SUPPORTING INFORMATION - TABLES & FIGURES

S1 Table. RECORD Statement

Joint impact of dementia and frailty on healthcare utilization and outcomes: a retrospective cohort study of long-stay home care recipients.

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	No.	STROBE items	RECORD items	Location in manuscript where items are reported
Title and abstract				
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	1.1 Included in abstract (*Methods*). 1.2 Included in abstract (*Methods*). 1.3 Included in abstract (*Methods*).
Introduction				
Background rationale	2	Explain the scientific background and rationale for the investigation being reported		2. Included, Introduction (pp. 4-5).
Objectives	3	State specific objectives, including any pre-specified hypotheses		3. Included, Introduction (pg. 5).
Methods				
Study Design	4	Present key elements of study design early in the paper		4. Included, *Study Design and Setting* (pp. 5-6).
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection		5. Included, *Study Design and Setting* (pp. 5-6).
Participants	6	*(a) Cohort study* - Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	RECORD 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	6.1 Included, *Study Cohort* (pg. 7).

		Case-control study - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case	possible, an explanation should be provided. RECORD 6.2: 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. RECORD 6.3: 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.	6.2 Included, *Dementia and Frailty* (pp. 7-8) and *Covariates* (pg. 8). 6.3 *Study Design and Setting* and *Study Cohort* (pp. 5-6), includes detailed information on linked data sources and number of clients included.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	RECORD 7.1: 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.	7.1 Included, exposure (*Dementia and Frailty, pp. 7-8*), outcomes (*Outcomes, pg. 9*), confounders (*Covariates, pg. 8*) and effect modifiers (*Frailty, pg. 8*). See also *Supplemental Material: Table S2.*
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		Included, *Methods*, pp. 6-9.
Bias	9	Describe any efforts to address potential sources of bias		Included, *Statistical Analyses*, pp. 9-10.
Study size	10	Explain how the study size was arrived at		Included, *Study Cohort*, pg. 7.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why		Included, *Dementia and Frailty* (pp. 7-8), *Covariates* (pg. 8), *Outcomes* (pg. 9) and *Statistical Analyses* (pp. 9-10).

Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study* - If applicable, explain how loss to follow-up was addressed *Case-control study* - If applicable, explain how matching of cases and controls was addressed *Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses		a) Included, *Statistical Analyses* (pg. 9). b) Included, *Statistical Analyses* (pg. 9). c) Included, *Statistical Analyses* (pg. 10). d) Included, *Statistical Analyses* (pg. 9). e) Included, *Statistical Analyses* (pg. 10).
Data access and cleaning methods		..	RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population. RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.	12.1 Included, *Study Design and Setting* (pp. 5-6). 12.2 Included, *Study Design and Setting* and *Study Cohort* (pp. 5-6).
Linkage		..	RECORD 12.3: 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.	12.3 Included, *Study Design and Setting* (pp. 5-6).
Results				
Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage.	RECORD 13.1: 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.	13.1 Included, *Study Design and Setting* and *Study Cohort* (pp. 5-7).

		(c) Consider use of a flow diagram		
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)		14. Included, *Results* (pg. 10, Table 1, S1 Figure and S3 Table).
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time *Case-control study* - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or summary measures		15. Included, *Results* (pp. 10-11, Table 1 and S4 Table).
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 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		16. Included, *Results* (pp. 10-11, Table 2, and Figure 1A-C).
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses		17. Included, *Results* (pp. 11-12, S5 & S6 Tables and Figures 2 & 3).
Discussion				
Key results	18	Summarise key results with reference to study objectives		18. Included, *Discussion* (pg. 12).

Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	RECORD 19.1: 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.	19.1 Included, *Discussion* (pp. 15-16).
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence		20. Included, *Discussion* (pp. 12-14) and *Conclusions* (pg. 16).
Generalisability	21	Discuss the generalisability (external validity) of the study results		21. Included, *Discussion* (pg. 15).
Other Information				
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		22. Included, *Acknowledgements / Disclaimer* (pg. 17).
Accessibility of protocol, raw data, and programming code		..	RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	22.1 Included, *Data Availability* (pg. 18).

