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Original Research

The Effect of Frailty on Independent Living After Surgery: A Population-Based Retrospective Cohort Study

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Abstract

BACKGROUND: Most people value quality of life over mere duration. At least 50% of people are extremely averse to ever living in a nursing home (NH).
OBJECTIVES: Assess whether pre-operative frailty is associated with new, post-operative NH placement.
DESIGN, SETTING: Retrospective, population-based cohort study in the Canadian province of Manitoba, 2000-2017.
PARTICIPANTS: 7408 persons ≥65 years undergoing any of 16 specific, elective, noncardiac surgeries of varying Operative Surgical Stress (OSS).
MEASUREMENTS: The primary outcome was new admission to a NH, or being placed on a waiting list for a NH, within 180 days of index hospital admission, among index hospital survivors. Frailty was assessed from administrative data by the Preoperative Frailty Index (pFI), which ranges 0-1. Other outcomes were 30-day and 90-180 day mortality, and post-hospital medical resource use to 180 days. Analyses used multivariable regression models, adjusted for age, sex, OSS, year of surgery, anesthetic technique, and socioeconomic status. P-values were adjusted for the six outcomes.
RESULTS: Subjects had mean age (±SD) of 74±7 yrs; 61% were male. pFI ranged 0-0.68, with a mean±SD of 0.21±0.09. All six outcomes were significantly associated with greater frailty. Each additional 0.1 unit increase in pFI was associated with a hazard ratio for new NH admission or wait-listing of 3.01 ($p<0.0006$).
CONCLUSIONS: While our study agrees with prior work indicating that greater frailty is associated with higher probability of post-operative discharge to a NH, it overcomes a number of limitations of all prior work. Strong arguments follow that prospective surgical candidates be evaluated for their degree of frailty, and that their informed consent include discussion of the possibility of survival with loss of independence.

Key words: Frailty, surgery, outcomes, nursing homes, mortality, health resources.

Introduction

Most people feel that their quality of life is at least as important as is its duration (1). Those with and without chronic illnesses indicate that loss of functional independence is a key determinant of low quality of life (2-4). In a landmark study, Fried et al. found that among outpatients over age 60 years with limited life expectancies, only 26% would accept even low burden treatments if the result would be severe functional impairment (5). Nursing homes (NH) are residential long-term care facilities providing around-the-clock personal and nursing care for people who are unable to care for themselves. In modern society, NH placement is a very common consequence of loss of physical or cognitive function (6, 7). When asked, half or more of people indicate an extreme aversion to ever living in a NH (8-11).

Legal and ethical principles concur that informed consent for surgical procedures should include discussion of all procedural risks that are common, and those that are serious in the context of patients' values and quality of life (12, 13). The above information indicates that the possibility of surgery resulting in the need for NH placement would be considered serious by most people.

For these reasons it is important to identify risk factors for postoperative NH placement among community-dwelling people. Frailty is a promising risk factor for this purpose. Frailty is a "multidimensional syndrome of loss of reserves (energy, physical ability, cognition, health) that gives rise to vulnerability" (14), and makes one less adaptable to stressors (15), such as surgery. Although it is more common with older age and a greater burden of chronic comorbid illness, one formulation identifies it as a phenotype (16) which can occur at any age and in the absence of any specific comorbidities. Frailty has been associated with a variety of adverse postoperative outcomes, including longer index hospital length of stay, complications, higher short-term and long-term mortality, and higher costs (17, 18).

A recently published meta-analysis identified 22 publications on whether frailty is related to postoperative discharge location (17), and we identified three others (19-21). However, this literature is problematic in regards to preoperative living situations considered, type of long-term care facilities, timing of admission to long-term care, and statistical methods. We undertook a population-based study that addresses all those limitations. We hypothesized that preoperative frailty is associated with the need for NH placement at or in the interval after index hospital discharge for elective, non-cardiac surgery. Furthermore, we hypothesized that frailty is associated with postoperative mortality and medical resource use.

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Table 1. Study outcomes, cohorts and methods of analysis

OUTCOME	OUTCOME TIMING	ANALYSIS METHOD
Time to new admission or wait-listing for NH placement [PRIMARY outcome]	≤180 days postoperatively	Cox time-to-event regression. Cause-specific hazard as primary. Competing risk of death as sensitivity analysis.
30 day mortality	to 30 days postoperatively	Logistic regression with Firth's adjustment for rare events
Post-90 day mortality	90-180 days postoperatively for those who survived to day 89	Cox time-to-event regression
#outpatient clinic visits (prorated to 180 days)	over the 180 days after index hospital discharge	Poisson regression of counts, with censoring at NH admission or wait-listing[1]
#emergency department visits (prorated to 180 days)	over the 180 days after index hospital discharge	Negative binomial regression of counts[2], with censoring at NH admission or wait-listing[1]
#hospital-days (prorated to 180 days)	over the 180 days after index hospital discharge	Zero-inflated Poisson regression of counts[3]

