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Multimorbidity and out-of-pocket expenditure on medicine in Europe

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1 # Multimorbidity and out-of-pocket expenditure on medicine in Europe:
2 # longitudinal analysis of 13 European countries between 2013-2015

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29

30   **Abstract**

31   **Background**: Many European Health Systems are implementing or increasing levels of cost-sharing
32   for medicine in response to the growing constrains on public spending on health despite their
33   negative impact on population health due to delay in seeking care.

34   **Objective**: This study aims to examine the relationships between multimorbidity (two or more
35   coexisting chronic diseases, CDs), complex multimorbidity (three or more CDs impacting at least
36   three different body systems), and out-of-pocket expenditure (OOPE) for medicine across European
37   nations.

38   **Methods**: This study utilized data on participants aged 50 years and above from two recent waves of
39   the Survey of Health, Ageing, and Retirement in Europe conducted in 2013 (n=55,806) and 2015
40   (n=51,237). Pooled cross-sectional and longitudinal study designs were used, as well as a two-part
41   model, to analyse the association between multimorbidity and OOPE for medicine.

42   **Results**: The prevalence of multimorbidity was 50·4% in 2013 and 48·2% in 2015. Nearly half of
43   those with multimorbidity had complex multimorbidity. Each additional CD was associated with a
44   34% greater likelihood of incurring any OOPE for medicine (Odds ratio=1·34, 95% CI=1·31 - 1·36).
45   The average incremental OOPE for medicine was 26·4 euros for each additional CD (95% CI=25·1 -
46   27·7), and 32·1 euros for each additional body system affected (95% CI 30·6 - 33·7). In stratified
47   analyses for country-specific quartiles of household income the average incremental OOPE for
48   medicine was not significantly different across groups.

49   **Conclusion**: Between 2013 and 2015 in 13 European Health Systems increased prevalence of CDs
50   was associated with greater likelihood of having OOPE on medication and an increase in the average
51   amount spent when one occurred. Monitoring this indicator is important considering the negative
52   association with treatment adherence and subsequent effects on health.

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65 **INTRODUCTION**

66 Multimorbidity, defined as the presence of two or more coexisting chronic diseases (CDs),(1) is on
67 the rise globally, and its prevalence is expected to rise further as the population ages (1-6). Because
68 of the high complexity of the care they require, people with multimorbidity incur greater health care
69 expenditure and poorer health outcomes, with these relationships being substantially stronger when
70 multimorbidity affects multiple body systems (7). Multimorbidity may have a dipropionate impact on
71 the poor, as studies have shown that the prevalence of multimorbidity is higher among them in high-
72 income nations, and they are more vulnerable to medical costs associated with multimorbidity (8).

73

74 While many nations throughout the world are making progress towards universal health coverage
75 (UHC), recent research have indicated that financial protection for medical costs is being eroded in
76 several European countries as a result of austerity measures and reduced public investment on health
77 (2). According to recent studies on UHC, cost sharing policies have been implemented in Europe
78 throughout the previous decade of public budget restraint, with most of the policy changes related to
79 medicine and outpatient care (2, 9). Monitoring out-of-pocket expenditure (OOPE) on healthcare
80 trends is crucial not just because of the financial burden associated with illness for individuals, but
81 also because of its impact on patients' access to health care, medial adherence, and chronic disease
82 management (2, 10-12).

83

84 Examining the influence of multimorbidity on OOPE for medicine is crucial for policy making
85 because studies have indicated that medicine accounts for the majority of OOPE for people suffering
86 from chronic conditions (13-15). According to a recent systematic study, an increase in the number of
87 chronic conditions was linked with increased OOPE on medicines (13), with the elderly population
88 being more susceptible to OOPE on medicine at all levels of multimorbidity (13, 16). Polypharmacy,
89 which is compounded by the use of single disease-centered guidelines to manage persons with
90 complex care needs, is common in people with multimorbidity and linked to an increase in OOPE on
91 medicine (17). Although recent data reported that OOPE on medicine for the general population
92 accounts for nearly or more than 20% of the health spending in many European countries, including
93 Czech Republic, Estonia, Germany, Italy, Slovenia, and Spain (18), the majority of previous
94 investigations were conducted in countries other than Europe (13), and none of these studies
95 investigated the impact of OOPE on medicine by socioeconomic groups across European nations. To
96 fill this important evidence vacuum, this study aims to investigate the relationship between
97 multimorbidity and OOPE on medicine using longitudinal national representative data from 13
98 European Health Systems from 2013 to 2015, and whether this varied by respondents'
99 socioeconomic position.

