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**Supplementary material**

Morin L, Wastesson J, Laroche ML, Fastbom J, Johnell K. How many older adults receive drugs of questionable clinical benefit near the end of life? A cohort study.

- Supplementary Table 1 – List of conditions potentially amenable to palliative care
- Supplementary Table 2 – The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.
- Supplementary Table 3 – Drugs of questionable clinical benefit for older adults ( $\geq 75$  years) with an estimated life expectancy of 3 months or less
- Supplementary Table 4 – Identification of chronic diseases between 5 years and 3 months before death from ICD-10 diagnostic codes and drug dispensing data
- Supplementary Table 5 – Estimation of the Hospital Frailty Risk Score from ICD-10 diagnostic codes
- Supplementary Table 6 – Identification of deaths related to acute and potentially unpredictable fatal events
- Supplementary Table 7 – Sensitivity analysis: continuation and initiation of drugs of questionable clinical benefit during the last 3 months of life of older adults who did not die from an acute and potentially unpredictable fatal event, compared with those who did.
- Supplementary Figure 1 – Subgroup analysis: continuation and initiation of drugs of questionable clinical benefit during the last 3 months of life by illness trajectory and age at death
- Supplementary Table 8 – Subgroup analysis: continuation and initiation of drugs of questionable clinical benefit during the last 3 months of life by living arrangement
- Supplementary Table 9 – Detailed list of drugs of questionable clinical benefit continued during the last 3 months of life
- Supplementary Table 10 – Detailed list of drugs of questionable clinical benefit initiated during the last 3 months of life

**Supplementary Table 1 – List of conditions potentially amenable to palliative care and categorization into illness trajectories**

Illness trajectory, conditions	ICD-10 codes
<b>Cancer (trajectory of short decline with an evident terminal phase)</b>	
Neoplasms and haematological malignancies	C00-C26, C30-C34, C37-C41, C43-C58, C60-C85, C88, C90-C97, D00-D09, D32, D33, D37-D48
<b>Organ failure (trajectory of long-term limitations with intermittent acute episodes)</b>	
Diabetes	E10-E14, G590, G632, H360, M142, N083
Other endocrinal diseases	E70-E72, E75-E77, E84-E85
Infectious and parasitic diseases	A520-A523, A527, A810, A812, B15-B19, B20-B24
Diseases of the blood	D60, D61, D69, D70, D752, D758, D86
Diseases of the cardiovascular system (incl. cerebrovascular diseases)	I231-I233, I238, I25, I50, I60-I64, I67, I688, I69, G46, I65, I66, I680-I682, I27, I42, I43, I51, I520, I70, I73, I74, I792, I970, I971, I978, I980, I981, I988
Diseases of the respiratory system (incl. abnormalities of breathing)	J40-J44, J47, J60-J62, J66, J701, J80, J841, J951-J953, J96, J980-J984, R060, R062-R065, R068
Diseases of the digestive system (incl. liver diseases)	K70-K77, K44, K50, K51, K55, K56, K85, K86, K871, K90
Diseases of the skin	L305, L40-L42, L44, L93, L945
Diseases of the musculoskeletal system	M360, M361, M05, M06, M13, M15, M21, M30-M35, M40-M43, M45-M51, M53, M54, M638, M80, M81, M820, M821, M843, M844, M86-M88, M907, M961
Diseases of the genitourinary system (incl. renal failure)	N02-N05, N11, N12, N136, N160, N18, N19, N25, N312, N318, N319, N82
Other (incl. congenital conditions)	Q01-Q06, Q078, Q079, Q20-Q28, Q31, Q33, Q40-Q45, Q60-Q68, Q714, Q75-Q79, Q850, Q86-87, Q89-Q93, Q95-Q97, Q99
<b>Prolonged dwindling (trajectory of progressive loss of physical and cognitive capacities)</b>	
Alzheimer's disease	G30-G32
Mental and behavioural disorders	F00, F01, F02, F03, F05, F06, R54
Parkinson's disease	G20-G23
Multiple sclerosis	G35-G37
Other diseases of the nervous system	G10, G12, G70-G73, G03-G05, G07, G478, G518, G551, G608, G80-G83, G90-G99

Abbreviations: ICD-10, International Classification of Diseases 10th revision

Reference: Morin L, Aubry R, Frova L, et al. Estimating the need for palliative care at the population level: A cross-national study in 12 countries. *Palliat Med.* 2017;31(6):526–36.

**Supplementary Table 2 – The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.**

Item no	Recommendation	Page or section
Title and abstract	1 The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included.	Page 2, abstract
	If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract.	Page 2, abstract
	If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	Page 2, abstract
<b>Introduction</b>		
Background/rationale	2 Explain the scientific background and rationale for the investigation being reported	Page 4
Objectives	3 State specific objectives, including any prespecified hypotheses	Page 5
<b>Methods</b>		
Study design	4 Present key elements of study design early in the paper	Page 6, §1
Setting	5 Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 6, §1
Participants	6 (1) The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided.	Page 6, §1, eTable1
	(2) Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided.	Page 6, §1 eTable1
	(3) If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	Figure 2
Variables	7 A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	eTables 3, 4, 5 Figure 1
Data sources/ measurement	8* For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 6, §3
Bias	9 Describe any efforts to address potential sources of bias	Page 7, §2
Study size	10 Explain how the study size was arrived at	N.A.
Quantitative variables	11 Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Pages 6–7
Statistical methods	12 (a) Describe all statistical methods, including those used to control for confounding	Page 7, §2
	(b) Describe any methods used to examine subgroups and interactions	Page 7, §2
	(c) Explain how missing data were addressed	Page 7, §2
	(d) If applicable, explain how loss to follow-up was addressed	N.A.
	(e) Describe any sensitivity analyses	Page 7, §2
Data access and cleaning methods	Authors should describe the extent to which the investigators had access to the database population used to create the study population.	Page 14, §1