NH, nursing home; Prorated, see Methods section of text; [1]censoring due to known reduction in external outpatient medical care received by NH residents in light of ready availability of NH physicians; [2]negative binomial count model was used due to overdispersion of Poisson count model; 3zero-inflated count model was used due to excess zeros in the distribution of hospital-days

Methods

Data for this retrospective, population-based cohort study derives from Research Data Repository of the Manitoba Centre for Health Policy (22), including the approximately 767,000 residents of the Winnipeg Health Region of the Canadian Province of Manitoba (23). Manitoba has universal, single-payer health care. General cohort inclusion criteria were people during 2010-2017: (i) aged 65 years or older on the date of index hospitalization in which they received, (ii) any of 16 specific, elective, noncardiac surgeries performed in a main operating room of an acute care hospital, (iii) living in the community pre-operatively, (iv) registered with the provincial health system for two years prior to the index procedure and (v) registered for the lesser of one year after the index procedure or until death.

Elective surgeries were identified in the Canadian Discharge Abstract Database (24) as having occurred within 36 hours after elective hospital admission. For patients who experienced more than one qualifying hospitalization during the study interval, only the first was included in our analyses.

The 16 procedures represented varying degrees of Operative Surgical Stress (OSS) (25). OSS ranges from 1-5 with higher values representing higher degrees of physiologic stress, and associated with increasing rates of postoperative death. For each OSS value 2, 3, 4 and 5, our analysis included the four procedures of highest frequency in Manitoba, identified using nationally standardized procedure codes (eTable 1). If during a qualifying hospitalization a patient had multiple qualifying surgical procedures, the one with highest OSS was considered the index procedure.

The exposure of interest was frailty, for which we used the Preoperative Frailty Index (pFI), a hybrid measure derived from readily available administrative (claims) data (26). It ranges from 0-1, with higher values indicating greater frailty.

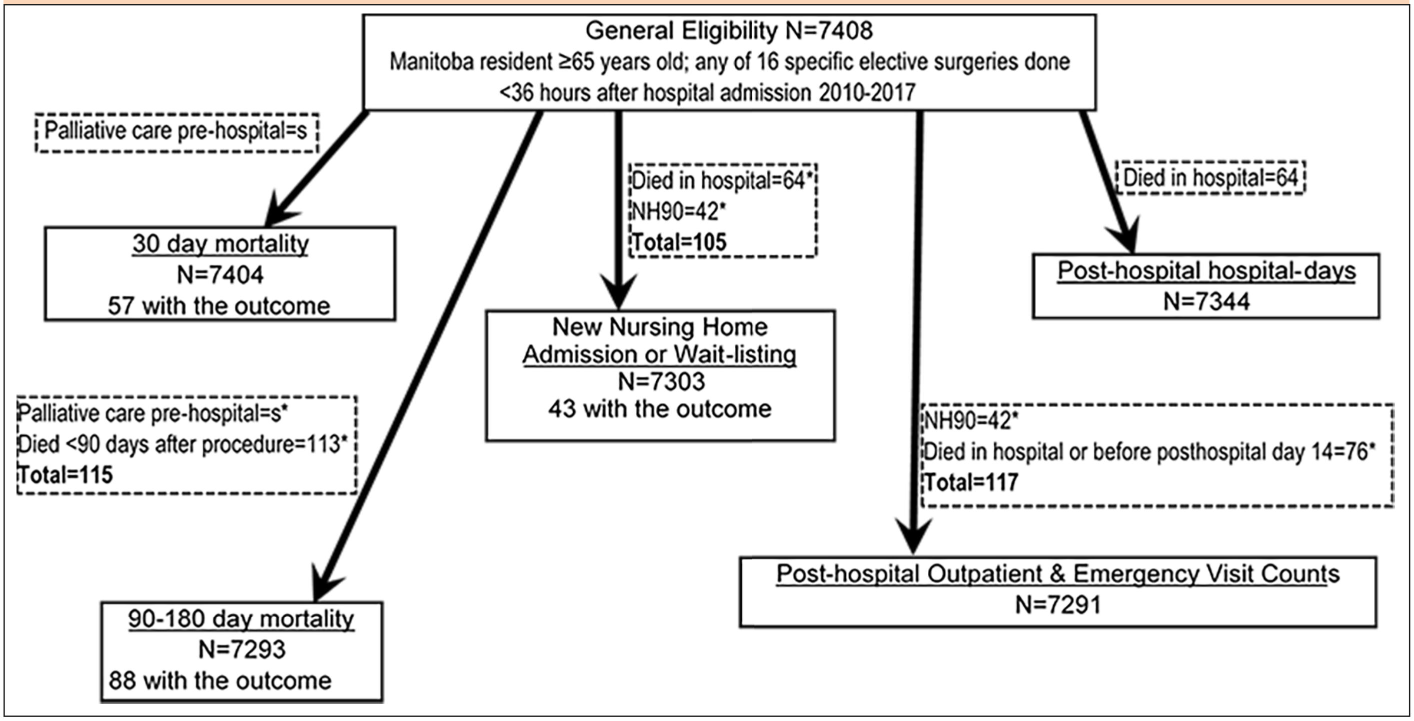
We evaluated six outcomes (Table 1). The outcome of primary interest was new admission to a NH, or being placed on the provincial waiting list for a NH, within 180 days of index hospital admission, among persons who left hospital alive. Thus persons in or awaiting NH care within 90 days prior to the index hospitalization were excluded. Unlike in some other jurisdictions, a large majority of people admitted to NHs in Manitoba die there (27), and thus this cohort essentially represents community-dwelling individuals who were newly and permanently admitted to NH in the six months after surgery.