100

101 **METHODS**

102 **Data and Sample**

103   We used two waves of data from wave 5 (2013) and wave 6 (2015) of the Survey of Health, Ageing,
104   and Retirement in Europe (SHARE), a European panel database containing nationally representative
105   samples of respondents aged fifty and over from 28 European countries and Israel (19). Respondents'
106   sociodemographic factors, health status (including the presence of chronic illnesses and disability),
107   and health care use and spending are all included in the data. SHARE's methodologies have been
108   described in depth elsewhere (19). It is worth mentioning that while the SHARE dataset's fourth
109   wave covered more nations, OOPE for medicine data was not collected in that wave. Also in wave 7,
110   the bulk of respondents (80%) had missing information on their OOPE for medicine. We did not use
111   wave 8 because it was disrupted by the COVID-19 pandemic outbreak. Data from the following 13
112   countries were considered: Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany,
113   Italy, Luxembourg, Slovenia, Spain, Sweden, and Switzerland, which were preset in both waves 5
114   and 6. Residential care homes residents were excluded from our sample because they are expected to
115   have different health seeking behaviour than noninstitutionalized respondents.

116

117   In 2013 57,879 (wave 5) and in 2015 53,929 (wave 6) individuals aged 50 years and older did not
118   live in a nursing facility. 55, 806 and 51,237 people, respectively, had comprehensive information on
119   the variables of interest listed below. We employed an unbalanced sample of 65,206 individuals with
120   107,043 observations from the two waves.

121

122   **Variables**

123   *Multimorbidity*

124   The main variable of interest was the number of coexisting CDs reported by each respondent. To
125   assess multimorbidity, we considered 17 CDs, including 16 self-reported health conditions (heart
126   attack/problem, hypertension, hypercholesterolemia, stroke/cerebral vascular illness, diabetes, cancer,
127   peptic ulcer, stomach or duodenal ulcer, chronic lung disease, arthritis/rheumatism, Parkinson
128   disease, cataracts, hip or femoral fracture, other fracture, osteoarthritis, Alzheimer
129   disease/dementia/organic brain syndrome/senility/other significant cognitive impairment, other
130   affective/emotional disorders), and one symptom-based health condition (depression). Participants
131   were asked to answer the following question: "Has a doctor ever told you that you had/do you
132   currently have any of the conditions listed on this card?" Clinical depression was the only chronic
133   disease that was not defined based on the answer to this question. The EURO-D scale was used to
134   measure and define it, in agreement with prior studies (1, 20), with scores of 4 or higher indicating
135   the presence of clinically significant depressive symptoms. Asthma and kidney illness were not
136   considered because they were not consistently asked about in the two waves.

137

138   Previous evidence suggested that individuals with complex multimorbidity, defined as the co-
139   occurrence of three or more chronic diseases that affect at least three different body (organ) systems
140   in one person (21, 22), have higher care needs, which might also translate into higher financial
141   burden.(17) Therefore, in our research we also assessed the presence of complex multimorbidity.
142   Using the International Classification of Diseases, 10th revision (ICD-10), CDs were further divided
143   into organ systems, with the following ten being included: neoplasms, endocrine, mental illness,

144 nervous system, eye, circulatory system, respiratory system, digestive system, musculoskeletal or
145 connective tissue, and fracture.

146

147 *Outcome variables*

148 OOPE on pharmaceuticals were the key outcome of interest. The enquiry "About how much did you
149 pay altogether for drugs in the last twelve months? (Include both doctor-prescribed and non-
150 prescription drugs)" led to OOPE on medicines. The OOPE on medicine is expressed in Euros and is
151 adjusted for inflation to the year of the latest data collection (2017) to allow comparisons across time.

152

153 *Covariates*

154 Additional study variables included age (50–59, 60–69, or 70 and older), sex (male, female), marital
155 status (married or in a civil partnership, others), residential country, educational attainment (less than
156 upper secondary, upper secondary, or tertiary education), household income per capita (in quartiles
157 within each country for each wave respectively; the poorest being Q1, the richest being Q4), as proxy
158 of socio-economic position (SEP).

159

160 **Statistical Analyses**

161 We first assessed the prevalence of multimorbidity and complex multimorbidity in each nation, as
162 well as by age group and socioeconomic position. In this analysis, sample weights in SHARE for
163 cross-sectional data were used to ensure that our estimates were comparable throughout time. We
164 further investigated patterns of multimorbidity and presented the percentage of people who had each
165 illness dyad.

