

Identifying best practices for care– dependent elderly by Benchmarking Costs and outcomes of community care



Validity of the interRAI–HC formal and informal care utilisation measurement and cost estimates

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Authors note

Data quality

The main analyses for this milestone were performed with InterRAI-HC and RUD Lite data from Finland, Iceland, Italy, and the Netherlands. Additional analyses also included data from Belgium and Germany. The data were controlled by a data management team and two researchers on out of range values, odd values, missing values, and a cross validation between variables was performed. More data quality checks will be performed in the near future. This may result in differences in results between this report and the final paper published on this study.

1 Abstract

Background

The interRAI-Home Care (interRAI-HC) is used in routine care to assess health outcomes and resource utilisation of community dwelling home care recipients. The interRAI-HC can potentially serve as input for the calculation of societal cost of care utilisation in economic evaluations. However, to estimate societal costs extrapolations of resources utilisation items is necessary. It is unclear whether this results in valid societal costs estimates. Therefore, the purpose of this study was to evaluate the convergent validity of the interRAI-HC instrument in comparison to the RUD-Lite instrument for the measurement of formal and informal resource utilisation among care-dependent community dwelling older adults from six European countries.

Methods

A cross-sectional within subject design was used. Participants were 65 years and older and received community care. The interRAI-HC and RUD Lite instrument were administered within a one month period by trained (research) nurses. The interRAI-HC is a validated comprehensive geriatric assessment instrument and provides information on the medical, psychological, social and functional capabilities, care needs, and formal and informal resource utilisation of community dwelling older adults. The RUD Lite measures resource utilisation from a societal perspective among older adults with dementia and has good psychometric properties for costs of care assessments. This instrument was used as reference to establish the convergent validity of the interRAI-HC for cost of care assessments. We hypothesised that there was strong agreement (Spearman's $\rho > 0.5$) between 12 resource utilisation categories, six costs of care estimates and total societal costs estimates derived from both instruments.

Results

Strong agreement was found between RUD Lite and interRAI-HC resource utilisation assessments for physician visits, physical therapy, psychological treatment, frequency and duration of hospital admission, homemaking services, meals on wheels, and informal care. The agreement for home health care and home nursing was weak, and the agreement for occupational therapy and emergency room visits was moderate. Agreement for all six cost categories; home care, physician visits, other health care services, hospital admissions, supportive care services, and informal care, was strong. The difference in total societal costs was €-321 between the RUD Lite and interRAI-HC, this difference was not statistically significant. Agreement between the instruments for total societal costs was strong (Spearman's $\rho = 0.62$).

Conclusion

The results suggest that the interRAI-HC instrument can be validly used to measure resource utilisation of formal and informal care services and to estimate societal cost of care utilisation in community dwelling older adults. Since interRAI-HC assessments are part of routine care in many organisations and countries already, this finding increases the feasibility of performing economic evaluations among community dwelling older adults with the interRAI-HC.

2 Background and objective

The population in countries across Europe is ageing rapidly (Lanzieri, 2011). Between 2010 and 2050, the proportion of adults aged 65 years and older is expected to increase from 8% to 16% (WHO, 2014). Many older adults experience difficulties in activities of daily living due to chronic illnesses or health-related disabilities which limit their ability to live independently in their homes (WHO, 2014). As a consequence, the demand for (long-term) formal and informal care services will grow substantially in the coming decades (Colombo, Llena-Nozal, Mercier, & Tjadens, 2011; WHO, 2014). Most older adults want to live independently in their own environment for as long as possible, and this is also encouraged by many European governments (Genet et al., 2011). Therefore the demand for community care is expected to rise steeply in the future. The combination of increasing numbers of older adults with care needs and a shrinking workforce will put heavy pressure on health care systems across Europe. Since budgets available for health care are limited, policy makers need to make decisions on how to allocate health care resources in the most efficient way.

Economic evaluations can inform such allocation decisions by providing information on the relative efficiency of alternative health care interventions (Drummond, Sculpher, Torrance, O'Brien, & Stoddart, 2005). To estimate costs in economic evaluations, the utilisation of health care and social care resources needs to be quantified. Information on resource utilisation is frequently collected retrospectively by means of self-report structured questionnaires or interviews, such as the Resource Utilization in Dementia (RUD) Lite instrument (Wimo & Windblad, 2003), the Client Service Receipt Inventory (CSRI) (Beecham & Knapp, 2001), or the Trimbos/iMTA questionnaire for Costs associated with Psychiatric Illness (TiC-P) (Bouwman et al., 2013). Another way to collect this information is from routine care assessments. An advantage of using a routine care instrument is that individuals are not exposed to additional questionnaires for measuring resource utilisation. An example of a routine care instrument is the interRAI Home Care instrument (interRAI-HC). The interRAI-HC is a standardised multidimensional geriatric assessment instrument that has been designed to assist in care planning, outcome measurement, quality improvement, and resource allocation for clients who receive care at home (Morris, 1997; Landi, 2000; Hirdes, 2008). Although the interRAI-HC was not specially designed to measure resource utilisation, it may also be used to estimate costs of care, as was done by Brown et al. (2009). The interRAI-HC assesses the utilisation of regularly used health care services in seven days prior to the assessment, and irregularly used health care services in 90 days prior to the assessment. To calculate the cost of care utilisation over a period of three months or longer, utilisation of health care services has to be extrapolated to longer periods. So far, it has not yet been studied whether the interRAI-HC results in valid estimates of resource utilisation and costs over a period of three months or more. In contrast, the RUD Lite instrument was specifically developed to measure utilisation of formal and informal care services and is widely used to estimate societal costs in community-dwelling people with dementia (Wimo, 1998; Wimo 2010).

In this paper, the convergent validity of the interRAI-HC instrument is evaluated in comparison to the RUD Lite instrument for the measurement of resource utilisation of formal and informal care services in a sample of care-dependent community dwelling older adults from six European countries.

3 Methods

3.1 Design

This study is part of the IBenC project. IBenC is a cross-European research project and is an acronym for “Identifying best practices for care-dependent elderly by Benchmarking Costs and outcomes of community care”. IBenC aims to provide insight into the costs and quality of community care delivery systems across Europe (IBenC, 2015). The study was approved by relevant legal authorised medical ethical committees in the countries that participated in the IBenC project.

For this sub-study, a cross-sectional within subject design was used to evaluate the convergent validity of the interRAI-HC in comparison with the RUD Lite instrument to measure resource utilisation and estimate costs from a societal perspective. Convergent validity evaluates the agreement between two measurements using hypotheses specifying the expected correlations between items that intend to measure the same construct, resource utilisation in the present study (de Vet, Terwee, Mokkink, & Knol, 2011). Convergent validity was evaluated, since there is no gold standard for resource utilisation measurements. The data collection for this sub-study took place between January 2013 and March 2015.

3.2 Setting and participants

Participants of the IBenC project were community dwelling older adults aged 65 years and older who received community care by a home care or community care organisation, or by a primary care nurse, and were expected to receive care for at least six more months after inclusion. Terminally ill persons, or cognitively impaired persons (score of three or higher on the Cognitive Performance Scale (CPS) (Morris et al., 1994)) without an informal caregiver who was willing to complete the study measurements on behalf of the participant, were not included in the study. Participants were recruited in six European countries: Belgium, Finland, Germany, Iceland, Italy, and The Netherlands. In every country, a subsample of at least 50 participants and their primary informal caregivers was selected for participation in this sub-study.

3.3 Procedure

The majority of the community care organisations that participated in the IBenC project used the interRAI-HC instrument in routine care to monitor the health and care status of their clients bi-annually. Clients receiving care from these organisations and who fulfilled the inclusion criteria were enrolled in the study in accordance with local ethical regulations. In community care organisations that did not use the interRAI-HC instrument in routine care, potential participants were invited by their community care organisations to participate in the IBenC study.

At the start of the data collection period, participants were invited by the national study centre or community care organisation to participate in an additional assessment on resource utilisation with the RUD Lite according to local protocols. Prior to the start of the additional assessments, written

informed consent was sought from the participants. When a participant was known to be cognitively impaired, informed consent from a close relative, legal representative or legal guardian on behalf of the participant was sought. All data collected within the study were anonymised before being transferred from the local study centres to the central iBenC data centre.

