

Using explainable artificial intelligence to predict potentially preventable hospitalizations: a population-based cohort study in Denmark

Supplemental Digital Content

Table 1. The definition of potentially preventable hospitalizations by the Danish Health Authority.¹

Condition	Primary diagnosis, ICD-10 codes
Dehydration	E869
Obstipation	K590
Lower respiratory disease	J12-J15, J18, J20-J22, J40-J47
Urinary tract infection	N30 (except N303 and N304)
Gastroenteritis	A09
Fractures	S02, S12, S22, S32, S42, S52, S62, S72, S82, S92
Nutritional anemia	D50, D51, D52, D53
Causa socialis	Z59, Z74, Z75
Decubitus	L89

Table 2. Ambulatory care sensitive conditions as defined by Davydov DS et al.²

Condition	Inclusions	Exclusions
Angina	Age 18+. Primary diagnosis: ICD-10 codes: I20.0, I20.1, I20.8, I20.9, I24.0, I24.1, I24.8, I24.9	All surgical procedures NCSP code: K
Chronic obstructive pulmonary disorder (COPD) exacerbation	Age 18+. Primary diagnosis: ICD-10 codes: J41.0, J41.1, J42.0-J42.9, J43.8, J43.9, J44.0-J44.9, J47.0-J47.9 J20.0-J20.9*, J40.0-J40.9*	*Only included if accompanied by a secondary diagnosis of any of the other codes listed under COPD
Congestive heart failure (CHF) exacerbation	Age 18+. Primary diagnosis: ICD-10 codes: I09.0-I09.9, I11.0, I13.0, I13.2, I13.9, I50.0, I50.1, I50.9, I46.9	Cardiac procedures NCSP codes: KFNG02, KFNG05, KFNA, KFNC, KFT, KFW, KFQ, BFCA01-BFCA07
Diabetes (with short-term complications)	Age 18+. Primary diagnosis ICD-10 codes: E10.0, E10.1, E11.0, E11.1	
Diabetes (uncontrolled (without short-term or long-term complications))	Age 18+. Primary diagnosis ICD-10 codes: E10.9, E11.9	
Diabetes (with long-term complications)	Age 18+. Primary diagnosis ICD-10 codes: E10.2-E10.8, E11.2-E11.8	
Hypertension (HTN)	Age 18+. Primary diagnosis ICD-10 codes: I10.0-I10.9, I11.9, I12.9, I13.9	Cardiac procedures NCSP codes: KFNG02, KFNG05, KFNA, KFNC, KFT, KFW, KFQ, BFCA01-BFCA07

Perforated appendicitis	Age 18+. Any diagnosis ICD-10 codes: K35.0, K35.1, K35.2, K35.3	
Pneumonia	Age 18+. Primary diagnosis ICD-10 codes: J13-J14.9, J15.3-J15.4, J15.7-J15.9, J16.0-J16.9, J18.0-J18.9	Sickle cell disorders ICD-10 codes: D57.0-D57.9
Urinary tract infections (UTI)	Age 18+. Primary diagnosis ICD-10 codes: N10.0-N12.9, N15.1-15.9, N30.0-N30.9, N34.0-N34.9, N39.0	
Adult asthma exacerbation	Age 18+. Primary diagnosis ICD-10 codes: J45, J46	
Amputations (diabetes-related)	Age 18+. Any diagnosis ICD-10 codes: Z89.4-Z89.7	Only included if accompanied by a diagnosis of diabetes (ICD-10 codes: E10-14, H36.0, O24, excluding O24.4) at the same admission. Excluding traumatic amputations of lower limb ICD-10 codes: S78.0-S78.9, S88.0-S88.9, S98.0-S98.4, T05.3-T05.5

Table 3. Codes for identifying subgroups of patients known to have pre-existing conditions.

Condition	Data source and codes
Diabetes	Danish National Patient Registry (ICD-10 codes): Charlson Comorbidity Index: Diabetes, uncomplicated: E10.0, E10.1, E10.9, E11.0, E11.1, E11.9 Diabetes, complicated: E10.2-E10.8, E11.2-E11.8 Elixhauser Comorbidity Index: Diabetes, uncomplicated: E10.0, E10.1, E10.9, E11.0, E11.1, E11.9, E12.0, E12.1, E12.9, E13.0, E13.1, E13.9, E14.0, E14.1, E14.9 Diabetes, complicated: E10.2-E10.8, E11.2-E11.8, E12.2-E12.8, E13.2-E13.8, E14.2-E14.8
	Danish National Database of Reimbursed Prescriptions (ATC codes): Rx-Risk Comorbidity Index: A10AA01–A10BX99
Chronic obstructive pulmonary disease	Danish National Patient Registry (ICD-10 codes): Charlson Comorbidity Index: Chronic pulmonary disease: J40-J47, J60-J67, J68.4, J70.1, J70.3, J84.1, J92.0, J96.1, J98.2, J98.3 Elixhauser Comorbidity Index: Chronic pulmonary disease: I27.8, I27.9, J40-J47, J60-J67, J68.4, J70.1, J70.3