166

167 We used two-part model to assess the connections between multimorbidity and OOPE in medicine.
168 When health expenditure represents the population as a whole, rather than just the users of health
169 care, the distributions usually display substantial skewness and have a large mass point at zero (i.e.,
170 truncated at zero) (23-25). In our sample, nearly one-third of observations have zero expenditures on
171 medicine. The health economics literature has settled on the two-part model as the best way to model
172 a dependent variable with a large mass at zero and many positive values (25, 26). Therefore, we first
173 modelled the probability that a person has any OOPE on medicine with a logit model using the full
174 sample and then estimated a generalised linear model (GLM) on the subset of people who have any
175 OOPE on medicine. Following literature (27), we used a Box- Cox test to determine which power
176 function for transforming the dependent expenditure to be closet to symmetric; and the estimated
177 coefficient was 0.06, corresponding to the natural log transformation. We used modified Park test to
178 determine the distribution family; we observed an estimated coefficient of 1.58 which suggested the
179 Gamma distribution. In summary, we use the log link and the gamma distribution for the GLM
180 model. We presented estimated adjusted odds ratios (OR) and coefficients (with 95 percent
181 confidence intervals) from first part and second part of the regression model, respectively. We further

182   estimated average incremental expenditure (in euros) on medicine (combined marginal effects from
183   both parts) of each additional CD from the model (25, 28).

184

185   Analyses were controlled for the covariates listed above. We used a pooled sample of all nations to
186   run the model, which contained dummy variables for each country. To account for the fact that some
187   people appeared in both waves, standard errors were clustered at the individual level to control for
188   serial correlation. Sub-group analysis was carried out by repeating the analysis for each
189   socioeconomic group and each country separately and we reported marginal effects of CDs on OOPE
190   on medicine. STATA 14.0 was used for all statistical analyses.

191

192   Two sets of sensitivity analysis were performed. First, instead of using continuous variables to
193   represent the number of CDs, we used a categorical variable to represent the number of conditions (0,
194   1, 2, 3, and 4 and more conditions) and repeated the primary analysis. Second, we used Cragg's
195   hurdle model for our main analysis, which has also been used in literature to deal with health
196   expenditure or outcomes with mass zeros (29, 30).

197

198   **RESULTS**

199   **Sample Characteristics**

200   We analysed 107,043 observations from 65,206 different people. 54% of our sample were female. In
201   2013, 66.9 percent of respondents were 60 years old or older, compared with 66.4 percent in 2015. In
202   2015, 60.4 percent of respondents had completed at least secondary school, and 30.8 percent were
203   employed (Table 1).

204

205   [Insert Table 1 here]

206

207   **Prevalence of multimorbidity and complex multimorbidity**

208   Figure 1 shows the prevalence of multimorbidity and complex multimorbidity in each country in
209   2013 and 2015. In 2013 and 2015, the prevalence of multimorbidity was 50.4 percent and 48.2
210   percent, respectively, and the prevalence of complex multimorbidity was 25.5 percent and 22.9
211   percent. Nearly half of individuals (49.0 percent) with multimorbidity had complex multimorbidity.
212   In 2015, the prevalence of multimorbidity ranged from 32.1 percent (Switzerland) to 53.3 percent
213   (Estonia) and ranged from 12.4 percent (Switzerland) to 26.9 percent (Estonia) for complex
214   multimorbidity. Though there was a decrease in the prevalence of multimorbidity and complex
215   multimorbidity within our full sample, five countries registered an increase (Austria, Belgium,
216   France, Slovenia and Estonia) from 2013 to 2015. Table S1 reports the prevalence of multimorbidity
217   and complex multimorbidity in each country.

218

219   [Insert Figure 1 here]

220

221   Multimorbidity is depicted in Figure 2 by age group and socioeconomic position. Multimorbidity and
222   complex multimorbidity were shown to be more common as people became older. The prevalence
223   was higher among respondents from lower socioeconomic groups within their country. Except for the
224   richest group, the prevalence of multimorbidity was comparable across other population groups
225   (between 67.3 percent and 68.5 percent) among respondents aged 70 and older. The prevalence
226   figures are presented in Table S2.

227

228   [Insert Figure 2 here]

229

230   On average, multimorbidity affected 1.7 body systems (95%CI 1.67 – 1.69) in 2013 and 1.6 body
231   systems (95%CI 1.55 – 1.57) in 2015 (Table S3), with circulatory system being the most affected
232   body system in both years (44.4%, 95%CI 44.1% - 44.8% in 2013 and 43.1%, 95%CI 42.8% - 43.5%
233   in 2015). Figure 3 depicts the prevalence of co-existing CDs from various body systems in people
234   with multimorbidity. The most common dyad was circulatory system condition and endocrine
235   condition (65.5 percent), followed by circulatory and eye condition (63.6 percent) and mental illness
236   and nervous system condition (61.5 percent).