The RUD Lite assessment took place within one month of the interRAI-HC assessment at the home of the participant. The RUD Lite assessments were performed by trained community care nurses (Belgium, Iceland) or trained research nurses (Germany, Italy, The Netherlands). In Finland, the RUD Lite assessments were completed by participants or informal caregivers themselves by means of a written questionnaire. If the participant was cognitively impaired, the (primary) informal caregiver completed the assessment. During the assessment, cognitively intact participants were asked for consent to approach their primary informal caregiver, in order to interview him or her on the amount of informal care provided to the participant. If participants did not consent, they answered these questions themselves.

3.4 Instruments

3.4.1 InterRAI-HC

The interRAI-HC is a standardised multidimensional geriatric assessment instrument that is widely used in routine care practices to assess the medical, psychological, social and functional capabilities, care needs, and formal and informal resource utilisation of community dwelling older adults (Hirdes et al., 2008; Landi et al., 2000; Morris et al., 1997). Information on utilisation of formal care services, including home health care (home health aid), home nursing, homemaking services, physical therapy, occupational therapy, and psychological treatment, was collected by registering the number of days and the total number of minutes of care received in the seven days prior to the assessment. With regard to physical therapy, occupational therapy, and psychological treatment, we assumed that the number of days per week that the service was received reflected the number of sessions received during a week. The utilisation of the supportive care service “meals on wheels” was registered in number of days the service was used during the seven days prior to the assessment. The number of hospital admissions, emergency room visits and visits to a physician (specialist, authorised assistant or general practitioner) were registered over the 90 days prior to the assessment (See also Appendix 1). The total number of hours of all informal care and active monitoring provided to a participant in the three days prior to the assessment were assessed to measure the utilisation of informal care services.

In order to estimate the amount of resource utilisation over a period of three months, the resource utilisation was extrapolated to three months for the items with a recall period of seven days. Resource utilisation (number of days, hours of care, or number of sessions) were multiplied by 13 (three months correspond to 13 weeks). Informal care was registered over the past three days. Therefore, the number of hours that informal care was provided was divided by three and multiplied by 91. The interRAI-HC questions on resource utilisation and the extrapolations used are described in Appendix 1. The interRAI-HC assesses the number of hospital stays but does not specify the number of nights. To estimate the number of nights, we used country-specific averages of length of stay during hospital admission in the year 2009 and multiplied these rates by the number of hospital

admissions (OECD, 2015). The average length of stay was calculated in the OECD database by dividing the number of bed days by the number of discharges during a year for all admissions, without taking into account age restrictions. Country-specific averages used in this study are listed in Table 1.

3.4.2 RUD Lite

The RUD Lite was specifically developed to measure resource utilisation from a societal perspective among older adults with dementia (Wimo et al., 2010; Wimo et al., 1998; Wimo & Windblad, 2003; Wimo & Nordberg, 2007; Wimo et al., 2013). The RUD Lite covers a wide range of care services that are not only used by people with dementia, but also by care dependent older adults without cognitive impairment. For the purpose of the present study the recall period of the RUD Lite was extended from 30 days to three months to match up with interRAI-HC recall periods. The adapted language versions were validated for the IBenC study by a process of forward translation, reconciliation and back translation review. The translations were performed by independent qualified translators.

Utilisation of home health care, home nursing, and homemaking services, was registered as average number of times per week and average number of hours and minutes per visit the service was received in the last three months prior the assessment. Use of meals on wheels was recorded as average number of meals per week. Physical therapy, occupational therapy, psychological treatment, emergency room visits, general practitioner visits and outpatient clinic visits were registered as total number of visits in the last three months prior to the assessment. For hospital admissions a distinction was made between admission days on a general ward and an Intensive Care Unit (ICUs). Information was recorded on the number of times a respondent was admitted in the past three months, as well as the total length of stay (number of nights) stratified for ward type.

Informal care provision and supervision provided by the primary informal caregiver was assessed as total number of days during the last three months, as well as the number of hours and minutes on a typical care day during this period. To estimate the total amount of time informal care was provided in the last three months, the number of days was multiplied by the recorded number of hours of informal care received. Also, the share of care provisioning by the primary informal caregiver was recorded (1-20%, 21-40%, 41-60%, 61-80%, 81-100%), as well as the number of other informal caregivers involved. The total amount of time of informal care was estimated by dividing the median value of the answer categories by the amount of time indicated by the primary informal caregiver.

In order to estimate the amount of resource utilisation over a period of three months, the average use of home care services recorded on a weekly basis was extrapolated over three months by multiplying the units by 13. The RUD Lite questions and the extrapolations used are described in Appendix 2.

3.5 Other measures

The interRAI-HC generates various functional scales: Cognitive functioning was assessed using the Cognitive Performance Scale (CPS). Moderate or severe cognitive impairment was considered to be present if the score on the CPS (range 0-6) was three or more (Morris et al., 1994).

The Depression Rating Scale (DRS, range 0-14) was used to assess depressive symptoms with a score of three or more indicating minor or major depressive disorder (Burrows, Morris, Simon, Hirdes, & Phillips, 2000).

Activities of daily living (ADL) needs were assessed using the interRAI Activities of Daily Living Hierarchy Scale (ADLH, range 0-6) with higher scores indicating higher ADL needs (Morris, Fries, & Morris, 1999) and difficulty in performing instrumental activities (iADL) was assessed using the interRAI Instrumental ADL Performance Scale (iADLP, range 0-48). Higher scores indicate more iADL dependencies (InterRAI, 2015).

Pain was considered to be present if the score on the Pain Scale (range 0-3) was one or more (Fries, Simon, Morris, Flodstrom, & Bookstein, 2001).

Multimorbidity was defined to be present when an individual indicated to have two or more chronic medical conditions (Van den Akker, Buntix, Metsemakers, Roos, & Knottnerus, 1998).

3.6 Cost estimates

Care utilisation was valued using Dutch standard costs (Hakkaart-van Rooijen, L., Tan, S., Bouwmans, 2010). Due to the lack of European standard costs, Dutch standard costs were used for all countries, in order to avoid variations in costs due to country specific differences in care valuation. All costs were adjusted for the year 2015 using consumer price indices (CBS, 2015). Six cost categories were distinguished: home care, physician visits, other health care services, hospital admissions, supportive care services, and informal care. Additionally, costs were summed into total societal costs. Table 1 lists the care services per cost category and prices per unit as used in this study. With regard to physician visits, the interRAI-HC makes no distinction between outpatient clinic visits and general practitioner visits. Therefore, physician visits assessed with the interRAI HC were valued using the price of outpatient clinic visits.

Table 1. Overview of used unit cost (in € 2015) and average length of stay (day)

Care service	Costs (€) per unit
Home care	
Home health care	44.77 per hour
Home nursing	70.56 per hour
Physician visits	
General practitioner visit	30.40 per visit
Outpatient clinic visits	78.16 per visit
Other health care services	
Physical therapy	39.08 per session
Occupational therapy	23.88 per session
Psychological treatment	86.85 per session
Hospital admissions	
Hospital admission with overnight stay	
General ward	496.11 per day with overnight stay
ICU	2369.82 per day with overnight stay
Average length of hospital stay*	
Belgium	7.0 days
Finland	12.5 days
Germany	9.7 days
Iceland	5.8 days
Italy	7.6 days
The Netherlands	5.8 days
Emergency room visit (without overnight stay)	163.92 per visit
Supportive care services	
Homemaking services	26.05 per hour
Meals on wheels	7.06 per day
Informal care	
Informal care	13.57 per hour

* Source: OECD, 2015

3.7 Analysis

All analyses were performed using SPSS statistics 20 (IBM Corp, 2011). The demographic and clinical characteristics of the participants, utilisation of formal and informal care, and costs estimates were described using descriptive statistics and frequencies. Differences in baseline characteristics between participants across countries were determined using Chi-square tests and ANOVAs. Mean differences in utilisation rates and costs between the RUD Lite and interRAI-HC were statistically tested using paired sample t-tests. Considering the skewed distribution of the health care utilisation and cost data, 95% confidence intervals (CIs) were estimated using bias-corrected accelerated bootstrapping (5000 replications).

The agreement between the resource utilisation measurements and cost estimates of the interRAI-HC instrument and the RUD Lite instrument was analysed using Spearman's ρ , since the distribution of resource utilisation and costs were skewed. According to Cohen et al. (1998) agreement of 0.10-

0.30 corresponds to weak agreement, 0.30-0.50 moderate agreement and 0.50 or higher corresponds to strong agreement.