	<p>Danish National Database of Reimbursed Prescriptions (ATC codes):</p> <p>Rx-Risk Comorbidity Index: R03AC02-R03DC03, R03DX05</p>
Cardiovascular disease	<p>Danish National Patient Registry (ICD-10 codes):</p> <p>Charlson Comorbidity Index: Congestive heart failure: I50, I11.0, I13.0, I13.2 Peripheral vascular disease: I70, I71, I72, I73, I74, I77 Myocardial infarction: I21, I22, I23 Cerebrovascular disease: I60-I69, G45, G46</p> <p>Elixhauser Comorbidity Index: Congestive heart failure: I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5-I42.9, I43, I50, P29.0 Peripheral vascular disorders: I70, I71, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9 Cardiac arrhythmias: I44.1-I44.3, I45.6, I45.9, I47-I49, R00.0, R00.1, R00.8, T82.1, Z45.0, Z95.0 Hypertension, uncomplicated: I10 Hypertension, complicated: I11-I13, I15 Pulmonary circulation disorders: I26, I27, I28.0, I28.8, I28.9 Valvular disease: A52.0, I05-I08, I09.1, I09.8, I34-I39, Q23.0-Q23.3, Z95.2-Z95.4 Coagulopathy: D65-D68, D69.1, D69.3-D69.6</p>
	<p>Danish National Database of Reimbursed Prescriptions (ATC codes):</p> <p>Rx-Risk Comorbidity Index: Congestive heart failure: C03DA02-C03DA99, C07AB07, C07AG02, C07AB12, C03CA01-C03CC01, C09AA01-C09AX99, C09CA01-C09CX99, Arrhythmia: C01AA05, C01BA01-C01BD01, C07AA07, Hypertension: C03AA01-C03BA11, C03DB01, C03DB99, C03EA01, C09BA02-C09BA09, C09DA02-C09DA08, C02AB01-C02AC05, C02DB02- C02DB99, C03CA01-C03CC01, C09CA01-C09CX99, Pulmonary hypertension: C02KX01-C02KX05, Anticoagulants: B01AA03-B01AB06, B01AE07, B01AF01, B01AF02, B01AX05, Antiplatelets: B01AC04-B01AC30 Hyperlipidaemia: A10BH03, C10AA01-C10BX09, Ischemic heart disease, angina: C01DA02-C01DA14, C01DX16, C08EX02 Ischemic heart disease, hypertension: C07AA01-C07AA06, C07AA08-C07AB01, C07AB02, C07AG01, C08CA01-C08DB01, C09DB01-C09DB04, C09DX01, C09BB02-C09BB10, C07AB03, C09DX03, C10BX03</p>

Table 4. Distribution of diagnoses grouped according to the definitions of potentially preventable hospitalizations.

Definition of potentially preventable hospitalizations	N (%)
Danish Health Authority (overall) ¹	16,443 (100)
Dehydration	1,067 (6)
Obstipation	643 (4)
Lower respiratory disease	8,766 (53)
Urinary tract infection	2,050 (12)
Gastroenteritis	257 (2)
Fractures	3,305 (20)
Nutritional anemia	282 (2)
Causa socialis	25 (0)
Decubitus	48 (0)
Davydow et al (overall) ²	13,896 (100)
Angina	620 (4)
Chronic obstructive pulmonary disorder exacerbation	2,756 (20)
Congestive heart failure exacerbation	46 (0)
Diabetes (with short-term complications)	25 (0)
Diabetes (uncontrolled (without short-term or long-term complications))	126 (1)
Diabetes (with long-term complications)	183 (1)
Hypertension	488 (4)
Perforated appendicitis	79 (1)
Pneumonia	5,575 (40)
Urinary tract infections	3,588 (26)
Adult asthma exacerbation	410 (3)
Amputations (diabetes-related)	3 (0)

Table 5. Healthcare utilization and clinical characteristics for citizens aged 65+ years in the Danish CROSS-TRACKS cohort in 2016-2017 within the one-year observation window prior to the date of contact with general practitioners classified according to whether the citizens experienced an acute potentially preventable hospitalization during follow-up throughout 2018.

Characteristics	Overall sample population		Potentially preventable hospitalization			
	N (%)	Median (IQR)	DHAŞ		Davydow¶	
			N (%)	Median (IQR)	N (%)	Median (IQR)
Filled prescriptions (ATC code)						
A. Alimentary tract and metabolism	119,934 (45)		10,323 (63)		9,176 (66)	
A01	62 (0)		22 (0)		16 (0)	
A02	69,892 (26)		6,497 (40)		5,807 (42)	
A03	6,185 (2)		941 (6)		796 (6)	
A04	98 (0)		8 (0)		9 (0)	
A05	180 (0)		18 (0)		18 (0)	
A06	2,856 (1)		542 (3)		466 (3)	
A07	7,424 (3)		1,027 (6)		963 (7)	
A08	34 (0)		10 (0)		10 (0)	
A09	550 (0)		111 (1)		85 (1)	
A10	41,240 (16)		3,233 (20)		2,974 (21)	
A11	313 (0)		63 (0)		83 (1)	
A12	36,835 (14)		4,422 (27)		3,869 (28)	
B. Blood and blood forming organs	122,431 (46)		10,540 (64)		9,179 (66)	
B01	111,879 (42)		9,799 (60)		8,611 (62)	
B02	253 (0)		48 (0)		44 (0)	
B03	22,586 (9)		2,231 (14)		1,880 (14)	
C. Cardiovascular system	196,357 (74)		13,977 (85)		11,981 (86)	
C01	26,362 (10)		2,990 (18)		2,709 (19)	
C02	3,299 (1)		283 (2)		279 (2)	
C03	81,949 (31)		8,026 (49)		6,971 (50)	

C05	138 (0)		38 (0)		19 (0)	
C07	80,301 (30)		6,571 (40)		5,859 (42)	
C08	71,304 (27)		4,946 (30)		4,183 (30)	
C09	118,938 (45)		7,860 (48)		6,806 (49)	
C10	112,580 (42)		7,463 (45)		6,659 (48)	
D. Dermatologicals	2,508 (1)		123 (1)		125 (1)	
D01	2,202 (1)		112 (1)		107 (1)	
D05	281 (0)		11 (0)		18 (0)	
D10	22 (0)		0 (0)		0 (0)	
D11	6 (0)		0 (0)		0 (0)	
G. Genito-urinary system and sex hormones	57,209 (22)		4,136 (25)		3,700 (27)	
G01	458 (0)		25 (0)		18 (0)	
G02	24 (0)		0 (0)		0 (0)	
G03	30,756 (12)		1,983 (12)		1,679 (12)	
G04	28,669 (11)		2,402 (15)		2,259 (16)	
H. Systemic hormonal preparations, excluding sex hormones and insulins	50,178 (19)		5,807 (35)		5,252 (38)	
H01	562 (0)		49 (0)		50 (0)	
H02	28,687 (11)		4,336 (26)		4,049 (29)	
H03	23,872 (9)		2,017 (12)		1,727 (12)	
H04	353 (0)		63 (0)		62 (0)	
H05	422 (0)		47 (0)		42 (0)	
J. Anti-infectives for systemic use	107,475 (41)		10,636 (65)		9,456 (68)	
J01	103,385 (39)		10,453 (64)		9,311 (67)	
J02	6,514 (2)		983 (6)		936 (7)	
J04	126 (0)		26 (0)		26 (0)	
J05	4,513 (2)		307 (2)		271 (2)	
L. Antineoplastic and immunomodulating agents	4,880 (2)		449 (3)		412 (3)	
L02	307 (0)		42 (0)		39 (0)	
L04	4,573 (2)		407 (2)		373 (3)	
M. Musculo-skeletal system	65,912 (25)		5,012 (30)		4,237 (30)	