237

238   [Insert Figure 3 here]

239

240   **Associations between multimorbidity and out-of-pocket expenditure on medicine**

241   On average, among those who occurred relevant costs, total OOPE increased from 331 to 338 euros
242   from 2013 to 215, with more than 50% of the total OOPE spent on medicine (50.2% in 2013 and
243   52.8% in 2015). The country with the largest proportion of total OOPE spent on medicine in 2015
244   was Estonia (71.1%), while the lowest was Switzerland (16.5%; Table S4).

245   Table 2 displays the results of a two-part model that combines logit regression with GLM. According
246   to the logit, each additional CD was associated with a 34% greater likelihood of incurring OOPE on
247   medicine (OR=1.34, 95% CI=1.31 - 1.36). The GLM model suggests that each additional CD was
248   associated with an increase in OOPE spending (regression coefficient 0.15, 95% CI=0.14-0.16). We
249   found that the average incremental spending of each additional CD was 26.4 euros (95%CI 25.1 -
250   27.7), according to the mean marginal effect incorporating both portions of the two-part model.

251

252   [Insert Table 2 here]

253

254 The association between the number of CDs affecting various body systems and OOPE on medicine
255 is shown in Table 3. The effects were similar to those considering CDs but were greater in their
256 magnitude. The average extra expenditure of an additional number of body system was 32.1 euros
257 (95 %CI=30.6 - 33.7), according to the mean marginal effect.

258

259 [Insert Table 3 here]

260

261 We repeated our main analysis using a categorical variable to represent the number of CDs (0, 1, 2, 3,
262 and 4 and more conditions); the results were very comparable to those in the main analyses; and the
263 results reveal that, when compared to persons without CD, those with four or more conditions spent
264 additional 140.7 euros on medicine (Tables S5 and S6). We also used Cragg's hurdle model instead
265 of two-part model for our main analysis. The marginal effects from hurdle model that combining the
266 selection model and outcome model (25.9 euros for additional one CD on OOPE on medicine) were
267 similar compared to those of two-part model. (Tables S7 and S8)

268

269 **Associations between multimorbidity and out-of-pocket expenditure on medicine by SEP**
270 **groups and country**

271 Figure 4 shows the average incremental OOPE on medicine (i.e. marginal effects) for an additional
272 CD by economic status and country. People from the richest quartile of their country spent more
273 OOPE for medicine for each additional CD, as compared with those from the poorest quartile (Q1:
274 25.52 euros, 95%CI=23.10 – 27.95; Q2: 25.00, 95%CI=22.94 – 27.05; Q3: 26.59, 95%CI= 24.09 –
275 29.10; Q4: 29.81, 95%CI=27.27 – 32.35), although confidence intervals overlapped. Belgium,
276 Denmark, and Estonia were the countries where people spent more on OOPE on average (66.0 euros,
277 61.0 euros and 55.7 euros respectively) for each additional number of CDs, while people from France
278 and Slovenia spent much less on medicine out-of- pocket from CDs (8.9 and 9.0 euros). Trends were
279 also confirmed when considering increase in CD from different body systems (Figure 4).

280

281 [Insert Figure 4 here]

282

283 **DISCUSSION**

284 Our study is the first study to focus on the relationships between multimorbidity, complex
285 multimorbidity, and OOPE for medicine across 13 European countries. We discovered that nearly
286 half (48.2 percent) of adults aged 50 and older had multimorbidity in 2015, and 22.9 percent had
287 complex multimorbidity. Although prevalence decreased slightly from 2013 levels (50.4 percent and
288 25.5 percent, respectively), patterns varied significantly between nations, which might partially be
289 explained by the different level of integrated care model implementation for individuals with

290 complex care needs in each country (1). The prevalence was highest among those over the age of 70
291 and those with a poor socioeconomic position. An increased number of CD was associated with an
292 increased risk of experiencing OOPE on medicine and an increase in the average amount spent when
293 one occurred. The average incremental expenditure of each additional CD was 26.4 euros. Whilst the
294 marginal estimated expenditure of OOPE on medicine varied considerably across countries, no
295 significant differences were observed in stratified analyses by country-specific quartiles of household
296 income. When complex multimorbidity was included, the association between multimorbidity and
297 OOPE on medicine was considerably stronger.