Item no	Recommendation	Page or section
	Authors should provide information on the data cleaning methods used in the study.	Page 6, §1
	State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	Page 6, §1
<b>Results</b>		
Participants	13* (a) Describe in detail the selection of the persons included in the study (i.e., study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram. (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	Page 8, §1 Figure 2 Page 8, §1 Figure 2
Descriptive data	14* (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	Table 1 Page 7, Table 1 N.A.
Outcome data	15* Report numbers of outcome events or summary measures over time	Table 2
Main results	16 (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Page 8, §2-3 N.A. N.A.
Other analyses	17 Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 8, §2-3 Supplementary Figure 1, eTable8
<b>Discussion</b>		
Key results	18 Summarise key results with reference to study objectives	Page 10, §1
Limitations	19 Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	Page 12§2 Page 13, lines 1-9
Interpretation	20 Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pages 10-11
Generalisability	21 Discuss the generalisability (external validity) of the study results	Page 12, §2
<b>Other information</b>		
Funding	22 Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 14, §2
Accessibility of protocol, raw data, and programming code	Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	Page 14, §6

*\*Reference: Benchimol EI, Smeeth L, Guttman A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The Reporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. PLoS Medicine 2015.*

For Peer Review

### Supplementary Table 3 – Drugs of questionable clinical benefit for older adults ( $\geq 75$ years) with an estimated life expectancy of 3 months or less

The following criteria were developed through a Delphi consensus method. Source: Morin L, Laroche M-L, Vetrano DL, Fastbom J, Johnell K. Adequate, questionable, and inadequate drug prescribing for older adults at the end of life: a European expert consensus. *Eur J Clin Pharmacol*; 2018;74(10):1333–42.

#### Continuation of questionable clinical benefit (ATC code)

Vitamin D (A11CC)  
 Calcium supplement (A12A)  
 Cardiac stimulants other than glycosides (C01C)  
 Antihypertensives, *excluding*  $\alpha$ -blockers (C02)  
 Peripheral vasodilators (C04)  
 Lipid-modifying agents (C10)  
 Immunostimulants (L03A)  
 Drugs for osteoporosis (M05B)  
 Antidementia drugs (N06D)

#### Initiation of questionable clinical benefit (ATC code)

Vitamin D (A11CC)  
 Calcium supplement (A12A)  
 Vitamin K antagonists (B01AA)  
 Novel oral anticoagulants (B01AE, B01AF)  
 Other anticoagulants (B01AD, B01AX)  
 Antianemic drugs (B03A, B03B, B03XA01)  
 Cardiac glycosides, *excluding* digoxin (C01A)  
 Other cardiac stimulants (C01C)  
 Antihypertensives (C02)  
 Peripheral vasodilators (C04)  
 Verapamil (C08DA01)  
 Angiotensin-converting-enzyme inhibitors (C09A, C09B)  
 Angiotensin II antagonists (C09C, C09D)  
 Lipid-modifying agents (C10)  
 Drugs for urinary incontinence, *excluding* oxybutynin (G04BD)  
 Finasteride (G04CA51)  
 Antineoplastic drugs (L01)  
 Endocrine therapies (L02)  
 Immunostimulant (L03A)  
 Immunosuppressants (L04A)  
 Drugs for osteoporosis (M05B)  
 Antidementia drugs (N06D)

Abbreviation: ATC, Anatomical Therapeutic Chemical classification

Additional information about each drug class can be found on the website of the WHO Collaborating Center for Drug Statistics Methodology: [https://www.whocc.no/atc\\_ddd\\_index](https://www.whocc.no/atc_ddd_index)

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**Supplementary Table 4 – Identification of chronic diseases between 5 years and 3 months before death from ICD-10 diagnostic codes and drug dispensing data**

The following algorithm was adapted from Calderón-Larrañaga A, Vetrano DL, Onder G, et al. Assessing and Measuring Chronic Multimorbidity in the Older Population: A Proposal for Its Operationalization. *Journals Gerontol A Biol Sci Med Sci.* 2017;72(10):1417-1423. Compared with the original assessment tool, 9 conditions were excluded from the total number of chronic diseases: allergies, anemia, asthma, chronic ulcer of the skin, colitis, dorsopathies, dyslipidemia, and sleep disorders because near the end of life these conditions can be secondary symptoms of the underlying illness or of the treatments rather than separate entities; and obesity because routinely collected ICD-10 code E66 has been deemed too inaccurate for this condition.