*Reference: Benchimol EI, Smeeth L, Guttmann 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. 2015 Oct 6;12(10):e1001885. doi: 10.1371/journal.pmed.1001885

Completed April 14, 2019 (CJM).

S2 Table. Description and coding of multimorbidity

In addition to dementia, we identified the presence of 16 chronic conditions, prevalent as of each home care clients' RAI-HC assessment date, based on data from hospital discharges (Discharge Abstract Database, DAD), physician billings (Ontario Health Insurance Plan, OHIP) and prescription drugs dispensed (Ontario Drug Benefits, ODB). Conditions included: acute myocardial infarction (AMI), asthma, (any) cancer, cardiac arrhythmia, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), chronic coronary syndrome, dementia, diabetes, hypertension, non-psychotic mood and anxiety disorders, other mental illnesses (including schizophrenia, delusions, and other psychoses; personality disorders; and substance abuse), osteoarthritis, osteoporosis, renal failure, rheumatoid arthritis, and stroke (excluding transient ischemic attack). These conditions were selected based on their system burden, in terms of population and economic burden, and have been used in multiple research studies of multimorbidity in Ontario.[3,36] Where applicable we used validated algorithms to ascertain cases (AMI, asthma, CHF, COPD, dementia, diabetes, hypertension and rheumatoid arthritis). All other conditions were defined based on the presence of any one inpatient hospital diagnostic code (DAD data) or two or more outpatient physician billing codes (OHIP data) within a 2 year period using relevant ICD-9 and ICD-10 codes (below). The earliest hospital or billing date was used to identify incident cases.

From these data we defined level of multimorbidity (i.e., chronic disease burden) based on a simple count of prevalent chronic conditions, which was coded as zero/one (reference), two, three, four, five, or six-plus conditions.

Condition [reference for validated algorithm]	ICD 9 / OHIP	ICD 10	ODB*
Acute Myocardial Infarction (AMI) [1]	410	I21, I22	
Osteoarthritis and other Arthritis:			
(A) Osteoarthritis	715	M15-M19	
(B) Other Arthritis (includes Synovitis, Fibrositis, Connective tissue disorders, Ankylosing spondylitis, Gout Traumatic arthritis, pyogenic arthritis, Joint derangement, Dupuytren's contracture, Other MSK disorders)	727, 729, 710, 720, 274, 716, 711, 718, 728, 739	M00-M03, M07, M10, M11-M14, M20-M25, M30-M36, M65-M79	
Arthritis - Rheumatoid arthritis [2]	714	M05-M06	
Asthma [3]	493	J45	
(all) Cancers	140-239	C00-C26, C30-C44, C45-C97	
Cardiac Arrhythmia	427 (OHIP) / 427.3 (DAD)	I48.0, I48.1	
Congestive Heart Failure [4]	428	I500, I501, I509	
Chronic Obstructive Pulmonary Disease [5]	491, 492, 496	J41, J43, J44	
Coronary syndrome (excluding AMI)	411-414	I20, I22-I25	
Dementia [6]	290, 331 (OHIP) / 046.1, 290.0, 290.1, 290.2, 290.3, 290.4, 294, 331.0, 331.1, 331.5, F331.82 (DAD)	F00, F01, F02, F03, G30	Cholinesterase Inhibitors
Diabetes [7]	250	E08 - E13	
Hypertension [8]	401, 402, 403, 404, 405	I10, I11, I12, I13, I15	
(Other) Mental Illnesses	291, 292, 295, 297, 298, 299, 301, 302, 303, 304, 305, 306, 307, 313, 314, 315, 319	F04, F050, F058, F059, F060, F061, F062, F063, F064, F07, F08, F10, F11, F12, F13, F14, F15, F16, F17, F18, F19, F20, F21, F22, F23, F24, F25, F26, F27, F28, F29, F340, F35, F36, F37, F430, F439, F453, F454, F458, F46, F47, F49, F50, F51, F52, F531, F538, F539, F54, F55, F56, F57, F58, F59, F60, F61, F62, F63, F64, F65, F66, F67, F681, F688, F69, F70, F71, F72, F73, F74, F75, F76, F77, F78, F79, F80, F81, F82, F83, F84, F85, F86, F87, F88, F89, F90, F91, F92, F931, F932, F933, F938, F939, F94, F95, F96, F97, F98	