298

299 Consistent with previous research demonstrating the health system impoverishment exacerbating the
300 burden of CD in European countries (1, 2, 5), our study discovered that multimorbidity is linked with
301 a substantial rise in OOPE for medication across all socioeconomic categories. However, most of the
302 previous studies focused on the effect of specific chronic conditions, whilst our study examined the
303 impact of multimorbidity, particularly complex multimorbidity.

304

Strength and limitations

306 To our knowledge the current study was the first to examine the impact of multimorbidity,
307 particularly complex multimorbidity on OOPE on medicine in older adults in Europe. Additionally,
308 our research was the first to use a panel data study methodology and to use nationally representative
309 data from 13 European nations. Several limitations merit discussion. To begin, self-reported
310 measures of CD and health care usage may have underestimated their frequency, especially among
311 older adults and those with lower socioeconomic and educational status, who are more prone to
312 underreport these variables (1, 31). Second, some of the country-specific differences we observed
313 might be explained by differences in the Health Systems, especially in regard to cost-sharing policies.
314 However, we conducted country-specific analyses for this specific reason and additionally controlled
315 pooled analyses for countries as fixed effects to remove this variability. Third, the SHARE
316 questionnaire does not contain questions regarding all CDs that are often included in clinical database
317 research (32). Additional research investigating the impact of multimorbidity associated with other
318 prevalent CDs (eg, Alzheimer's disease, and mental health problems) and chronic infectious diseases
319 (eg, TB, AIDS, long coronavirus disease) is also needed. The social patterning of multimorbidity in
320 Europe needs further study that should cover a broader variety of morbidities and more rigors
321 measurements of both mental and physical health than has been previously documented. Future
322 research with an appropriate powering will be necessary to determine the effect of multimorbidity as
323 well as what specific multimorbidity dyads and complex multimorbidity contribute the most to the
324 increasing of OOPE in general and specifically of OOPE on medicine.

325

Policy implications

327 European health systems have lagged behind in responding to the growing burden of multimorbidity
328 (1, 2, 5). Over the last few years, national and international guidelines have been produced to
329 improve care for persons with multimorbidity (33, 34) and integrated care models targeting
330 individuals with specific combinations of chronic diseases have been introduced in a number of
331 countries. However, in the majority of European nations, the quality of care for persons with multiple

332 morbidities remains suboptimal due to fragmented care pathways focused on a single condition,
333 increasing the risk of polypharmacy and associated health expenditure (17, 35). Furthermore, the
334 COVID-19 pandemic has exacerbated health system challenges by reducing integrated care pathways
335 and geriatric rehabilitation services despite increased demand (36).

336

337 Multimorbidity is related with a higher reliance on healthcare and, thus, an increased expenditure on
338 healthcare (1, 2). While new research indicates a global decline in OOPE, this is not the case for
339 OOPE as a share of income (37). Additionally, our findings indicated that OOPE on medications is
340 increasing in European countries over time. As medicine accounts for the majority of out-of-pocket
341 expenditure (13-15), monitoring this statistic is critical, considering increased OOPE on medicine is
342 connected with a larger chance of non-adherence, which has a negative effect on health (11).

343

344 While the increase in OOPE on medicine can be interpreted as further evidence of the erosion of the
345 UHC in European Health Systems, we also discovered that those with lower socioeconomic position
346 were less likely to incur OOPE on medicine. Whilst these findings might be implying that some form
347 of social protection for cost-sharing policies remains in place, we also found that the average
348 expenditure for each additional CD, estimated using marginal effects, was characterized by a positive
349 but non statistically significant gradient when moving from the poorest to the richest group. These
350 differences might be explained by several factors, which might impact the association between CD
351 and OOPE on medicine differently. First, the efficacy of social protection policies might be limited
352 without fully exempting those who are worse off from payment. Second, the most disadvantaged
353 groups might be unable to afford to pay for the medications they need, which might result in delay in
354 seeking care with negative impact on their health. These aspects warrant further research.

355 Ultimately, our findings indicating a significant increase in OOPE for medicine for individuals with
356 multimorbidity are troubling. As CDs can last a lifetime, they can impose significant financial strain
357 over time. Our findings emphasise the importance of enhancing financial protection for individuals
358 with many comorbidities, as they will face a much-increased level of OOPE for medications.