Chronic disease	Clinical diagnoses (ICD-10 codes)	Drug dispensing data (ATC codes and drug indications)
Source(s) of data:	(a) Swedish Cause of Death Register (b) Swedish National Patient Register	Swedish Prescribed Drug Register
Atrial fibrillation	I48	Drug indications in combination with ATC codes C07A, B01A, C01AA05, C01D, C01B or C08D
Autoimmune diseases	I73.1; L10 (excl. L10.5); L12; L40; L41; L93-L95; M30-M36 (excl. M32.0; M34.2; M35.7-M35.9; M36.0; M36.1; M36.2; M36.3)	Drug indications or ATC code D05
Blindness, visual loss	H54 (excl. H54.3); Z44.2; Z97.0	
Blood and blood forming organ diseases	D66-D69 (excl. D68.3; D68.4; D69.5); D71; D72.0; D73.0-D73.2; D74 (excl. D74.8); D75.0; D76.1; D76.3; D77; D80 (excl. D80.7); D81-D84; D86; D89 (excl. D89.1; D89.3)	Drug indication
Bradycardias and conduction diseases	I44.1-I44.3; I45.3; I45.5; Z95.0	Drug indication in combination with ATC codes C01A, C01B or C07A
Cardiac valve diseases	I05-I08; I09.1; I09.8; I34-I38; I39.0-I39.4; Q22; Q23; Z95.2-Z95.4	Drug indication
Cataract and other lens diseases	H25-H28; Q12; Z96.1	Drug indication
Cerebrovascular disease	G45; G46; I60-I64; I67; I69	Drug indication in combination with ATC codes B01A, C10, or N03AX
Chromosomal abnormalities	Q90-Q99	
Chronic infectious diseases	A15-A19; A30; A31; A50-A53 (excl. A51); A65-A67; A69.2; A81; B20-B24; B38.1; B39.1; B40.1; B57.2-B57.5; B65; B92; B94; J65; M86.3-M86.6	J04A, excl. J04AB01, J04AB02, J04AB03 and J04AC
Chronic kidney disease	I12.0; I13.0-I13.9; N01, N02, N04, N05; N07; N08; N11; N18.3-N18.9; Q60; Q61.1-Q61.9; Z90.5; Z94.0	Drug indication in combination with ATC codes A02AH, A11, A12, B03AX, C09 or C03CA
Chronic liver disease	B18; K70 (excl. K70.0; K70.1); K71.3-K71.5; K71.7; K72.1; K73; K74; K75.3-K75.8; K76.1; K76.6; K76.7; K77.8; Q44.6; Z94.4	Drug indication or ATC codes A05AA02, A06AD11



Chronic disease	Clinical diagnoses (ICD-10 codes)	Drug dispensing data (ATC codes and drug indications)
Chronic pancreas, biliary tract and gallbladder diseases	K80.0; K80.1; K80.2; K80.8; K81.1; K86 (excl. K86.2; K86.3; K86.9); Q44.0-Q44.5; Q45.0	ATC code A09AA02
COPD, emphysema, chronic bronchitis	J41-J44; J47	ATC code R03BB, or drug indication in combination with ATC codes H02AB, J01A, J01C, N02A, R03, or R05.
Deafness, hearing loss	H80; H90; H91.1; H91.3; H91.9; Q16; Z45.3; Z46.1; Z96.2; Z97.4	
Dementia	F00-F03; F05.1; G30; G31 [R54 if only cause of death available]	ATC code N06D, or drug indication
Depression and mood diseases	F30-F34; F38; F39; F41.2	Drug indication in combination with ATC codes N03A, N05AD, N05AH, N05AN, N05AX, N06A
Diabetes	E10; E11; E13; E14; E89.1	ATC code A10
Ear, nose, throat diseases	H60.4; H66.1-H66.3; H70.1; H71; H73.1; H74.1; H81.0; H83.1; H83.2; H95; J30.0; J31-J33; J34.1-J34.3; J35; J37; J38.0; J38.6; K05.1; K05.3; K07; K11.0; K11.7; Q30-Q32; Q35-Q38	
Epilepsy	G40 (excl. G40.5)	Drug indication
Esophagus, stomach and duodenum diseases	I85; I86.4; I98.2; I98.3; K21; K22.0; K22.2; K22.4; K22.5; K22.7; K23.0; K23.1; K25.4-K25.7; K26.4-K26.7; K27.4-K27.7; K28.4-K28.7; K29.3-K29.9; K31.1-K31.5; Q39; Q40; Z90.3	ATC code A02BX, or drug indication in combination with ATC code A02
Glaucoma	H40.1-H40.9	ATC code S01ED or drug indication
Heart failure	I11.0; I13.0; I13.2; I27; I28.0; I42; I43; I50; I51.5; I51.7; I52.8; Z94.1; Z94.3	Drug indication in combination with ATC codes C01, C03, C07A or C09
Hematological neoplasms	C81-C96	
Hypertension	I10-I15	Drug indication in combination with ATC codes C02, C03, C07, C08, or C09
Inflammatory arthropathies	M02.3; M05-M14; M45; M46.0; M46.1; M46.8; M46.9	ATC code M01CB, or drug indication in combination with ATC codes H02AB, L04, M04
Inflammatory bowel disease	K50; K51	ATC code A07E, or indication for Crohn's disease
Ischemic heart disease	I20-I22; I24; I25; Z95.1; Z95.5	ATC code C01DA or C01EB18, or drug indication in combination with ATC codes C01 to C10.
Migraine and facial pain syndromes	G43; G44.0-G44.3; G44.8; G50	ATC code N02C or drug indication
Multiple sclerosis	G35	Drug indication
Neurotic, stress-related and somatoform diseases	F40-F48 (excl. F43.0; F43.2)	
Osteoarthritis and other degenerative joint diseases	M15-M19; M36.2; M36.3	Drug indication in combination with ATC code M