The agreement between the total costs of care were also analysed using a Bland and Altman plot (Bland and Altman, 1986). For each participant, the mean of the total societal cost of care based on the RUD Lite and the interRAI-HC was plotted against the difference between total societal cost of care estimates between the RUD Lite and the interRAI-HC. The variability of the differences in cost estimates between the two instruments, and the limits of agreement, that is the interval in which approximately 95% of the differences should lie, were visualized in this plot.

3.7.1 Hypotheses

To evaluate the convergent validity of the interRAI-HC for resource utilisation measurement as compared to the RUD Lite, we hypothesised that the strength of the agreement between interRAI-HC and the RUD Lite *resource utilisation items* was strong (Spearman's $\rho > 0.50$). Twelve predefined hypotheses on resource utilisation were tested: hours of home health care, hours of home nursing, number of physician visits, number of physical therapy sessions, number of occupational therapy sessions, number of psychological treatment sessions, number and duration of hospital admissions, number of emergency room visits, hours of homemaking services, number of meals on wheels, and hours of informal care. We also hypothesised that the agreement between *cost of care estimates* within the six different cost categories and the total societal cost of care utilisation collected with the interRAI-HC instrument and the RUD Lite instrument was strong (seven hypotheses, Spearman's $\rho > 0.50$). In total 19 hypotheses were tested.

3.7.2 Sensitivity analysis

Three sensitivity analyses were performed. A sensitivity analysis was performed using data from Belgium, Finland, Iceland, Italy, and the Netherlands, to test the agreement between cost of care estimates from a health care perspective meaning that informal care costs were excluded from this analysis. We hypothesised that the agreement between total health care cost estimates with the RUD Lite instrument and the interRAI-HC instrument was strong as well (Spearman's $\rho > 0.50$). A second sensitivity analysis was performed using German, Finish, Icelandic, Italian, and Dutch data, to test the agreement for total care cost without home care costs. The following cost categories were included to calculate the total care costs: physician visits, other health care services, hospital admissions, supportive care services, and informal care. We hypothesized that the agreement between total care costs estimates with the RUD Lite and the interRAI-HC instrument was strong (Spearman's $\rho > 0.50$).

Country-specific averages of length of stay during hospital admission based on the OECD database were used in this study to estimate the number of nights spend in the hospital, because this was not recorded with the interRAI-HC. Since the length of stay in the OECD database is based on the number of days spent in the hospital instead of the number of nights as recorded with the RUD Lite, we did a sensitivity analysis in which we subtracted 1 from the average number of hospital days to obtain an estimate of the average number of hospitalization nights.

4 Results

4.1 Study sample

The subsample consisted of 905 participants. In total, 209 (23%) subjects were excluded from data-analyses due to missing values on one or more of the resource utilisation items of the interRAI-HC or RUD Lite. From these 209, one was from Iceland, five from Italy, 28 from Finland, and 10 from the Netherlands. For all German subjects ($n = 63$) specified information was missing on the utilisation of home health care assessed with the RUD Lite, therefore they were excluded from the main analysis. Also all Belgium subjects ($n=102$) were excluded from the main analysis since informal care estimates were not assessed in Belgium due to an error in the Belgian interRAI-HC software. Significant differences ($p < 0.05$) between the participants and the excluded subjects were found. Compared to the participants, the excluded subjects were younger, lived less often alone, reported a higher utilisation of home care services (including home nursing and home health care) assessed with the interRAI-HC, scored higher on ADLH and IADLP, experienced less frequently multimorbidity, and a lower number of caregivers was present.

In total, 639 participants were included in the analyses. A total of 342 informal caregivers were additionally interviewed on the amount of informal care provided to the participant. Participants were on average 83.3 years of age (SD 7.2) and 67% was female. On average participants were limited dependent in ADL and 95% needed limited or more assistance with iADL. Table 2 describes the demographic and clinical characteristics of the participants. Statistically significant differences ($p < 0.05$) between participants across countries were found for age, living status, hours of home care, CPS, DRS, pain, multimorbidity and number of caregivers.

Table 2. Characteristics of the study population

	Total (n=696)	Finland (n=354)	Iceland (n=102)	Italy (n=97)	Netherlands (n=143)	Test statistics	p- value
Mean age (SD)	83.3 (7.2)	83.0 (7.2)	84.8 (6.2)	84.5 (7.6)	82.2 (7.3)	$F = 3.95$	<0.01
Female (n, %)	463 (67%)	238 (67%)	70 (69%)	57 (59%)	98 (69%)	$\chi^2 = 3.17$	0.37
Living alone (n, %)	244 (35%)	287 (81%)	65 (64%)	7 (7%)	93 (65%)	$\chi^2 = 182.50$	<0.01
Mean home care hours (SD)	46.1 (54.7)	60.1 (53.2)	22.3 (34.4)	14.7 (18.6)	49.8 (70.5)	$F = 27.97$	<0.01
Cognitive impairment (CPS ≥ 3) (n, %)	97 (14%)	41 (12%)	6 (6%)	48 (49%)	2 (1%)	$\chi^2 = 128.09$	<0.01
Depressive symptoms (DRS > 3) (n, %)	105 (15%)	28 (8%)	12 (12%)	28 (29%)	37 (26%)	$\chi^2 = 42.48$	<0.01
Mean ADLH score (SD)	1.2 (1.9)	0.8 (1.3)	0.5 (0.9)	4.5 (1.7)	0.7 (1.3)	$F = 243.82$	<0.01
Mean iADLH score (SD)	27.2 (13.2)	27.3 (12.6)	23.4 (11.1)	40.5 (10.7)	21.4 (11.7)	$F = 49.06$	<0.01
Pain (Pain Scale > 0)	419 (60%)	233 (66%)	68 (67%)	43 (45%)	75 (52%)	$\chi^2 = 20.18$	<0.01
Multimorbidity (n, %)	423 (61%)	210 (59%)	62 (61%)	73 (75%)	78 (55%)	$\chi^2 = 11.18$	0.01
Having an informal caregiver (n, %)							
No caregiver present	76 (11%)	59 (17%)	0 (0%)	0 (0%)	17 (12%)	$\chi^2 = 128.90$	<0.01
One caregiver	238 (34%)	158 (45%)	3 (3%)	40 (41%)	37 (26%)		
Two or more caregivers	382 (55%)	137 (39%)	99 (97%)	57 (59%)	89 (62%)		

4.2 Convergent validity

4.2.1 Resource utilisation

Table 3 provides an overview of the utilisation rates of formal and informal care services over a period of three months as assessed with the RUD Lite and the interRAI-HC. Resource utilisation assessed with the RUD Lite was significantly higher for hours of home nursing, the number of physician visits, and significantly lower for the hours of home health care services, the duration of hospital admissions and the number of meals as compared to interRAI-HC assessments ($p < 0.05$). All other differences in resource utilisation estimates between the RUD Lite and interRAI-HC were not statistically significant.

Table 3. Community care resource utilisation estimates over a three-month period assessed with the RUD Lite and InterRAI-HC (n=696)

