coping behaviour, for  
271 example by arranging adjustments at home and the acquisition of aids.

272

### 273 **Strengths and limitations**

274 The main strength of this study was the use of the GeriatrICS, a broad scoped ICF Core Set including  
275 the most relevant health-related problems of community-dwelling older adults. ICF Core Sets can be  
276 a useful tool for problem assessment, goal setting and evaluation in rehabilitation management [41].  
277 A minority of the recently developed Core Sets has been used for evaluation of change [42-46]. The  
278 GeriatrICS provided insight into the differences between frail participants and participants with  
279 complex care needs.

280 However, the results should be interpreted while taking some of the limitations of this study  
281 into account. First, the potential for causal inferences based on the results is limited as this was a  
282 pretest-posttest study with no control group, due to the fact that the GeriatrICS was not  
283 administered in the control group of the original trial [47]. Second, the health-related problems of  
284 older adults were pragmatically and retrospectively grouped into six coherent clusters. However, the  
285 clusters were comparable to the components of current geriatric assessment tools [48-52],  
286 supporting the clustering. Also, we made quite many comparisons, which may have caused findings  
287 to be spuriously significant [53]. Furthermore, as we used a real life sample in this study, we may  
288 have to deal with selection bias as a result of a relatively high dropout rate. Dropouts were due to a



289 positive event, e.g. a participant being transferred to the Robust profile, or due to a negative event,  
290 e.g. death of a participant or transfer to a nursing home. In both situations, the case manager could  
291 not, or did not, perform an end evaluation – which reflects the real-life situation in health care. As a  
292 consequence, these participants dropped out of our sample for analyses. However, there were only  
293 small differences between respondents and dropouts concerning baseline characteristics. Finally,  
294 the method of classification of participants into risk profiles may have affected findings. We used  
295 two self-reported, multidimensional instruments measuring frailty and complexity of care needs  
296 from a broad perspective. Other frailty instruments may have led to different risk profiles [54].

297

### 298 **Implications**

299 The GeriatrICS can be used to identify health-related problems in older adults and to provide person-  
300 centred and integrated care and support. We found that mobility problems were frequent and hard  
301 to counteract. The prevention of mobility problems remains challenging [34]. In addition, the  
302 improvements after twelve months may indicate that the self-management abilities and coping  
303 strategies of older adults were strengthened. Coping is therefore an issue on which case managers  
304 and caregivers should focus. Proactive coping in particular (being future-oriented) may be a good  
305 way to deal with the consequences of ageing, besides maintenance of meaningful activities and  
306 relationships [55].

307 We found improvements in the prevalence and severity of health-related problems of older  
308 adults after twelve months in a single group pretest-posttest design, which limits the potential for  
309 causal inferences. Future studies should therefore also include a control group. Furthermore, our  
310 findings should be replicated while including robust older adults as the focus in this study was on  
311 those at risk of experiencing health-related problems, i.e. frail older adults and older adults with  
312 complex care needs. Also, this study should be replicated in other geographical areas, cultures and  
313 healthcare systems.

314

**315 Conclusion**

316 The most prevalent and most severe problems at baseline were related to Mental Functions and  
317 Mobility. The prevalence and severity of health-related problems decreased or remained stable in  
318 most clusters after receiving person-centred and integrated care for twelve months, except for  
319 Mobility-related problems, which showed a more varying pattern. These results are encouraging and  
320 may indicate that individual, person-centred and integrated care and support from Embrace offers a  
321 route to counteracting the decline in physical, cognitive and social functioning associated with  
322 ageing.

