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Association between frailty, chronic conditions and socio-economic status in community-dwelling older adults attending primary care: A cross-sectional study using practice-based research network data

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This manuscript contains:

2 Figures

2 Tables

1 Appendix

Abstract:

Objectives: Frailty is a multidimensional syndrome of loss of reserves in energy, physical ability, cognition, and general health. Frail patients are more susceptible to adverse health outcomes

and acute health system use. This study examined associations between level of frailty and chronic conditions and socioeconomic status.

Design: cross-sectional cohort study

Setting: The MUSIC Network is a PBRN in Hamilton, Ontario, composed of 55 family physicians providing care to 38,000 patients who represent a broad cross section of patients. MUSIC hosts a regularly updated, deidentified, longitudinal database containing primary care practice data.

Participants: Patients aged 65 years or older, rostered to one of 37 family physicians at 2 clinical sites within the MUSIC Network and with a recent clinical encounter.

Intervention: MUSIC Network physicians assigned a frailty score to patients using the nine-point Clinical Frailty Scale (CFS). We linked frailty scores to chronic conditions and neighbourhood-level socioeconomic status to examine associations between these domains.

Results: Among the 2043 patients assessed, the prevalence of low (scoring 1-3), medium (scoring 4-6) and high frailty (scoring 7-9) was 55.9%, 40.3% and 3.8% respectively. The prevalence of five or more chronic diseases was 11% among low, 26% among medium and 44% among high frailty groups ($\chi 2 = 137.92$, DoF 2, <0.001). More disabling conditions appeared in the top 50% of conditions in the highest frailty group compared to the low and medium groups. Increasing frailty was significantly associated with lower neighbourhood income ($\chi 2 = 61.42$, DoF 8 p <0.001) and higher neighbourhood material deprivation $\chi 2 = 55.24$ Dof 8, p <0.001).

Conclusion: There appears to be a triple disadvantage of disease burden, frailty, and socioeconomic disadvantage. This knowledge, as well as specific disease patterns, can support a health equity approach in planning health care for older adults within primary care.

Article Summary

Strengths and limitations of this study

Strengths

- The CFS frailty scores were completed for 77% of eligible patients supporting the feasibility and ease of use of the tool within primary care
- Data collection for our analyses draws on 3 data types: prospective collected frailty scores, MUSIC Network database for patient recruitment and disease conditions and socioeconomic data sourced from the Canadian Census data

Weaknesses

- This study is cross-sectional therefore we cannot deduce the direction of causation of the associations between socio-economic status, multimorbidity and level of frailty
- We used neighbourhood-level income and deprivation status in the absence of directly collected, patient-level socio-economic status which is not collected in the Primary Care EMR record
- We limited the cohort to patients for whom a single dissemination area (DA) code mapped to their postal code and those with a recent encounter for whom the clinician had enough knowledge to complete a CFS, but do not expect this to affect the associations found.

Keywords:

Frailty

Multimorbidity

Chronic Disease

Socioeconomic Status

Social Deprivation

Health Equity

Primary Care

Abbreviations:

MUSIC: McMaster University Sentinel and Information Collaboration

PBRN: Practice-based Research Network

CFS: Clinical Frailty Scale©

PCCF: Postal Code Conversion File^{OM}

CHASS: Computing in the Humanities and Social Sciences

DA: Dissemination area

Introduction:

Frailty is considered a multidimensional syndrome of loss of reserves in energy, physical ability, cognition, and general health. There are approximately 1.6 million people in Canada living with frailty.[1] Frail patients are complex and more susceptible to adverse health outcomes compared to non-frail people of the same chronological age.[2] Left unchecked, frail patients experience diminished quality of life, high risk for hospitalization and long-term care admission and increased mortality.[3-5] Primary care plays a central role in management, coordination and prevention as the medical home for patients[6] with a key role in identifying and managing frailty.[7,8]

While frailty is not fully explained by the presence of specific health conditions, a large proportion of people experiencing frailty also have multiple chronic medical conditions (multimorbidity).[9-11] Multimorbidity negatively affects patient-important outcomes like disability, social participation, and self-rated physical and mental health and it contributes to care burden[12,13], and the need for acute care services[11]. The combination of frailty and multimorbidity is likely to exacerbate their respective load of associative issues.

Low socioeconomic status is associated with multimorbidity, health risks, poorer prognoses, and challenges in accessing equitable care.[14-17] Lower socioeconomics status also reduces access to primary care[15,18]. The addition of a socioeconomic lens on the multimorbid and frail population can help focus effective interventions and distribute resources more effectively. In primary care, the longitudinal comprehensive primary care framework can be leveraged with

clinicians identifying their frail patients, guiding them to appropriate goal-directed care, and helping them to proactively manage their complex health and social needs.

Reliable screening tools for frailty are easy to use in primary care settings.[19,20] Identification of prefrail and frail patients in primary care creates the opportunity to develop targeted interventions that address quality of life, burden of unnecessary treatment, and assess barriers.[2,3,21-23]. Such approaches are likely to improve the individual patient's health and experience of equitably delivered health care and ameliorate resource utilization. Planning and evaluating programs in primary care designed to meet the needs of all frail older adults would be better guided with an understanding of how chronic disease patterns and social factors (socioeconomic status) intersect and are patterned across prefrail and frail states.[21] We found little evidence that examined the intersection of frailty, multimorbidity and socioeconomic status, and with this study, we sought to explore their relationship.

We hypothesized that patients with a greater number of chronic conditions, especially disabling conditions, and with lower socioeconomic status would be more likely to have a higher clinical frailty score. Our aim was to describe the distribution of frailty among older adult patients in primary care, and to describe association between chronic conditions, socioeconomic status and frailty.

Methods

We conducted a cross-sectional study of a cohort of older adults, created using electronic medical records from a primary care practice-based research network (PBRN). Clinical frailty

assessments and neighbourhood-level income and deprivation data were linked to the patient's clinical data available from their electronic medical records.

Setting

The MUSIC Network is a PBRN in Hamilton, Ontario, Canada. Data holdings include a regularly updated, deidentified, longitudinal database containing primary care practice data. There are 55 family physicians associated with the MUSIC Network. This study was based on a sub-set of the 37 physicians in the MUSIC PBRN, who's previously described 38,000 patients represent a broad cross section of patients.[24,25]

Participants

Patients aged 65 years or older, currently rostered (as of Jan2020) to family physicians of the MUSIC network subgroup described above, were eligible to be included in the cohort.

Patient and Public Involvement

None

Data Collection and Preparation

Frailty Score Assignment

The Clinical Frailty Scale© (CFS) is a frailty screening tool that applies clinical judgement for scoring personal capacity, independence related to fitness and self-management of health. It can be reliably used to predict outcomes of mortality, comorbidity, functional, decline, mobility, and cognitive decline. The CFS features a clinically validated 9-point scale ranging from 1 (very fit) to 9 (terminally ill) with scores of ≥5 indicating a frail state.[19,26]. With low administration time (less than 1 minute per patient assessment) and low cost, the CFS has seen high utility

across many clinical practice domains[19,27,28]. The CFS has good inter-rater agreement between physicians and multidisciplinary teams and correlates well with other frailty scoring instruments.[27,28]

The participating physicians' EMR was used to identify rostered patients over the age of 65 and who had attended a clinical encounter within the last 12 months. The family physicians were provided with a list of eligible patients in their care, accompanied by the CFS scoring guide (Appendix A). Physicians were asked to complete frailty assessments (selecting a CFS score between 1-9) of patients whom they felt confident that they could assess based on their overall knowledge of the patient. There were no specific exclusion criteria.

Scored lists were collected from each provider and securely entered within a research database, replacing all patient identifiers with the MUSIC patient ID. Scores were completed for 77% of eligible patients.

Cohort Creation and Data Linkage

The final cohort for this study included 2043 patients whose physician had assessed their frailty level and who had: 1) a postal code in Hamilton that could accurately be linked to neighbourhood-level information (described below) and 2) accessible disease diagnoses through the MUSIC-PBRN database.

To capture conditions, we used the ICD9 disease codes which are recorded by physicians, within the disease registry module of the EMR. Coded conditions include disorders such as COPD and heart failure as well as risk factors such as hypertension and dyslipidemia. Condition codes considered to be similar (i.e., variations of the same base condition) were grouped, for

example, Dementia (ICD9 290) and Alzheimers (ICD9 331.0) to form meaningful groupings for frequency analysis.

We used the Postal Code^{OM} Conversion File (PCCF), complementary to the 2016 Canadian Census,[29] to translate patients' postal codes to the geographic census unit of dissemination area. A dissemination area (DA) is a small geographic census area composed of one or more neighbouring blocks, with a population of 400 to 700 persons.[29] In this, the cohort was limited to only patients having a 1:1 mapping between their postal code and matching DA to facilitate a simple and direct means of linking dissemination area to socioeconomic status data.

The Canadian Socio-Economic Information Management System database was accessed via the Computing in the Humanities and Social Sciences (CHASS) Canadian Census Analyser[30] to retrieve economic family after-tax income decile group data[31]. Economic family after-tax neighbourhood income decile groups can provide a rough ranking of an individual's relative economic position. These income decile data were organized by dissemination area (DA) geographical units. We calculated the median decile for each DA unit represented in our cohort and linked this value to each patient via the postal code to DA map. We further collapsed the decile groups into quintiles to achieve reasonable category sizes for statistical analysis.

A second set of socioeconomic data from the Ontario Marginalization Index[32] was also linked to the dataset using the same postal code to DA translation. The index provides a measure of material deprivation, an estimate of the inability for individuals and communities to access and

attain basic material needs using indicators of income, quality of housing, educational attainment, and family structure characteristics.

Data Analysis

We described the distribution of patient demographic characteristics, frailty, chronic conditions, and SES variables using simple descriptive analyses (means, median, frequencies and proportions, as appropriate). A review of the distribution of the CFS scores showed some score categories had very small numbers, therefore, for analysis purposes, we further grouped the cohort's frailty scores as low (scored 1-3), medium (scored 4-6), and high (scored 7-9).