Chronic disease	Clinical diagnoses (ICD-10 codes)	Drug dispensing data (ATC codes and drug indications)
Osteoporosis	M80-M82	ATC codes M05BA; M05BB; M05BX03; M05BX53, or drug indication in combination with ATC code M05
Other cardiovascular diseases	I09 (excl. I09.1; I09.8); I28.1; I31.0; I31.1; I45.6; I49.5; I49.8; I70-I72 (excl. I70.2); I79.0; I79.1; I95.0; I95.1; I95.8; Q20; Q21; Q24-Q28; Z95.8; Z95.9	
Other digestive diseases	K66.0; K90.0-K90.2; K91.1; K93; Q41-Q43; R15; Z90.4; Z98.0	
Other eye diseases	H02.2-H02.5; H04 (excl. H04.3); H05 (excl. H05.0); H10.4; H17; H18.4-H18.9; H19.3; H19.8; H20.1; H21; H31.0-H31.2; H31.8; H31.9; H33; H35.2-H35.5; H35.7-H35.9; H36; H47-H49 (excl. H47.0; H47.1; H48.1); H51; Q10-Q15 (excl. Q12); Z94.7	
Other genitourinary diseases	B90.1; N20.0; N20.2; N20.9; N21.0; N21.8; N21.9; N22; N30.1-N30.4; N31; N32.0; N32.3; N32.8; N32.9; N33; N35; N39.3; N39.4; N48.0; N48.4; N48.9; N70.1; N71.1; N73.1; N73.4; N73.6; N76.1; N76.3; N81; N88; N89.5; N90.5; N95.2; Q54; Q62.0-Q62.4; Q62.7; Q62.8; Q63.8; Q63.9; Q64.0; Q64.1; Q64.3-Q64.9; Z90.6; Z90.7; Z96.0	Drug indication
Other metabolic diseases	E20-E31 (excl. E23.1; E24.2; E24.4; E27.3; E30); E34 (excl. E34.3; E34.4); E35 (excl. E35.0); E40-E46 (excl. E44.1); E64; E70-E72; E74-E77; E79 (excl. E79.0); E80 (excl. E80.4); E83-E89 (excl. E86; E87; E88.3; E89.0; E89.1); K90.3; K90.4; K90.8; K90.9; K91.2; M83; M88; N25	
Other musculoskeletal and joint diseases	B90.2; M21.2-M21.9; M22-M24; M25.2; M25.3; M35.7; M61; M65.2-M65.4; M70.0; M72.0; M72.2; M72.4; M75.0; M75.1; M75.3; M75.4; M79.7; M84.1; M89; M91; M93; M94; M96; M99; S38.2; S48; S58; S68; S78; S88; S98; T05; T09.6; T11.6; T13.6; T14.7; T90-T98; Q65; Q66; Q68; Q71-Q74; Q77; Q78; Q79.6; Q79.8; Q87; Z44.0; Z44.1; Z89.1-Z89.9; Z94.6; Z96.6; Z97.1	Drug indication
Other neurological diseases	B90.0; D48.2; G04.1; G09-G14 (excl. G13.0; G13.1); G24-G26 (excl. G25.1; G25.4; G25.6); G32; G37; G51-G53 (excl. G51.0); G70; G71; G72.3-72.9; G73 (excl. G73.2-G73.4); G80-G83 (excl. G83.8); G90; G91; G93.8; G93.9; G95; G99; M47.1; Q00-Q07; Q76.0	

Chronic disease	Clinical diagnoses (ICD-10 codes)	Drug dispensing data (ATC codes and drug indications)
Other psychiatric and behavioral diseases	F04; F06; F07; F09; F10.2; F10.6; F10.7; F11.2; F11.6; F11.7; F12.2; F12.6; F12.7; F13.2; F13.6; F13.7; F14.2; F14.6; F14.7; F15.2; F15.6; F15.7; F16.2; F16.6; F16.7; F17.2; F17.6; F17.7; F18.2; F18.6; F18.7; F19.2; F19.6; F19.7; F50; F52; F60-F63; F68; F70-F89; F95; F99	ATC code N07BB or indication for alcohol-related dependence
Other respiratory diseases	B90.9; E66.2; J60-J67; J68.4; J70.1; J70.3; J70.4; J84; J92; J94.1; J95.3; J95.5; J96.1; J98 (excl. J98.1); Q33; Q34; Z90.2; Z94.2; Z94.3; Z96.3	
Other skin diseases	L13; L28; L30.1; L43 (excl. L43.2); L50.8; L58.1; L85; Q80; Q81; Q82.1; Q82.2; Q82.9	
Parkinson and parkinsonism	G20-G23 (excl. G21.0)	ATC codes N04BA; N04BC; N04BX, or drug indication
Peripheral neuropathy	B91; G54-G60; G62.8; G62.9; G63 (excl. G63.1); M47.2; M53.1; M54.1	Drug indication
Peripheral vascular disease	I70.2; I73 (excl. I73.1; I73.8); I79.2; I79.8	ATC code B01AC23
Prostate diseases	N40; N41.1; N41.8	ATC code G04C (excl. G04CB), or drug indication
Schizophrenia and delusional diseases	F20; F22; F24; F25; F28	Drug indication in combination with ATC code N05
Solid neoplasms	All C (excl. C81-C96); D00-D09; D32.0; D32.1; D32.9; D33.0-D33.4; Q85	ATC code L01X, or drug indication
Thyroid disease	E00-E03 (excl. E03.5); E05; E06.2; E06.3; E06.5; E07; E35.0; E89.0	ATC codes H03AA; H03B; or drug indication in combination with ATC code H03
Venous and lymphatic diseases	I78.0; I83; I87; I89; I97.2; Q82.0	

Abbreviations: ICD-10: International Classification of Diseases, 10th revision; ATC: Anatomical Therapeutic Chemical classification system

#### More information about the Swedish cause of death register, the Swedish national patient register and the Swedish Prescribed Drug Register:

- Brooke HL, Talbäck M, Hörnblad J, et al. The Swedish Cause of Death Register. *Eur J Epidemiol.* 2017;32(9):765-773.
- Ludvigsson JF, Andersson E, Ekbom A, et al. External review and validation of the Swedish national inpatient register. *BMC Public Health.* 2011;11(1):450.
- Wettermark B, Hammar N, Fored CM, et al. The new Swedish Prescribed Drug Register. Opportunities for pharmacoepidemiological research and experience from the first six months. *Pharmacoepidemiol Drug Saf.* 2007;16(7):726-735.