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453

454 **Figures and Tables**

455 **Figure 1.** Flowchart of participants

456 **Table 1.** Background characteristics of participants (n (%), unless stated otherwise)

457 **Table 2.** Items of the GeriatrICS grouped into clusters of health-related problems as experienced by  
458 community-dwelling frail older adults

459 **Table 3.** Baseline scores and change in prevalence and severity of health-related problems as  
460 assessed with the GeriatrICS after twelve months of person-centred and integrated care: results of  
461 the whole sample and per risk profile

462 **Table 4.** Baseline and change in prevalence and severity of health-related problems as assessed with  
463 the GeriatrICS after twelve months of person-centred and integrated care: results of participants  
464 with a problem at baseline, for the whole sample and per risk profile

**Table 1.** Background characteristics of participants

	Total (n=136)	Complex care needs (n=80)	Frail (n=56)	p
Age at T0 in years, median (IQR)	80.5 (78.1-84.8)	81.4 (78.9-85.4)	79.7 (77.2-82.8)	0.013
Female	94 (69.1)	54 (67.5)	40 (71.4)	0.707
Married/unmarried living together	65 (47.8)	42 (52.5)	23 (41.1)	0.224
Community-living	133 (97.8)	77 (96.3)	56 (100.0)	0.268
Low education level <sup>1</sup>	81 (59.6)	48 (60.0)	33 (58.9)	1.000
Low income <sup>2</sup>	61 (54.0)	34 (51.5)	27 (57.4)	0.570
No. of chronic conditions, mean (SD)	3.4 (1.7)	3.6 (1.6)	3.1 (1.8)	0.099
Multiple chronic conditions	58 (42.6)	43 (53.8)	15 (26.8)	0.003
Use of ≥4 different medications	105 (77.2)	66 (82.5)	39 (69.6)	0.098
INTERMED-E-SA, median (IQR)	16.0 (12.0-20.0)	19.0 (17.0-21.8)	12.0 (10.3-14.0)	<0.001
GFI, median (IQR)	6.0 (5.0-8.0)	7.0 (5.0-8.0)	6.0 (5.0-7.0)	0.244
Health status (EQ-5D-3L), median (IQR)	0.69 (0.65-0.78)	0.69 (0.65-0.78)	0.73 (0.65-0.81)	0.028
Health status (EQ-VAS), median (IQR)	65.0 (50.0-70.0)	60.0 (50.0-70.0)	70.0 (65.0-80.0)	<0.001
QOL report mark, mean (SD)	6.7 (1.2)	6.4 (1.2)	7.2 (0.9)	<0.001
ADL (Katz-15), median (IQR)	2.0 (1.0-4.0)	3.0 (1.3-5.0)	1.0 (0.0-3.0)	<0.001

ADL = Activities of daily living; EQ-5D-3L = EuroQol-5D-3L; EQ-VAS = EuroQol-5D visual analogue scale; GFI = Groningen Frailty Indicator; INTERMED-E-SA = INTERMED for the Elderly Self-Assessment; IQR = Interquartile range; QOL= Quality of life.

<sup>1</sup> Low: (Less than) primary school or low vocational training

<sup>2</sup> Low: <€1350 per month

Numbers, followed by percentages between brackets, are presented – unless stated otherwise.

Differences between risk profiles were tested using independent t-tests for continuous variables, Chi-square tests for categorical variables, and Mann-Whitney U tests for non-normally distributed continuous variables and ordinal variables.



**Table 2.** Items of the GeriatrICS grouped into clusters of health-related problems as experienced by community-dwelling frail older adults

Cluster	GeriatrICS item (ICF category)
Mental Functions	b144 Memory functions
	b152 Emotional functions
Physical Health	b210 Seeing functions
	b230 Hearing functions
	b410 Heart functions
	b420 Blood pressure functions
	b525 Defecation functions
	b620 Urination functions
	b810 Protective functions of the skin
Mobility	b240 Sensations associated with hearing and vestibular function
	b455 Exercise tolerance functions
	b710 Mobility of joint functions
	b730 Muscle power functions
	d410 Changing basic body position
	d450 Walking
	d470 Using transportation
Personal Care	d510 Washing oneself
	d520 Caring for body parts
	d540 Dressing
Nutrition	b530 Weight maintenance functions
	d550 Eating
	d560 Drinking
Support	d760 Family relationships
	e310 Immediate family
	e320 Friends
	e325 Acquaintances, peers colleagues, neighbours and community members
	e570 Social security services, systems and policies
	e575 General social support services, systems and policies
	e580 Health services, systems and policies

ICF=International Classification of Functioning, Disability and Health.