We examined bivariate associations between frailty and other patient characteristics (demographics, multimorbidity and SES). Age was categorized as 65-69, 70-74, 75-79, 80-84, 85-89 and > 90 years. Male and female captured sex groupings. Income quintiles included scores of 1 (lowest income) to 5 (highest income). Material deprivation quintiles included groupings of 1 (least deprived) to 5 (most deprived). The number of chronic conditions (disorders and risk factors) were grouped as 0, 1, 2-4, 5+ and categorized having 1 or more conditions versus none.

We examined associations using Chi-square, and ANOVA as appropriate. Statistical significance was set at alpha<0.05 (two-tailed). The data were analyzed using IBM SPSS Statistics (Version 28) predictive analytics software.

The study was approved by the Hamilton Integrated Research Ethics Board (HiREB No. 10683).

Results

Demographics

The mean age of the patients (n= 2043) was 76 years (as of Feb 2020) and 60.5% (1235/2043) were female. Two-thirds of the patients (63.5%, 1296/2043) had two or more chronic conditions.

Frailty Distribution

Figure 1 shows the frailty distribution over all 9 CFS categories with a slightly skewed distribution with fewer patients in the frailest categories and the highest proportion of patients scored as 3.

Median Income Distribution

Figure 2 shows the full distribution of median economic family after-tax income deciles (1 as lowest income decile, 10 as highest income decile). There was a near-normal distribution with the highest proportion of patients in decile 6. Grouping deciles into quintiles with 1 designated as lower income and 5 as higher income, most patients were in the middle quintile (3) (38.3%) with the smallest proportions in the lowest (5.1%) and highest income (4.5%) quintiles (Table 1).

Table 1: Associations between frailty score and demographic characteristics, deprivation indicators and multimorbidity (N=2,043).

Characteristic	Overall	Low Frailty, n (%)	Medium Frailty, n (%)	High Frailty, n (%)	*P-value*
Frailty group	2,043	1,141 (55.9)	824 (40.3)	78 (3.8)	
Demographics					
Mean Age (SD)	76 (7.8)	73.3 (5.9)	79.1 (8.2)	85.2 (9.0)	<0.001[a]
Median Age (Range)	74 (65-103)	72 (65-99)	78 (65-103)	86 (66-102)	<0.001[b]
Age grouping					
65-69	589 (29)	440 (39)	143 (17)	6 (8)	<0.001[c]
70-74	540 (26)	355 (31)	176 (21)	9 (12)	
75-79	374 (18)	210 (18)	156 (19)	8 (10)	
80-84	247 (12)	84 (7)	148 (18)	15 (19)	
85-89	173 (9)	40 (4)	120 (15)	13 (17)	
> 90 y	120 (6)	12 (1)	81 (10)	27 (35)	
Female, n (%)	1236 (61)	647 (57)	535 (65)	54 (69)	<0.001[c]
Male, n (%)	807 (40)	494 (43)	289 (35)	24 (31)	
Median income quintile [d]					
1 (low)	104 (5)	35 (3)	65 (8)	4 (5)	<0.001[c]
2	545 (27)	269 (24)	250 (30)	26 (33)	
3	783 (38)	429 (38)	324 (39)	30 (39)	
4	520 (26)	348 (31)	157 (19)	15 (19)	
5 (high)	91 (5)	60 (5)	28 (3)	3 (4)	
Deprivation quintile [e]					
1 (least deprived)	411 (20)	286 (25)	113 (14)	12 (15)	<0.001[c]
2	302 (15)	182 (16)	106 (13)	14 (18)	
3	348 (17)	179 (16)	156 (19)	13 (17)	
4	530 (26)	277 (24)	228 (28)	25 (32)	
5 (most deprived)	452 (22)	217 (19)	221 (27)	14 (18)	
Multimorbidity [f]					
No. chronic conditions [f]					
0	338 (17)	261 (23)	73 (9)	4 (5)	
1+	1,705 (84)	880 (77)	751 (91)	74 (95)	<0.001[c]
1	409 (20)	267 (23)	133 (16)	9 (12)	<0.001[c]
2-4	923 (45)	487 (43)	405 (49)	31 (40)	
5+	373 (18)	126 (11)	213 (26)	34 (44)	

[a] *P* value from ANOVA test

[b] *P* value from Kruskal-Wallis test

[c] *P* value from χ2 test for categorical data

[d] Mean value of Economic family after-tax income decile group data at dissemination area level, based on Statistics Canada 2016 Census data.

[e] Deprivation score categories from the Ontario Marginalization Index at dissemination area level

[f] Chronic disorders and risk factor conditions coded by physicians with ICD9

Associations between Frailty Level, and Demographic Characteristics Socioeconomic Status and Multimorbidity

Mean age ascended across frailty groups at 73 years in the low frailty group, 78 years in the medium frailty group and 85 years in the high frailty group (ANOVA, F = 231.62, DoF 2, p <0.0001) (Table 1). The proportion of patients who were female increased across low, medium and high frailty groups (57%, 65%, 69% respectively) (*χ2=16.12, df=3, p<0.001*).

The distribution of income quintiles was significantly different across the frailty groups (*χ2 = 61.42, df=8, p <0.001).* There is some trend of moderate and higher frailty patients associated with lower income quintiles compared to patients with low frailty. (Table 1).

There were significant differences in proportions of patients in different frailty groups across the material deprivation quintile groupings (χ2=55.243, df=8, p <0.001). Table 1 also shows certain trending of the higher frailty group associated with greater deprivation, compared to the moderate and low frailty groups that show less deprivation.

Patients with higher frailty were more likely to have at least one coded condition (95%, 91% and 77% in the high, medium and low frailty groupings, respectively ($\chi 2 = 75.7254$, DoF 2, $p < 0.0001$). Furthermore, the accumulation of chronic disease (1, 2-4 or 5+ conditions) differed across frailty groups ($\chi 2 = 169.6$ Dof 6, $p < 0.001$). The data show a trend of more multimorbidity burden in the high frail group (12%, 40%, 44% for 1, 2-3 and 5+ conditions), whereas the low frailty and medium frailty groups showed higher proportions in the 2-4 conditions category (43% and 49% for low frailty and medium frailty, respectively) ($p<0.001$).

Chronic Conditions Patterns

Table 2 shows the most frequent chronic conditions and risk factors (e.g., hypertension and hyperlipidemia) in each frailty grouping. A core set of high frequency conditions composed at least 50% of all conditions in all three frailty groups but more conditions were included in the top 50% as frailty increased. In the low frailty group, 5 conditions composing the risk factors hypertension and hyperlipidemia and the disorders diabetes, osteoarthritis/joint pain, and depression - unipolar) comprised 52% of their conditions. These 5 conditions persisted in the medium frailty group with the addition of 2 more conditions (back, neck pain and sciatica and cardiac dysrhythmia) composing 51% of conditions. In the high-scored frailty group, 9 conditions comprised 52% of the conditions, with dementia/Alzheimers, congestive heart failure and acute and chronic coronary artery disease (CAD) appearing uniquely and displacing back, neck pain and sciatica. Among other burdensome disease, chronic obstructive pulmonary disease was a relatively common condition in the high and medium frailty groups (falling within

54% of all conditions for both) and but less so in the low frailty group (falling within the top 70% of all conditions).

Table 2: Array and Proportion of Conditions (Disorders and Risk Factors[c]) in each Frailty Grouping among the 2043 primary care patients

Frailty Score 1-3	Proportion of Grouping Diagnoses	Frailty Score 4-6	Proportion of Grouping Diagnoses	Frailty Score 7-9	Proportion of Grouping Diagnoses
Hypertension [c]	19%	Hypertension[c]	14.9%	Hypertension[c]	11.8%
Diabetes	12%	Diabetes	9.7%	Osteoarthritis and Joint Pain	7.3%
Hyperlipidemia/ Dyslipidemia[c]	8.3%	Osteoarthritis and Joint Pain	7.7%	Diabetes	6.4%
Osteoarthritis and Joint Pain	7.2%	Hyperlipidemia/ Dyslipidemia[c]	5.8%	Dementia/ Alzheimers[b]	5.6%
Depression (unipolar)	5.9%	Depression (unipolar)	5.5%	Cardiac Dysrhythmia	5.6%
		Back, Neck Pain and Sciatica[a]	4%	Depression	4.5%
		Cardiac Dysrhythmia[a]	3.3%	Congestive Heart Failure[b]	3.6%
				Hyperlipidemia/ Dyslipidemia[c]	3.4%
				Acute and Chronic CAD[b]	3.40%
Total proportion	**52.3%**		**50.7%**		**51.5%**

[a] first appears in medium frailty group
[b] first appears in high frailty group
[c] Risk Factors type among conditions

Discussion

In this study of older adult patients in primary care, almost half of the patients evaluated by their family physician had a moderate or high level of frailty. Higher frailty level was associated with older age, being female and having more chronic conditions, especially life-limiting or

disabling conditions such as cardiovascular diseases and dementia. Higher frailty level was also associated with indicators of lower socio-economic status.

The usability of the CFS in primary care was evidenced in our study with frailty scores completed for 77% of eligible patients. This directly collected data was a strength of the study, as was the study setting within a practice based research network where disease coding in the EMR has been strengthened through previous initiatives.[24]

The cohort showed a near normal distribution across high, medium, and low frailty groups, with the most common scores lying in the middle quintile. As expected in a community dwelling cohort, there were fewer older adults in the most-frail group as these patients are more likely to need long-term care accommodation supports.[4]

We have identified the most common conditions that affect the older adult primary care population and have demonstrated how this pattern shifts across categories of increasing frailty. Furthermore, in those experiencing high frailty conditions, substantial and life-limiting morbidity appear more commonly, and so does burdensome management requirements, greater risk for hospitalization, and lowered quality of life.[11-13,33]

We found that living in neighbourhoods of lower income and higher social material deprivation was more common among patients with moderate and high frailty. These differences have important implications at population level and may reflect large numbers of patients at risk for negative health outcomes. Socio-economic disadvantages may be compounded by costs

associated with living with frailty (e.g., need for mobility aids) in addition to the costs of managing the individual health conditions.[5,11]

Limitations

The study design is cross-sectional therefore we cannot deduce the direction of causation of the associations between socio-economic status, multimorbidity and level of frailty.