Supplementary Table 5 – Estimation of the Hospital Frailty Risk Score from ICD-10 diagnostic codes

The Hospital Frailty Risk Score was initially developed and validated for older adults in acute care settings. For the present study, it was computed based on ICD-10 codes reported in all inpatient and specialized outpatient care discharge reports from 5 years to 3 months before death. Source: Gilbert T, Neuburger J, Kraindler J, et al. Development and validation of a Hospital Frailty Risk Score focusing on older people in acute care settings using electronic hospital records: an observational study. *Lancet*. 2018;391(10132):1775-1782.

#	ICD-10 code	Description	Weight
1	F00	Dementia in Alzheimer's disease	7.1
2	G81	Hemiplegia	4.4
3	G30	Alzheimer's disease	4
4	I69	Sequelae of cerebrovascular disease (secondary codes)	3.7
5	R29	Other symptoms and signs of the nervous and musculoskeletal systems	3.6
6	N39	Other disorders of urinary system (e.g. urinary tract infection)	3.2
7	F05	Delirium, not induced by alcohol and other psychoactive substances	3.2
8	W19	Unspecified fall	3.2
9	S00	Superficial injury of head	3.2
10	R31	Unspecified haematuria	3
11	B96	Other bacterial agents as the cause of diseases	2.9
12	R41	Other symptoms and signs involving cognitive functions and awareness	2.7
13	R26	Abnormalities of gait and mobility	2.6
14	I67	Other cerebrovascular diseases	2.6
15	R56	Convulsions, not elsewhere classified	2.6
16	R40	Somnolence, stupor and coma	2.5
17	T83	Complications of genitourinary prosthetic devices, implants and grafts	2.4
18	S06	Intracranial injury	2.4
19	S42	Fracture of shoulder and upper arm	2.3
20	E87	Other disorders of fluid, electrolyte and acid-base balance	2.3
21	M25	Other joint disorders, not elsewhere classified	2.3
22	E86	Volume depletion	2.3
23	R54	Senility	2.2
24	Z50	Care involving use of rehabilitation procedures	2.1
25	F03	Unspecified dementia	2.1
26	W18	Other fall on same level	2.1
27	Z75	Problems related to medical facilities and other health care	2
28	F01	Vascular dementia	2
29	S80	Superficial injury of lower leg	2
30	L03	Cellulitis	2
31	H54	Blindness and low vision	1.9
32	E53	Deficiency of other B group vitamins	1.9
33	Z60	Problems related to social environment	1.8
34	G20	Parkinson's disease	1.8
35	R55	Syncope and collapse	1.8
36	S22	Fracture of rib(s), sternum and thoracic spine	1.8
37	K59	Other functional intestinal disorders	1.8
38	N17	Acute renal failure	1.8
39	L89	Decubitus ulcer	1.7

Supplementary Table 5 – Continued

#	ICD-10 code	Description	Weight
40	Z22	Carrier of infectious disease	1.7
41	B95	Streptococcus and staphylococcus	1.7
42	L97	Ulcer of lower limb, not elsewhere classified	1.6
43	R44	Other symptoms and signs involving general sensations and perceptions	1.6
44	K26	Duodenal ulcer	1.6
45	I95	Hypotension	1.6
46	N19	Unspecified renal failure	1.6
47	A41	Other septicaemia	1.6
48	Z87	Personal history of other diseases and conditions	1.5
49	J96	Respiratory failure, not elsewhere classified	1.5
50	X59	Exposure to unspecified factor	1.5
51	M19	Other arthrosis	1.5
52	G40	Epilepsy	1.5
53	M81	Osteoporosis without pathological fracture	1.4
54	S72	Fracture of femur	1.4
55	S32	Fracture of lumbar spine and pelvis	1.4
56	E16	Other disorders of pancreatic internal secretion	1.4
57	R94	Abnormal results of function studies	1.4
58	N18	Chronic renal failure	1.4
59	R33	Retention of urine	1.3
60	R69	Unknown and unspecified causes of morbidity	1.3
61	N28	Other disorders of kidney and ureter, not elsewhere classified	1.3
62	R32	Unspecified urinary incontinence	1.2
63	G31	Other degenerative diseases of nervous system, not elsewhere classified	1.2
64	Y95	Nosocomial condition	1.2
65	S09	Other and unspecified injuries of head	1.2
66	R45	Symptoms and signs involving emotional state	1.2
67	G45	Transient cerebral ischaemic attacks and related syndromes	1.2
68	Z74	Problems related to care-provider dependency	1.1
69	M79	Other soft tissue disorders, not elsewhere classified	1.1
70	W06	Fall involving bed	1.1
71	S01	Open wound of head	1.1
72	A04	Other bacterial intestinal infections	1.1
73	A09	Diarrhoea and gastroenteritis of presumed infectious origin	1.1
74	J18	Pneumonia, organism unspecified	1.1
75	J69	Pneumonitis due to solids and liquids	1
76	R47	Speech disturbances, not elsewhere classified	1
77	E55	Vitamin D deficiency	1
78	Z93	Artificial opening status	1
79	R02	Gangrene, not elsewhere classified	1
80	R63	Symptoms and signs concerning food and fluid intake	0.9
81	H91	Other hearing loss	0.9
82	W10	Fall on and from stairs and steps	0.9
83	W01	Fall on same level from slipping, tripping and stumbling	0.9
84	E05	Thyrotoxicosis [hyperthyroidism]	0.9