**Table 3.** Baseline scores and change in prevalence and severity of health-related problems after twelve months of person-centred and integrated care: results of the whole sample and per risk profile as assessed with the GeriatricS

	Prevalence of health-related problems												Severity of health-related problems											
	Whole sample (n=136)				Older adults with complex care needs (n=80)				Frail older adults (n=56)				Whole sample (n=136)				Older adults with complex care needs (n=80)				Frail older adults (n=56)			
	T0 (%)	Δ (%)	P	ES	T0 (%)	Δ (%)	P	ES	T0 (%)	Δ (%)	P	ES	T0	Δ	p	ES	T0	Δ	p	ES	T0	Δ	p	ES
<b>Mental Functions</b>																								
b144 Memory functions	41.2	1.5	0.877	0.05	35.0	8.8↑	0.248	0.29	50.0	-8.9↓	0.302	0.38	1.4	-0.3↓↓	0.042	0.25	1.1	0.0	0.743	0.05	1.9*	-0.7↓↓	0.011	0.49
b152 Emotional functions	73.1+	-11.2↓↓	0.025	0.45	75.0+	-11.3↓	0.124	0.38	70.4+	-11.1↓	0.146	0.61	3.1+	-0.8↓↓	<0.001	0.44	3.3+	-0.8↓↓	0.005	0.45	2.8+	-0.8↓↓	0.024	0.44
<b>Physical Health</b>																								
b210 Seeing functions	48.5	8.2↑	0.136	0.28	47.5	7.5↑	0.377	0.21	50.0	9.3↑	0.267	0.45	1.9	0.2	0.318	0.12	1.8	0.0	0.972	0.01	2.1+	0.5↑	0.101	0.32
b230 Hearing functions	50.0	3.7	0.522	0.14	43.8	3.8	0.690	0.13	59.3	3.7	0.791	0.16	1.9	-0.1	0.773	0.04	1.5	-0.1	0.762	0.05	2.4+*	0.0	0.836	0.04
b410 Heart functions	51.5	-5.2↓	0.310	0.22	55.0	0.0	1.000	0.00	46.3	-13.0↓	0.065	0.83	1.7	-0.3	0.186	0.16	1.7	-0.1	0.632	0.08	1.7	-0.5↓	0.095	0.33
b420 Blood pressure functions	44.8	0.0	1.000	0.00	51.3*	0.0	1.000	0.00	35.2	0.0	1.000	0.00	1.2	0.1	0.951	0.01	1.4	0.2	0.843	0.03	1.0	0.0	0.920	0.02
b525 Defecation functions	36.6	-3.0	0.626	0.12	40.0	2.5	0.850	0.08	31.5	3.7↑	0.754	0.22	1.4	-0.3	0.189	0.16	1.4	-0.2	0.733	0.05	1.4	-0.5↓	0.073	0.35
b620 Urination functions	50.4	-4.5	0.451	0.15	56.3	5.0	0.584	0.15	41.5	3.8	0.791	0.16	1.9	-0.4↓	0.105	0.20	2.1+	-0.5↓	0.155	0.23	1.6	-0.3	0.453	0.15