Information on individual socio-economic status is not routinely collected in primary care. We have assumed neighbourhood-level income and deprivation status provide reasonable accuracy with respect to the actual socioeconomic status of individual patients within our frailty cohort. Neighbourhood-level information on indicators such as income may not reflect actual wealth among older adults who are more likely to have left the workforce due to retirement.

We limited the cohort to patients for whom a single dissemination area (DA) code mapped to their postal code. This affects sample size but there is no reason to think it would affect the associations found. Similarly, the limitation of the cohort to those with a recent encounter for whom the clinician had enough knowledge to complete a CFS should not affect the associations seen.

Conclusions

Awareness of the triple disadvantage of disease burden, frailty, and socioeconomic disadvantage, as well as specific disease patterns can support a health equity approach to care for older adults within primary care.

The confluence of health and social disadvantage and increasing frailty highlights the need for targeted health and social care approaches for achieving improved health equity. Our findings also underscore the need to anticipate required healthcare services and to use finite resources most effectively. Grounding these requirements in primary care is highly appropriate as evidence shows primary care is a strong mechanism for reducing health inequity, fostering access to comprehensive longitudinal care as well as targeted clinical and program innovations that are effective in reducing modifiable health inequity.[34]

Contributorship Statement

Substantial contributions to the conception or design of the work: DM, JL, MH Acquisition of data: DM, JL Analysis or interpretation of data for the work: DM, JL, MH Drafting the work or revising it critically for important intellectual content; All Authors. Final approval of the version to be published: All Authors. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: All Authors. DM is the guarantor.

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Competing Interest

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/disclosure-of-interest/ and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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Data Sharing Statement

The dataset is available by contact with the corresponding author Dr. Dee Mangin mangind@mcmaster.ca.

Ethics

The study was approved by the Hamilton Integrated Research Ethics Board (HiREB No. 10683). Patient consent was waived as this study applied deidentified retrospective data.

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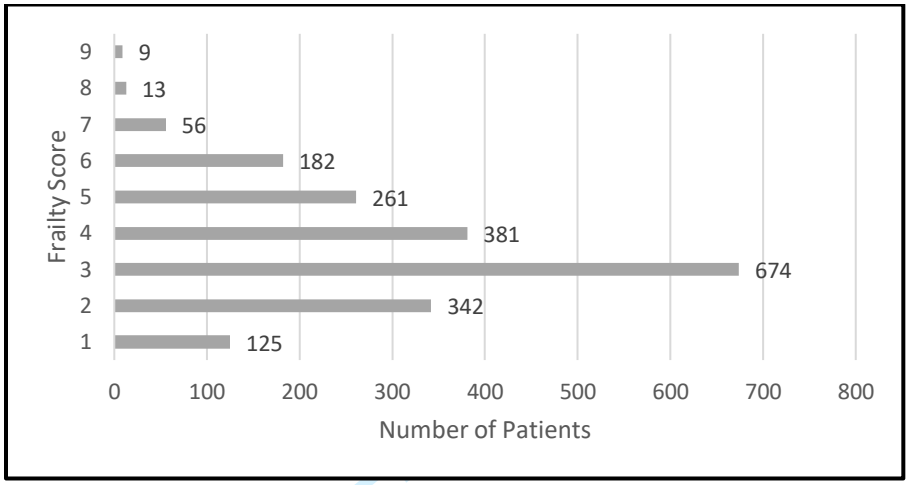
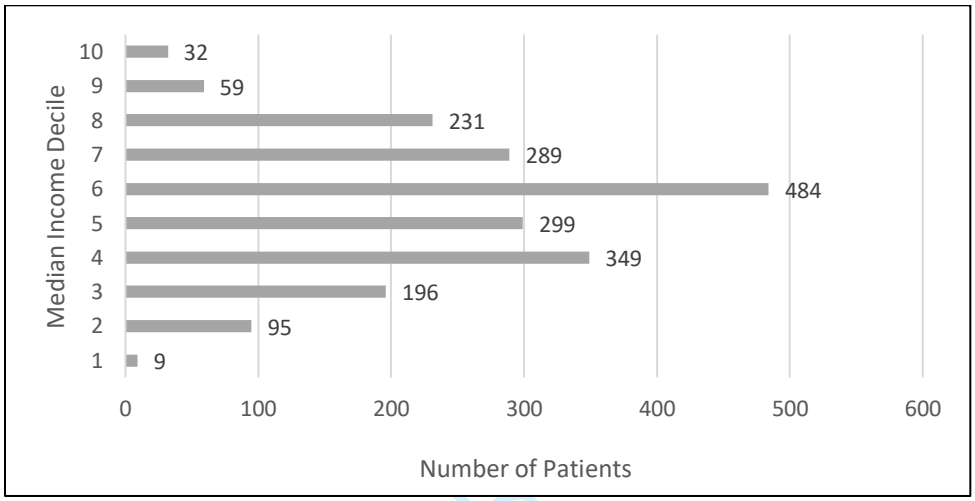
Figure 1: Frailty Score[a] Distribution among the 2043 primary care patients



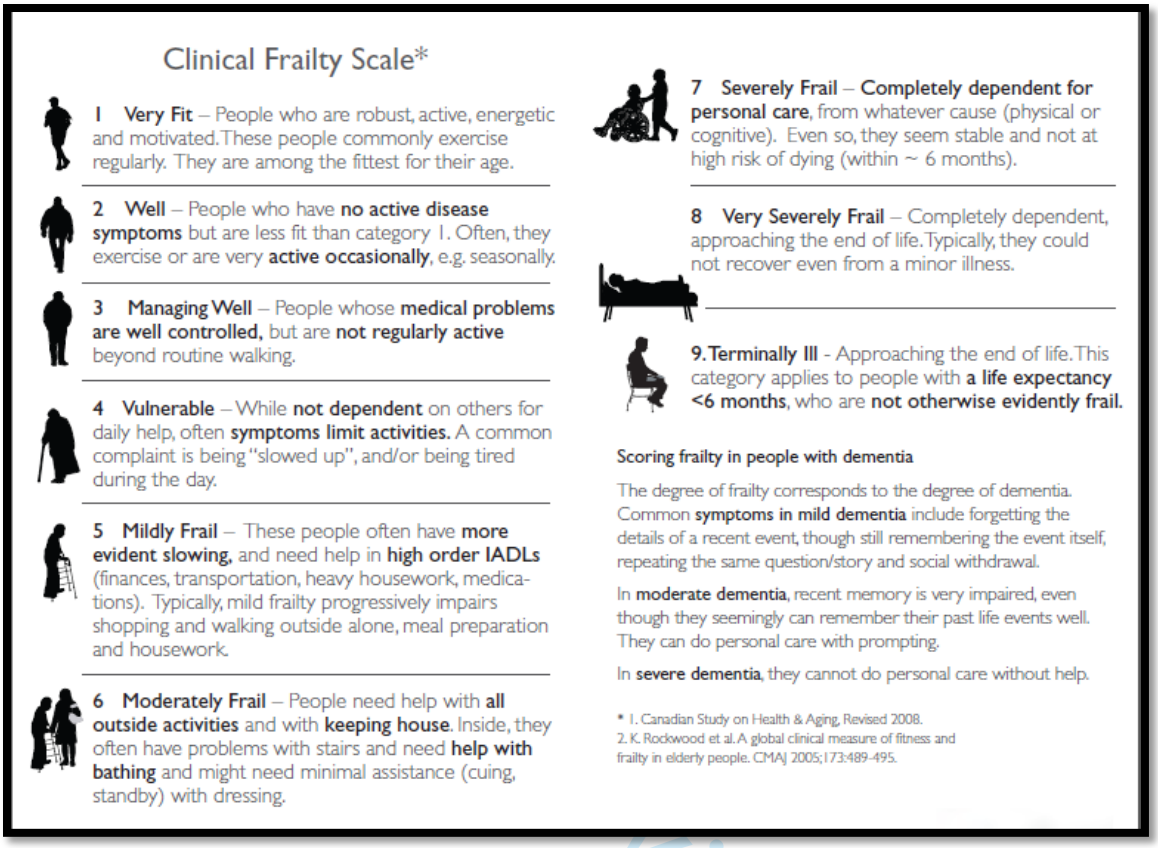
[a] Frailty scored on a 9-point scale ranging from 1 (very fit) to 9 (terminally ill) with scores of ≥5 indicating a frail state. [19,26]

Figure 2: Median Family After-Tax Neighbourhood Income Decile[a] Distribution among the 2043 Patients



[a] Median economic family after-tax income decile (1 as lowest income decile, 10 as highest income decile).

Appendix A: The Clinical Frailty Scale©



Clinical Frailty Scale*

1 Very Fit – People who are robust, active, energetic and motivated. These people commonly exercise regularly. They are among the fittest for their age.

2 Well – People who have **no active disease symptoms** but are less fit than category 1. Often, they exercise or are very **active occasionally**, e.g. seasonally.

3 Managing Well – People whose **medical problems are well controlled,** but are **not regularly active** beyond routine walking.

4 Vulnerable – While **not dependent** on others for daily help, often **symptoms limit activities.** A common complaint is being "slowed up", and/or being tired during the day.

5 Mildly Frail – These people often have **more evident slowing,** and need help in **high order IADLs** (finances, transportation, heavy housework, medications). Typically, mild frailty progressively impairs shopping and walking outside alone, meal preparation and housework.

6 Moderately Frail – People need help with **all outside activities** and with **keeping house**. Inside, they often have problems with stairs and need **help with bathing** and might need minimal assistance (cuing, standby) with dressing.