Service use category	<i>RUD Lite</i>		<i>InterRAI-HC</i>		<i>Mean Difference</i> <i>(RUD Lite- interRAI)</i>	<i>Spearman's ρ</i>
	Use of service n (%)	Mean (SD)	Use of service n (%)	Mean (SD)	Mean (95% CI)	
Home care						
Home health care hours	193 (28%)	13.1 (49.3)	559 (80%)	37.9 (49.5)	-24.7 (-29.4; -20.1)	0.01
Home nursing hours	444 (64%)	34.9 (57.3)	330 (47%)	8.3 (23.2)	26.7 (22.5; 31.1)	0.22*
Physician visits						
Physician visits (GP + outpatient clinic visits)	369 (53%)	1.5 (2.6)	264 (38%)	1.1 (2.2)	0.4 (0.3; 0.6)	0.62*
General practitioner visits	284 (41%)	0.9 (1.6)	-	-	-	-
Outpatient clinic visits	181 (26%)	0.6 (1.8)	-	-	-	-
Other health care services						
Physical therapy sessions	124 (18%)	2.2 (6.2)	85 (12%)	2.2 (6.6)	0 (-0.4; 0.3)	0.72*
Occupational therapy sessions	17 (2%)	0.1 (0.4)	3 (0%)	0.1 (1.2)	0 (-0.1; 0.1)	0.14*
Psychological treatment	5 (1%)	0.0 (0.2)	4 (1%)	0.1 (1)	-0.1 (-0.1; -0.0)	0.67*
Hospital admissions						
Hospital admission with overnight stay, times	118 (17%)	0.2 (0.6)	128 (18%)	0.3 (1.1)	-0.1 (-0.2; 0.0)	0.67*
Hospital admission with overnight stay, nights	108 (16%)	1.5 (5)	128 (18%)	2.8 (8.2)**	-1.3 (-1.9; -0.8)	0.64*
Nights general ward	106 (15%)	1.5 (4.9)	-	-	-	-
Nights ICU	15 (2%)	0.0 (0.4)	-	-	-	-
Emergency room visits without overnight stay	119 (17%)	0.3 (1.1)	116 (17%)	0.2 (0.7)	0.0 (0.0; 0.1)	0.46*
Supportive care services						
Homemaking services hours	223 (32%)	15.2 (58.0)	272 (39%)	13.9 (24.5)	1.3 (-2.3; 5.9)	0.66*
Meals on wheels	222 (32%)	21.9 (37.5)	265 (38%)	27.8 (38.2)	-5.9 (-7.8; -3.8)	0.74*
Informal care hours	442 (64%)	247.1 (518)	514 (74%)	238.7 (441.5)	8.4 (-19.8; 36.3)	0.66*

* $p < 0.01$

** Estimated using OECD data (OECD, 2015)

Eight of the 12 predefined hypotheses regarding the agreement between RUD Lite and interRAI-HC resource utilisation measurement were confirmed. The confirmed hypotheses involved the number of physician visits, the number of physical therapy sessions, the number of psychological treatment sessions, the number and duration of hospital admissions, the number of hours of homemaking services received, the number of meals, and the amount of informal caregiver time. For the number of hours of home health care, the number of hours of home nursing, the number of occupational

therapy sessions, and the number of emergency room visits, our hypotheses could not be confirmed (Spearman's $\rho > 0.5$). Country-specific care utilisation estimates and agreement between the two types of assessments can be found in Appendix 3.

4.2.2 Costs of care

Table 4 provides an overview of the estimated costs over a period of three months as assessed with the RUD Lite and the interRAI-HC. Home care service utilisation costs estimates were statistically significantly higher assessed with RUD Lite in comparison to interRAI-HC costs assessments (mean difference € 773, 95% CI 501; 1,052). Estimated costs for hospital admissions were significantly lower assessed with RUD Lite as compared to interRAI-HC assessments (mean difference €-551, 95% CI (-847; -263). No significant difference in total societal costs of care the between RUD Lite and interRAI-HC assessments was found. In Appendix 4 country-specific cost of care estimates are reported.

All seven predefined hypotheses on the agreement of the cost of care estimates between the RUD Lite and interRAI-HC were confirmed (Spearman's $\rho > 0.5$).

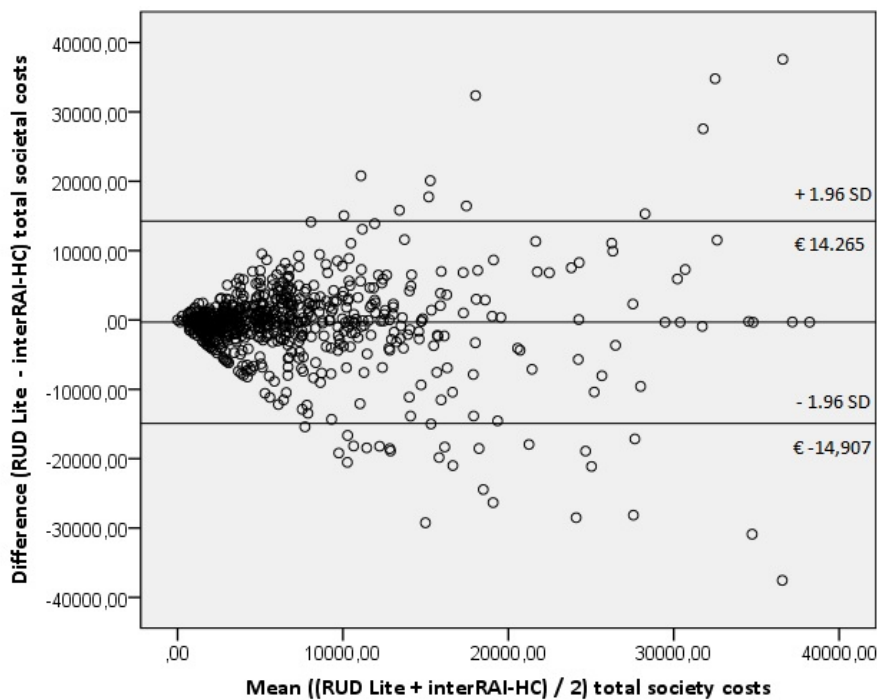
Table 4. Comparison of cost of care estimates (€) over a three month period between care utilisation assessed with the RUD Lite and interRAI-HC

Service use category	<i>RUD Lite</i>	<i>InterRAI-HC</i>	<i>Difference</i> (<i>RUD Lite-InterRAI</i>)	<i>Spearman's ρ</i>
	Mean (SD)	Mean (SD)	Mean (95% CI)	
Home care	3,053 (4,439)	2,279 (2,760)	773 (501; 1,052)	0.50*
Physician visits	75 (155)	83 (175)	-8 (-18; 2)	0.58*
Other health care services	89 (245)	96 (284)	-7 (-22; 7)	0.70*
Hospital admissions	892 (2,888)	1,442 (4,121)	-551 (-847; -263)	0.61*
Supportive care services	552 (1,516)	1,285 (3,613)	-7 (-102; 102)	0.70*
Informal care	3,353 (7,029)	559 (705)	114 (-255; 479)	0.66*
Total societal costs	7,377 (,8828)	3,239 (5,991)	-321 (-867; 220)	0.62*

* p-values are < 0.01

The Bland Altman plot shows that cost differences for the total societal costs between the two methods are becoming larger as the mean of the cost estimates of the two methods is increasing (see Figure 1). This becomes especially clear for participants for whom the mean of the two methods is €10,000 or more. The 95% limits of agreement are wide (-14,907; 14,265) showing considerable variation between the methods.

Figure 1. Bland and Altman plot for the mean difference and 95% limits of agreement for cost of care estimates between the RUD Lite and the interRAI-HC



4.2.3 Sensitivity analysis

A total of 731 subjects were included in the first sensitivity analysis in which the agreement between cost of care estimates from a health care perspective was tested. The demographic and clinical characteristics of these subjects are described in Appendix 5. The difference in total health care costs was €289 between the RUD Lite and interRAI-HC, this difference was not statistically significant. Agreement between the instruments for total health care costs was strong (Spearman's $\rho = 0.60$).

In the second sensitivity analysis in which home care costs were excluded, a total of 733 subjects were included. The demographic and clinical characteristics of these subjects can be found in Appendix 6. The difference in total care costs was €-508 between the RUD Lite and interRAI-HC, also this difference was not statistically significant. Agreement between the instruments for total care costs was strong (Spearman's $\rho = 0.79$).

The use of country-specific averages of length of stay during hospital admission based on the OECD database minus one day resulted in a smaller difference in hospital admission costs between the RUD Lite and the interRAI cost estimates (mean difference € -393 instead of €-551), but this difference was still statistically significant ($p < 0.01$).

5 Conclusion

5.1 Main findings

The objective of this study was to evaluate the convergent validity of the interRAI-HC instrument in comparison to the RUD Lite instrument for estimating formal and informal care utilisation and associated costs in community-dwelling care-dependent older adults from six European countries. In total, 15 of the 19 predefined hypotheses (79%) were confirmed: strong agreement was found between *care utilisation assessments* with RUD Lite and interRAI-HC for eight out of 12 hypotheses (physician visits, physical therapy, psychological treatment, hospital admissions, homemaking services, meals on wheels, and informal caregiver time), and all seven *cost of care utilisation* hypotheses (home care, physician visits, other health care services, hospital admissions, supportive care services, informal care and total societal care costs). These results suggest good convergent validity of the interRAI-HC resource utilisation assessments as compared to the RUD Lite amongst older adults in a community setting.