M01	40,852 (15)		2,236 (14)		1,904 (14)	
M03	1,267 (0)		189 (1)		160 (1)	
M04	9,453 (4)		983 (6)		919 (7)	
M05	19,911 (8)		2,185 (13)		1,792 (13)	
N. Nervous system	141,934 (54)		12,003 (73)		10,193 (73)	
N02	121,439 (46)		10,585 (64)		9,028 (65)	
N03	13,569 (5)		1,554 (9)		1,382 (10)	
N04	6,691 (3)		767 (5)		660 (5)	
N05	6,964 (3)		806 (5)		739 (5)	
N06	44,087 (17)		4,661 (28)		4,045 (29)	
N07	2,432 (1)		271 (2)		240 (2)	
P. Antiparasitic products, insecticides and repellents	9,901 (4)		1,082 (7)		956 (7)	
P01	9,901 (4)		1,082 (7)		956 (7)	
R. Respiratory system	68,084 (26)		7,728 (47)		6,995 (50)	
R01	16,307 (6)		1,007 (6)		870 (6)	
R02	18 (0)		0 (0)		0 (0)	
R03	46,077 (17)		6,696 (41)		6,091 (44)	
R05	7,924 (3)		799 (5)		709 (5)	
R06	11,779 (4)		948 (6)		917 (7)	
S. Sensory organs	16,686 (6)		1,140 (7)		1,028 (7)	
S01	16,686 (6)		1,140 (7)		1,028 (7)	
V. Various	37 (0)		14 (0)		10 (0)	
V01	14 (0)		2 (0)		0 (0)	
V03	23 (0)		12 (0)		10 (0)	
Blood tests						
B-Hemoglobin (any measurement, mmol/L)	154,868 (58)	8 (8-9)	12,789 (78)	8 (7-9)	11,121 (80)	8 (7-9)
B-Leukocytes (any measurement, x 10 ⁹ /L)	129,296 (49)	7 (6-9)	11,716 (71)	8 (7-10)	10,203 (73)	8 (7-10)
B-Neutrophils (any measurement, x 10 ⁹ /L)	365 (0)	6 (4-8)	31 (0)	7 (5-8)	36 (0)	7 (5-8)
B-Sedimentation reaction (any measurement, mm)	23,985 (9)	16 (9-34)	2,768 (17)	26 (13-50)	2,552 (18)	25 (13-50)
B-Platelets (any measurement, x 10 ⁹ /L)	113,408 (43)	243 (201-292)	10,798 (66)	248 (201-302)	9,440 (68)	246 (200-297)

Hemoglobin A1c (any measurement, mmol/L)	165,042 (62)	41 (38-45)	11,374 (69)	42 (38-47)	9,832 (71)	42 (38-47)
Glomerular filtration rate (eGFR) (any measurement, ml/min/1.73m ²)	186,810 (70)	69 (57-80)	13,750 (84)	64 (49-77)	11,823 (85)	64 (48-77)
P(aB)-Hydrogen carbonate (any measurement, mmol/L)	16,955 (6)	25 (23-26)	3,543 (22)	25 (23-27)	3,287 (24)	25 (23-27)
P(aB)-Potassium (any measurement, mmol/L)	17,001 (6)	4 (4-4)	3,534 (21)	4 (4-4)	3,282 (24)	4 (4-4)
P(aB)-Chloride (any measurement, mmol/L)	8,991 (3)	106 (102-108)	1,717 (10)	105 (102-108)	1,605 (12)	105 (102-108)
P(aB)-Lactate (any measurement, mmol/L)	17,040 (6)	1 (1-2)	3,547 (22)	1 (1-2)	3,293 (24)	1 (1-2)
P(aB)-Sodium (any measurement, mmol/L)	16,989 (6)	137 (134-139)	3,532 (21)	137 (134-139)	3,281 (24)	137 (135-139)
P(aB)-pCO ₂ (any measurement, kPa)	17,136 (6)	5 (4-6)	3,562 (22)	5 (4-6)	3,305 (24)	5 (4-6)
P(aB)-pH (any measurement, -log[H ⁺])	17,126 (6)	7 (7-7)	3,562 (22)	7 (7-7)	3,305 (24)	7 (7-7)
P(aB)-pO ₂ (any measurement, kPa)	17,121 (6)	11 (9-13)	3,555 (22)	10 (9-12)	3,300 (24)	10 (9-11)
P(vB)-Hydrogen carbonate (any measurement, mmol/L)	2,805 (1)	24 (22-25)	463 (3)	24 (21-26)	466 (3)	24 (21-26)
P(vB)-pCO ₂ (any measurement, kPa)	1,156 (0)	6 (5-7)	168 (1)	6 (5-7)	171 (1)	6 (6-7)
P(vB)-pH (any measurement, -log[H ⁺])	1,222 (0)	7 (7-7)	195 (1)	7 (7-7)	186 (1)	7 (7-7)
P-Albumin (any measurement, g/l)	116,049 (44)	42 (38-44)	10,884 (66)	39 (36-42)	9,508 (68)	39 (36-42)
P-Bilirubine (any measurement, µmol/L)	90,648 (34)	8 (6-11)	9,020 (55)	8 (6-11)	7,901 (57)	8 (6-11)
P-C-reactive protein (CRP) (any measurement, mg/L)	93,877 (35)	6 (2-25)	9,923 (60)	15 (4-46)	8,731 (63)	15 (4-47)
P-Glucose (any measurement, mmol/L)	14,865 (6)	8 (6-9)	2,370 (14)	8 (6-10)	2,173 (16)	8 (6-10)
P-Potassium (any measurement, mmol/L)	202,358 (76)	4 (4-4)	14,616 (89)	4 (4-4)	12,506 (90)	4 (4-4)
P-Creatinine (any measurement, µmol/L)	206,513 (78)	80 (67-96)	14,756 (90)	84 (69-106)	12,633 (91)	86 (70-109)
P-Lactate dehydrogenase (any measurement, U/L)	44,208 (17)	192 (169-223)	5,136 (31)	195 (172-228)	4,538 (33)	196 (172-229)
Diagnoses (ICD code)						
A00–B99. Certain infectious and parasitic diseases	5,158 (2)		1,042 (6)		1,050 (8)	
A0	818 (0)		147 (1)		127 (1)	
A1	10 (0)		3 (0)		3 (0)	
A2	52 (0)		7 (0)		10 (0)	
A3	48 (0)		22 (0)		18 (0)	
A4	3,375 (1)		731 (4)		770 (6)	
A5	3 (0)		0 (0)		0 (0)	
A6	29 (0)		5 (0)		4 (0)	
A7	7 (0)		0 (0)		0 (0)	