7 Severely Frail – **Completely dependent for personal care**, from whatever cause (physical or cognitive). Even so, they seem stable and not at high risk of dying (within ~ 6 months).

8 Very Severely Frail – Completely dependent, approaching the end of life. Typically, they could not recover even from a minor illness.

9. Terminally Ill - Approaching the end of life. This category applies to people with **a life expectancy <6 months**, who are **not otherwise evidently frail.**

Scoring frailty in people with dementia

The degree of frailty corresponds to the degree of dementia. Common **symptoms in mild dementia** include forgetting the details of a recent event, though still remembering the event itself, repeating the same question/story and social withdrawal.

In **moderate dementia**, recent memory is very impaired, even though they seemingly can remember their past life events well. They can do personal care with prompting.

In **severe dementia**, they cannot do personal care without help.

* 1. Canadian Study on Health & Aging, Revised 2008.
2. K. Rockwood et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173:489-495.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	4	a cross-sectional study of a cohort
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	4	done
Introduction			6-7	
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-7	… a large proportion of people experiencing frailty also have multimorbidity … Low socioeconomic status is associated with multimorbidity, health risks, poorer prognoses, and challenges in accessing equitable care. … Reliable screening tools for frailty are easy to use in primary care … Planning and evaluating programs in primary care designed to meet the needs of all frail older adults would be better guided with an understanding of how chronic disease patterns and social factors (socioeconomic status) intersect and are patterned across prefrail and frail states. … We found little evidence that examined the intersection of

				frailty, multimorbidity and socioeconomic status, and with this study, we sought to explore their relationship.
Objectives	3	State specific objectives, including any prespecified hypotheses	7	We hypothesized that patients with a greater number of chronic conditions, especially disabling conditions, and with lower socioeconomic status would be more likely to have a higher clinical frailty score. Our aim was to describe the distribution of frailty among older adult patients in primary care, and to describe association between chronic conditions, socioeconomic status and frailty.
Methods				
Study design	4	Present key elements of study design early in the paper	8	We conducted a cross-sectional study of a cohort of older adults, created using electronic medical records from a primary care practice-based research network (PBRN). Clinical frailty assessments and neighbourhood income and deprivation data were linked to the patient's clinical data available from their electronic medical records.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure,	8	The MUSIC Network is a

		follow-up, and data collection		PBRN in Hamilton, Ontario, Canada. Data holdings include a regularly updated, deidentified, longitudinal database containing primary care practice data. Patients aged 65 years or older, currently rostered (as of Jan2020) to family physicians of the MUSIC network subgroup described above, were eligible to be included in the cohort.
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *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	9	The participating physicians' EMR was used to identify rostered patients over the age of 65 and who had attended a clinical encounter within the last 12 months.
		(*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		
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11	Variables include frailty score, socioeconomic status (income and deprivation score) and level of multimorbidity
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	11-12	We described the distribution of patient demographic characteristics, frailty, chronic conditions, and SES variables using simple descriptive

				analyses (means, median, frequencies and proportions, as appropriate)… We examined bivariate associations between frailty and other patient characteristics (demographics, multimorbidity and SES).
Bias	9	Describe any efforts to address potential sources of bias	9	Physicians were asked to complete frailty assessments (selecting a CFS score between 1-9) of patients whom they felt confident that they could assess based on their overall knowledge of the patient.
Study size	10	Explain how the study size was arrived at	9	The final cohort for this study included 2043 patients whose physician had assessed their frailty level and who had: 1) a postal code in Hamilton that could accurately be linked to neighbourhood level information (described below) and 2) accessible disease diagnoses through the MUSIC-PBRN database.

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11	A review of the distribution of the CFS scores showed some score categories had very small numbers, therefore, for analysis purposes, we further grouped the cohort's frailty scores as low (scored 1-3), medium (scored 4-6), and high (scored 7-9). We examined bivariate associations between frailty and other patient characteristics (demographics, multimorbidity and SES). Age was categorized as 65-69, 70-74, 75-79, 80-84, 85-89 and > 90 years. Male and female captured sex groupings. Income quintiles included scores of 1 (lowest income) to 5 (highest income). Material deprivation quintiles included groupings of 1 (least deprived) to 5 (most deprived). The number of chronic conditions (disorders and risk factors) were grouped as 0, 1, 2-4, 5+ and categorized having 1 or more conditions versus none.
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	12	We examined associations using Chi-square, and ANOVA as appropriate. Statistical significance was set at alpha<0.05 (two-tailed). The data were analyzed using IBM SPSS Statistics (Version 28) predictive analytics software.

		(*b*) Describe any methods used to examine subgroups and interactions		Not applicable
		(*c*) Explain how missing data were addressed		Not applicable
		(*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		Not applicable
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9	The final cohort for this study included 2043 patients whose physician had assessed their frailty level and who had: 1) a postal code in Hamilton that could accurately be linked to neighbourhood level information (described below) and 2) accessible disease diagnoses through the MUSIC-PBRN database.
		(b) Give reasons for non-participation at each stage		Provided above
		(c) Consider use of a flow diagram		Described textually
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12, 25-26	The mean age of the patients (n= 2043) was 76 years (as of Feb 2020) and 60.5% (1235/2043) were female. Two-thirds of the patients (63.5%, 1296/2043) had two or more chronic conditions. And also Table 1.
		(b) Indicate number of participants with missing data for each variable of interest		None
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	9-10	Rostered patients with recent encounters identified and physicians were asked to complete

				frailty assessments (selecting a CFS score between 1-9) …Frailty scored patients were linked to current disease coded data in the EMR and to neighbourhood level income and deprivation data.
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	13-14; 25-26	We studies associations between frailty level, and demographic characteristics, socioeconomic status and multimorbidity and chronic conditions patterns. Summarized in Table 1.
		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		
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		Not applicable
		(*b*) Report category boundaries when continuous variables were categorized	11, 25-26	Age categories: 65-69, 70-74, 75-79, 80-84, 85-89, > 90 y The number of chronic conditions (disorders and risk factors) were grouped as 0, 1, 2-4, 5+ and categorized having 1 or more conditions versus none. See Table 1.
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		Not applicable

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-12	We grouped the cohort by frailty score as low (scored 1-3), medium (scored 4-6), and high (scored 7-9). Male and female captured sex groupings. Income quintiles included scores of 1 (lowest income) to 5 (highest income). Material deprivation quintiles included groupings of 1 (least deprived) to 5 (most deprived). We examined associations using Chi-square, and ANOVA as appropriate. Statistical significance was set at alpha<0.05 (two-tailed). The data were analyzed using IBM SPSS Statistics (Version 28) predictive analytics software.
Discussion				
Key results	18	Summarise key results with reference to study objectives	12-14	Two-thirds of the patients (63.5%, 1296/2043) had two or more chronic conditions. The distribution of income quintiles was significantly different across the frailty groups ($\chi 2$ = 61.42, df=8, p <0.001). The data show a trend of more multimorbidity burden in the high frail group (12%, 40%, 44% for 1, 2-3 and 5+ conditions), whereas the low frailty and medium frailty groups showed higher proportions in the 2-4 conditions

				category (43% and 49% for low frailty and medium frailty, respectively) (p<0.001).
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	16	As a cross-sectional study, we cannot deduce the direction of causation of the associations between socio-economic status, multimorbidity and level of frailty. We have assumed neighbourhood level income and deprivation status provide reasonable accuracy with respect to the actual socioeconomic status of individual patients within our frailty cohort. We limited the cohort to patients for whom a single dissemination area (DA) code mapped to their postal code. This affects sample size but there is no reason to think it would affect the associations found
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17	Awareness of the triple disadvantage of disease burden, frailty, and socioeconomic disadvantage, as well as specific disease patterns can support a health equity approach to care for older adults within primary care.
Generalisability	21	Discuss the generalisability (external validity) of the study results	17	This study highlights the need to anticipate and fund targeted health and social care approaches for achieving improved health equity

				and doing this through primary care.
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	3	Funding source: INSPIRE-PHC Program, Applied Health Research Question, Ontario Ministry of Health: Total Funding: $31,680.

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Association between frailty, chronic conditions and socio-economic status in community-dwelling older adults attending primary care: A cross-sectional study using practice-based research network data

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Association between frailty, chronic conditions and socio-economic status in community-dwelling older adults attending primary care: A cross-sectional study using practice-based research network data

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This manuscript contains:

2 Figures

2 Tables

1 Appendix

Abstract:

Objectives: Frailty is a multidimensional syndrome of loss of reserves in energy, physical ability, cognition, and general health. Primary care is key in preventing and managing frailty, mindful of the social dimensions that contribute to its risk, prognosis, and the best fit of patient

supports. We studied associations between frailty levels and both chronic conditions and socioeconomic status.

Design: cross-sectional cohort study

Setting: A practice-based research network (PBRN) in Ontario, Canada, providing primary care to 38,000 patients. The PBRN hosts a regularly updated, deidentified, longitudinal database containing primary care practice data.

Participants: Patients aged 65 years or older, with a recent encounter, rostered to family physicians at the PBRN.

Intervention: Physicians assigned a frailty score to patients using the nine-point Clinical Frailty Scale (CFS). We linked frailty scores to chronic conditions and neighbourhood-level socioeconomic status to examine associations between these three domains.

Results: Among 2043 patients assessed, the prevalence of low (scoring 1-3), medium (scoring 4-6) and high frailty (scoring 7-9) was 55.9%, 40.3%, and 3.8% respectively. The prevalence of five or more chronic diseases was 11% among low, 26% among medium and 44% among high frailty groups ($\chi 2 = 137.92$, DoF 2, <0.001). More disabling conditions appeared in the top 50% of conditions in the highest frailty group compared to the low and medium groups. Increasing frailty was significantly associated with lower neighbourhood income ($\chi 2 = 61.42$, DoF 8 p <0.001) and higher neighbourhood material deprivation $\chi 2 = 55.24$ Dof 8, p <0.001).