b810 Protective functions of the skin	47.4	-6.7↓	0.200	0.26	43.0	2.5	0.832	0.10	53.6	-12.5↓	0.143	0.48	1.7	-0.6↓↓	0.007	0.33	1.6	-0.5↓	0.134	0.24	2.0+	-0.7↓↓	0.008	0.52
<b>Mobility</b>																								
b240 Sensations associated with hearing and vestibular function	64.2+	-6.0	0.302	0.19	70.0+	1.3	1.000	0.04	55.6	-13.0↓	0.167	0.43	2.6+	-0.7↓↓	0.008	0.33	3.05*	-0.8↓↓	0.039	0.33	2.0+	-0.6↓	0.088	0.33
b455 Exercise tolerance functions	64.2+	5.2↑	0.337	0.20	65.0+	10.0↑	0.152	0.38	63.0+	1.9	1.000	0.07	2.4+	0.1	0.774	0.04	2.2+	0.5↑	0.148	0.23	2.6+	-0.4↓	0.143	0.28
b710 Mobility of joint functions	74.4+	0.0	1.000	0.00	67.5+	5.0	0.541	0.19	84.9+	-7.5↓	0.424	0.32	3.5+	-0.6↓↓	0.004	0.36	3.2+	-0.4↓	0.099	0.26	3.9+	-0.9↓↓	0.011	0.51
b730 Muscle power functions	47.4	11.3↑↑	0.037	0.38	51.3	12.5↑	0.100	0.38	41.5	9.4↑	0.302	0.38	1.5	0.4	0.164	0.17	1.3	0.5	0.117	0.25	1.8	0.1	0.743	0.06
d410 Changing basic body position	56.3	0.7	1.000	0.03	58.2	1.3	1.000	0.05	53.6	0.0	1.000	0.00	2.1+	-0.2	0.344	0.12	2.2+	-0.5↓	0.196	0.21	2.0+	0.1	0.854	0.03
d450 Walking	62.7+	3.7	0.542	0.13	63.3+	3.8	0.664	0.16	61.8+	3.6	0.832	0.10	2.6+	-0.1	0.564	0.07	2.6+	-0.2	0.600	0.08	2.7+	0.0	0.821	0.04
d470 Using transportation	14.7	6.6↑	0.188	0.27	13.8	8.8↑	0.210	0.35	16.1	3.6	0.791	0.16	0.5	0.1	0.284	0.13	0.4	0.2↑	0.182	0.21	0.8	0.0	0.932	0.02
<b>Personal Care</b>																								
d510 Washing oneself	19.9	-0.7	1.000	0.03	26.3*	1.3	1.000	0.04	10.7	0.0	1.000	0.00	0.6	0.0	0.979	0.00	0.7*	0.1	0.879	0.02	0.4	-0.1	0.725	0.07
d520 Caring for body parts	16.2	2.2	0.735	0.09	22.5*	1.3	1.000	0.04	7.1	7.1↑	0.344	0.47	0.3	0.1	0.545	0.07	0.4*	0.2	0.333	0.15	0.3	-0.1	0.787	0.05
d540 Dressing	15.4	7.4↑	0.123	0.33	20.0	11.3↑	0.124	0.38	8.9	1.8	1.000	0.16	0.4	0.1	0.159	0.17	0.4	0.2↑	0.127	0.24	0.3	0.0	1.000	0.00

