

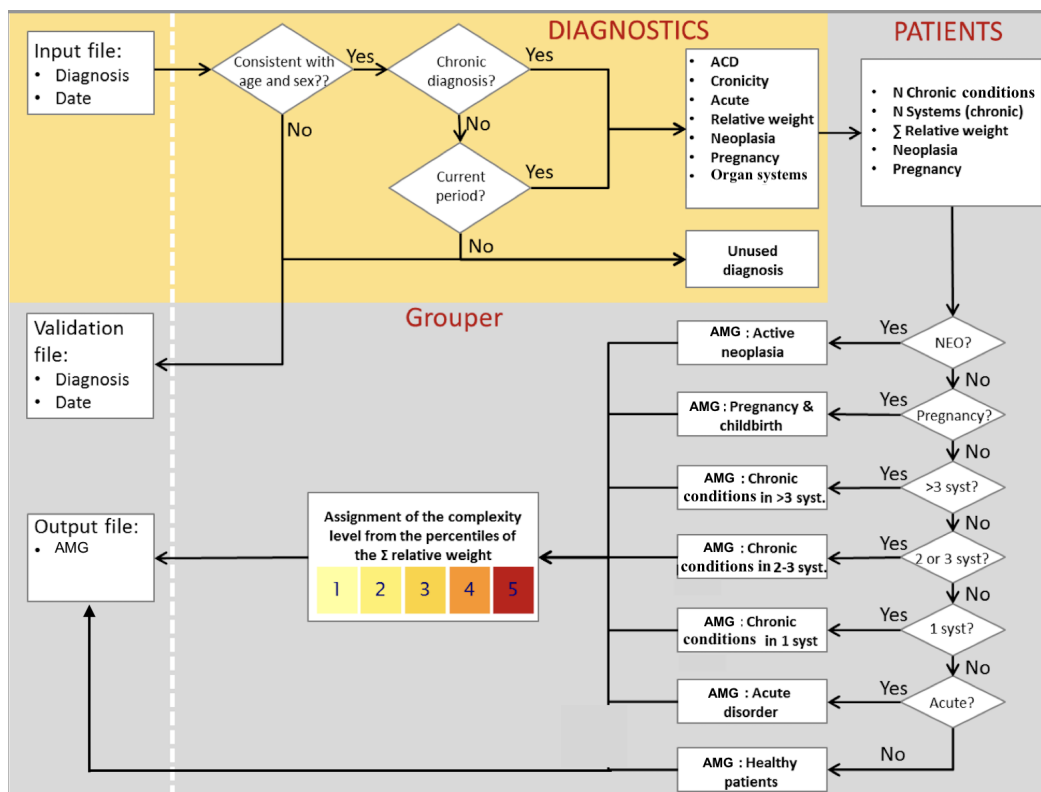
Appendix: Living longer in declining health: factors
driving health care costs among older people

Appendix

Appendix 1. Adjusted Morbidity Groups (AMGs)

In our data a patient is allocated annually to a specific Adjusted Morbidity Group (AMG) according to the ICD10 [1] diagnostic codes recorded across all settings in which the patient received healthcare during the year. The design of AMGs and the process by which each patient is allocated to a specific AMG is explained in the supplementary material of [2] and [3]. Figure A1 summarises the allocation process, which involves two main stages: first, verifying the Diagnostic information and a constructing a set of variables from the ICD10 codes and, second, using these variables to Group each patient to a specific AMG.

Figure A1: AMGs Algorithm



Source: Adapted from supplementary material in Monterder et al. [3]

1) Diagnostics

The first step of the Diagnostics stage involves validating the patient's age and sex.

The next step is to ascertain whether or not the patient has a acute or chronic conditions, and if the latter, what chronic conditions these are. Chronic conditions are defined using a modifica-

tion of the Chronic Condition Indicator (CCI), generated by Agency for Healthcare Research and Quality (AHRQ). ICD10 codes are collapsed into Diagnostic Code Groups (ACDs) using AHRQ's Clinical Classification Software, with ICD10 codes that refer to the same disease being grouped into ACD categories. The coding process also identifies acute disease; neoplasms (cancer); pregnancy and childbirth; and the organ system.