Supplementary Table 5 – Continued

#	ICD-10 code	Description	Weight
85	M41	Scoliosis	0.9
86	R13	Dysphagia	0.8
87	Z99	Dependence on enabling machines and devices	0.8
88	U80	Agent resistant to penicillin and related antibiotics	0.8
89	M80	Osteoporosis with pathological fracture	0.8
90	K92	Other diseases of digestive system	0.8
91	I63	Cerebral Infarction	0.8
92	N20	Calculus of kidney and ureter	0.7
93	F10	Mental and behavioural disorders due to use of alcohol	0.7
94	Y84	Other medical procedures as the cause of abnormal reaction	0.7
95	R00	Abnormalities of heart beat	0.7
96	J22	Unspecified acute lower respiratory infection	0.7
97	Z73	Problems related to life-management difficulty	0.6
98	R79	Other abnormal findings of blood chemistry	0.6
99	Z91	Personal history of risk-factors, not elsewhere classified	0.5
100	S51	Open wound of forearm	0.5
101	F32	Depressive episode	0.5
102	M48	Spinal stenosis (secondary code only)	0.5
103	E83	Disorders of mineral metabolism	0.4
104	M15	Polyarthrosis	0.4
105	D64	Other anaemias	0.4
106	L08	Other local infections of skin and subcutaneous tissue	0.4
107	R11	Nausea and vomiting	0.3
108	K52	Other noninfective gastroenteritis and colitis	0.3
109	R50	Fever of unknown origin	0.1

Abbreviations: ICD-10: International Classification of Diseases, 10th revision.

**Supplementary Table 6 – Identification of deaths related to acute and potentially unpredictable fatal events**

ICD Chapter	Main criteria	Conditional argument
	<i>ICD-10 codes listed as underlying cause of death</i>	<i>Inpatient or specialized outpatient care admission in the past 5 years</i>
Certain infectious and parasitic diseases	A00; A01; A02; A03; A04; A05; A06; A07; A08; A09; A39; A40; A41; A499; A80; A81; A87; B371; B375; B377; B440; B441; B448; B449; B99	
Diseases of the blood and blood-forming organs	D611; D619; D649	
Endocrine, nutritional and metabolic diseases	E86	
Diseases of the nervous system	G000; G001; G002; G003; G009; G039; G040; G048; G049; G060; G062; G931; G936	
Ischaemic and pulmonary heart diseases	I20; I21; I23; I25; I249; I249; I255; I26; I28	No history of ischemic heart disease (I20-I25) or pulmonary embolism (I26)
Other forms of heart disease	I30; I33; I40; I461; I469	
Cerebrovascular diseases	I60; I61; I62; I63; I64; I65; I66; I67	No history of cerebrovascular disease (I60-I69)
Diseases of arteries, arterioles and capillaries	I71; I72; I74; I97	
Diseases of the respiratory system	J069; J09; J10; J11; J12; J13; J14; J15; J18; J22; J690; J81; J851; J852; J93; J958; J960	
Diseases of the digestive system	K250; K251; K252; K253; K254; K255; K256; K257; K259; K260; K261; K263; K264; K265; K266; K269; K550; K65; K720; K810; K859	
Diseases of the musculoskeletal system and connective tissue	M726	
Diseases of the genitourinary system	N00; N04; N10; N17; N390; N990; N998	No history of diabetes (E10-14) or renal failure (N18-19)
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	R02; R572; R570; R571	
Injury, poisoning and certain other consequences of external causes	S065; S066; S068; S069; S071; S10-99; T00-T99	
External causes of morbidity and mortality	V00-V99; X60-79; X80-84	

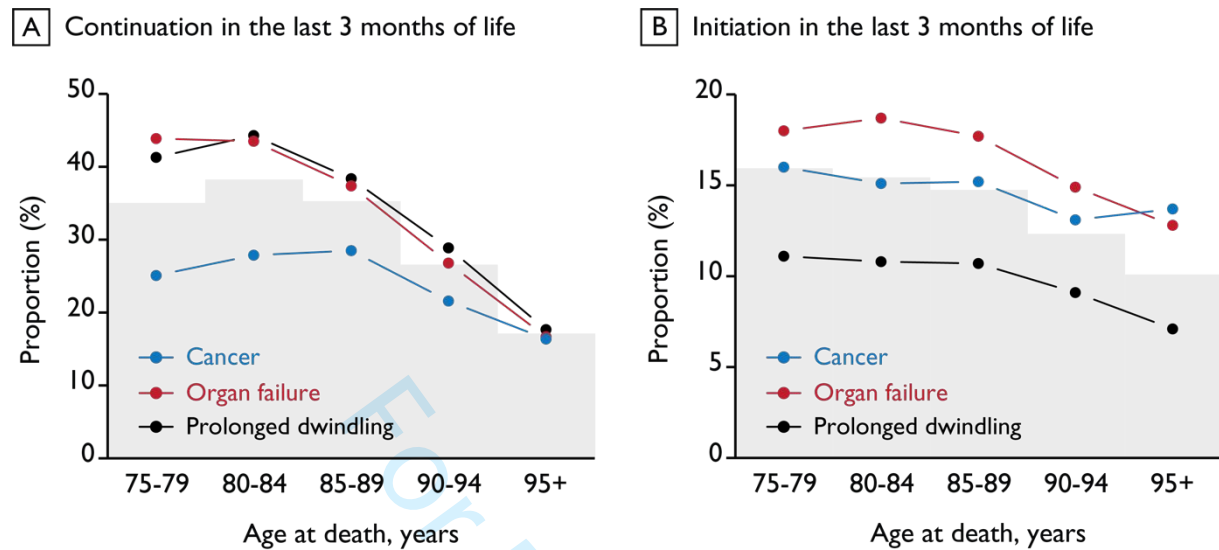
**Supplementary Table 7 – Sensitivity analysis: continuation and initiation of drugs of questionable clinical benefit during the last 3 months of life of older adults who did not die from an acute and potentially unpredictable fatal event, compared with those who did**