Mortality outcomes were 30-day mortality, and 180-day mortality among those who survived to 90 days; the latter functionally removes the contribution of short-term mortality from consideration (28). Reasoning that persons in palliative care are not specifically seeking to avoid death, we excluded those preoperatively or postoperatively enrolled in provincial palliative care programs from the mortality outcomes.

Post-hospital resource use outcomes among those who were discharged alive were the numbers of: outpatient clinic visits, emergency department visits, and inpatient hospital-days. These were prorated to 180 days, e.g. a person who had 3 visits and died at post-hospital day#60 would have a prorated value of 9 visits over 180 days. Because pro-rating could appear to result in resource use outliers among those who died soon after discharge (e.g. one emergency room visit post-discharge but before death at 7 days would be pro-rated to 26 visits), we excluded individuals who died within 14 days post-discharge. And because NH residents receive much of their care from physicians in the nursing homes themselves, for these outcomes we also excluded persons living in NHs before the index surgery or who were admitted to a NH directly after the index hospitalization.

Analyses were via multivariable regression models (Table 1). We allowed for the possibility that frailty was nonlinearly related to the outcomes by expressing the pFI as a 4-knot restricted cubic spline. Nonlinearity was identified by a combination of statistical significance of the omnibus test for the nonlinear spline terms and graphical judgement (29). If the relationship was linear we report the linear coefficient; for nonlinear relationships we indicate the statistical significance

Figure 1. Patient flow diagram



Exclusions shown in dotted boxes; NH90, nursing home resident or on the provincial waiting list for nursing home placement anytime within 90 days prior to index hospitalization; *subcategories of exclusions not mutually exclusive; s, count censored due to ranging from 1 to 4

of the omnibus test for all the spline terms, and show the relationship graphically (29).

Six covariates included in our analysis were: age; sex; OSS; year of surgery; anesthetic technique (general vs. any other); and area-level socioeconomic status assessed by the standardized SEFI-2 score, for which higher values represent lower socioeconomic status (30). Comorbid health conditions were excluded because numerous of them are included in the pFI.

For some of our outcomes, including the primary outcome, there were relatively few events compared to the number of covariates we wished to include. To avoid model overfitting by ensuring the usual goal of at least 10 events per independent variable (31), we performed variable reduction using principal components analysis (32), retaining at least the components with eigenvalues exceeding 1.0 (Appendix 1) (32).

Statistical analysis used SAS 9.4 (SAS Institute, Cary, NC). To avoid inflated Type I error rates in allowing equal consideration to the associations between frailty and the six outcomes, we used a Bonferroni correction factor of six to adjust the p-values for relationships with pFI (33).

Results

The general cohort sample included 7408 subjects (Figure 1). They were mostly older persons (mean±SD age, 74±7 yrs), mostly male, and spent a median of 5.1 days hospitalized for the index surgery (Table 2). The pFI ranged 0-0.68 with a mean±SD of 0.21±0.09. Among the six outcomes (Table 3), 0.6% of previously home-dwelling subjects were newly admitted or wait-listed for a nursing home within 180 days.

Analysis of that outcome of primary interest included 7303 subjects (Figure 1), of whom 43 experienced it at a median time of 89 days after index hospital admission (interquartile range 66-107 days). Each additional 0.1 unit increase in pFI was associated with a hazard ratio for new NH admission or wait-listing of 3.01 (95% C.I. 2.42-3.76; $p<0.0006$; Table 4). This cause-specific hazard ratio was virtually identical to that obtained taking account of death as a competing risk (34).