A8	10 (0)		2 (0)		2 (0)
B0	241 (0)		46 (0)		35 (0)
B1	75 (0)		20 (0)		15 (0)
B2	27 (0)		16 (0)		16 (0)
B3	380 (0)		77 (0)		72 (1)
B4	47 (0)		9 (0)		9 (0)
B5	11 (0)		0 (0)		0 (0)
B6	4 (0)		0 (0)		0 (0)
B7	2 (0)		0 (0)		0 (0)
B8	19 (0)		2 (0)		3 (0)
B9	278 (0)		48 (0)		54 (0)
C00–D48. Neoplasms	25,455 (10)		2,909 (18)		2,577 (19)
C0	126 (0)		20 (0)		14 (0)
C1	1,573 (1)		209 (1)		147 (1)
C2	869 (0)		113 (1)		93 (1)
C3	1,389 (1)		360 (2)		320 (2)
C4	2,074 (1)		254 (2)		234 (2)
C5	3,039 (1)		248 (2)		185 (1)
C6	5,302 (2)		539 (3)		542 (4)
C7	2,765 (1)		440 (3)		384 (3)
C8	877 (0)		148 (1)		133 (1)
C9	683 (0)		133 (1)		113 (1)
D0	925 (0)		123 (1)		107 (1)
D1	7,184 (3)		641 (4)		618 (4)
D2	1,311 (0)		97 (1)		83 (1)
D3	1,576 (1)		173 (1)		166 (1)
D4	980 (0)		188 (1)		135 (1)
D50–D89. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	5,792 (2)		1,029 (6)		894 (6)
D5	1,253 (0)		238 (1)		194 (1)
D6	4,163 (2)		731 (4)		633 (5)

D7	439 (0)		75 (0)		70 (1)	
D8	385 (0)		76 (0)		75 (1)	
E00–E90. Endocrine, nutritional, and metabolic diseases	20,888 (8)		2,527 (15)		2,454 (18)	
E0	3,984 (2)		433 (3)		419 (3)	
E1	9,145 (3)		1,240 (8)		1,289 (9)	
E2	1,519 (1)		166 (1)		166 (1)	
E3	179 (0)		25 (0)		25 (0)	
E4	158 (0)		36 (0)		30 (0)	
E5	573 (0)		96 (1)		93 (1)	
E6	2,116 (1)		229 (1)		259 (2)	
E7	3,918 (1)		347 (2)		378 (3)	
E8	4,203 (2)		735 (4)		649 (5)	
F00–F99. Mental and behavioral disorders	6,821 (3)		973 (6)		863 (6)	
F0	3,391 (1)		492 (3)		410 (3)	
F1	678 (0)		88 (1)		101 (1)	
F2	297 (0)		40 (0)		44 (0)	
F3	2,357 (1)		306 (2)		257 (2)	
F4	1,076 (0)		154 (1)		164 (1)	
F5	64 (0)		2 (0)		5 (0)	
F6	42 (0)		7 (0)		5 (0)	
F7	71 (0)		23 (0)		22 (0)	
F8	20 (0)		7 (0)		7 (0)	
F9	53 (0)		13 (0)		13 (0)	
G00–G99. Diseases of the nervous system	11,986 (5)		1,345 (8)		1,188 (9)	
G0	126 (0)		22 (0)		16 (0)	
G1	122 (0)		18 (0)		11 (0)	
G2	1,516 (1)		233 (1)		186 (1)	
G3	1,671 (1)		210 (1)		180 (1)	
G4	5,183 (2)		540 (3)		527 (4)	
G5	2,343 (1)		198 (1)		167 (1)	