For use of home health care services and home nursing services only weak agreement was found, and moderate agreement was found for occupational therapy sessions and emergency room visits without overnight stay between the RUD Lite and interRAI-HC assessments. The weak agreement found for home health care and home nursing may be a result of slightly different descriptions used for these care services in the two questionnaires. The RUD Lite instrument provides more comprehensive categories for 'home health aid / health care assistant' and 'district nurse (all types of home visits by registered nurses or similar staff)', in comparison to the interRAI-HC instrument that uses only the terms 'home health aides' and 'home nurse'. When focussing on the rates of home care utilisation assessed with the RUD Lite versus interRAI-HC assessments, more participants reported to receive home nursing (64% versus 47%), and less home health care (28% versus 80%), suggesting ambiguity in the category descriptions. However, the agreement for costs of home care, including the costs of home health care (home health aid) and home nursing, was strong between both instruments. Thus, although there may be differences in the descriptions and the reported amount of home care service utilisation between the RUD Lite and interRAI-HC instruments, the combined estimate of costs for home care use appears to be valid.

The moderate agreement found for the number of occupational therapy sessions and emergency room visits without overnight stay between the RUD Lite and the InterRAI-HC might be a result of the low to zero utilisation of occupation therapy across countries. When looking at country specific agreements for emergency room visits, we noticed that for emergency room visits weak agreement was found for the rates assessed in Iceland, and strong agreement was found for the rates assessed in the other countries. But also like the strong agreement found for the home care cost category, where individual services had low agreement, the agreement for cost of other health services (including occupational therapy sessions) and cost of hospital admissions (including number of emergency room visits) was strong.

For the purpose of the study, only information on utilisation of formal and informal care services that were included in both the interRAI-HC and RUD Lite instrument were taken into account. These care services cover health care services that are most frequently used by older adults in the community. Brown et al (2009) have previously used the InterRAI-HC instrument to estimate cost of care delivery

in a sample of elderly people who are in need of supportive care. In that study, a wide range of irregularly provided care services and preventive examinations were also included. Most of these services are provided for specific diseases (e.g. chemotherapy) or very infrequently (e.g. mammography). Therefore, these services and examinations are expected to contribute only marginally to the total societal costs in a general elderly population and were left out from the current study. Also, in the RUD Lite some resource utilisation services are addressed that are not included in the interRAI-HC. These include care related transportation, psychiatrist, social worker and hours of day care received. Future research is needed to assess the importance of these items for total societal cost estimates and the necessity to include additional items in the interRAI-HC for the purpose of cost of care assessments.

The resource utilisation services included in this study are similar to other cost studies among older adults (Brettschneider et al., 2015; Metzelthin et al., 2015). Metzelthin et al. (2015) calculated the cost of care utilisation over a 24 month period for 346 community dwelling frail older adults in the Netherlands. In that study, information on resource utilisation was collected from health care insurance registries, local hospitals, and directly from the respondents by means of telephone interviews and postal questionnaires. The cost estimates reported in this study (over a three month period), were in line with the estimates found in our study. Only for home care, hospital care, and informal care, approximately 150 to 400% higher costs were found in the current study.

5.2 Strengths and limitations

One of the strengths of this study is that participants from six European countries were included, making the results generalisable for various care contexts. Although some country differences in the agreement between the RUD Lite and the interRAI were present (See Appendixes 3 and 4), the study results show good convergent validity of the interRAI-HC for care utilisation and costs of care estimates across countries. Another strength is that the interviews were administered in the homes of the participant and were, in the case of the interRAI-HC instrument, part of routine care. This has kept the burden for the participants low.

The RUD Lite was chosen as reference instrument because previous studies showed that it has good clinimetric properties when assessing costs of resource utilization of formal and informal care services (Wimo et al., 2010). However, the RUD Lite cannot be considered a gold standard for measuring resource utilisation of formal and informal care services. Also, since the interRAI used a recall period of three months for some service utilisation items, the recall period of the RUD Lite was extended from 30 days to three months. Although it is suggested in the literature that recall periods up to six months are suitable to measure resource utilization (van den Brink et al., 2005), it is unclear to what extent the validity and reliability of the RUD Lite are affected by this adaptation.

A limitation of the study is that we had to exclude approximately one third of the subjects from analyses due missing values on the resource utilisation items in the interRAI-HC or RUD Lite. Also, the utilisation of some health care services, such as psychological treatment was very low across countries (1% of the study population used this service on average). Therefore, the results found for these services should be interpreted with caution.

A number of assumptions were made in this study. Although hospital admissions are known to be a major cost driver for the total health care costs, the interRAI-HC does not record the number of nights spent in a hospital. Therefore, we used the average number of hospitalization days according

to the OECD to calculate the total number of days a participant was admitted to a hospital. Secondly, the interRAI HC does not distinguish between general practitioner visits and outpatient clinic visits. A pragmatic choice was made to value physician visits with the price of outpatient clinic visits, since we assumed that most visits were to an outpatient clinic. However, this might have led to an overestimation of the costs for physician visits in the interRAI-HC since part of these visits may concern less expensive general practitioner visits. Another limitation concerns variation in assessor, mode and timing of the administration of the RUD Lite and the interRAI-HC across countries: two countries administered the instruments by the same assessor during the same contact or after a short period of time (Netherlands and Italy), while in other countries the assessors differed (Belgium, Italy, Iceland) or self-report instead of interview took place (Finland). This may have led to slightly higher agreements than when the questionnaires would have been administered by two independent assessors

This may also explain the large variation in the home health care and home nursing utilisation estimates reported in the interRAI-HC instrument and the RUD Lite instrument in Finland. The study sample consisted for 50% of Finnish participants, the large variation found in Finland probably have led to a lower overall agreement between home health care and home nursing between both questionnaires in the total study population. Finally, Dutch standard costs were used to value care utilisation, this could potentially have an effect on the agreement between the various cost estimates. The use of country specific cost valuations will probably result in lower agreement between the cost of care estimates between both questionnaires.

5.3 Conclusion and recommendations

To the best of our knowledge, this is the first study to assess the convergent validity for resource utilisation measurement of a routine care instrument, the interRAI-HC, as compared to a specifically developed resource utilisation instrument, the RUD Lite. The results suggest that the interRAI-HC instrument can be validly used to measure resource utilisation of formal and informal care services and to estimate societal cost of care utilisation of community dwelling older adults. This finding can substantially improve the feasibility of performing economic evaluations among community dwelling older adults, since the interRAI-HC is internationally already part of routine care in many organisations. By being able to estimate costs using an instrument that is used in routine care, the burden for patients for this type of assessments is reduced considerably. However, to make the interRAI-HC more suitable for costs of care assessments, it is recommended to add the number of overnight hospital stays to the instrument, as well as to include a distinction between visits to a general practitioner and a specialist which will enable more accurate cost estimates. Also, it is recommended to assess the influence of using country-specific valuations on agreement between the assessments.

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Appendix 1 – interRAI-HC resource utilisation and extrapolation

Overview of the interRAI-HC items on resource utilisation and the extrapolations used.

Care service	Definition used in questionnaire	Item - content	Recall period	Extrapolation*
Home health care	Home health aides	Number of days Total minutes	Last 7 days (or since last assessment if less than 7 days)	H*13
Home nursing	Home nurse	Number of days Total minutes	Last 7 days (or since last assessment if less than 7 days)	H*13
Homemaking services	Homemaking services	Number of days Total minutes	Last 7 days (or since last assessment if less than 7 days)	H*13
Meals on wheels	Meals	Number of days	Last 7 days (or since last assessment if less than 7 days)	D*13
Physical therapy	Physical therapy	Number of days Total minutes	Last 7 days (or since last assessment if less than 7 days)	D*13 [#]
Occupational therapy	Occupational therapy	Number of days Total minutes	Last 7 days (or since last assessment if less than 7 days)	D*13 [#]
Psychological treatment	Psychological therapy (by any licensed mental health professional)	Number of days Total minutes	Last 7 days (or since last assessment if less than 7 days)	D*13 [#]
Hospital admission with overnight stay	Inpatient acute hospital with overnight stay	Number of times	Last 90 days (or since last assessment if less than 90 days)	NA
General ward	NA	NA	NA	NA
Nights ICU	NA	NA	NA	NA
Emergency room visit (without overnight stay)	Emergency room visit (not counting overnight stay)	Number of times	Last 90 days (or since last assessment if less than 90 days)	NA
General practitioner	Physician visit (specialist or authorised assistant or practitioner)	Number of times	Last 90 days (or since last assessment if less than 90 days)	NA
Outpatient clinic visit				
Informal care	<i>Informal care and active monitoring Help received from all family, friends, and neighbours for instrumental and personal activities of daily living</i>	Total number of hours	Last 3 days	H/3*91

* D=days; H=total hours; NA=not applicable; T=times; 91 days=13 weeks=3 months.