The third step involves calculating a relative weight to be used to identify the patient's level of complexity. The weights were calculated based on a statistical analysis of the relationship between diagnostic information and utilisation of health services for the entire Catalan population of 7.5 million in 2011 [3]. The utilisation measures included in that analysis were:

- mortality,
- primary care contacts,
- outpatient visits,
- hospital admissions,
- community health centers, care homes and hospices,
- mental health care,
- prescriptions and medicines provided in hospital.

For the purposes of that analysis, these measures were aggregated into three main groups: mortality, health care needs and prescriptions. The statistical model yielded a numerical value of complexity for each ACD, which serves as the relative weight.

2) Grouping process allocation

The process of Grouping to a specific AMG utilises information constructed in the first stage, namely: the number of chronic conditions (N chronic conditions); the number of organ systems affected by these chronic conditions (N systems (chronic)); the sum of relative weights across organ systems (\sum relative weight); neoplasia; and pregnancy and childbirth.

Each patient is allocated to one of the 36 mutually exclusive AMGs each year. To arrive at the AMG, patients are first allocated to one of seven broad morbidity categories and then into their AMG according to their clinical complexity.

The seven broad morbidity categories are structured in a hierarchy. Assignment is carried out by affording priority according to the following sequence:

1. patient identified as having an active neoplasia
2. patient identified with pregnancy and/or childbirth-related

3. patient has 4 or more body systems affected by chronic conditions
4. patient has 2 or 3 body systems affected by chronic conditions
5. patient has 1 body system affected by chronic conditions
6. patient has an acute illness and
7. none of the above, hence the healthy population

Once a patient is allocated to one of the seven broad categories, they are then allocated to a complexity level. With the exception of the healthy category, each of the other six morbidity categories is divided into five levels of clinical complexity based on the relative weight assigned to each ACD. The assignment of the five complexity levels are obtained from the percentiles (40th, 70th, 85th, and 95th) of the sum of the relative weight (\sum relative weight) in each of the six morbidity categories.

Appendix 2. Exploring the Healthy category of the AMG

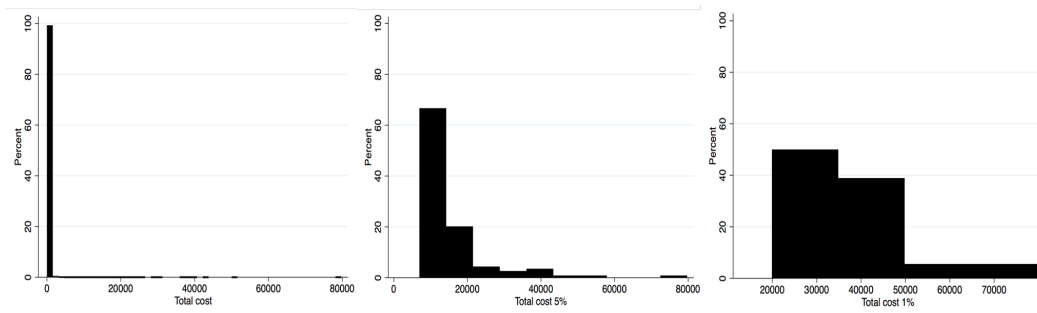
Although 88,025 (63%) of those in the “healthy” AMG category incurred no healthcare costs and 113,985 (81%) had no pharmaceutical costs during the year, a large proportion of those in this group did have some positive expenditure (see left side graph of Figure A2 - (I)). Mean total costs were 119€ and mean pharmaceutical costs were 12€ for all those in this category.

Indeed, some of those in the "healthy" group had very high costs, high enough to place them among those with the highest 5% and 1% annual costs in the full sample. Among the 5% there were 114 (0.08%) people in the "healthy" AMG category; and among the 1% there were 18 (0.01%) in the "healthy" category.