Table 3. Continued

	Prevalence of health-related problems												Severity of health-related problems											
	Whole sample (n=136)				Older adults with complex care needs (n=80)				Frail older adults (n=56)				Whole sample (n=136)				Older adults with complex care needs (n=80)				Frail older adults (n=56)			
	T0 (%)	Δ (%)	P	ES	T0 (%)	Δ (%)	P	ES	T0 (%)	Δ (%)	P	ES	T0	Δ	p	ES	T0	Δ	p	ES	T0	Δ	p	ES
<b>Nutrition</b>																								
b530 Weight maintenance functions	30.8	-0.8	1.000	0.02	27.5	0.0	1.000	0.00	35.8	1.9	1.000	0.07	1.0	-0.2	0.355	0.11	0.9	-0.3	0.452	0.12	1.1	-0.2	0.548	0.12
d550 Eating	11.8	-0.7	1.000	0.06	16.3	1.3	1.000	0.07	5.4	0.0	1.000	0.00	0.3	-0.1	0.283	0.13	0.5*	-0.2	0.262	0.18	0.1	0.0	1.000	0.00
d560 Drinking	22.1	-10.3↓↓	0.018	0.56	27.5	-11.3↓	0.078	0.51	14.3	-8.9↓	0.180	0.69	0.8	-0.5↓↓	0.002	0.38	0.9	-0.5↓↓	0.021	0.37	0.6	-0.5↓↓	0.035	0.41
<b>Support</b>																								
d760 Family relationships	22.1	0.0	1.000	0.00	18.8	3.8	0.664	0.16	26.8	-5.4↓	0.581	0.26	0.8	-0.2	0.317	0.12	0.6	0.0	0.946	0.01	1.0	-0.4↓	0.119	0.30
e310 Immediate family	16.2	2.2	0.728	0.10	17.5	6.3↑	0.405	0.24	14.3	3.6↑	0.754	0.22	0.5	0.0	0.573	0.07	0.5	0.1	0.928	0.01	0.4	-0.2	0.412	0.16
e320 Friends	27.2	-2.9	0.635	0.11	27.5	3.8	0.710	0.11	26.8	-12.5↓	0.065	0.83	0.8	-0.4↓	0.029	0.27	0.7	-0.2	0.394	0.14	1.0	-0.6↓↓	0.015	0.47
e325 Acquaintances, peers, colleagues, neighbours and community members	27.2	-3.7	0.472	0.18	31.3	0.0	1.000	0.00	21.4	-8.9↓	0.227	0.54	0.9	-0.3↓	0.099	0.20	0.8	-0.2	0.395	0.13	1.1	-0.5↓	0.106	0.31
e570 Social security services, systems and policies	15.4	-5.9↓	0.096	0.53	16.3	-8.8↓	0.118	0.56	14.3	1.8↑	1.000	0.38	0.5	-0.2	0.268	0.13	0.4	-0.2↓	0.154	0.23	0.7	-0.1	0.610	0.10
e575 General social support services, systems and policies	15.4	-8.8↓↓	0.031	0.55	16.3	-7.5↓	0.210	0.44	14.3	-10.7↓	0.109	0.77	0.6	-0.5↓↓	0.005	0.35	0.6	-0.4↓↓	0.035	0.34	0.7	-0.5↓	0.074	0.34
e580 Health services, systems and policies	21.3	-6.6↓	0.176	0.29	16.3	0.0	1.000	0.00	28.6	-16.1↓↓	0.035	0.77	0.8	-0.3	0.055	0.23	0.6	-0.2	0.513	0.10	1.0	-0.5↓↓	0.016	0.47

ES=Effect size *d*, thresholds <0.2 trivial, ≥0.2- 0.5 small, ≥0.5-0.8 medium, ≥0.8 large

T0=Baseline measurement

Δ=Change between baseline and follow-up measurements

\* Significant difference ( $p < 0.05$ ) at baseline between participants with complex care needs and frail participants.

^ Change between baseline and follow-up measurements is statistically significant after Bonferroni correction.

Missing values ranged between 1 and 3 per item.

+ High prevalence ≥60.0%/high severity score at T0 ≥2.0

↓↓ Significant and clinically relevant decrease in prevalence/severity

↓ Non-significant, but clinically relevant decrease in prevalence/severity

↑↑ Significant and clinically relevant increase in prevalence/severity

↑ Non-significant, but clinically relevant increase in prevalence/severity

**Table 4.** Baseline and change in prevalence and severity of health-related problems after twelve months of person-centred and integrated care: results of participants with a problem at baseline, for the whole sample and per risk profile as assessed with the Geriatrics