G6	1,081 (0)		139 (1)		128 (1)	
G7	208 (0)		30 (0)		24 (0)	
G8	222 (0)		42 (0)		42 (0)	
G9	462 (0)		59 (0)		66 (0)	
H00–H95. Diseases of the eye, adnexa, ear, and mastoid process	21,540 (8)		1,876 (11)		1,678 (12)	
H0	988 (0)		96 (1)		68 (0)	
H1	1,492 (1)		134 (1)		132 (1)	
H2	10,604 (4)		992 (6)		861 (6)	
H3	6,178 (2)		595 (4)		574 (4)	
H4	1,801 (1)		140 (1)		130 (1)	
H5	1,647 (1)		215 (1)		190 (1)	
H6	100 (0)		11 (0)		10 (0)	
H7	66 (0)		3 (0)		3 (0)	
H8	469 (0)		37 (0)		30 (0)	
H9	4,831 (2)		328 (2)		262 (2)	
I00–I99. Diseases of the circulatory system	51,359 (19)		5,786 (35)		5,219 (38)	
I0	16 (0)		9 (0)		6 (0)	
I1	14,010 (5)		1,500 (9)		1,375 (10)	
I2	11,948 (5)		1,535 (9)		1,498 (11)	
I3	7,403 (3)		844 (5)		708 (5)	
I4	22,075 (8)		2,709 (16)		2,436 (18)	
I5	6,467 (2)		1,097 (7)		952 (7)	
I6	5,509 (2)		715 (4)		677 (5)	
I7	4,655 (2)		612 (4)		589 (4)	
I8	2,785 (1)		267 (2)		206 (1)	
I9	1,209 (0)		218 (1)		188 (1)	
J00–J99. Diseases of the respiratory system	16,649 (6)		3,923 (24)		3,568 (26)	
J0	301 (0)		72 (0)		57 (0)	
J1	6,035 (2)		1,573 (10)		1,444 (10)	
J2	152 (0)		39 (0)		39 (0)	

J3	515 (0)		48 (0)		47 (0)	
J4	9,963 (4)		2,725 (17)		2,548 (18)	
J6	155 (0)		34 (0)		32 (0)	
J7	41 (0)		8 (0)		10 (0)	
J8	860 (0)		155 (1)		130 (1)	
J9	2,372 (1)		578 (4)		520 (4)	
K00–K93. Diseases of the digestive system	20,926 (8)		2,206 (13)		1,914 (14)	
K0	700 (0)		86 (1)		90 (1)	
K1	213 (0)		15 (0)		17 (0)	
K2	3,397 (1)		391 (2)		317 (2)	
K3	1,082 (0)		138 (1)		136 (1)	
K4	3,054 (1)		272 (2)		214 (2)	
K5	8,997 (3)		1,020 (6)		859 (6)	
K6	3,516 (1)		335 (2)		326 (2)	
K7	766 (0)		100 (1)		81 (1)	
K8	1,948 (1)		190 (1)		184 (1)	
K9	812 (0)		144 (1)		121 (1)	
L00–L99. Diseases of the skin and subcutaneous tissue	5,143 (2)		599 (4)		507 (4)	
L0	986 (0)		101 (1)		91 (1)	
L1	94 (0)		14 (0)		14 (0)	
L2	403 (0)		42 (0)		40 (0)	
L3	237 (0)		29 (0)		29 (0)	
L4	308 (0)		26 (0)		29 (0)	
L5	654 (0)		68 (0)		57 (0)	
L6	248 (0)		26 (0)		6 (0)	
L7	260 (0)		20 (0)		22 (0)	
L8	830 (0)		157 (1)		129 (1)	
L9	1,947 (1)		223 (1)		173 (1)	
M00–M99. Diseases of the musculoskeletal system and connective tissue	47,874 (18)		4,219 (26)		3,730 (27)	
M0	2,664 (1)		361 (2)		350 (3)	

M1	14,467 (5)		1,085 (7)		1,048 (8)	
M2	3,888 (1)		168 (1)		162 (1)	
M3	1,862 (1)		200 (1)		186 (1)	
M4	5,235 (2)		427 (3)		392 (3)	
M5	3,483 (1)		330 (2)		324 (2)	
M6	2,952 (1)		270 (2)		254 (2)	
M7	9,865 (4)		695 (4)		608 (4)	
M8	15,802 (6)		2,019 (12)		1,721 (12)	
M9	148 (0)		16 (0)		10 (0)	
N00–N99. Diseases of the genitourinary system	19,234 (7)		2,440 (15)		2,360 (17)	
N0	127 (0)		6 (0)		4 (0)	
N1	4,472 (2)		796 (5)		826 (6)	
N2	1,241 (0)		137 (1)		123 (1)	
N3	8,345 (3)		1,396 (8)		1,354 (10)	
N4	2,654 (1)		187 (1)		192 (1)	
N5	132 (0)		11 (0)		4 (0)	
N6	365 (0)		56 (0)		54 (0)	
N7	282 (0)		23 (0)		31 (0)	
N8	3,412 (1)		201 (1)		173 (1)	
N9	1,537 (1)		90 (1)		78 (1)	
O00–O99. Pregnancy, childbirth, and the puerperium	3 (0)		0 (0)		0 (0)	
O2	3 (0)		0 (0)		0 (0)	
P00–P96. Certain conditions originating in the perinatal period	2 (0)		0 (0)		0 (0)	
P3	2 (0)		0 (0)		0 (0)	
Q00–Q99. Congenital malformations, deformations, and chromosomal abnormalities	866 (0)		68 (0)		90 (1)	
Q0	45 (0)		10 (0)		15 (0)	
Q1	39 (0)		2 (0)		2 (0)	
Q2	181 (0)		15 (0)		17 (0)	
Q3	20 (0)		3 (0)		5 (0)	
Q4	18 (0)		7 (0)		7 (0)	