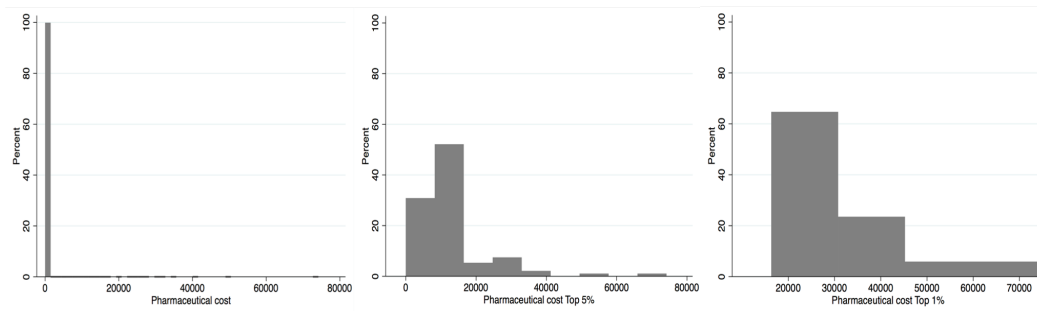
For the 114 people among those with the 5% highest costs, their mean annual total costs were 15,544€ and their pharmaceutical costs were 12,470€ (see central graphs of Figure A2). Their pharmaceutical costs as a proportion of total costs averaged 77%, ranging from 0% to 99%. For the 18 people among those with the 1% highest costs, their mean annual total costs were 34,781€ and their pharmaceutical costs were 30,770€ (see right side graphs of Figure A2). Their pharmaceutical costs as a proportion of total costs averaged 90%, ranging from 66% to 99%. It appears, therefore, that for those considered "healthy" but with high costs, pharmaceutical costs are the main (but not sole) reason for their costs.

This implies that the "healthy" label applied by the AMG system should not be interpreted as meaning that someone is in full health. Rather, the group also comprises those with un-recorded ICD and ATC codes and those with ICD and ATC codes that are not used by the grouping algorithm to allocate people to the other 30 AMGs.

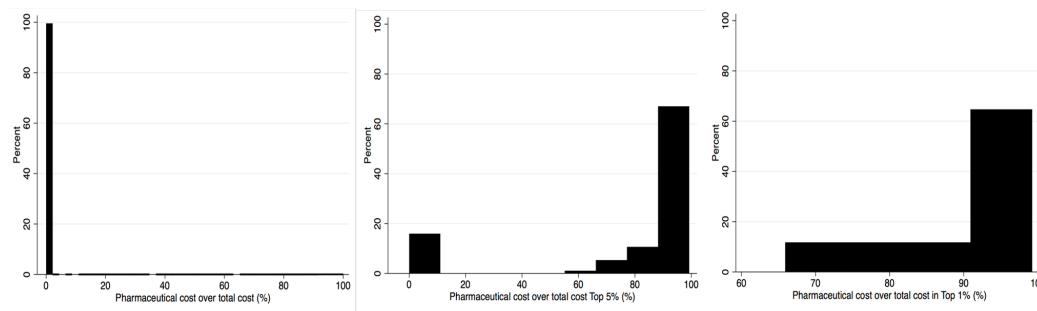
Figure A2: Annual total cost and pharmaceutical cost for AMG=healthy



(I) - Annual total cost



(II) - Annual pharmaceutical cost



(III) - Pharmaceutical cost over total cost (%)

Appendix 3. Results from models excluding AMGs

Table A1: Results: Annual Costs, Top 5% and Top 1% (omitting AMGs)