Mood, anxiety, depression and other nonpsychotic disorders	296, 300, 309, 311	F30, F31, F32, F33, F34 (excl. F34.0), F38, F39, F40, F41, F42, F43.1, F43.2, F43.8, F44, F45.0, F45.1, F45.2, F48, F53.0, F68.0, F93.0, F99
Osteoporosis	733	M81, M82
Renal failure	403, 404, 584, 585, 586, v451	N17, N18, N19, T82.4, Z49.2, Z99.2
Stroke (excluding transient ischemic attack)	430, 431, 432, 434, 436	I60-I64

NOTES:

Abbreviations: ICD = International Classification of Disease; ODB = Ontario Drug Benefit program database; OHIP = Ontario Health Insurance Plan, physician billings database;

All case definitions look back to 2001 to ascertain disease status, with the exception of AMI (1 year prior to index), Cancer (2 years), Mood Disorder (2 years) and Other Mental Illnesses (2 years)

AMI, Asthma, COPD, CHF, Dementia, Diabetes Hypertension and Rheumatoid Arthritis are based on validated case algorithms (see Sources 1-8 below, respectively). All other conditions required at least one diagnosis recorded in acute care (CIHI) or two diagnoses recorded in physician billings within a two-year period.

*ODB prescription drug records are not available for the majority of persons under the age of 65

1. Austin PC, Daly PA, Tu JV. A multicenter study of the coding accuracy of hospital discharge administrative data for patients admitted to cardiac care units in Ontario. American Heart Journal 2002;144:290–6.
2. Widdifield J, Bernatsky S, Paterson JM, Tu K, Ng R, Thorne JC, Pope JE, Bombardier C. Accuracy of Canadian health administrative databases in identifying patients with rheumatoid arthritis: a validation study using the medical records of rheumatologists. Arthritis Care Res 2013; 65(10): 1582-1591.
3. Gershon AS, Wang C, Guan J, Vasilevska-Ristovska J, Cicutto L, To T. Identifying patients with physician-diagnosed asthma in health administrative databases. Can Respir J 2009;16:183–8.
4. Schultz SE, Rothwell DM, Chen Z, Tu K. Identifying cases of congestive heart failure from administrative data: a validation study using primary care patient records. Chronic Diseases and Injuries in Canada 2013;33:160–6.
5. Gershon AS, Wang C, Guan J, Vasilevska-Ristovska J, Cicutto L, To T. Identifying Individuals with Physician Diagnosed COPD in Health Administrative Databases. Copd 2009;6:388–94.
6. Jaakkimainen RL, Bronskill SE, Tierney MC, Herrmann N, Green D, Young J, et al. Identification of Physician-Diagnosed Alzheimer's Disease and Related Dementias in Population-Based Administrative Data: A Validation Study Using Family Physicians' Electronic Medical Records. J Alzheimers Dis. IOS Press; 2016 Aug 10;54(1):337–49
7. Hux JE, Ivis F, Flintoft V, Bica A. Diabetes in Ontario: Determination of prevalence and incidence using a validated administrative data algorithm. Diabetes Care 2002;25:512–6.
8. Tu K, Campbell NR, Chen Z-L, Cauch-Dudek KJ, McAlister FA. Accuracy of administrative databases in identifying patients with hypertension. Open Med 2007;1:e18–26.