[#] This is based on the assumption that the number of days per week that the service was received reflected the number of sessions received in a week

Appendix 2 – RUD Lite resource utilisation and extrapolation

Overview of the RUD Lite items and the extrapolations used.

Care service	Definition used in questionnaire	Item - content	Recall period	Extrapolation *
Home health care	Home health aid /health care assistant	Number of times on <i>average</i> per week <i>Average</i> number of hours per visit <i>Average</i> number of minutes per visit	last 3 months	H*T*13
Home nursing	District nurse (all types of home visits by registered nurses or similar staff)	Number of times on <i>average</i> per week <i>Average</i> number of hours per visit <i>Average</i> number of minutes per visit	last 3 months	H*T*13
Homemaking services	Domestic aid	Number of times on <i>average</i> per week <i>Average</i> number of hours per visit <i>Average</i> number of minutes per visit	last 3 months	H*T*13
Meals on wheels	Meals on wheels	Number of times on average per week	last 3 months	T*13
Physical therapy	Physiotherapist	Number of visits	last 3 months	NA
Occupational therapy	Occupational therapist	Number of visits	last 3 months	NA
Psychological treatment	Psychologist	Number of visits	last 3 months	NA
Hospital admission with overnight stay	Hospital admission	Number of times	last 3 months	NA
General ward	Admission general ward	Total number of nights	last 3 months	NA
ICU	Admission ICU	Total number of nights	last 3 months	NA
Emergency room visit (without overnight stay)	care in hospital emergency room	Number of times	last 3 months	NA
General practitioner	General practitioner	Number of visits	last 3 months	NA
Outpatient clinic visit	Specialist at an outpatient clinic	Number of visits	last 3 months	NA
Informal care	informal care (ADL/iADL/supervising) <i>primary informal caregiver</i>			
<i>Informal caregiver version</i>	Time spend assisting the client with tasks such as toilet visits, eating, dressing, grooming, walking and bathing	Number of days Time per day (hours, minutes) on a <i>typical care day</i>	last 3 months	H*D
	Time spend assisting the client with tasks such as shopping, food preparation, housekeeping, laundry, transportation, taking medication and managing financial matters	Number of days Time per day (hours, minutes) on a <i>typical care day</i>	last 3 months	H*D
	Time spend supervising the client (i.e. preventing dangerous events)	Number of days Time per day (hours, minutes) on a <i>typical care day</i>	last 3 months	H*D
<i>Patient version</i>	Time primary caregiver spend assisting you with tasks such as toilet visits, eating, dressing, grooming, walking and bathing	Number of days Time per day (hours, minutes) on a <i>typical care day</i>	last 3 months	H*D
	Time primary caregiver spend assisting you with tasks such as shopping, food preparation, housekeeping, laundry, transportation, taking medication and managing financial matters	Number of days Time per day (hours, minutes) on a <i>typical care day</i>	last 3 months	H*D

* D=days; H=total hours; NA=not applicable; T=times; 91 days=13 weeks=3 months.



Appendix 3 – Country specific resource utilisation

Community care resource utilisation estimates over a three month period assessed with the RUD Lite and InterRAI-HC by country.

Country = Finland (n=354)

Service use category	RUD Lite		InterRAI-HC		Mean Difference (RUD Lite- interRAI)	Spear- man's ρ
	Use of service n (%)	Mean (SD)	Use of service n (%)	Mean (SD)	Mean (95% CI)	
Home care						
Home health care hours	26 (7%)	8.6 (52)	334 (94%)	51.9 (51.9)	-43.2 (-50.5; -35.5)	0.02
Home nursing hours	248 (70%)	49.1 (65.6)	196 (55%)	8.3 (15.7)	40.8 (34.3; 47.9)	0.01
Physician visits						
Physician visits (GP + outpatient clinic visits)	128 (36%)	0.8 (1.5)	89 (25%)	0.5 (1.2)	0.3 (0.1; 0.4)	0.37*
General practitioner visits	102 (29%)	0.6 (1.3)	15 (4%)	0.6 (3.1)	-0.1 (-0.4; 0.2)	0.47*
Outpatient clinic visits	44 (12%)	0.2 (0.6)	-	-	-	-
Other health care services						
Physical therapy sessions	34 (10%)	0.5 (2.2)	-	-	-	-
Occupational therapy sessions	2 (1%)	0.0 (0.1)	2 (1%)	0.1 (1.0)	-0.1 (-0.2; 0.0)	-0.01
Psychological treatment	2 (1%)	0.0 (0.1)	0 (0%)	0.0 (0.0)	0 (-0.0; 0.0)	0.00
Hospital admissions						
Hospital admission with overnight stay, times	54 (15%)	0.3 (0.7)	64 (18%)	0.3 (0.6)	0 (-0.1; 0.1)	0.45*
Hospital admission with overnight stay, nights	46 (13%)	1.4 (5.6)	64 (18%)	3.2 (8.0)**	-2.4 (-3.8; -1.1)	0.42*
Nights general ward	46 (13%)	1.4 (5.5)	-	-	-	-
Nights ICU	1 (0%)	0.0 (0.2)	-	-	-	-
Emergency room visits without overnight stay	56 (16%)	0.3 (1.5)	66 (19%)	0.3 (0.9)	0 (-0.1; 0.1)	0.27*
Supportive care						
Homemaking services hours	34 (10%)	4.3 (16.6)	90 (25%)	8.2 (22.7)	-3.9 (-6.8; -1.1)	0.14*
Meals on wheels	172 (49%)	35.3 (43.6)	208 (59%)	43.8 (40.5)	-8.5 (-12.1; -4.8)	0.65*
Informal care hours	154 (44%)	132.1 (409.6)	248 (70%)	142.2 (348.0)	-10 (-49.3; 31)	0.46*

* $p < 0.01$

** Estimated using OECD data (OECD, 2015)

Country = Iceland (n=102)

Service use category	RUD Lite		InterRAI-HC		Mean Difference	Spear- man's ρ
	Use of service n (%)	Mean (SD)	Use of service n (%)	Mean (SD)	(RUD Lite- interRAI) Mean (95% CI)	
Home care						
Home health care hours	88 (86%)	30.6 (39.3)	77 (75%)	18.2 (33.2)	12.4 (7.9; 17.0)	0.68*
Home nursing hours	36 (35%)	2.7 (6.6)	38 (37%)	4.1 (9.9)	-1.4 (-3.5; 0)	0.61*
Physician visits						
Physician visits (GP + outpatient clinic visits)	71 (70%)	1.5 (1.4)	27 (26%)	0.6 (1.2)	0.9 (0.6; 1.2)	0.39*
General practitioner visits	33 (32%)	0.4 (0.7)	-	-	-	-
Outpatient clinic visits	58 (57%)	1 (1.3)	-	-	-	-
Other health care services						
Physical therapy sessions	30 (29%)	5.2 (9.6)	22 (22%)	4.6 (9.8)	0.6 (-0.8; 2.0)	0.68*
Occupational therapy sessions	1 (1%)	0 (0.1)	0 (0%)	0 (0)	0 (0.0-0.0)	-
Psychological treatment	0 (0%)	0 (0)	0 (0%)	0 (0)	-	-
Hospital admissions						
Hospital admission with overnight stay, times	19 (19%)	0.2 (0.5)	18 (18%)	0.2 (0.4)	0 (0.0; 0.1)	0.63*
Hospital admission with overnight stay, nights	19 (19%)	1.8 (4.7)	18 (18%)	1.1 (2.4)**	0.7 (0; 1.5)	0.64*
Nights general ward	19 (19%)	1.8 (4.7)	-	-	-	-
Nights ICU	0 (0%)	0 (0)	-	-	-	-
Emergency room visits without overnight stay	23 (23%)	0.3 (0.6)	8 (8%)	0.1 (0.5)	0.2 (0; 0.3)	0.64*
Supportive care services						
Homemaking services hours	86 (84%)	11.6 (7.9)	81 (79%)	21.4 (21.5)	-9.8 (-14.3; -5.9)	0.25*
Meals on wheels	25 (25%)	15 (30.5)	25 (25%)	16.4 (31.6)	-1.4 (-6; 3.2)	0.48*
Informal care hours	95 (93%)	192.7 (270.5)	91 (89%)	228.7 (397.8)	-36 (-108.8; 28.1)	0.74*