	(1) Logit (AME) Top 5%	(2) Logit (AME) Top 1%	(3) Logit (AME) Trans. to top 5%	(4) Logit (AME) Trans. to top 1%
Female	-0.020*** (0.001)	-0.006*** (0.0003)	-0.012*** (0.0003)	-0.004*** (0.0002)
Age - 65-74	0.012*** (0.001)	0.003*** (0.0003)	0.008*** (0.0003)	0.002*** (0.0002)
Age - 75-84	0.037*** (0.001)	0.007*** (0.0003)	0.027*** (0.0004)	0.005*** (0.0002)
Age - 85-94	0.046*** (0.001)	0.005*** (0.0004)	0.035*** (0.001)	0.003*** (0.0003)
Age >=95	0.015*** (0.003)	-0.001 (0.001)	0.021*** (0.002)	-0.0002 (0.0007)
SES 18,000-100,000	-0.024*** (0.001)	-0.005*** (0.0002)	-0.014*** (0.0003)	-0.003*** (0.0002)
SES >100,000	-0.035*** (0.002)	-0.006*** (0.001)	-0.023*** (0.001)	-0.005*** (0.001)
SES exempt	0.020*** (0.002)	0.004*** (0.001)	0.010*** (0.001)	0.003*** (0.001)
Died in January	-0.018*** (0.003)	-0.003* (0.001)	-0.016*** (0.002)	-0.003*** (0.001)
Died in February	0.034*** (0.005)	-0.001 (0.002)	0.0001 (0.003)	-0.001 (0.001)
Died in March	0.093*** (0.006)	0.008*** (0.002)	0.028*** (0.004)	0.006*** (0.002)
Died in April	0.166*** (0.009)	0.017*** (0.003)	0.059*** (0.006)	0.011*** (0.003)
Died in May	0.203*** (0.009)	0.034*** (0.004)	0.086*** (0.007)	0.017*** (0.003)
Died in June	0.263*** (0.011)	0.058*** (0.006)	0.108*** (0.008)	0.039*** (0.005)
Died in July	0.259*** (0.010)	0.064*** (0.006)	0.119*** (0.007)	0.045*** (0.005)
Died in August	0.272*** (0.010)	0.077*** (0.006)	0.135*** (0.008)	0.044*** (0.005)
Died in September	0.319*** (0.011)	0.112*** (0.007)	0.160*** (0.009)	0.079*** (0.007)
Died in October	0.331*** (0.011)	0.111*** (0.007)	0.175*** (0.009)	0.076*** (0.006)
Died in November	0.357*** (0.011)	0.120*** (0.007)	0.183*** (0.009)	0.087*** (0.006)
Died in December	0.356*** (0.010)	0.120*** (0.007)	0.204*** (0.008)	0.089*** (0.006)
N	1,485,170	1,485,170	1,264,675	1,264,675
AIC/BIC or Pseudo R ²	0.067	0.059	0.056	0.057
Region fixed-effects	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
SE cluster	patient-level	patient-level	patient-level	patient-level
Years	2011-2017	2011-2017	2011-2017	2012-2017

Notes: Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. SES: Socioeconomic status. Average Marginal Effects (AME) reported. Reference category: male, age 55-64, SES < 18,000, alive.

Table A2: Results: Frequency and persistence among the Top 5% and Top 1% (omitting AMGs)

	(1) OLS Frequency top 5%	(2) OLS Frequency top 1%	(3) OLS Persistence top 5% cons.	(4) OLS Persistence top 1% cons.
Female	-0.101*** (0.004)	-0.030*** (0.002)	-0.089*** (0.003)	-0.029*** (0.002)
Age - 65-74	0.065*** (0.004)	0.015*** (0.002)	0.057*** (0.004)	0.014*** (0.002)
Age - 75-84	0.197*** (0.005)	0.030*** (0.002)	0.164*** (0.005)	0.028*** (0.002)
Age - 85-94	0.148*** (0.006)	-0.016*** (0.003)	0.115*** (0.006)	-0.014*** (0.003)
Age >=95	-0.238*** (0.017)	-0.124*** (0.006)	-0.232*** (0.016)	-0.118*** (0.006)
SES 18,000-100,000	-0.128*** (0.004)	-0.024*** (0.002)	-0.110*** (0.003)	-0.022*** (0.002)
SES >100,000	-0.189*** (0.013)	-0.029*** (0.007)	-0.164*** (0.012)	-0.027*** (0.006)
SES exempt	0.089*** (0.012)	0.017*** (0.005)	0.073*** (0.011)	0.015*** (0.005)
Died 2011	-0.105*** (0.022)	0.040*** (0.013)	-0.032 (0.021)	0.044*** (0.012)
Died 2012	0.205*** (0.024)	0.138*** (0.014)	0.278*** (0.023)	0.141*** (0.013)
Died 2013	0.399*** (0.026)	0.158*** (0.014)	0.453*** (0.024)	0.159*** (0.014)
Died 2014	0.536*** (0.028)	0.218*** (0.016)	0.539*** (0.026)	0.209*** (0.015)
Died 2015	0.612*** (0.028)	0.207*** (0.015)	0.583*** (0.026)	0.200*** (0.015)
Died 2016	0.655*** (0.029)	0.207*** (0.016)	0.581*** (0.027)	0.188*** (0.015)
Died 2017	0.711*** (0.030)	0.237*** (0.016)	0.604*** (0.027)	0.211*** (0.015)
N	224,249	224,249	224,249	224,249
R²	0.090	0.038	0.090	0.038
Region fixed-effects	Yes	Yes	Yes	Yes
SE cluster	patient-level	patient-level	patient-level	patient-level
Years	2011-2017	2011-2017	2011-2017	2011-2017

Notes: Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. SES: Socioeconomic status. Average Marginal Effects (AME). Reference category: male, age 55-64, SES <18,000, alive. The month when the patient died is also included in the models as dummy variables.