S3 Table. Distribution of 16 chronic conditions among long-stay home care clients aged 50+ years in Ontario, by dementia status

Chronic Condition	Overall Sample % (n)	No Dementia* % (n)	Dementia* % (n)
	N=153,125	N=112,169	N=40,956
Hypertension	83.6 (128,017)	83.6 (93,828)	83.5 (34,189)
Osteoarthritis	66.3 (101,447)	66.9 (75,046)	64.5 (26,401)
Diabetes	40.8 (62,462)	42.5 (47,631)	36.2 (14,831)
Coronary Syndrome (excl. AMI)	33.9 (51,858)	34.2 (38,378)	32.9 (13,480)
Congestive Heart Failure	26.8 (41,103)	28.8 (32,254)	21.6 (8,849)
Cancer	22.5 (34,477)	24.1 (27,033)	18.2 (7,444)
Arrhythmia	22.0 (33,744)	22.3 (25,060)	21.2 (8,684)
Chronic Obstructive Pulmonary Dis.	20.6 (31,543)	22.4 (25,107)	15.7 (6,436)
Mood & Anxiety Disorders (nonpsychotic)	20.1 (30,773)	19.1 (21,409)	22.9 (9,364)
Asthma	18.6 (28,496)	19.8 (22,191)	15.4 (6,305)
Renal failure	17.7 (27,065)	18.8 (21,070)	14.6 (5,995)
Stroke	15.0 (22,985)	15.2 (17,046)	14.5 (5,939)
Osteoporosis	14.0 (21,412)	13.3 (14,962)	15.7 (6,450)
Other Mental Health Conditions	8.4 (12,920)	8.1 (9,110)	9.3 (3,810)
Rheumatoid Arthritis	4.4 (6,746)	4.9 (5,443)	3.2 (1,303)
Acute Myocardial Infarction	1.4 (2,193)	1.6 (1,847)	0.8 (346)

***** Estimates for those without vs with dementia were significantly different ($p<0.001$), except for hypertension ($p=0.423$)

S4 Table. Distribution of the most frequent causes of hospitalization among all urgent admissions† during 1-year follow-up, by ICD-10 chapter and dementia status

ICD-10 Chapter	Overall Sample	No Dementia	Dementia
	N=94,057	N=71,845	N=22,212
Diseases of the circulatory system	16352 (17.4)	13,166 (18.3)	3,186 (14.3)
Diseases of the respiratory system	16097 (17.1)	12,612 (17.6)	3,485 (15.7)
Symptoms, signs and abnormal clinical and lab findings not elsewhere classified	9350 (9.9)	6,943 (9.7)	2,407 (10.8)
Injury, poisoning and other external causes	9311 (9.9)	6,693 (9.3)	2,618 (11.8)
Diseases of the digestive system	7693 (8.2)	6,266 (8.7)	1,427 (6.4)
Diseases of the genitourinary system	7000 (7.4)	5,131 (7.1)	1,869 (8.4)
Certain infectious and parasitic diseases	4944 (5.3)	3,845 (5.4)	1,099 (4.9)
Mental and behavioural disorders	4462 (4.7)	2,460 (3.4)	2,002 (9.0)
Factors influencing health status and contact with health services	3837 (4.1)	2,887 (4.0)	950 (4.3)
Endocrine, nutritional and metabolic diseases	3681 (3.9)	2,984 (4.2)	697 (3.1)
Diseases of the musculoskeletal system and connective tissue	3071 (3.3)	2,556 (3.6)	515 (2.3)
Diseases of the nervous system	2845 (3.0)	1,684 (2.3)	1,161 (5.2)
Neoplasms	2364 (2.5)	2,012 (2.8)	352 (1.6)
Diseases of the skin and subcutaneous tissue	1730 (1.8)	1,499 (2.1)	231 (1.0)
Diseases of the blood and blood-forming mechanisms	1125 (1.2)	944 (1.3)	181 (0.8)