Conclusion: This study demonstrates the triple disadvantage of frailty, disease burden, and socioeconomic disadvantage. Frailty care needs a health equity approach: We demonstrate the utility and feasibility of collecting patient-level data within primary care. Such data can relate social risk factors, frailty, and chronic disease toward flagging patients with the greatest need and creating targeted interventions.

Article Summary

Strengths and limitations of this study

Strengths

- Data collection was facilitated with clinical championing contributing to a high Clinical Frailty Scale scoring completion rate (77%) of among eligible patients), supporting internal and external validity
- A primary care practice-based research network was the source of both the prospective frailty assessment and retrospective clinical electronic medical record data demonstrating the research capacity of PBRN data
- Socioeconomic status was linked to patients through Canadian Census data

Weaknesses

- This study is cross-sectional therefore we cannot deduce the direction of causation of the associations between socio-economic status, multimorbidity and level of frailty
- We used neighbourhood-level income and deprivation status in the absence of directly collected, patient-level socio-economic status which is not collected in the Primary Care EMR record

Keywords:

Frailty

Multimorbidity

Chronic Disease

Socioeconomic Status

Social Deprivation

Health Equity

Primary Care

Abbreviations:

MUSIC: McMaster University Sentinel and Information Collaboration

PBRN: Practice-based Research Network

CFS: Clinical Frailty Scale©

PCCF: Postal Code Conversion File^{OM}

CHASS: Computing in the Humanities and Social Sciences

DA: Dissemination area

Introduction:

Frailty is considered a multidimensional syndrome of loss of reserves in energy, physical ability, cognition, and general health. There are approximately 1.6 million people in Canada living with frailty.[1] Frail patients are complex and more susceptible to adverse health outcomes compared to non-frail people of the same chronological age.[2] Left unchecked, frail patients experience diminished quality of life, high risk for hospitalization and long-term care admission and increased mortality.[3-5]

Primary care, as the medical home for patients, plays a central role in chronic condition prevention and management, and care coordination [6]. Evidence clearly shows that stronger primary care is associated with better population outcomes, achieved through the key mechanisms of access (first contact), comprehensiveness, coordination and continuity (longitudinal care) and as such, has the potential to be the most equity enhancing aspect of clinical care.[7] On this premise, primary care plays a key role in preventing, identifying and managing frailty[8], while taking into consideration the social dimensions that contribute to its associated risk, prognosis and facilitators or barriers to clinical intervention and supports.[9]

While frailty is not fully explained by the presence of specific health conditions, a large proportion of people experiencing frailty also have multiple chronic medical conditions (multimorbidity).[10-12] Multimorbidity negatively affects patient-important outcomes like disability, social participation, and self-rated physical and mental health and it contributes to care burden[13,14], and the need for acute care services.[12] The combination of frailty and multimorbidity is likely to exacerbate their respective load of associative issues.

Low socioeconomic status is associated with multimorbidity, health risks, poorer prognoses, and challenges in accessing equitable care.[15-18] Lower socioeconomics status also reduces access to primary care[16,19]. The addition of a socioeconomic lens on the multimorbid and frail population can help focus effective interventions and distribute resources more effectively. In primary care, the longitudinal comprehensive primary care framework can be leveraged with clinicians identifying their frail patients, guiding them to appropriate goal-directed care, and helping them to proactively manage their complex health and social needs.

Reliable screening tools for frailty are easy to use in primary care settings.[20,21] Identification of prefrail and frail patients in primary care creates the opportunity to develop targeted interventions that address quality of life, burden of unnecessary treatment, and assess barriers.[2,3,22-24]. Such approaches are likely to improve the individual patient's health and experience of equitably delivered health care and ameliorate resource utilization. Planning and evaluating programs in primary care designed to meet the needs of all frail older adults would be better guided with an understanding of how chronic disease patterns and social factors (socioeconomic status) intersect and are patterned across prefrail and frail states.[22] We found little evidence that examined the intersection of frailty, multimorbidity and socioeconomic status, and with this study, we sought to explore their relationship.

We hypothesized that patients with a greater number of chronic conditions, especially disabling conditions, and with lower socioeconomic status would be more likely to have a higher clinical frailty score. Our aim was to describe the distribution of frailty among older adult patients in primary care, and to describe the association between chronic conditions, socioeconomic status

and frailty. This study adds a unique analysis of this association within a primary care population with directly collected clinical frailty scores, not routinely applied in this population.

Methods

We conducted a cross-sectional study of a cohort of older adults, created using electronic medical records from a primary care practice-based research network (PBRN). Clinical frailty assessments and neighbourhood-level income and deprivation data were linked to the patient's clinical data available from their electronic medical records.

Setting

The MUSIC Network is a PBRN in Hamilton, Ontario, Canada. Data holdings include a regularly updated, deidentified, longitudinal database containing primary care practice data. There are 55 family physicians associated with the MUSIC Network. This study was based on a sub-set of the 37 physicians in the MUSIC PBRN and their previously described 38,000 patients represent a broad cross section of patients.[25,26]

Participants

Patients aged 65 years or older, currently rostered (as of Jan2020) to family physicians of the MUSIC network subgroup described above, were eligible to be included in the cohort.

Patient and Public Involvement

None

Data Collection and Preparation

Frailty Score Assignment

The Clinical Frailty Scale© (CFS) is a frailty screening tool that applies clinical judgement for scoring personal capacity, independence related to fitness and self-management of health. It can be reliably used to predict outcomes of mortality, comorbidity, functional, decline, mobility, and cognitive decline. The CFS features a clinically validated 9-point scale ranging from 1 (very fit) to 9 (terminally ill) with scores of ≥5 indicating a frail state.[20,27]. With low administration time (less than 1 minute per patient assessment) and low cost, the CFS has seen high utility across many clinical practice domains.[20,28,29] The CFS scoring instrument has been validated in a variety of healthcare settings including primary care and patients do not need to be seen in person for the physician to form an accurate score.[21] The CFS has good inter-rater agreement between physicians and multidisciplinary teams and correlates well with other frailty scoring instruments.[28,29]

Physicians were approached personally by the network leadership to discuss the rationale for the study and the utility of its results, to assess their support and perception of clinical relevance before formally engaging in the study. The participating physicians' EMR was used to identify rostered patients over the age of 65 and who had attended a clinical encounter within the last 6 months. Rostered patients are patients who are attached to a particular family physician who provides longitudinal primary care. The family physicians were provided with a list of eligible patients in their care, accompanied by the CFS scoring guide (Appendix A). Physicians were asked to complete frailty assessments (selecting a CFS score between 1-9) for

patients for whom they were confident that they could assess, based on their overall knowledge of the patient. This provided a reasonable, current assessment across the study population. There were no other specific exclusion criteria.

Scored lists were collected from each provider and securely entered within a research database, replacing all patient identifiers with the MUSIC patient ID. Scores were completed for 77% of eligible patients.

Cohort Creation and Data Linkage

The final cohort for this study included 2043 patients whose physician had assessed their frailty level and who had: 1) a postal code in Hamilton that could accurately be linked to neighbourhood-level information (described below) and 2) accessible disease diagnoses through the MUSIC-PBRN database.

To capture conditions, we used the ICD9 disease codes which are recorded by physicians, within the disease registry module of the EMR. Coded conditions include disorders such as COPD and heart failure as well as risk factors such as hypertension and dyslipidemia. Previous work that improved the quantity and the consistency of chronic disease codes recorded within the MUSIC PBRN EMR featured quick-pick lists of "preferred terms" for common and discrete primary care conditions such as unipolar depression (311), and bipolar depression (296), both with distinct codes.[25] For this study, certain conditions considered to be similar (i.e., variations of the same base condition) were grouped, for example, Dementia (ICD9 290) and Alzheimers (ICD9 331.0), in order to form meaningful groupings for frequency analysis.

We used the Postal Code[OM] Conversion File (PCCF), complementary to the 2016 Canadian Census,[30] to translate patients' postal codes to the geographic census unit of dissemination area. A dissemination area (DA) is a small geographic census area composed of one or more neighbouring blocks, with a population of 400 to 700 persons.[30] In this, the cohort was limited to only patients having a 1:1 mapping between their postal code and matching DA to facilitate a simple and direct means of linking dissemination area to socioeconomic status data.

The Canadian Socio-Economic Information Management System database was accessed via the Computing in the Humanities and Social Sciences (CHASS) Canadian Census Analyser[31] to retrieve economic family after-tax income decile group data[32]. Economic family after-tax neighbourhood income decile groups can provide a rough ranking of an individual's relative economic position. These income decile data were organized by dissemination area (DA) geographical units. We calculated the median decile for each DA unit represented in our cohort and linked this value to each patient via the postal code to DA map. We further collapsed the decile groups into quintiles to achieve reasonable category sizes for statistical analysis.

A second set of socioeconomic data from the Ontario Marginalization Index[33] was also linked to the dataset using the same postal code to DA translation. The index provides a measure of material deprivation, an estimate of the inability for individuals and communities to access and attain basic material needs using indicators of income, quality of housing, educational attainment, and family structure characteristics.

Data Analysis

We described the distribution of patient demographic characteristics, frailty, chronic conditions, and SES variables using simple descriptive analyses (means, median, frequencies and proportions, as appropriate). A review of the distribution of the CFS scores showed some score categories had very small numbers, therefore, for analysis purposes, we further grouped the cohort's frailty scores as low (scored 1-3), medium (scored 4-6), and high (scored 7-9).

We examined bivariate associations between frailty and other patient characteristics (demographics, multimorbidity and SES). Age was categorized as 65-69, 70-74, 75-79, 80-84, 85-89 and > 90 years. Male and female captured sex groupings. Income quintiles included scores of 1 (lowest income) to 5 (highest income). Material deprivation quintiles included groupings of 1 (least deprived) to 5 (most deprived). We examined chronic conditions (disorders and risk factors) in two ways: firstly, dichotomising as having 1 or more conditions versus none

We examined associations using Chi-square, and ANOVA as appropriate. Chi square test for association between frailty level grouping and other factors was used with all variables except age which was a continuous variable, where we used ANOVA.