* $p < 0.01$

** Estimated using OECD data (OECD, 2015)

Country = Italy (n=97)

Service use category	RUD Lite		InterRAI-HC		Mean Difference	Spear- man's ρ
	Use of service n (%)	Mean (SD)	Use of service n (%)	Mean (SD)	(RUD Lite- interRAI) Mean (95% CI)	
Home care						
Home health care hours	27 (28%)	5.6 (14.5)	27 (28%)	5.8 (14.5)	-0.2 (-0.6; -0.1)	1.00*
Home nursing hours	63 (65%)	8.6 (11.4)	63 (65%)	8.9 (11.5)	-0.3 (-0.8; 0.1)	0.94*
Physician visits						
Physician visits (GP + outpatient clinic visits)	49 (51%)	1.4 (2.1)	49 (51%)	1.3 (2.1)	0 (-0.0; 0.1)	0.98*
General practitioner visits	49 (51%)	1.2 (1.8)	-	-	-	-
Outpatient clinic visits	8 (8%)	0.1 (0.4)	-	-	-	-
Other health care services						
Physical therapy sessions	5 (5%)	0.3 (1.3)	6 (6%)	1.1 (4.5)	-0.8 (-1.5; -0.2)	0.91*
Occupational therapy sessions	0 (0%)	0.0 (0.0)	0 (0%)	0.0 (0.0)	-	-
Psychological treatment	0 (0%)	0.0 (0.0)	0 (0%)	0.0 (0.0)	-	-
Hospital admissions						
Hospital admission with overnight stay, times	33 (34%)	0.4 (0.6)	34 (35%)	0.4 (0.6)	0 (-0.0; -0.0)	0.98*
Hospital admission with overnight stay, nights	31 (32%)	3.4 (5.8)	34 (35%)	3.1 (4.5)**	0.1 (-0.4; 0.5)	0.93*
Nights general ward	31 (32%)	3.1 (5.2)	-	-	-	-
Nights ICU	11 (11%)	0.3 (0.8)	-	-	-	-
Emergency room visits without overnight stay	27 (28%)	0.3 (0.5)	29 (30%)	0.3 (0.5)	0 (-0.1; -0.0)	0.96*
Supportive care services						
Homemaking services hours	2 (2%)	0.3 (2.7)	2 (2%)	0.3 (2.7)	-	1.00*
Meals on wheels	1 (1%)	0.0 (0.0)	0 (0%)	0.0 (0.0)	-	-
Informal care hours	86 (89%)	609.3 (635.6)	76 (78%)	496 (511.9)	113.3 (53.7; 179.5)	0.89*

* p < 0.01

** Estimated using OECD data (OECD, 2015)

Country = Netherlands (n=143)

Service use category	RUD Lite		InterRAI-HC		Mean Difference (RUD Lite- interRAI)	Spear- man's ρ
	Use of service n (%)	Mean (SD)	Use of service n (%)	Mean (SD)	Mean (95% CI)	
Home health care						
Home health care hours	52 (36%)	16.9 (60.2)	121 (85%)	38.9 (53.7)	-22.1 (-31.5; -12.3)	0.17*
Home nursing hours	97 (68%)	40.8 (59.1)	33 (23%)	10.9 (43.0)	29.9 (19.9; 40.3)	0.33*
Physician visits						
Physician visits (GP + outpatient clinic visits)	121 (85%)	3.5 (4.2)	99 (69%)	2.7 (3.7)	0.8 (0.4; 1.3)	0.75*
General practitioner visits	100 (70%)	1.8 (2.1)	-	-	-	-
Outpatient clinic visits	71 (50%)	1.6 (3.4)	-	-	-	-
Other health care services						
Physical therapy sessions	55 (38%)	5.5 (9.2)	42 (29%)	5.4 (9.3)	0.2 (-0.7; 1.0)	0.82*
Occupational therapy sessions	14 (10%)	0.2 (0.9)	1 (1%)	0.2 (2.2)	0.1 (-0.3; 0.3)	0.28*
Psychological treatment	3 (2%)	0.1 (0.5)	4 (3%)	0.4 (2.2)	-0.3 (- 0.6; -0.1)	0.86*
Hospital admissions						
Hospital admission with overnight stay, times	12 (8%)	0.1 (0.4)	12 (8%)	0.5 (2.1)	-0.4 (-0.7; -0.1)	1.00*
Hospital admission with overnight stay, nights	12 (8%)	0.5 (2.1)	12 (8%)	2.9 (12.4)**	-2.6 (-4.8; -0.8)	1.00*
Nights general ward	10 (7%)	0.5 (2.1)	-	-	-	-
Nights ICU	3 (2%)	0 (0.2)	-	-	-	-
Emergency room visits without overnight stay	13 (9%)	0.1 (0.4)	13 (9%)	0.1 (0.3)	0 (-0.0; 0.1)	0.74*
Supportive care services						
Homemaking services hours	101 (71%)	55 (116.9)	99 (69%)	32 (27.5)	23.1 (8.1; 41.7)	0.82*
Meals on wheels	24 (17%)	8.5 (22.6)	32 (22%)	15.1 (30.7)	-6.6 (-10.6; -2.9)	0.81*
Informal care hours	107 (75%)	324.6 (663.7)	99 (69%)	310.1 (538.0)	14.5 (-51.4; 82.7)	0.71*

* $p < 0.01$

** Estimated using OECD data (OECD, 2015)

Appendix 4 – Country specific cost of care estimates

Comparison of cost of care estimates (€) over a three month period between care utilisation assessed with the RUD Lite and interRAI-HC by country.

Country = Finland (n=354)

Service use category	<i>RUD Lite</i>	<i>InterRAI-HC</i>	<i>Difference</i> (<i>RUD Lite-InterRAI</i>)	<i>Spearman's ρ</i>
	Mean (SD)	Mean (SD)	Mean (95% CI)	
Home care	3,852 (5,006)	2,906 (2,504)	946 (471; 1,449)	0.35*
Physician visits	33 (67)	38 (91)	-5 (-15; 5)	0.35*
Other health care services	21 (85)	26 (127)	-5 (-19; 7)	0.44*
Hospital admissions	755 (2,981)	1,663 (4,000)	-908 (-1,338; -467)	0.44*
Supportive care services	361 (537)	1,534 (3,683)	-161 (-241; -83)	0.49*
Informal care	1,793 (5,558)	522 (678)	-136 (-669; 421)	0.46*
Total societal costs	6,447 (8,407)	1,929 (4,722)	-636 (-1,473; 215)	0.41*

* p-values are < 0.01

Country = Iceland (n=102)

Service use category	<i>RUD Lite</i>	<i>InterRAI-HC</i>	<i>Difference</i> (<i>RUD Lite-InterRAI</i>)	<i>Spearman's ρ</i>
	Mean (SD)	Mean (SD)	Mean (95% CI)	
Home care	1,555 (1,781)	1,103 (1,629)	452 (221; 688)	0.48*
Physician visits	95 (101)	45 (91)	50 (29; 69)	0.42*
Other health care services	202 (375)	179 (383)	23 (-31; 77)	0.67*
Hospital admissions	922 (2,363)	554 (1,214)	368 (37; 764)	0.59*
Supportive care services	408 (334)	461 (1,008)	-266 (-388; -157)	0.58*
Informal care	2,615 (3,671)	674 (672)	-488 (-1,477; 381)	0.90*
Total societal costs	5,398 (4,895)	3,103 (5,399)	-260 (-1,217; 642)	0.74*

* p-values are < 0.01

Country = Italy (n=97)