Table A3: Results: Frequency and persistence among Top 5% and Top 1% (covariates at 2011)

	(1) OLS Freq.5%	(2) OLS Freq.1%	(3) OLS Pers.5%	(4) OLS Pers.1%	(5) OLS Freq.5%	(6) OLS Freq.1%	(7) OLS Pers.5%	(8) OLS Pers.1%
Female	-0.101*** (0.004)	-0.030*** (0.002)	-0.089*** (0.003)	-0.029*** (0.002)	-0.052*** (0.003)	-0.018*** (0.002)	-0.048*** (0.003)	-0.017*** (0.002)
Age - 65-74	0.065*** (0.004)	0.015*** (0.002)	0.057*** (0.004)	0.014*** (0.002)	-0.005 (0.004)	0.001 (0.002)	-0.004 (0.004)	0.001 (0.002)
Age - 75-84	0.197*** (0.005)	0.030*** (0.002)	0.164*** (0.005)	0.028*** (0.002)	0.005 (0.005)	-0.012*** (0.002)	-6.18e-05 (0.005)	-0.011*** (0.002)
Age - 85-94	0.148*** (0.006)	-0.016*** (0.003)	0.115*** (0.006)	-0.014*** (0.003)	-0.139*** (0.006)	-0.078*** (0.003)	-0.128*** (0.006)	-0.071*** (0.003)
Age >=95	-0.238*** (0.017)	-0.124*** (0.006)	-0.232*** (0.016)	-0.118*** (0.006)	-0.369*** (0.018)	-0.137*** (0.007)	-0.344*** (0.016)	-0.131*** (0.006)
SES 18,000-100,000	-0.128*** (0.004)	-0.024*** (0.002)	-0.110*** (0.003)	-0.022*** (0.002)	-0.050*** (0.003)	-0.006*** (0.002)	-0.044*** (0.003)	-0.006*** (0.002)
SES >100,000	-0.189*** (0.013)	-0.029*** (0.007)	-0.164*** (0.012)	-0.027*** (0.006)	-0.051*** (0.013)	0.002 (0.007)	-0.047*** (0.011)	0.001 (0.006)
SES exempt	0.089*** (0.012)	0.017*** (0.005)	0.073*** (0.011)	0.015*** (0.005)	0.052*** (0.011)	0.008 (0.005)	0.042*** (0.010)	0.007 (0.005)
Died 2011	-0.105*** (0.022)	0.040*** (0.013)	-0.032 (0.021)	0.044*** (0.012)	-0.983*** (0.024)	-0.222*** (0.014)	-0.764*** (0.021)	-0.197*** (0.013)
Died 2012	0.205*** (0.024)	0.138*** (0.014)	0.278*** (0.023)	0.141*** (0.013)	-0.575*** (0.023)	-0.083*** (0.014)	-0.371*** (0.021)	-0.062*** (0.013)
Died 2013	0.399*** (0.026)	0.158*** (0.014)	0.453*** (0.024)	0.159*** (0.013)	-0.389*** (0.023)	-0.061*** (0.014)	-0.202*** (0.022)	-0.042*** (0.014)
Died 2014	0.536*** (0.028)	0.218*** (0.016)	0.539*** (0.026)	0.209*** (0.015)	-0.011 (0.024)	0.069*** (0.015)	0.085*** (0.023)	0.072*** (0.015)
Died 2015	0.612*** (0.028)	0.207*** (0.015)	0.583*** (0.026)	0.200*** (0.015)	0.200*** (0.025)	0.098*** (0.015)	0.241*** (0.024)	0.100*** (0.014)
Died 2016	0.655*** (0.029)	0.207*** (0.016)	0.581*** (0.027)	0.188*** (0.015)	0.334*** (0.026)	0.122*** (0.015)	0.314*** (0.024)	0.109*** (0.014)
Died 2017	0.711*** (0.030)	0.237*** (0.016)	0.604*** (0.027)	0.211*** (0.015)	0.433*** (0.026)	0.166*** (0.016)	0.373*** (0.024)	0.146*** (0.015)
Acute disease c1					0.007 (0.007)	0.003 (0.003)	0.008 (0.007)	0.003 (0.003)
Acute disease c2					0.004 (0.008)	0.002 (0.004)	0.004 (0.008)	0.002 (0.004)
Acute disease c3					0.012 (0.015)	0.008 (0.007)	0.014 (0.015)	0.005 (0.005)
Acute disease c4					0.019 (0.027)	0.025 (0.021)	0.021 (0.027)	0.025 (0.021)
Acute disease c5					0.016 (0.026)	0.004 (0.011)	0.019 (0.026)	0.004 (0.011)