	Number of participants with a health-related problem at baseline <sup>a</sup>						Severity of health-related problems											
	Whole sample		Older adults with complex care needs		Frail older adults		Whole sample				Older adults with complex care needs				Frail older adults			
	T0 (n)	Δ (%)	T0 (n)	Δ (%)	T0 (n)	Δ (%)	T0	Δ	p	ES	T0	Δ	p	ES	T0	Δ	p	ES
<b>Mental Functions</b>																		
b144 Memory functions	56	-35.7	28	-35.7	28	-35.7	3.4	-1.4↓^	<0.001	0.96	3.1	-1.2↓^	0.001	0.96	3.8	-1.7↓^	0.001	0.98
b152 Emotional functions	98	-27.6	60	-30.0	38	-23.7	4.2+	-1.4↓^	<0.001	0.79	4.3+	-1.5↓^	<0.001	0.85	4.0+	-1.3↓	0.004	0.70
<b>Physical Health</b>																		
b210 Seeing functions	65	-26.2	38	-34.2	27	-14.8	3.9	-0.7↓	0.047	0.35	3.8	-1.2↓	0.011	0.61	4.1+	0.1	0.919	0.03
b230 Hearing functions	67	-26.9	35	-31.4	32	-18.8	3.7	-0.9↓	0.018	0.42	3.5	-1.1↓	0.040	0.51	4.0+	-0.5↓	0.202	0.32
b410 Heart functions	69	-30.4	44	-27.3	25	-36.0	3.4	-1.2↓^	<0.001	0.69	3.2	-1.1↓	0.002	0.68	3.7	-1.4↓	0.016	0.72
b420 Blood pressure functions	60	-38.3	41*	-36.6	19	-42.1	2.7	-0.9↓	0.002	0.58	2.6	-0.8↓	0.026	0.51	2.8	-1.2↓	0.035	0.73
b525 Defecation functions	49	-42.9	32	-46.9	17	-35.3	3.8	-1.8↓^	<0.001	0.82	3.4	-1.5↓	0.003	0.80	4.6+	-2.1↓↓	0.015	0.91
b620 Urination functions	67	-35.8	45	-37.8	22	-36.4	3.8	-1.6↓^	<0.001	0.76	3.8	-1.6↓^	<0.001	0.80	3.8	-1.6↓	0.038	0.66
b810 Protective functions of the skin	64	-37.5	34	-35.3	30	-40.0	3.7	-1.9↓^	<0.001	0.93	3.7	-1.9↓	0.004	0.75	3.7	-1.9↓^	<0.001	1.26
<b>Mobility</b>																		
b240 Sensations associated with hearing and vestibular function	86	-31.4	56	-25.0	30	-43.3	4.1+	-1.7↓^	<0.001	0.76	4.3+	-1.7↓^	<0.001	0.70	3.6	-1.7↓^	0.001	0.92
b455 Exercise tolerance functions	86	-18.6	52	-15.4	34	-23.5	3.7	-0.6↓	0.024	0.35	3.4	-0.1	0.579	0.11	4.2+	-1.3↓	0.003	0.78
b710 Mobility of joint functions	99	-21.2	54	-18.5	45	-20.0	4.7+	-1.3↓^	<0.001	0.75	4.7+	-1.4↓^	<0.001	0.79	2.4	-1.2↓	0.002	0.70
b730 Muscle power functions	63	-25.4	41	-24.4	22	-22.7	3.2	-0.9↓	0.003	0.54	2.6	-0.7↓	0.049	0.45	4.4+*	-1.3↓	0.028	0.70
d410 Changing basic body position	76	-23.7	46	-23.9	30	-23.3	3.7	-1.2↓^	0.001	0.56	3.7	-1.5↓	0.003	0.65	3.8	-0.7	0.148	0.38
d450 Walking	84	-21.4	50	-18.0	34	-29.4	4.2+	-1.2↓^	0.001	0.53	4.0+	-1.0↓	0.033	0.44	4.4+	-1.3↓	0.007	0.69
d470 Using transportation	20	-70.0↓↓	11	-72.7↓↓	9	-66.7↓	3.6	-2.4↓↓^	0.001	1.17	2.7	-1.9↓	0.025	1.09	4.7+	-2.8	0.017	1.36
<b>Personal Care</b>																		
d510 Washing oneself	27	-66.7↓	21*	-66.7↓	6	-66.7↓	2.9	-1.5↓	0.029	0.62	2.5	-1.2	0.131	0.48	4.2+	-2.5	0.068	1.24
d520 Caring for body parts	22	-72.7↓↓	18*	-72.2↓↓	4	-75.0↓↓	2.0	-1.4↓	0.003	1.02	1.6	-0.8↓	0.013	0.91	4.3+*	-3.8	0.066	1.71
d540 Dressing	21	-57.1↓	16	-56.3↓	5	-60.0↓	2.3	-1.4↓^	0.001	1.26	2.1	-1.4↓	0.002	1.30	3.0	-1.2	0.109	1.18
<b>Nutrition</b>																		
b530 Weight maintenance functions	41	-61.0↓	22	-72.7↓↓	19	-42.1	3.1	-2.0↓↓^	<0.001	1.07	3.2	-2.6↓↓^	<0.001	1.48	3.1	-1.3↓	0.044	0.69
d550 Eating	16	-62.5↓	13	-69.2↓	3	-33.3	2.6	-2.0↓↓^	0.001	1.45	2.9	-2.3↓↓^	0.001	1.62	1.3	-0.7	0.317	0.89
d560 Drinking	30	-70.0↓↓	22	-68.2↓	8	-87.5↓↓	3.6	-3.0↓↓^	<0.001	1.45	3.4	-2.6↓↓^	<0.001	1.40	4.1+	-3.9↓↓	0.012	1.63