Statistical significance was set at alpha<0.05 (two-tailed). The data were analyzed using IBM SPSS Statistics (Version 28).

The study was approved by the Hamilton Integrated Research Ethics Board (HiREB No. 10683).

Results

Demographics

The mean age of the patients (n= 2043) was 76 years (as of Feb 2020) and 60.5% (1235/2043) were female. Two-thirds of the patients (63.5%, 1296/2043) had two or more chronic conditions (Table 1).

Frailty Distribution

Figure 1 shows the frailty distribution over all 9 CFS categories with a slightly skewed distribution with fewer patients in the frailest categories and the highest proportion of patients scored as 3.

Median Income Distribution

Figure 2 shows the full distribution of median economic family after-tax income deciles (1 as lowest income decile, 10 as highest income decile). There was a near-normal distribution with the highest proportion of patients in decile 6. Grouping deciles into quintiles with 1 designated as lower income and 5 as higher income, most patients were in the middle quintile (3) (38.3%) with the smallest proportions in the lowest (5.1%) and highest income (4.5%) quintiles (Table 1).

Table 1: Associations between frailty score and demographic characteristics, deprivation indicators and multimorbidity (N=2,043).

Characteristic	Overall	Low Frailty, n (%)	Medium Frailty, n (%)	High Frailty, n (%)	*P-value*
Frailty group	2,043	1,141 (55.9)	824 (40.3)	78 (3.8)	
Demographics					
Mean Age (SD)	76 (7.8)	73.3 (5.9)	79.1 (8.2)	85.2 (9.0)	<0.001[a]
Median Age (Range)	74 (65-103)	72 (65-99)	78 (65-103)	86 (66-102)	<0.001[b]
Age grouping					
65-69	589 (29)	440 (39)	143 (17)	6 (8)	<0.001[c]
70-74	540 (26)	355 (31)	176 (21)	9 (12)	
75-79	374 (18)	210 (18)	156 (19)	8 (10)	
80-84	247 (12)	84 (7)	148 (18)	15 (19)	
85-89	173 (9)	40 (4)	120 (15)	13 (17)	
> 90 y	120 (6)	12 (1)	81 (10)	27 (35)	
Female, n (%)	1236 (61)	647 (57)	535 (65)	54 (69)	<0.001[c]
Male, n (%)	807 (40)	494 (43)	289 (35)	24 (31)	
Median income quintile [d]					
1 (low)	104 (5)	35 (3)	65 (8)	4 (5)	<0.001[c]
2	545 (27)	269 (24)	250 (30)	26 (33)	
3	783 (38)	429 (38)	324 (39)	30 (39)	
4	520 (26)	348 (31)	157 (19)	15 (19)	
5 (high)	91 (5)	60 (5)	28 (3)	3 (4)	
Deprivation quintile [e]					
1 (least deprived)	411 (20)	286 (25)	113 (14)	12 (15)	<0.001[c]
2	302 (15)	182 (16)	106 (13)	14 (18)	
3	348 (17)	179 (16)	156 (19)	13 (17)	
4	530 (26)	277 (24)	228 (28)	25 (32)	
5 (most deprived)	452 (22)	217 (19)	221 (27)	14 (18)	
Multimorbidity [f]					
No. chronic conditions [f]					
0	338 (17)	261 (23)	73 (9)	4 (5)	
1+	1,705 (84)	880 (77)	751 (91)	74 (95)	<0.001[c]
1	409 (20)	267 (23)	133 (16)	9 (12)	<0.001[c]
2-4	923 (45)	487 (43)	405 (49)	31 (40)	
5+	373 (18)	126 (11)	213 (26)	34 (44)	

[a] *P* value from ANOVA test

[b] *P* value from Kruskal-Wallis test

[c] *P* value from χ2 test for categorical data

[d] Mean value of Economic family after-tax income decile group data at dissemination area level, based on Statistics Canada 2016 Census data.

[e] Deprivation score categories from the Ontario Marginalization Index at dissemination area level

[f] Chronic disorders and risk factor conditions coded by physicians with ICD9

Associations between Frailty Level, and Demographic Characteristics Socioeconomic Status and Multimorbidity

Mean age ascended across frailty groups at 73 years in the low frailty group, 78 years in the medium frailty group and 85 years in the high frailty group (ANOVA, F = 231.62, DoF 2, p <0.0001) (Table 1). The proportion of patients who were female increased across low, medium and high frailty groups (57%, 65%, 69% respectively) (*χ2=16.12, df=3, p<0.001*).

The distribution of income quintiles was significantly different across the frailty groups (*χ2 = 61.42, df=8, p <0.001).* There is some trend of moderate and higher frailty patients associated with lower income quintiles compared to patients with low frailty. (Table 1).

There were significant differences in proportions of patients in different frailty groups across the material deprivation quintile groupings (χ2=55.243, df=8, p <0.001). Table 1 also shows certain trending of the higher frailty group associated with greater deprivation, compared to the moderate and low frailty groups that show less deprivation.

Patients with higher frailty were more likely to have at least one coded condition (95%, 91% and 77% in the high, medium and low frailty groupings, respectively ($\chi 2 = 75.7254$, DoF 2, $p < 0.0001$). Furthermore, the accumulation of chronic disease (1, 2-4 or 5+ conditions) differed across frailty groups ($\chi 2 = 169.6$ Dof 6, $p < 0.001$). The data show a trend of more multimorbidity burden in the high frail group (12%, 40%, 44% for 1, 2-4 and 5+ conditions), whereas the low frailty and medium frailty groups showed higher proportions in the 2-4 conditions category (43% and 49% for low frailty and medium frailty, respectively) ($p<0.001$).

Chronic Conditions Patterns

Table 2 shows the most frequent chronic conditions and risk factors (e.g., hypertension and hyperlipidemia) in each frailty grouping. A core set of high frequency conditions composed at least 50% of all conditions in all three frailty groups but more conditions were included in the top 50% as frailty increased. In the low frailty group, 5 conditions composing the risk factors hypertension and hyperlipidemia and the disorders diabetes, osteoarthritis/joint pain, and depression - unipolar) comprised 52% of their conditions. These 5 conditions persisted in the medium frailty group with the addition of 2 more conditions (back, neck pain and sciatica and cardiac dysrhythmia) composing 51% of conditions. In the high-scored frailty group, 9 conditions comprised 52% of the conditions, with dementia/Alzheimers, congestive heart failure and acute and chronic coronary artery disease (CAD) appearing uniquely and displacing back, neck pain and sciatica. Among other burdensome disease, chronic obstructive pulmonary disease was a relatively common condition in the high and medium frailty groups (falling within

54% of all conditions for both) and but less so in the low frailty group (falling within the top 70% of all conditions).

Table 2: Array and Proportion of Conditions (Disorders and Risk Factors[c]) in each Frailty Grouping among the 2043 primary care patients

Frailty Score 1-3	Proportion of Grouping Diagnoses	Frailty Score 4-6	Proportion of Grouping Diagnoses	Frailty Score 7-9	Proportion of Grouping Diagnoses
Hypertension [c]	19%	Hypertension[c]	14.9%	Hypertension[c]	11.8%
Diabetes	12%	Diabetes	9.7%	Osteoarthritis and Joint Pain	7.3%
Hyperlipidemia/ Dyslipidemia[c]	8.3%	Osteoarthritis and Joint Pain	7.7%	Diabetes	6.4%
Osteoarthritis and Joint Pain	7.2%	Hyperlipidemia/ Dyslipidemia[c]	5.8%	Dementia/ Alzheimers[b]	5.6%
Depression (unipolar)	5.9%	Depression (unipolar)	5.5%	Cardiac Dysrhythmia	5.6%
		Back, Neck Pain and Sciatica[a]	4%	Depression	4.5%
		Cardiac Dysrhythmia[a]	3.3%	Congestive Heart Failure[b]	3.6%
				Hyperlipidemia/ Dyslipidemia[c]	3.4%
				Acute and Chronic CAD[b]	3.40%
Total proportion	**52.3%**		**50.7%**		**51.5%**

[a] first appears in medium frailty group
[b] first appears in high frailty group
[c] Risk Factors type among conditions

Discussion

In this study of older adult patients in primary care, almost half of the patients evaluated by their family physician had a moderate or high level of frailty. Higher frailty level was associated with older age, being female and having more chronic conditions, especially life-limiting or

disabling conditions such as cardiovascular diseases and dementia. Higher frailty level was also associated with indicators of lower socio-economic status.

The usability of the CFS in primary care was evidenced in our study with frailty scores completed for 77% of eligible patients. This directly collected data was a strength of the study, as was the study setting within a practice-based research network where disease coding in the EMR has been strengthened through previous initiatives.[25] We attribute the high scoring completion rate on a combination of factors: clinicians were engaged prior to deciding to go forward with the study, the study aligned with physicians' interests in supporting frail patients as well as effective leadership and clinical championing of this study and its data collection requirements.

The cohort showed a near normal distribution across high, medium, and low frailty groups, with the most common scores lying in the middle quintile. As expected in a community dwelling cohort, there were fewer older adults in the most-frail group as these patients are more likely to need long-term care accommodation supports.[4]

We have identified shifts in the patterns of the most common conditions that affect the older adult primary care population across categories of increasing frailty. Furthermore, in those experiencing high frailty conditions, substantial and life-limiting morbidity appear more commonly, and so does their burdensome management requirements, greater risk for hospitalization, and lowered quality of life.[12-14,34]

We found that living in neighbourhoods of lower income and higher social material deprivation was more common among patients with moderate and high frailty. These differences have important implications at population level and may reflect large numbers of patients at risk for negative health outcomes. Socio-economic disadvantages may be compounded by costs associated with living with frailty (e.g., need for mobility aids) in addition to the costs of managing the individual health conditions.[5,12]

A health equity approach involves specific targeting of programs or resources to those most disadvantaged. The associations among frailty, chronic disease, and socioeconomic status, shown in this study, can support a health equity approach in planning health care for older adults within primary care. Ideally, the availability of all three data pieces would enable focused targeting of programs or resources to older adults who are most disadvantaged in primary care, but the unique disease patterns we identified in higher frailty groups also provides a marker of likely triple disadvantage.