359

360 **Conclusion**

361 Although majority of the European Health Systems have yet to implement specific clinical
362 guidelines, the management of multimorbidity should be an absolute public health priority,
363 considering that over half of adults aged 50 and older in Europe have multimorbidity, and almost a
364 quarter has complex multimorbidity. We found that increased number of CDs was associated with an
365 increased risk of experiencing OOPE on medication and an increase in the average amount spent
366 when one occurred. When complex multimorbidity was included, the association between
367 multimorbidity and OOPE on medicine was considerably stronger. The average incremental OOPE
368 on medicine associated with number of CDs varied substantially across countries but not between
369 SEP groups. As medicine accounts for the majority of OOPE, monitoring this indicator is critical as it
370 can be considered as a proxy of erosion of the UHC in European Health Systems and because
371 increased OOPE on medicine is connected with a larger chance of non-adherence to treatment, which
372 has a negative effect on health.

373

374

375

376   **Figure 1. Prevalence of multimorbidity and complex multimorbidity among people ages 50 and**
377   **older in 13 European countries, 2013-2015**

378   Notes: Complex sample weight applied to the analysis. MM: multimorbidity, defined as the presence
379   of two or more chronic diseases. Complex MM: complex multimorbidity, defined as having three or
380   more chronic diseases impacting at least three different body systems in one person.

381

382   **Figure 2. Prevalence of multimorbidity (A) and complex multimorbidity (B) among people**
383   **ages 50 and older in 13 European countries, analysis in pooled sample of 2013 and 2015, by age**
384   **and socio-economic position**

385   Notes: Complex sample weights applied to the analyses. MM: multimorbidity, defined as the
386   presence of two or more of chronic diseases. Complex MM: complex multimorbidity, defined as
387   having three or more chronic diseases impacting at least three different body systems in one person.
388   Socio-economic position measured using household income per capita, in quintiles within each
389   country for each wave respectively; the poorest being Q1 =1, the richest being Q4=4.

390

391   **Figure 3. The prevalence of co-existing chronic diseases from different body systems for each**
392   **body system condition for people with multimorbidity**

393   Notes: Numbers in the bubble and bubble size represents the prevalence of co-existing chronic
394   diseases from the two corresponding body systems.

395

396   **Figure 4. Average incremental out-of-pocket expenditures on medicine for each additional**
397   **chronic diseases by economic position and country.**

398   Notes: The figure shows the average incremental out-of-pocket expenditures on medicine (i.e.
399   marginal effects) for each additional chronic disease by economic status and country. Estimates were
400   derived from a log link GLM model with gamma distribution. Socio-economic position measured
401   using household income per capita, in quintiles within each country for each wave respectively; the
402   poorest being Q1 =1, the richest being Q4=4.

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410   **Table 1. Sample characteristics of respondents from 13 European countries**

411   Notes: Descriptive statistics were calculated using the survey weights provided.

	2013		2015	
	N	%	N	%
Age group				
50-59 years	14854	33.1%	11786	33.6%
60-69 years	19749	29.5%	18592	29.9%
70+ years	21203	37.4%	20859	36.5%
Gender				
male	24895	46.0%	22469	46.3%
female	30911	54.0%	28768	53.7%
Marital status				
other	16658	35.0%	15806	35.5%
married or in a civil partnership	39148	65.0%	35431	64.5%
Educational attainment				
less than upper secondary	21814	42.7%	19277	39.6%
upper secondary	21482	37.1%	20062	38.9%
above	12509	20.2%	11898	21.5%
Household income				
Q1	13971	26.2%	12826	25.7%
Q2	13936	24.7%	12795	24.3%

Q3	13953	24.6%	12809	24.4%
Q4	13946	24.6%	12806	25.5%
Country				
Austria	3965	2.5%	3068	2.6%
Germany	5433	28.1%	4214	28.5%
Sweden	4376	3.0%	3740	3.0%
Spain	6139	13.6%	4953	13.7%
Italy	4498	20.3%	4883	20.1%
France	4307	20.4%	3673	20.1%
Denmark	3926	1.7%	3554	1.7%
Switzerland	2932	2.5%	2694	2.5%
Belgium	5312	3.4%	5412	3.4%
Czech Republic	5220	3.2%	4516	3.2%
Luxembourg	1509	0.1%	1483	0.1%
Slovenia	2829	0.7%	3972	0.7%
Estonia	5360	0.4%	5075	0.4%
N	55,806		51,237	

413   **Table 2. Association between multimorbidity with OOPE on medicine among people ages 50**
414   **and older in 13 European countries between 2013-2015.**

415   Notes: Estimates obtained from two-part model that the first part is modeled through a logit model to
416   estimate the likelihood of incurring OOPE on medicine, and second part using a generalized linear
417   model with gamma distribution and log link function to model the amount of OOPE on medicine if
418   occurred. Standard errors were clustered at the individual level to control for serial correlation.
419   Margins shows combined marginal effects from both parts of the two-part model. Confidence
420   interval in parentheses. *** statistical significance at the 1% level; ** statistical significance at the
421   5% level; *, statistical significance at the 10% level. GLM: generalised linear model; CD: chronic
422   diseases; CI: confidence interval.