Q5	12 (0)		0 (0)		0 (0)
Q6	363 (0)		28 (0)		41 (0)
Q7	49 (0)		0 (0)		0 (0)
Q8	100 (0)		3 (0)		3 (0)
Q9	39 (0)		0 (0)		0 (0)
R00–R99. Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified	34,631 (13)		4,255 (26)		3,907 (28)
R0	8,519 (3)		1,059 (6)		1,007 (7)
R1	8,015 (3)		996 (6)		820 (6)
R2	1,988 (1)		226 (1)		221 (2)
R3	6,100 (2)		723 (4)		743 (5)
R4	2,404 (1)		269 (2)		266 (2)
R5	6,482 (2)		909 (6)		816 (6)
R6	5,029 (2)		1,017 (6)		936 (7)
R7	1,101 (0)		158 (1)		149 (1)
R8	264 (0)		8 (0)		4 (0)
R9	3,315 (1)		439 (3)		413 (3)
S00–T98. Injury, poisoning, and certain other consequences of external causes	24,103 (9)		2,637 (16)		2,182 (16)
S0	2,821 (1)		358 (2)		257 (2)
S1	261 (0)		24 (0)		32 (0)
S2	975 (0)		131 (1)		102 (1)
S3	1,132 (0)		196 (1)		170 (1)
S4	2,683 (1)		226 (1)		209 (2)
S5	2,616 (1)		239 (1)		198 (1)
S6	2,809 (1)		220 (1)		196 (1)
S7	2,810 (1)		399 (2)		276 (2)
S8	2,552 (1)		312 (2)		239 (2)
S9	1,652 (1)		177 (1)		152 (1)
T0	513 (0)		54 (0)		57 (0)
T1	758 (0)		80 (0)		73 (1)
T2	81 (0)		0 (0)		2 (0)

T3	69 (0)		11 (0)		6 (0)	
T4	135 (0)		33 (0)		25 (0)	
T5	148 (0)		24 (0)		13 (0)	
T6	202 (0)		15 (0)		10 (0)	
T7	599 (0)		60 (0)		54 (0)	
T8	5,143 (2)		651 (4)		630 (5)	
T9	1,896 (1)		204 (1)		138 (1)	
X60-Y09. External causes of morbidity and mortality	38 (0)		1 (0)		1 (0)	
X6	28 (0)		0 (0)		0 (0)	
X7	11 (0)		1 (0)		1 (0)	
Z00-Z99. Factors influencing health status and contact with health services	70,064 (26)		7,021 (43)		6,408 (46)	
Z0	57,610 (22)		5,849 (36)		5,372 (39)	
Z1	228 (0)		22 (0)		21 (0)	
Z2	647 (0)		103 (1)		71 (1)	
Z3	14 (0)		0 (0)		0 (0)	
Z4	623 (0)		71 (0)		76 (1)	
Z5	5,020 (2)		532 (3)		475 (3)	
Z6	78 (0)		21 (0)		11 (0)	
Z7	3,726 (1)		555 (3)		511 (4)	
Z8	1,827 (1)		123 (1)		114 (1)	
Z9	13,964 (5)		1,741 (11)		1,584 (11)	
Procedures (ICD code)						
A. Administrative information	93,824 (35)		9,038 (55)		8,035 (58)	
AA	46,705 (18)		5,921 (36)		5,277 (38)	
AF	64,921 (24)		5,775 (35)		5,213 (38)	
AG	656 (0)		80 (0)		69 (0)	
AP	11,091 (4)		1,505 (9)		1,357 (10)	
AR	1,201 (0)		146 (1)		146 (1)	
AT	134 (0)		14 (0)		13 (0)	
AU	21 (0)		11 (0)		10 (0)	

AV	82 (0)		24 (0)		19 (0)	
AW	6,045 (2)		945 (6)		867 (6)	
B. Treatment and care	134,033 (51)		11,807 (72)		10,390 (75)	
BA	7,465 (3)		586 (4)		531 (4)	
BB	680 (0)		71 (0)		58 (0)	
BC	40 (0)		2 (0)		2 (0)	
BD	6,915 (3)		594 (4)		480 (3)	
BE	1,331 (1)		302 (2)		292 (2)	
BF	5,069 (2)		565 (3)		473 (3)	
BG	58,731 (22)		7,721 (47)		6,935 (50)	
BI	2,774 (1)		355 (2)		334 (2)	
BJ	19,613 (7)		2,460 (15)		2,233 (16)	
BL	37,008 (14)		4,441 (27)		4,033 (29)	
BM	60,314 (23)		6,981 (42)		6,300 (45)	
BN	5,191 (2)		561 (3)		510 (4)	
BO	5,969 (2)		960 (6)		845 (6)	
BP	1,005 (0)		192 (1)		170 (1)	
BQ	1,242 (0)		45 (0)		51 (0)	
BR	1,408 (1)		137 (1)		132 (1)	
BS	1,775 (1)		190 (1)		200 (1)	
BT	17,461 (7)		2,938 (18)		2,590 (19)	
BU	2,011 (1)		222 (1)		182 (1)	
BV	94,885 (36)		9,398 (57)		8,388 (60)	
BW	98,379 (37)		9,736 (59)		8,676 (62)	
BX	241 (0)		24 (0)		28 (0)	
F. Functionality, disability, and state of health	653 (0)		172 (1)		162 (1)	
FA	6 (0)		0 (0)		0 (0)	
FB	606 (0)		164 (1)		159 (1)	
FE	115 (0)		11 (0)		13 (0)	
FS	42 (0)		7 (0)		3 (0)	

K. Surgical procedures	68,652 (26)		6,054 (37)		5,356 (39)	
KA	2,170 (1)		171 (1)		129 (1)	
KB	346 (0)		14 (0)		9 (0)	
KC	11,364 (4)		1,019 (6)		914 (7)	
KD	467 (0)		40 (0)		37 (0)	
KE	716 (0)		85 (1)		84 (1)	
KF	2,833 (1)		246 (1)		243 (2)	
KG	854 (0)		160 (1)		129 (1)	
KH	599 (0)		58 (0)		47 (0)	
KJ	11,538 (4)		1,062 (6)		1,005 (7)	
KK	3,537 (1)		379 (2)		362 (3)	
KL	2,284 (1)		142 (1)		127 (1)	
KN	12,334 (5)		853 (5)		685 (5)	
KP	2,181 (1)		220 (1)		210 (2)	
KQ	6,414 (2)		824 (5)		752 (5)	
KT	6,451 (2)		719 (4)		636 (5)	
KU	31,561 (12)		3,085 (19)		2,790 (20)	
KY	64 (0)		3 (0)		7 (0)	
N. Anesthesia, intensive care, prehospital	34,376 (13)		3,435 (21)		2,988 (22)	
NA	34,302 (13)		3,412 (21)		2,967 (21)	
NZ	4,394 (2)		472 (3)		418 (3)	
U. Examinations	69,225 (26)		6,579 (40)		5,827 (42)	
UC	2,561 (1)		229 (1)		201 (1)	
UF	1,440 (1)		125 (1)		109 (1)	
UW	5,060 (2)		818 (5)		757 (5)	
UX	65,430 (25)		6,184 (38)		5,504 (40)	
W. Clinical physiology and nuclear medicine	11,732 (4)		2,202 (13)		2,071 (15)	
WB	20 (0)		0 (0)		0 (0)	
WE	217 (0)		13 (0)		17 (0)	
WG	216 (0)		12 (0)		12 (0)	