We have also shown the utility and feasibility of collecting frailty data in a PBRN. The MUSIC Network immediately used these data in a targeted approach to COVID-19 remote care monitoring during Ontario's first and most serious wave of the pandemic. As it was not practically possible to contact all older adults, the MUSIC clinical teams used prepared digital files that sorted older adults by frailty score, with chronic conditions information. This enabled the Family Health Teams to take an equity focused approach, prioritizing contact with a subgroup of older adult patients who were scored higher for frailty to provide COVID education and to ensure food and medication security.

The high uptake of CFS coding shows that frailty measures could become routine data points that are scored regularly and recorded within the EMR. Future work should also be directed at systematically and standardly collecting and integrating, as a first step, neighbourhood level SES data available from census data, and then ideally moving to patient level SES data within the primary care EMR. SES, frailty, and chronic disease markers could be automatically combined within the EMR to identify patients at risk of a poor prognosis. Patient level EMR flags or practice level dashboard could alert providers or quality specialists, respectively, to the need for interventions for addressing social and clinical risk factors for these patients, and to allow program development within clinics of larger groupings to direct resources to those with greatest need.

Limitations

The study design is cross-sectional therefore we cannot deduce the direction of causation of the associations between socio-economic status, multimorbidity and level of frailty.

Information on individual socio-economic status is not routinely collected in primary care. We have assumed neighbourhood-level income and deprivation status provide reasonable accuracy with respect to the actual socioeconomic status of individual patients within our frailty cohort. Neighbourhood-level information on indicators such as income may not reflect actual wealth among older adults who are more likely to have left the workforce due to retirement.

We limited the cohort to patients for whom a single dissemination area (DA) code mapped to their postal code. This affects sample size but there is no reason to think it would affect the associations found. Similarly, the limitation of the cohort to those with a recent encounter for whom the clinician had enough knowledge to complete a CFS should not affect the associations seen.

Conclusions

Awareness of the triple disadvantage of frailty, disease burden, and socioeconomic disadvantage, as well as specific disease patterns can support a health equity approach to care for older adults within primary care.

The confluence of health and social disadvantage and increasing frailty highlights the need for targeted health and social care approaches for achieving improved health equity. Our findings also underscore the need to anticipate required healthcare services and to use finite resources most effectively. Grounding this approach in primary care with the appropriate data supports, is highly appropriate as evidence shows primary care is a strong mechanism for reducing health inequity, fostering access to comprehensive longitudinal care as well as targeted clinical and program innovations that are effective in reducing modifiable health inequity.[7]

Figure Legend/Caption

Figure 1 Caption: Frailty Score[a] Distribution among the 2043 primary care patients

Figure 1 Legend: [a]Frailty scored on a 9-point scale ranging from 1 (very fit) to 9 (terminally ill) with scores of ≥5 indicating a frail state. [20,27]

Figure 2 Caption: Median Family After-Tax Neighbourhood Income Decile[a] Distribution among the 2043 Patients

Figure 2 Legend: [a]Median economic family after-tax income decile (1 as lowest income decile, 10 as highest income decile).

Contributorship Statement

Substantial contributions to the conception or design of the work: DM, JL, MH. Acquisition of data: DM, JL. Analysis or interpretation of data for the work: DM, JL, MH. Drafting the work or revising it critically for important intellectual content: DM, JL, CR, HS, TP, SW, MH. Final approval of the version to be published: DM, JL, CR, HS, TP, SW, MH. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: DM, JL, CR, HS, TP, SW, MH. DM is the guarantor.

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Competing Interest

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/disclosure-of-interest/ and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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Data Sharing Statement

The dataset is available by contact with the corresponding author Dr. Dee Mangin mangind@mcmaster.ca.

Ethics

The study was approved by the Hamilton Integrated Research Ethics Board (HiREB No. 10683). Patient consent was waived as this study applied deidentified retrospective data.

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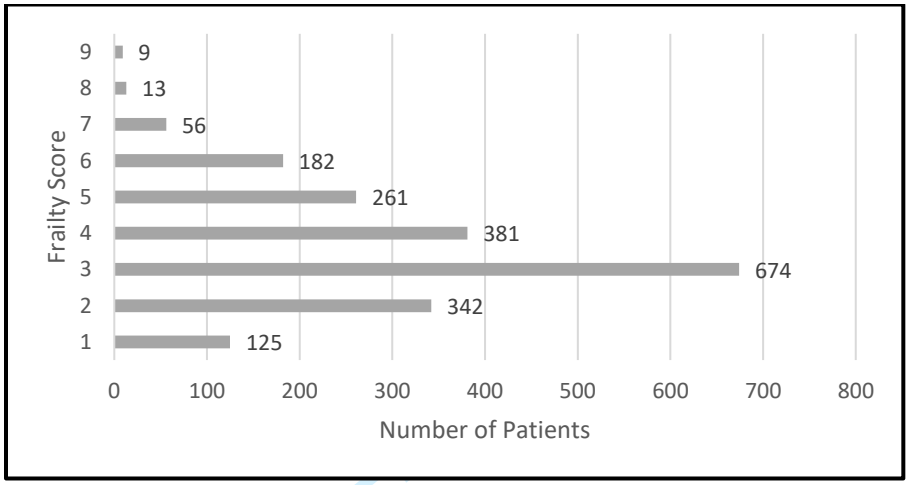
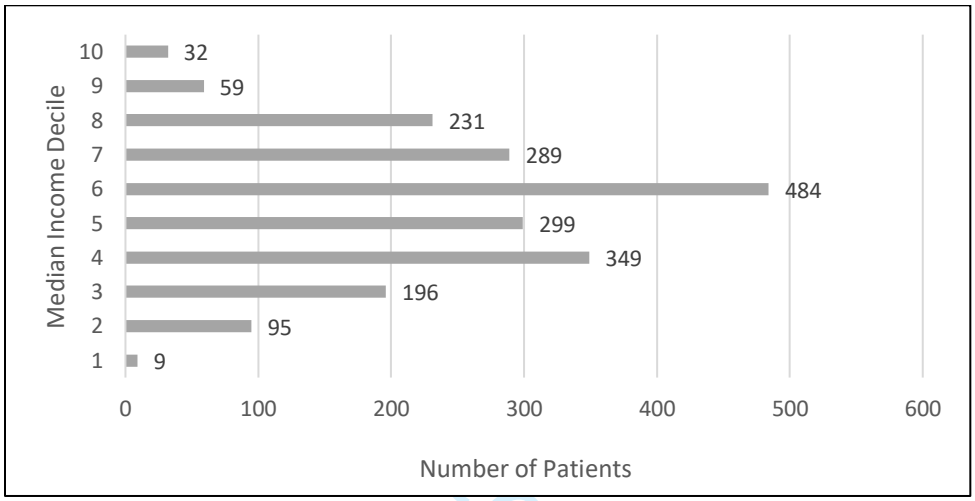
Figure 1: Frailty Score[a] Distribution among the 2043 primary care patients



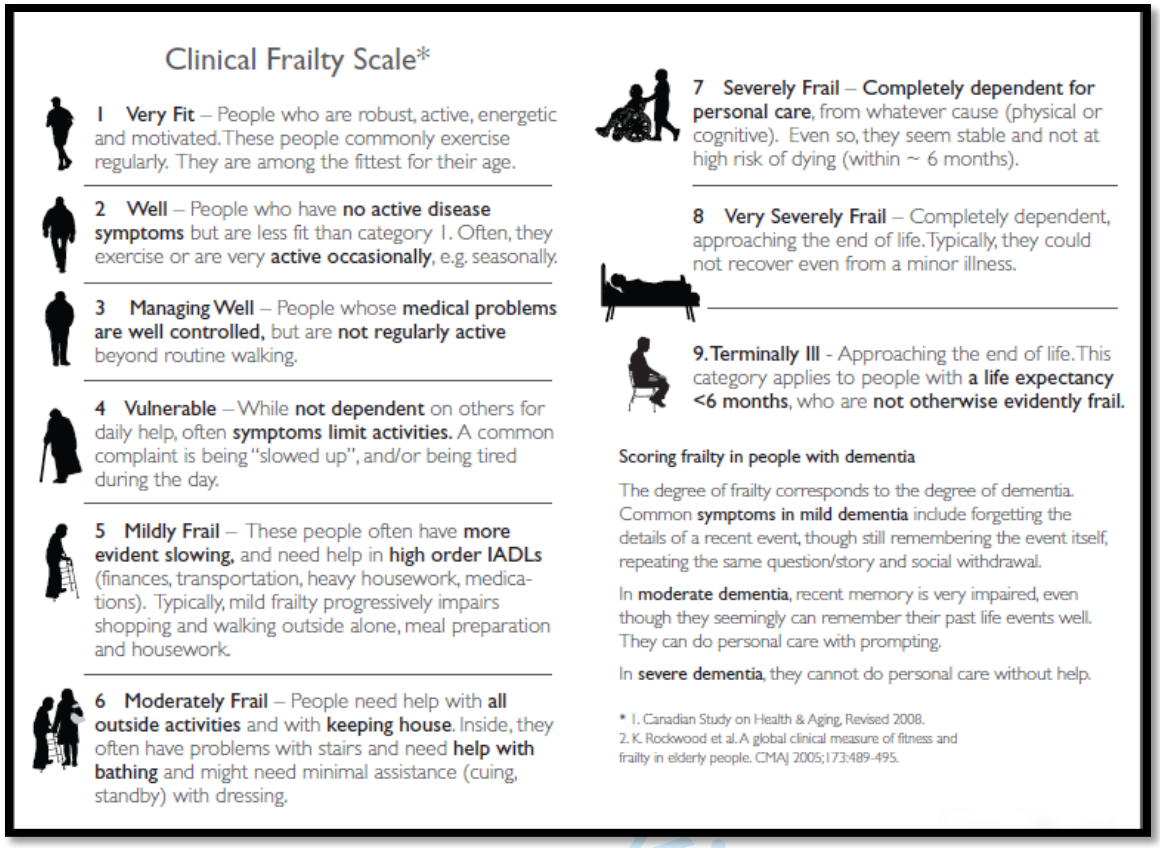
[a] Frailty scored on a 9-point scale ranging from 1 (very fit) to 9 (terminally ill) with scores of ≥5 indicating a frail state.[20,27]

Figure 2: Median Family After-Tax Neighbourhood Income Decile[a] Distribution among the 2043 Patients



[a] Median economic family after-tax income decile (1 as lowest income decile, 10 as highest income decile).