<b>Died from acute and potentially unpredictable fatal event</b>	<b>Continuation</b>		<b>Initiation</b>	
	No (n=48 497)	Yes (n=9918)	No (n=48 497)	Yes (n=9918)
<b>Overall proportion</b>	31.8	32.7	13.7	15.4
<b>Sex</b>				
Men	31.8	31.6	14.7	15.3
Women	31.8	33.6	13.0	15.5
<b>Age at time of death</b>				
75–84 years	36.5	39.6	15.3	17.3
85–94 years	31.1	32.1	13.3	15.2
95 year and older	17.6	15.2	9.9	10.7
<b>Illness trajectory</b>				
Cancer	25.6	31.0	14.9	17.4
Organ failure	35.9	32.6	16.9	16.5
Prolonged dwindling	33.7	33.5	9.4	11.9
<b>Number of chronic diseases</b>				
0-1	10.3	12.0	9.3	12.8
2-3	20.4	19.8	10.5	12.4
4-5	27.2	30.2	12.4	14.1
≥6	37.2	38.2	15.1	16.9
<b>Hospital Frailty Risk Score</b>				
Low risk (<5)	26.5	28.7	14.8	16.3
Intermediate risk (5-15)	33.6	36.1	13.4	14.7
High risk (>15)	43.1	43.5	11.1	12.7
<b>Living arrangement</b>				
Community-dwelling	31.0	32.9	17.5	18.6
Nursing home	33.0	32.5	8.6	10.1
<b>Marital status</b>				
Married	34	35.6	15.5	16.7
Single or divorced	32.1	31.4	13.3	14.8
Widowed	30.4	31.7	12.8	14.9
<b>Level of education</b>				
Primary education	31.5	31.2	13.6	15.3
Secondary education	32.7	34.9	13.9	15.3
Tertiary education	31.6	33.7	13.5	16.3

Missing values: level of education, 1302 (2.2%)



**Supplementary Figure 1 – Subgroup analysis: continuation and initiation of drugs of questionable clinical benefit during the last 3 months of life, by illness trajectory and age at death**



*Legend Supplementary Figure 1: Shaded areas represent the overall age-specific proportion of older adults who continued and initiated at least one drug of questionable clinical benefit during the last 3 months before death.*

**Supplementary Table 8 – Subgroup analysis: continuation and initiation of drugs of questionable clinical benefit during the last 3 months of life, by living arrangement**

Living arrangement	Continuation		Initiation	
	Community (n=33 862)	Nursing home (n=24 553)	Community (n=33 862)	Nursing home (n=24 553)
Overall proportion	31.3	32.9	17.7	8.8
Sex				
Men	31.0	33.3	17.5	9.2
Women	31.6	32.7	18.0	8.6
Age at time of death				
75–84 years	34.8	42.6	18.1	9.1
85–94 years	29.7	33.0	17.7	9.2
95 year and older	17.1	17.2	15.2	7.2
Illness trajectory				
Cancer	23.8	33.5	16.3	10.0
Organ failure	36.2	32.4	19.4	11.2
Prolonged dwindling	35.3	33.1	16.3	7.3
Number of chronic diseases				
0-1	9.8	11.5	14.5	4.5
2-3	17.2	24.1	15.3	5.3
4-5	25.1	31.2	16.4	7.9
≥6	37.5	37.0	18.9	10.3
Hospital Frailty Risk Score				
Low risk (<5)	27.0	26.8	18.0	8.9
Intermediate risk (5-15)	34.4	33.6	17.8	9.0
High risk (>15)	45.2	41.9	16.0	8.4
Marital status				
Married	32.7	38.7	17.9	9.2
Single or divorced	31.1	33.1	17.2	8.8
Widowed	30.0	31.1	17.9	8.7
Level of education				
Primary education	31.3	31.6	17.8	9.0
Secondary education	32.0	34.6	17.6	9.0
Tertiary education	30.0	35.4	17.5	8.0

**Supplementary Table 9 – Detailed list of drugs of questionable clinical benefit continued during the last 3 months of life**

Drug class (ATC code)	Total	Illness trajectory		
		Cancer	Organ Failure	Prolonged Dwindling
	No. / No. at risk (%)	No. / No. at risk (%)	No. / No. at risk (%)	No. / No. at risk (%)
Statins and other lipid-lowering agents (C10A)	8394 / 12 875 (65.2%)	2104 / 4023 (52.3%)	4707 / 6546 (71.9%)	1583 / 2306 (68.6%)
Calcium supplements (A12A)	6855 / 9856 (69.6%)	1517 / 2591 (58.5%)	3127 / 4392 (71.2%)	2211 / 2873 (77.0%)
Antidementia drugs (N06D)	4463 / 5459 (81.8%)	633 / 804 (78.7%)	617 / 751 (82.2%)	3213 / 3904 (82.3%)
Drugs for osteoporosis (M05B)	1581 / 2668 (59.3%)	461 / 855 (53.9%)	780 / 1258 (62.0%)	340 / 555 (61.3%)
Vitamin D (A11CC)	1225 / 1905 (64.3%)	245 / 414 (59.2%)	737 / 1097 (67.2%)	243 / 394 (61.7%)
Immunostimulants (L03A)	32 / 75 (42.7%)	30 / 71 (42.3%)	2 / 4 (50.0%)	0 / 0 (0.0%)
Peripheral vasodilators (C04)	0 / 0 (0.0%)	0 / 0 (0.0%)	0 / 0 (0.0%)	0 / 0 (0.0%)
Antihypertensives excl $\alpha$ -blocker (C02)	42 / 62 (67.7%)	8 / 16 (50.0%)	31 / 42 (73.8%)	3 / 4 (75.0%)
Cardiac stimulants other than glycosides (C01C)	65 / 185 (35.1%)	12 / 31 (38.7%)	15 / 49 (30.6%)	38 / 105 (36.2%)