WH	257 (0)		64 (0)		61 (0)	
WK	23 (0)		1 (0)		1 (0)	
WL	11,270 (4)		2,154 (13)		2,023 (15)	
WT	16 (0)		0 (0)		0 (0)	
Z. Additional information (eg, surgical access, assessment of test results)	3,062 (1)		334 (2)		301 (2)	
ZP	3,018 (1)		334 (2)		300 (2)	
ZW	44 (0)		0 (0)		1 (0)	

§ Definition by the Danish Health Authority.¹

¶ Definition by Davydow DS et al.²

Table 6. Evaluation of the predictive performance of models for potentially preventable hospitalizations within the following year among citizens aged 65+ years known to have pre-existing conditions in the CROSS-TRACKS cohort in 2016-2017.

Population with pre-existing condition			Outcome								
			DHA§			Davydow¶			Davydow¶, disease specific		
Condition	Unique patients	Contacts with GP	PPH* N (%)	AUROC† (95% CI)	AUPRC‡ (95% CI)	PPH* N (%)	AUROC† (95% CI)	AUPRC‡ (95% CI)	PPH* N (%)	AUROC† (95% CI)	AUPRC‡ (95% CI)
Diabetes	5,897	45,262	3,632 (8)	0.761 (0.746-0.776)	0.232 (0.216-0.248)	3,315 (7)	0.762 (0.745-0.777)	0.232 (0.231-0.232)	696 (2)	0.730 (0.696-0.765)	0.043 (0.031-0.055)
COPD	8,133	51,739	7,175 (14)	0.750 (0.739-0.761)	0.342 (0.321-0.364)	6,501 (13)	0.747 (0.733-0.762)	0.318 (0.299-0.338)	10,237 (20)	0.737 (0.716-0.758)	0.430 (0.391-0.468)
CVD	31,139	207,969	14,646 (7)	0.780 (0.774-0.786)	0.240 (0.234-0.246)	12,555 (6)	0.788 (0.780-0.797)	0.233 (0.224-0.242)	2,685 (1)	0.630 (0.600-0.661)	0.026 (0.019-0.034)

Predictors included in the models: age, gender, cohabitation status, socioeconomic status, municipality care, contacts with primary healthcare, Charlson Comorbidity Index disease groups, prescription medicine by ATC code, blood tests, contacts with secondary healthcare, diagnoses, procedures, vital parameters, BMI, smoking status, and alcohol intake.

§ Definition by the Danish Health Authority.¹

¶ Definition by Davydow DS et al.²

* Potentially preventable hospitalization.

† Area under the ROC curve.

‡ Average precision.

GP, general practitioner; COPD, Chronic obstructive pulmonary disease; CVD, Cardiovascular disease.

Table 7. Evaluation of the predictive performance of models for potentially preventable hospitalizations within the following year among 189,514 unique citizens aged 18+ years at 910,366 contacts with general practitioners resulting in 19,932 (2.2%) potentially preventable hospitalizations according to the definition by Davydow et al in the CROSS-TRACKS cohort in 2016-2017.

	AUROC† (95% CI)	AUPRC‡ (95% CI)
Baseline model	0.766 (0.758-0.774)	0.068 (0.066-0.070)
Model 1	0.829 (0.822-0.835)	0.119 (0.107-0.130)
Model 2	0.869 (0.864-0.874)	0.199 (0.181-0.217)
Model 3	0.871 (0.865-0.877)	0.206 (0.183-0.229)

Predictors included in the models:

Baseline model: age and gender.

Model 1: Baseline model + cohabitation status, socioeconomic status, municipality care, and contacts with primary healthcare.

Model 2: Model 1 + Charlson Comorbidity Index disease groups, prescription medicine by ATC code, and blood tests.

Model 3: Model 2 + contacts with secondary healthcare, diagnoses, procedures, vital parameters, BMI, smoking status, and alcohol intake.

† Area under the ROC curve.

‡ Average precision.