†N=94,057 urgent admissions among 58,551 home care clients (38.2% with at least one urgent hospitalization); Of those with an admission, 63.7% had 1 admission over the follow-up, 22.5% had 2 admissions, and 13.8% had 2+

S5 Table. Sensitivity analysis showing estimated associations† between dementia, frailty (categorical FI), and dementia-frailty interaction, and 1-year health outcomes among long-stay home care clients aged 50+ years in Ontario

Outcome	Age-Sex Adj. s/HR	Age-Sex Adj. s/HR	Fully Adj. s/HR‡ Model 1	Fully Adj. s/HR‡ Model 2
Urgent Hospitalization				
Dementia	0.815* (0.800,0.832)	--	0.847* (0.830,0.864)	0.847* (0.816,0.880)
Frailty – Robust		1 [Ref gp]	1 [Ref gp]	1 [Ref gp]
Pre-frail		1.318* (1.292,1.345)	1.229* (1.204,1.255)	1.223* (1.195,1.252)
Frail		1.580* (1.546,1.614)	1.431* (1.400,1.463)	1.441* (1.405,1.479)
Dementia-Pre-frail	--	--	--	1.023 (0.974,1.073)
Dementia-Frail	--	--	--	0.975 (0.927,1.025)
p for interaction (Wald test)	--	--	--	0.124
LTC Admission				
Dementia	2.749* (2.679,2.821)	--	2.632* (2.563,2.703)	3.891* (3.687,4.107)
Frailty – Robust		1 [Ref gp]	1 [Ref gp]	1 [Ref gp]
Pre-frail		1.544* (1.494,1.596)	1.634* (1.580,1.690)	1.895* (1.804,1.992)
Frail		2.476* (2.395,2.559)	2.563* (2.478,2.652)	3.675* (3.499,3.860)
Dementia-Pre-frail	--	--	--	0.755* (0.706,0.807)
Dementia-Frail	--	--	--	0.493* (0.461,0.527)
p for interaction (Wald test)	--	--	--	<0.001
Mortality				
Dementia	0.901* (0.874,0.928)	--	0.882* (0.856,0.909)	0.697* (0.650,0.748)
Frailty – Robust		1 [Ref gp]	1 [Ref gp]	1 [Ref gp]
Pre-frail		1.524* (1.471,1.579)	1.466* (1.414,1.519)	1.386* (1.331,1.443)
Frail		2.565* (2.477,2.655)	2.425* (2.340,2.512)	2.240* (2.151,2.333)
Dementia-Pre-frail	--	--	--	1.286* (1.181,1.401)
Dementia-Frail	--	--	--	1.379* (1.270,1.497)
p for interaction (Wald test)	--	--	--	<0.001

† For urgent hospitalization and LTC admission, estimates are sub-distribution hazard ratios (sHRs) and corresponding 95% confidence intervals from Fine-Gray model; for mortality, estimates are hazard ratios (HRs) and corresponding 95% confidence intervals from Cox proportional hazards regression model.
‡ Models adjusted for age, sex, marital status, rurality, income quintile and multimorbidity count; Model 2 additionally includes dementia-frailty interaction term.
* $p<0.05$

S6 Table. Estimated cumulative incidence (urgent hospitalization, LTC admission) and cumulative hazard (mortality) at 1-year, based on multivariable regression models that include dementia-frailty (categorical FI) interaction

	Urgent Hospitalization (cumulative incidence)	LTC Placement (cumulative incidence)	Death (cumulative hazard)
Dementia, Robust	.28	.20	.07
Dementia, Pre-Frail	.33	.28	.13
Dementia, Frail	.36	.34	.22
No Dementia, Robust	.32	.06	.10
No Dementia, Pre-Frail	.37	.10	.14
No Dementia, Frail	.42	.19	.23

S1 Figure. Distribution of baseline frailty (FI) by dementia status