*Note: the number of individuals at risk corresponds to the population already treated with each specific drug class between 12 and 3 months before death.*

*Antidementia drugs include both anticholinesterases (donepezil, rivastigmine, and galantamine) and memantine.*

Supplementary Table 10 – Detailed list of drugs of questionable clinical benefit initiated during the last 3 months of life

Drug class (ATC code)	Total	Illness trajectory		
		Cancer	Organ Failure	Prolonged Dwindling
	No. / No. at risk (%)	No. / No. at risk (%)	No. / No. at risk (%)	No. / No. at risk (%)
Antianemic drugs (B03A, B03B, B03XA01)	2090 / 35 959 (3.6%)	675 / 10 657 (6.3%)	909 / 14 307 (6.4%)	506 / 10 995 (4.6%)
ACE Inhibitors or Angiotensin II Antagonists (C09)	1333 / 35 858 (2.3%)	283 / 10 241 (2.8%)	794 / 12 079 (6.6%)	256 / 13 538 (1.9%)
Statins and other lipid-lowering agents (C10A)	686 / 45 540 (1.2%)	164 / 12 315 (1.3%)	423 / 16 833 (2.5%)	99 / 16 392 (0.6%)
Novel Oral Anticoagulants (B01AE, B01AF)	848 / 56 396 (1.5%)	155 / 15 862 (1.0%)	510 / 22 239 (2.3%)	183 / 18 295 (1.0%)
Vitamin K Antagonists (B01AA)	680 / 51 042 (1.2%)	128 / 14 574 (0.9%)	461 / 19 060 (2.4%)	91 / 17 408 (0.5%)
Other anticoagulants (B01AD B01AX)	5 / 58414 (0.0%)	2 / 16338 (0.0%)	3 / 23378 (0.0%)	0 / 18698 (0.0%)
Antineoplastic drugs (L01)	259 / 57613 (0.4%)	230 / 15635 (1.5%)	18 / 23309 (0.1%)	11 / 18669 (0.1%)
Endocrine therapies (L02)	264 / 54883 (0.5%)	225 / 13543 (1.7%)	31 / 22905 (0.1%)	8 / 18435 (0.0%)
Immunostimulants (L03A)	21 / 58340 (0.0%)	19 / 16267 (0.1%)	2 / 23375 (0.0%)	0 / 18698 (0.0%)
Immunosuppressants (L04A)	117 / 57586 (0.2%)	42 / 16013 (0.3%)	50 / 22993 (0.2%)	25 / 18580 (0.1%)
Finasteride (G04CA51)	0 / 58415 (0.0%)	0 / 16338 (0.0%)	0 / 23379 (0.0%)	0 / 18698 (0.0%)
Vitamin D (A11CC)	432 / 56510 (0.8%)	100 / 15924 (0.6%)	223 / 22282 (1.0%)	109 / 18304 (0.6%)
Calcium supplement (A12A)	1002 / 48559 (2.1%)	335 / 13747 (2.4%)	466 / 18987 (2.5%)	201 / 15825 (1.3%)
Cardiac glycosides excluding digoxin (C01A_excl)	0 / 58415 (0.0%)	0 / 16338 (0.0%)	0 / 23379 (0.0%)	0 / 18698 (0.0%)
Other cardiac stimulants (C01C)	21 / 58230 (0.0%)	7 / 16307 (0.0%)	3 / 23330 (0.0%)	11 / 18593 (0.1%)
Antihypertensives (C02)	56 / 57913 (0.1%)	8 / 16201 (0.0%)	43 / 23073 (0.2%)	5 / 18639 (0.0%)
Peripheral vasodilators (C04)	0 / 58415 (0.0%)	0 / 16338 (0.0%)	0 / 23379 (0.0%)	0 / 18698 (0.0%)
Verapamil (C08DA01)	24 / 57941 (0.0%)	9 / 16209 (0.1%)	13 / 23152 (0.1%)	2 / 18580 (0.0%)
Urinary incontinence excluding oxybutynin (G04BD)	200 / 57090 (0.4%)	90 / 15794 (0.6%)	78 / 22868 (0.3%)	32 / 18428 (0.2%)
Antidementia drugs (N06D)	359 / 52956 (0.7%)	35 / 15534 (0.2%)	78 / 22628 (0.3%)	246 / 14794 (1.7%)
Drugs for osteoporosis (M05B)	286 / 55747 (0.5%)	114 / 15483 (0.7%)	132 / 22121 (0.6%)	40 / 18143 (0.2%)

Note: the number of individuals at risk amounts to the decedents who were not previously treated and had at least one refill during the last 3 months before death.  
Antianemic drugs include iron supplements, vitamin B12, folic acid, and erythropoietin.