Table 4. Continued

	Number of participants with a health-related problem at baseline <sup>#</sup>						Severity of health-related problems											
	Whole sample		Older adults with complex care needs		Frail older adults		Whole sample				Older adults with complex care needs				Frail older adults			
	T0 (n)	Δ (%)	T0 (n)	Δ (%)	T0 (n)	Δ (%)	T0	Δ	p	ES	T0	Δ	p	ES	T0	Δ	p	ES
<b>Support</b>																		
d760 Family relationships	30	-60.0↓	15	-60.0↓	15	-53.3↓	3.4	-2.4↓↓ <sup>^</sup>	<0.001	1.43	3.0	-2.4↓↓ <sup>^</sup>	0.001	1.45	3.8	-2.3↓↓ <sup>^</sup>	0.001	1.45
e310 Immediate family	22	-72.7↓↓	14	-64.3↓	8	-75.0↓↓	2.8	-1.9↓ <sup>^</sup>	<0.001	1.37	2.9	-1.9↓	0.002	1.43	2.8	-2.4↓↓	0.027	1.32
e320 Friends	37	-59.5↓	22	-59.1↓	15	-60.0↓	3.0	-2.3↓↓ <sup>^</sup>	<0.001	1.31	2.5	-2.0↓↓ <sup>^</sup>	<0.001	1.38	3.7	-2.5↓↓	0.004	1.26
e325 Acquaintances, peers, colleagues, neighbours and community members	37	-45.9	25	-40.0	12	-66.7↓	3.4	-2.1↓↓ <sup>^</sup>	<0.001	0.89	2.7	-1.2↓	0.031	0.64	5.0+*	-3.8↓↓	0.005	1.41
e570 Social security services, systems and policies	21	-61.9↓	13	-84.6↓↓	8	-25.0	3.5	-1.6↓	0.048	0.64	2.7	-1.5↓	0.026	0.97	4.9+*	-1.4	0.344	0.49
e575 General social support services, systems and policies	21	-90.5↓↓	13	-84.6↓↓	8	-100.0↓↓	4.0+	-3.7↓↓ <sup>^</sup>	<0.001	1.47	3.5	-3.1↓↓	0.003	1.41	4.6+	-4.6↓↓	0.012	1.63
e580 Health services, systems and policies	29	-75.9↓↓	13	-76.9↓↓	16	-75.0↓↓	3.7	-2.6↓↓ <sup>^</sup>	<0.001	1.15	3.8	-3.2↓↓	0.008	1.21	3.6	-2.1↓↓	0.005	1.13

ES=Effect size *d*, thresholds <0.2 trivial, ≥0.2- 0.5 small, ≥0.5-0.8 medium, ≥0.8 large

T0=Baseline measurement

Δ=Change between baseline and follow-up measurements

<sup>#</sup> Testing the change in prevalence per ICF item could not be performed, given that at baseline (T0) 100% of the older adults had a health-related problem with that ICF item.

\* Significant difference (p<0.05) between participants with complex care needs and frail participants.

<sup>^</sup> Change between baseline and follow-up measurements is statistically significant after Bonferroni correction.

Missing values ranged between 1 and 2 per item.