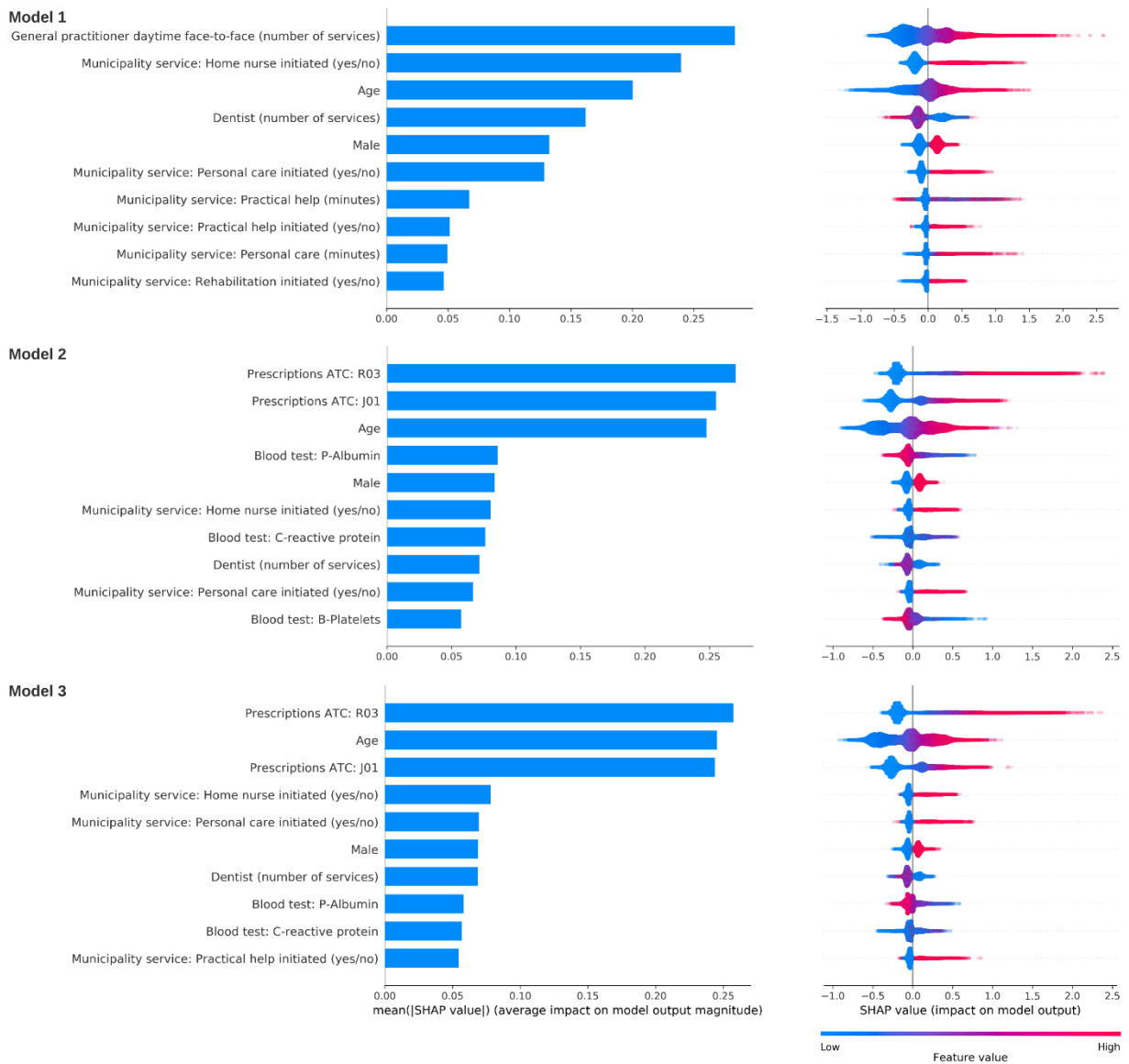


Figure 3. SHAP summary plots for prediction models for potentially preventable hospitalizations using the definition by Davydow et al among citizens aged 65+ years.

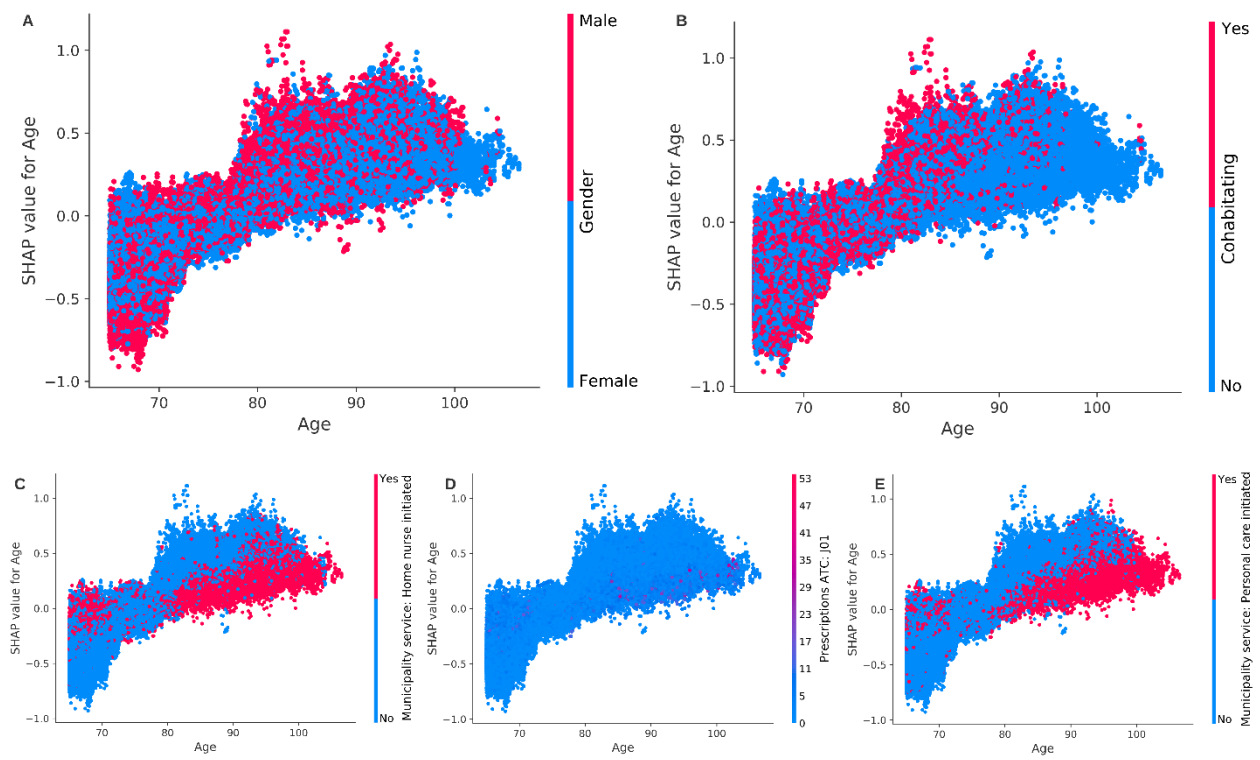


Figure 4. SHAP dependency plots for prediction model for potentially preventable hospitalizations using the definition by Davydow et al among citizens aged 65+ years.

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