Neoplasm c1					0.292*** (0.011)	0.076*** (0.006)	0.262*** (0.010)	0.071*** (0.005)
Neoplasm c2					0.909*** (0.020)	0.215*** (0.011)	0.765*** (0.018)	0.199*** (0.010)
Neoplasm c3					1.522*** (0.030)	0.394*** (0.019)	1.256*** (0.027)	0.361*** (0.017)
Neoplasm c4					1.888*** (0.037)	0.543*** (0.027)	1.586*** (0.034)	0.507*** (0.025)
Neoplasm c5					2.315*** (0.052)	0.828*** (0.042)	1.995*** (0.050)	0.748*** (0.038)
1 LTC c1					0.013*** (0.004)	0.003 (0.002)	0.013*** (0.004)	0.003 (0.002)
1 LTC c2					0.023*** (0.003)	0.008*** (0.001)	0.024*** (0.003)	0.008*** (0.001)
1 LTC c3					0.064*** (0.007)	0.012*** (0.003)	0.058*** (0.007)	0.011*** (0.0023)
1 LTC c4					0.146*** (0.013)	0.022*** (0.004)	0.135*** (0.012)	0.021*** (0.004)
1 LTC c5					0.191*** (0.018)	0.046*** (0.007)	0.172*** (0.016)	0.044*** (0.007)
2-3 LTC c1					0.044*** (0.004)	0.009*** (0.002)	0.043*** (0.003)	0.009*** (0.002)
2-3 LTC c2					0.100*** (0.004)	0.018*** (0.002)	0.094*** (0.004)	0.018*** (0.002)
2-3 LTC c3					0.184*** (0.006)	0.030*** (0.002)	0.168*** (0.006)	0.028*** (0.002)
2-3 LTC c4					0.253*** (0.009)	0.043*** (0.003)	0.229*** (0.008)	0.041*** (0.003)
2-3 LTC c5					0.490*** (0.013)	0.101*** (0.006)	0.424*** (0.011)	0.093*** (0.005)
4+ LTC c1					0.233*** (0.006)	0.036*** (0.002)	0.208*** (0.005)	0.034*** (0.002)
4+ LTC c2					0.486*** (0.008)	0.085*** (0.003)	0.424*** (0.007)	0.080*** (0.003)
4+ LTC c3					0.829*** (0.014)	0.157*** (0.006)	0.694*** (0.012)	0.145*** (0.006)
4+ LTC c4					1.298*** (0.018)	0.287*** (0.010)	1.069*** (0.016)	0.267*** (0.009)
4+ LTC c5					2.031*** (0.028)	0.613*** (0.020)	1.712*** (0.026)	0.560*** (0.019)
N	224,249	224,249	224,249	224,249	224,249	224,249	224,249	224,249
R ²	0.090	0.038	0.090	0.038	0.257	0.103	0.235	0.099
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE cluster	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Years	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017	2011-2017

Notes: Freq: multiple years among top; Pers: multiple years among top; Significance levels: *** p<0.01, ** p<0.05, * p<0.1. SES: Socioeconomic status. Average Marginal Effects (AME). Reference category: male, age 55-64, SES <18,000, alive, healthy. The month when the patient died is also included in the models as dummy variables.

References

- [1] WHO. International Statistical Classification of Diseases and Related Health Problems 10th Revision; 2019. Available from: <https://icd.who.int/browse10/2019/en#/>.
- [2] Monterde D, Vela E, Clèries M. Los grupos de morbilidad ajustados: nuevo agrupador de morbilidad poblacional de utilidad en el ámbito de la atención primaria. *Aten Primaria*. 2016;48(10):674-82.
- [3] Monterde D, Vela E, Cleries M, Garcia-Eroles L, Roca J, Pérez-Sust P. Multimorbidity as a Predictor of Health Service Utilization in Primary Care: A Registry-Based Study of the Catalan Population. *BMC Fam Pract*. 2020;21(1):39.