+ High severity score at T0 ≥4.0

↓↓ Decrease in prevalence ≥-70% / significant and clinically relevant decrease in severity ≥2.0

↓ Decrease in prevalence -50% to -70% / significant and clinically relevant decrease in severity <2.0

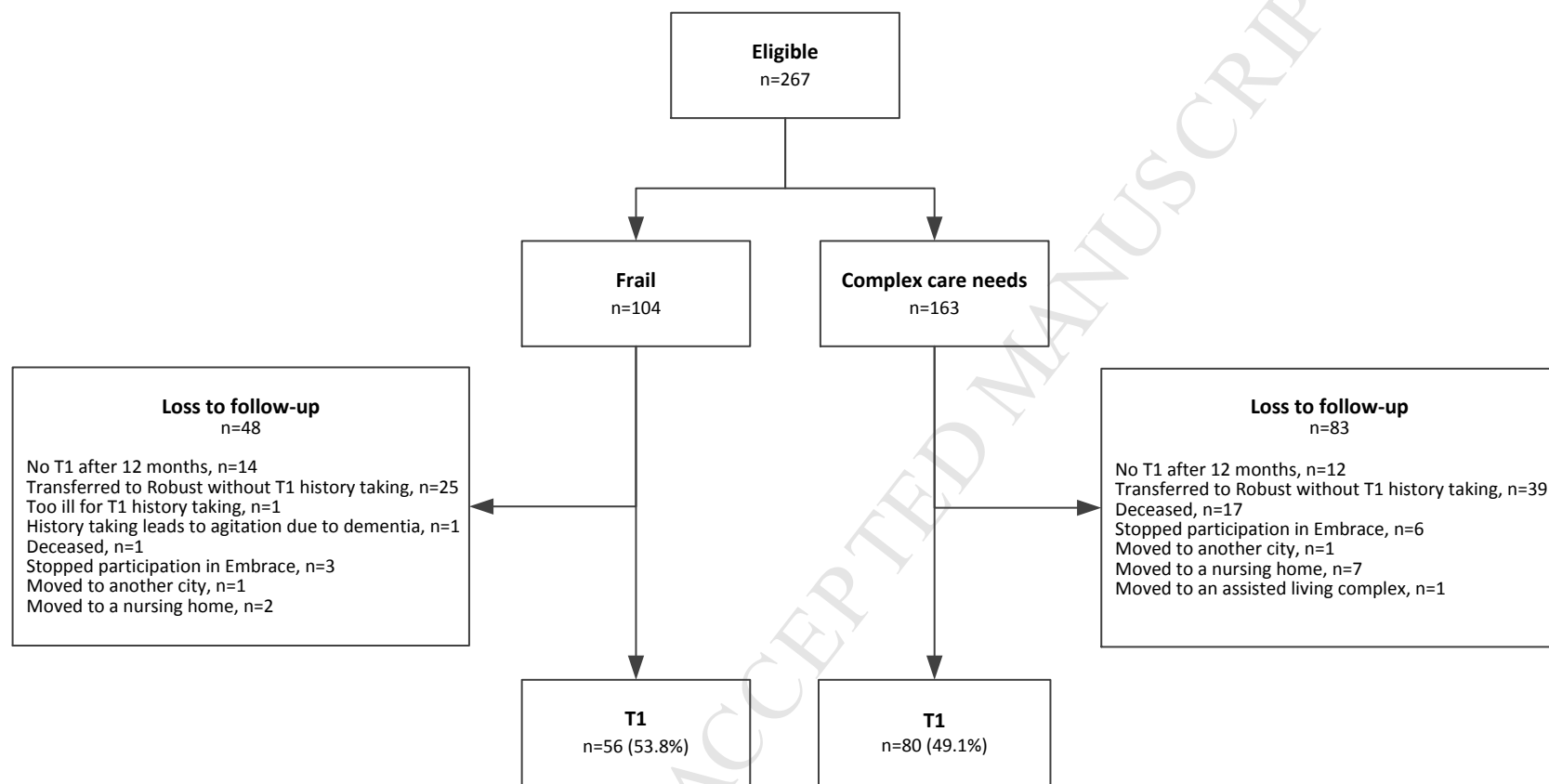


Figure 1. Flowchart of participants