Service use category	<i>RUD Lite</i>	<i>InterRAI-HC</i>	<i>Difference</i> (<i>RUD Lite-InterRAI</i>)	<i>Spearman's ρ</i>
	Mean (SD)	Mean (SD)	Mean (95% CI)	
Home care	858 (1,049)	889 (1,045)	-31 (-74; 5)	0.94*
Physician visits	47 (80)	105 (160)	-58 (-75; -42)	0.98*
Other health care services	11 (52)	42 (175)	-31 (-62; -7)	0.91*
Hospital admissions	2,206 (4,173)	1,570 (2,272)	636 (179; 1,144)	0.94*
Supportive care services	9 (71)	9 (71)	--	1.00*
Informal care	8,268 (8,625)	6,730 (6,947)	1,537 (729; 2,435)	0.89*
Total societal costs	9,321 (7,843)	9,345 (7,364)	-24 (-561; 543)	0.90*

* p-values are < 0.01

Country = Netherlands (n=143)

	<i>RUD Lite</i>	<i>InterRAI-HC</i>	<i>Difference (RUD Lite-InterRAI)</i>	<i>Spearman's ρ</i>
Service use category	Mean (SD)	Mean (SD)	Mean (95% CI)	
Home care	3,632 (4,933)	2,511 (3,965)	1,120 (553; 1,701)	0.68*
Physician visits	184 (278)	209 (289)	-25 (-61; 19)	0.72*
Other health care services	227 (360)	246 (433)	-18 (-69; 27)	0.79*
Hospital admissions	317 (1,195)	1,444 (6172)	-1,126 (-2,077; -353)	0.90*
Supportive care services	1,493 (3,041)	1,197 (5,111)	554 (161; 1,047)	0.78*
Informal care	4,405 (9,006)	940 (774)	197 (-698; 1,122)	0.71*
Total societal costs	9,772 (11,564)	4,208 (7,300)	214 (-1,274; 1,732)	0.80*

* p-values are < 0.01

Appendix 5 – Sensitivity analysis total health care cost

A sensitivity analyses was performed to evaluate the convergent validity of the interRAI-HC compared to the RUD Lite for total health care costs estimates. In this analysis informal care costs were excluded. An overview of the results is presented below.

Characteristics of the subjects that were included in the sensitivity analysis.

	Total (n=731)	Belgium (n=32)	Finland (n=354)	Iceland (n=102)	Italy (n=97)	Netherlands (n=146)
Mean age (SD)	83.2 (7.2)	82.7 (6.7)	83 (7.2)	84.8 (6.2)	84.5 (7.6)	82.1 (7.2)
Female (n, %)	465 (67%)	-	238 (67%)	70 (69%)	57 (59%)	100 (68%)
Living alone (n, %)	457 (63%)	3 (9%)	287 (81%)	65 (64%)	7 (7%)	95 (65%)
Mean home care hours (SD)	48.5 (57.9)	98.9 (93.5)	60.1 (53.2)	22.3 (34.4)	14.7 (18.6)	50.2 (70)
Cognitive impairment (CPS ≥ 3) (n, %)	103 (14%)	5 (17%)	41 (12%)	6 (6%)	48 (49%)	3 (2%)
Depressive symptoms (DRS > 3) (n, %)	110 (15%)	5 (16%)	28 (8%)	12 (12%)	28 (29%)	37 (25%)
Mean ADLH score (SD)	1.3 (1.9)	3.3 (1.4)	0.8 (1.3)	0.5 (0.9)	4.5 (1.7)	0.7 (1.3)
Mean iADLH score (SD)	27.5 (13.2)	34.2 (10.5)	27.3 (12.6)	23.4 (11.1)	40.5 (10.7)	21.5 (11.8)
Pain (Pain Scale > 0)	439 (60%)	19 (59%)	233 (66%)	68 (67%)	43 (45%)	76 (52%)
Multimorbidity (n, %)	441 (60%)	16 (50%)	210 (59%)	62 (61%)	73 (75%)	80 (55%)
Having an informal caregiver (n, %)						
No caregiver present	76 (10%)	0 (0%)	59 (17%)	3 (3%)	40 (41%)	17 (12%)
One caregiver	252 (34%)	11 (34%)	158 (45%)	99 (97%)	57 (59%)	40 (27%)
Two or more caregivers	399 (55%)	17 (53%)	137 (39%)	68 (67%)	43 (45%)	89 (61%)

Comparison of cost of care estimates (€) over a three month period between care utilisation assessed with the RUD Lite and interRAI-HC.

Service use category	<i>RUD Lite</i>	<i>InterRAI-HC</i>	<i>Difference</i> (<i>RUD Lite-InterRAI</i>)	<i>Spearman's ρ</i>
	Mean (SD)	Mean (SD)	Mean (95% CI)	
Home care	3,231 (4,575)	2,423 (2,934)	807 (554; 1077)	0.53*
Physician visits	83 (187)	88 (182)	-5 (-17; 8)	0.56*
Other health care services	115 (315)	121 (357)	-6 (-25; 12)	0.70*
Hospital admissions	890 (2,875)	1,411 (4,149)	-521 (-824; -241)	0.61*
Supportive care services	586 (1,531)	572 (709)	14 (-78; 120)	0.71*
Total health care costs	4,905 (5,866)	4,615 (5,381)	289 (-87; 684)	0.60*

Appendix 6 – Sensitivity analysis total care cost (home care costs are excluded)

A second sensitivity analysis was performed to evaluate the convergent validity of the interRAI-HC compared to the RUD Lite for the cost of care estimates when home care costs are excluded. An overview of the results is presented below.

Characteristics of subjects that were included in the second sensitivity analysis.

	Total (n=773)	Finland (n=366)	Germany (n=61)	Iceland (n=102)	Italy (n=99)	Netherlands (n=145)
Mean age (SD)	83.4 (7.3)	83 (7.2)	84.2 (8)	84.8 (6.2)	84.6 (7.6)	82.1 (7.3)
Female (n, %)	514 (66%)	248 (68%)	39 (64%)	70 (69%)	57 (58%)	100 (69%)
Living alone (n, %)	500 (65%)	298 (81%)	36 (59%)	65 (64%)	7 (7%)	94 (65%)
Mean home care hours (SD)	47.2 (55.2)	60.1 (53.2)	58.9 (60)	22.3 (34.4)	14.7 (18.6)	49.8 (70.5)
Cognitive impairment (CPS ≥ 3) (n, %)	115 (15%)	44 (12%)	13 (21%)	6 (6%)	50 (51%)	2 (1%)
Depressive symptoms (DRS > 3) (n, %)	116 (15%)	31 (8%)	7 (11%)	12 (12%)	28 (28%)	38 (26%)
Mean ADLH score (SD)	1.3 (1.9)	0.8 (1.3)	2.4 (1.8)	0.5 (0.9)	4.5 (1.7)	0.7 (1.3)
Mean iADLH score (SD)	27.3 (13.6)	27.2 (12.7)	27.6 (16.3)	23.4 (11.1)	40.6 (10.7)	21.5 (11.8)
Pain (Pain Scale > 0)	428 (60%)	242 (66%)	24 (39%)	68 (67%)	43 (44%)	75 (52%)
Multimorbidity (n, %)	458 (59%)	218 (60%)	6 (10%)	62 (61%)	75 (76%)	79 (54%)
Having an informal caregiver (n, %)						
No caregiver present	82 (11%)	59 (16%)	38 (62%)	3 (3%)	40 (40%)	17 (12%)
One caregiver	286 (37%)	167 (46%)	17 (28%)	99 (97%)	59 (60%)	38 (26%)
Two or more caregivers	405 (52%)	140 (38%)	24 (39%)	68 (67%)	43 (44%)	90 (62%)

Comparison of cost of care estimates (€) over a three month period between care utilisation assessed with the RUD Lite and interRAI-HC.

Service use category	<i>RUD Lite</i>	<i>InterRAI-HC</i>	<i>Difference</i> <i>(RUD Lite-InterRAI)</i>	<i>Spearman's ρ</i>
	Mean (SD)	Mean (SD)	Mean (95% CI)	
Physician visits	76 (149)	94 (174)	-18 (-28; -6)	0.61*
Other health care services	92 (247)	106 (299)	-14 (-30; 2)	0.66*
Hospital admissions	859 (2,838)	1,395 (4,090)	-536 (-822; -272)	0.59*
Supportive care services	540 (1,476)	534 (687)	6 (-82; 109)	0.70*
Informal care	2,814 (6,072)	3,305 (6,023)	10 (-16; 34)	0.65*
Total societal costs	4,381 (7,264)	4,942 (7,330)	-508 (-809; -204)	0.79*