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	First part Logit		Second part GLM		Overall	
	Coefficient	95% CI	Coefficient	95% CI	Margins	95% CI
Number of CDs	1.34***	(1.31 - 1.36)	0.15***	(0.14 - 0.16)	26.39***	(25.10 - 27.68)
Age groups (ref: 50-59 years)						
60-69	1.00	(0.94 - 1.08)	0.07***	(0.02 - 0.12)	7.99***	(2.50 - 13.49)
70+	0.97	(0.90 - 1.04)	0.18***	(0.13 - 0.22)	19.90***	(14.40 - 25.41)
Gender (ref: male)						
Female	1.26***	(1.19 - 1.33)	0.05**	(0.01 - 0.08)	12.06***	(7.46 - 16.65)
Marital status (ref: other)						
Married	1.06*	(1.00 - 1.13)	0.07***	(0.03 - 0.11)	9.62***	(4.92 - 14.32)
Educational attainment (ref: less than secondary school)						
Upper secondary	1.28***	(1.19 - 1.38)	0.02	(-0.03 - 0.06)	9.01***	(3.34 - 14.69)
Tertiary	1.30***	(1.19 - 1.42)	0.10***	(0.04 - 0.16)	19.67***	(12.35 - 26.99)
Socio-economics position (ref: Q1 poorest)						
Q2	1.28***	(1.20 - 1.37)	-0.04**	(-0.08 - -0.00)	2.08	(-3.05 - 7.22)
Q3	1.42***	(1.32 - 1.53)	-0.03	(-0.07 - 0.02)	6.89**	(1.11 - 12.68)
Q4	1.28***	(1.19 - 1.39)	0.05*	(0.00 - 0.09)	12.96***	(6.69 - 19.23)
Country (ref: Austria)						
Germany	1.70***	(1.55 - 1.86)	-0.61***	(-0.66 - -0.56)	-50.13***	(-57.33 - -42.92)
Sweden	3.01***	(2.71 - 3.35)	-0.43***	(-0.48 - -0.38)	-19.26***	(-26.63 - -11.89)
Spain	1.31***	(1.16 - 1.49)	-0.84***	(-0.92 - -0.76)	-72.82***	(-81.02 - -64.62)
Italy	1.25***	(1.14 - 1.38)	-0.05*	(-0.10 - 0.01)	3.48	(-5.27 - 12.22)
France	0.68***	(0.62 - 0.74)	-0.83***	(-0.90 - -0.76)	-86.26***	(-93.49 - -79.03)
Denmark	2.52***	(2.29 - 2.77)	-0.08***	(-0.13 - -0.02)	25.11***	(16.22 - 34.00)

Switzerland	0.63***	(0.57 - 0.69)	0.27***	(0.20 - 0.33)	12.38**	(1.50 - 23.26)
Belgium	3.78***	(3.40 - 4.19)	0.19***	(0.14 - 0.24)	89.91***	(79.88 - 99.94)
Czech Republic	3.62***	(3.14 - 4.18)	-0.97***	(-1.03 - -0.91)	-66.90***	(-74.15 - -59.65)
Luxembourg	1.67***	(1.47 - 1.90)	0.12***	(0.04 - 0.19)	42.99***	(28.76 - 57.23)
Slovenia	0.51***	(0.47 - 0.56)	-0.98***	(-1.06 - -0.89)	-98.54***	(-105.73 - -91.35)
Estonia	4.26***	(3.87 - 4.69)	-0.16***	(-0.21 - -0.12)	24.27***	(16.71 - 31.83)
Year						
2015	1.05**	(1.00 - 1.10)	0.00	(-0.03 - 0.03)	1.78	(-1.99 - 5.56)

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444 **Table 3. Association between complex multimorbidity with OOPE on medicine among people**
445 **ages 50 and older in 13 European countries between 2013-2015.**

446 Notes: Estimates obtained from two-part model that the first part is modeled through a logit model to
447 estimate the likelihood of incurring OOPE on medicine, and second part using a generalized linear
448 model with gamma distribution and log link function to model the amount of OOPE on medicine if
449 occurred. Standard errors were clustered at the individual level to control for serial correlation.
450 Margins show combined marginal effects from both parts of the two-part model. Confidence interval
451 in parentheses. *** statistical significance at the 1% level; ** statistical significance at the 5% level;
452 *, statistical significance at the 10% level. GLM: generalised linear model; CD: chronic diseases; CI:
453 confidence interval.