Appendix A: The Clinical Frailty Scale©



Clinical Frailty Scale*

1 Very Fit – People who are robust, active, energetic and motivated. These people commonly exercise regularly. They are among the fittest for their age.

2 Well – People who have **no active disease symptoms** but are less fit than category 1. Often, they exercise or are very **active occasionally**, e.g. seasonally.

3 Managing Well – People whose **medical problems are well controlled,** but are **not regularly active** beyond routine walking.

4 Vulnerable – While **not dependent** on others for daily help, often **symptoms limit activities.** A common complaint is being "slowed up", and/or being tired during the day.

5 Mildly Frail – These people often have **more evident slowing,** and need help in **high order IADLs** (finances, transportation, heavy housework, medications). Typically, mild frailty progressively impairs shopping and walking outside alone, meal preparation and housework.

6 Moderately Frail – People need help with **all outside activities** and with **keeping house**. Inside, they often have problems with stairs and need **help with bathing** and might need minimal assistance (cuing, standby) with dressing.

7 Severely Frail – **Completely dependent for personal care**, from whatever cause (physical or cognitive). Even so, they seem stable and not at high risk of dying (within ~ 6 months).

8 Very Severely Frail – Completely dependent, approaching the end of life. Typically, they could not recover even from a minor illness.

9. Terminally Ill - Approaching the end of life. This category applies to people with **a life expectancy <6 months**, who are **not otherwise evidently frail.**

Scoring frailty in people with dementia

The degree of frailty corresponds to the degree of dementia. Common **symptoms in mild dementia** include forgetting the details of a recent event, though still remembering the event itself, repeating the same question/story and social withdrawal.

In **moderate dementia**, recent memory is very impaired, even though they seemingly can remember their past life events well. They can do personal care with prompting.

In **severe dementia**, they cannot do personal care without help.

* 1. Canadian Study on Health & Aging, Revised 2008.
2. K. Rockwood et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173:489-495.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	4	a cross-sectional study of a cohort
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	4	done
Introduction			6-7	
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-7	… a large proportion of people experiencing frailty also have multimorbidity … Low socioeconomic status is associated with multimorbidity, health risks, poorer prognoses, and challenges in accessing equitable care. … Reliable screening tools for frailty are easy to use in primary care … Planning and evaluating programs in primary care designed to meet the needs of all frail older adults would be better guided with an understanding of how chronic disease patterns and social factors (socioeconomic status) intersect and are patterned across prefrail and frail states. … We found little evidence that examined the intersection of

				frailty, multimorbidity and socioeconomic status, and with this study, we sought to explore their relationship.
Objectives	3	State specific objectives, including any prespecified hypotheses	7	We hypothesized that patients with a greater number of chronic conditions, especially disabling conditions, and with lower socioeconomic status would be more likely to have a higher clinical frailty score. Our aim was to describe the distribution of frailty among older adult patients in primary care, and to describe association between chronic conditions, socioeconomic status and frailty.
Methods				
Study design	4	Present key elements of study design early in the paper	8	We conducted a cross-sectional study of a cohort of older adults, created using electronic medical records from a primary care practice-based research network (PBRN). Clinical frailty assessments and neighbourhood income and deprivation data were linked to the patient's clinical data available from their electronic medical records.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure,	8	The MUSIC Network is a

		follow-up, and data collection		PBRN in Hamilton, Ontario, Canada. Data holdings include a regularly updated, deidentified, longitudinal database containing primary care practice data. Patients aged 65 years or older, currently rostered (as of Jan2020) to family physicians of the MUSIC network subgroup described above, were eligible to be included in the cohort.
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *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	9	The participating physicians' EMR was used to identify rostered patients over the age of 65 and who had attended a clinical encounter within the last 12 months.
		(*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		
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11	Variables include frailty score, socioeconomic status (income and deprivation score) and level of multimorbidity
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	11-12	We described the distribution of patient demographic characteristics, frailty, chronic conditions, and SES variables using simple descriptive

				analyses (means, median, frequencies and proportions, as appropriate)… We examined bivariate associations between frailty and other patient characteristics (demographics, multimorbidity and SES).
Bias	9	Describe any efforts to address potential sources of bias	9	Physicians were asked to complete frailty assessments (selecting a CFS score between 1-9) of patients whom they felt confident that they could assess based on their overall knowledge of the patient.
Study size	10	Explain how the study size was arrived at	9	The final cohort for this study included 2043 patients whose physician had assessed their frailty level and who had: 1) a postal code in Hamilton that could accurately be linked to neighbourhood level information (described below) and 2) accessible disease diagnoses through the MUSIC-PBRN database.

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11	A review of the distribution of the CFS scores showed some score categories had very small numbers, therefore, for analysis purposes, we further grouped the cohort's frailty scores as low (scored 1-3), medium (scored 4-6), and high (scored 7-9). We examined bivariate associations between frailty and other patient characteristics (demographics, multimorbidity and SES). Age was categorized as 65-69, 70-74, 75-79, 80-84, 85-89 and > 90 years. Male and female captured sex groupings. Income quintiles included scores of 1 (lowest income) to 5 (highest income). Material deprivation quintiles included groupings of 1 (least deprived) to 5 (most deprived). The number of chronic conditions (disorders and risk factors) were grouped as 0, 1, 2-4, 5+ and categorized having 1 or more conditions versus none.
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	12	We examined associations using Chi-square, and ANOVA as appropriate. Statistical significance was set at alpha<0.05 (two-tailed). The data were analyzed using IBM SPSS Statistics (Version 28) predictive analytics software.

		(*b*) Describe any methods used to examine subgroups and interactions		Not applicable
		(*c*) Explain how missing data were addressed		Not applicable
		(*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		Not applicable
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9	The final cohort for this study included 2043 patients whose physician had assessed their frailty level and who had: 1) a postal code in Hamilton that could accurately be linked to neighbourhood level information (described below) and 2) accessible disease diagnoses through the MUSIC-PBRN database.
		(b) Give reasons for non-participation at each stage		Provided above
		(c) Consider use of a flow diagram		Described textually
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12, 25-26	The mean age of the patients (n= 2043) was 76 years (as of Feb 2020) and 60.5% (1235/2043) were female. Two-thirds of the patients (63.5%, 1296/2043) had two or more chronic conditions. And also Table 1.
		(b) Indicate number of participants with missing data for each variable of interest		None
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	9-10	Rostered patients with recent encounters identified and physicians were asked to complete

				frailty assessments (selecting a CFS score between 1-9) …Frailty scored patients were linked to current disease coded data in the EMR and to neighbourhood level income and deprivation data.
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	13-14; 25-26	We studies associations between frailty level, and demographic characteristics, socioeconomic status and multimorbidity and chronic conditions patterns. Summarized in Table 1.
		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		
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		Not applicable
		(*b*) Report category boundaries when continuous variables were categorized	11, 25-26	Age categories: 65-69, 70-74, 75-79, 80-84, 85-89, > 90 y The number of chronic conditions (disorders and risk factors) were grouped as 0, 1, 2-4, 5+ and categorized having 1 or more conditions versus none. See Table 1.
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		Not applicable

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Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-12	We grouped the cohort by frailty score as low (scored 1-3), medium (scored 4-6), and high (scored 7-9). Male and female captured sex groupings. Income quintiles included scores of 1 (lowest income) to 5 (highest income). Material deprivation quintiles included groupings of 1 (least deprived) to 5 (most deprived). We examined associations using Chi-square, and ANOVA as appropriate. Statistical significance was set at alpha<0.05 (two-tailed). The data were analyzed using IBM SPSS Statistics (Version 28) predictive analytics software.
Discussion				
Key results	18	Summarise key results with reference to study objectives	12-14	Two-thirds of the patients (63.5%, 1296/2043) had two or more chronic conditions. The distribution of income quintiles was significantly different across the frailty groups ($\chi 2$ = 61.42, df=8, p <0.001). The data show a trend of more multimorbidity burden in the high frail group (12%, 40%, 44% for 1, 2-3 and 5+ conditions), whereas the low frailty and medium frailty groups showed higher proportions in the 2-4 conditions

				category (43% and 49% for low frailty and medium frailty, respectively) (p<0.001).
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	16	As a cross-sectional study, we cannot deduce the direction of causation of the associations between socio-economic status, multimorbidity and level of frailty. We have assumed neighbourhood level income and deprivation status provide reasonable accuracy with respect to the actual socioeconomic status of individual patients within our frailty cohort. We limited the cohort to patients for whom a single dissemination area (DA) code mapped to their postal code. This affects sample size but there is no reason to think it would affect the associations found
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17	Awareness of the triple disadvantage of disease burden, frailty, and socioeconomic disadvantage, as well as specific disease patterns can support a health equity approach to care for older adults within primary care.
Generalisability	21	Discuss the generalisability (external validity) of the study results	17	This study highlights the need to anticipate and fund targeted health and social care approaches for achieving improved health equity

				and doing this through primary care.
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	3	Funding source: INSPIRE-PHC Program, Applied Health Research Question, Ontario Ministry of Health: Total Funding: $31,680.

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.