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Multimorbidity and out-of-pocket expenditure on medicine in Europe

	First part Logit		Second part GLM		Overall	
	Coefficient	95% CI	Coefficient	95% CI	Margins	95% CI
Number of CDs from different body systems	1.43***	(1.39 - 1.46)	0.18***	(0.17 - 0.20)	32.14***	(30.55 - 33.74)
Age groups (ref: 50-59 years)						
60-69	1.00	(0.93 - 1.07)	0.07***	(0.02 - 0.11)	7.48***	(1.96 - 12.99)
70+	0.95	(0.88 - 1.02)	0.17***	(0.13 - 0.22)	18.94***	(13.43 - 24.46)
Gender (ref: male)						
Female	1.25***	(1.18 - 1.32)	0.04**	(0.01 - 0.08)	11.38***	(6.77 - 15.99)
Marital status (ref: other)						
Married	1.06*	(1.00 - 1.13)	0.07***	(0.03 - 0.11)	9.71***	(5.01 - 14.41)
Educational attainment (ref: less than secondary school)						
Upper secondary	1.28***	(1.19 - 1.38)	0.02	(-0.03 - 0.06)	9.11***	(3.42 - 14.79)
Tertiary	1.30***	(1.20 - 1.42)	0.10***	(0.04 - 0.15)	19.78***	(12.49 - 27.06)
Socio-economics position (ref: Q1 poorest)						
Q2	1.28***	(1.20 - 1.37)	-0.05**	(-0.09 - -0.01)	1.60	(-3.58 - 6.78)
Q3	1.42***	(1.32 - 1.53)	-0.03	(-0.08 - 0.02)	6.32**	(0.49 - 12.15)
Q4	1.28***	(1.18 - 1.38)	0.04	(-0.01 - 0.08)	11.69***	(5.39 - 17.98)
Country (ref: Austria)						
Germany	1.68***	(1.54 - 1.84)	-0.62***	(-0.67 - -0.56)	-51.41***	(-58.67 - -44.15)
Sweden	3.00***	(2.70 - 3.33)	-0.44***	(-0.49 - -0.39)	-20.92***	(-28.33 - -13.51)
Spain	1.32***	(1.16 - 1.49)	-0.84***	(-0.92 - -0.76)	-73.54***	(-81.82 - -65.25)
Italy	1.24***	(1.13 - 1.36)	-0.06**	(-0.11 - -0.00)	1.62	(-7.17 - 10.41)
France	0.66***	(0.61 - 0.72)	-0.85***	(-0.92 - -0.78)	-88.53***	(-95.78 - -81.28)
Denmark	2.49***	(2.27 - 2.74)	-0.09***	(-0.14 - -0.03)	23.64***	(14.67 - 32.61)

Switzerland	0.62***	(0.57 - 0.69)	0.26***	(0.19 - 0.32)	10.54*	(-0.36 - 21.45)
Belgium	3.73***	(3.36 - 4.14)	0.18***	(0.13 - 0.23)	88.06***	(77.95 - 98.17)
Czech Republic	3.60***	(3.12 - 4.15)	-0.97***	(-1.03 - -0.91)	-67.70***	(-75.07 - -60.33)
Luxembourg	1.63***	(1.44 - 1.86)	0.11***	(0.03 - 0.18)	40.68***	(26.47 - 54.89)
Slovenia	0.51***	(0.47 - 0.56)	-0.99***	(-1.07 - -0.90)	-100.07***	(-107.27 - -92.87)
Estonia	4.25***	(3.87 - 4.68)	-0.16***	(-0.21 - -0.12)	24.76***	(17.12 - 32.41)
Year						
2015	1.05**	(1.01 - 1.10)	0.00	(-0.03 - 0.03)	1.83	(-1.96 - 5.61)

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491 **Author contributions**

492 RP, TP, and JTL conceived the study. RP, TP, and JTL devised the study methodology. RP and TP did the
493 formal data analysis. RP, TP, SWM, and JTL wrote the first draft of the manuscript. All authors reviewed and
494 edited the manuscript. RP and JTL supervised the study. RP had final responsibility for the decision to submit
495 for publication.

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515 Survey of Health, Ageing and Retirement in Europe (SHARE) data are accessible after registration
516 with the SHARE project at the following addresses: wave 5 (DOI:10.6103/SHARE.w5.710) and
517 wave 6 (DOI:10.6103/SHARE.w6.710).

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