All five secondary postoperative outcomes were also associated with preoperative frailty (Table 4). This includes short-term (30-day) mortality, intermediate-term (90-180 day) mortality, and post-hospital utilization of outpatient physician visits, emergency department visits, and hospital-days. For both outpatient physician visits and hospital-days, the relationship with frailty was statistically nonlinear. However the former was effectively linear (eFigure 1A), while for the latter the relationship was relatively flat for pFI values from 0 to 0.2, increasing linearly thereafter (eFigure 1B).

Discussion

We found that frailty is a strong risk factor for home-dwelling people to require nursing home placement after elective surgery. Each rise in the McIsaac frailty scale of 0.1 units, or 1.1 standard deviation of its distribution in our sample, was associated with a 3-fold higher hazard for this outcome. Increasing frailty was also associated with higher mortality rates and medical resource use. Of note, the distribution of pFI in our subjects was similar to that in the original work in which it was described (26).

Table 2. Characteristics of all subjects meeting general cohort criteria, N=7408. Values are mean±SD or n (%) unless otherwise indicated

VARIABLE	VALUE
Age (yrs)	74.3 ± 6.7
Female sex	2851 (38.5)
Socioeconomic Factor-2 score	-0.29 ± 0.77
Charlson Comorbidity Index, median (IQR)	2 (1, 4)
Charlson Comorbidity Index	
0	1726 (23.3)
1	1202 (16.2)
2	1492 (20.1)
≥3	2988 (40.4)
Duration of index procedure (mins) , median (IQR)	121 (92, 190)
Index hospital length of stay (days), median (IQR)	5.1 (3.1, 8.1)
McIsaac Frailty Index (pFI)	
mean±SD	0.21 ± 0.09
median (IQR)	0.22 (0.15, 0.27)
range	0-0.68
Index procedure year	
2010	1052 (14.2)
2011	989 (13.4)
2012	902 (12.1)
2013	870 (11.7)
2014	909 (12.3)
2015	964 (13.0)
2016	903 (12.2)
2017	819 (11.1)
Operative Surgical Stress (OSS) score	
2	479 (6.5)
3	4472 (60.3)
4	2057 (27.8)
5	400 (5.4)
Anesthetic technique	
general	4044 (54.6)
neuraxial	3337 (45.1)
regional or local	10 (0.1)
others	17 (0.2)
Admitted to intensive care unit >36 hrs post-procedure	121 (1.6)
Returned to operating room at any time after index procedure	133 (1.8)

SD, standard deviation; IQR, interquartile range; NH, nursing home

We identified 25 existing publications assessing whether frailty is related to postoperative discharge location (17, 19-21). Generally, but not universally, these reported significant associations between frailty and not being able to go back home after surgery. However, these all have important limitations which our study avoided. Only three limited consideration to people living in the community preoperatively (35-37). Only four distinguished discharge to NH from discharge to temporary non-home locations, such as rehabilitation facilities (19, 35, 36, 38). All 25 restricted consideration to immediate hospital discharge location, ignoring the possibility of post-hospital recognition of the need for long-term placement; the relevance of this limitation is indicated by our finding that half of those newly entering nursing homes did so more than 80 days postoperatively. And none performed the statistical adjustments needed to address inflated Type I error rates from performing multiple comparisons (39, 40).

More generally, frailty has been associated with adverse outcomes in virtually every type of cohort assessed, including postoperatively (17), in patients with critical illness (41), chronic conditions such as asthma and diabetes (42, 43), and in advanced age (44). McIsaac et al. demonstrated that the effect of frailty on death in elective surgical patients is largely related to higher rates of postoperative complications (18).

In addition to avoiding the above-mentioned methodologic problems of prior work, our study has salient strengths. It is

Table 3. Study outcomes of all subjects meeting general cohort criteria, N=7408. Values are mean±SD or n (%) unless otherwise indicated

PARAMETER	VALUE
New nursing home admission/wait listing within 180 days after index procedure	43 (0.6)
Death within 30 days after index procedure	57 (0.8)
Death 90-180 days after index procedure	88 (1.2)
Outpatient physician visits from hospital discharge to 180 days later (prorated)	
median (IQR)	6 (4-9)
mean±SD	7.2 ± 4.2
range	0-58
Emergency department visits from hospital discharge to 180 days later (prorated)	
median (IQR)	0 (0-1)
mean±SD	0.51 ± 1.14
range	0-27
Hospital-days from hospital discharge to 180 days later (prorated)	
median (IQR)	0 (0-0)
mean±SD	3.0 ± 13.0
range	0-180

SD, standard deviation; IQR, interquartile range

Table 4. Association, per 0.1 unit increase of McIsaac Frailty Score (pFI) with study outcomes

Outcome	# principal components included[1]	#subjects (# with outcome)	Association measure	Point estimate[2]	95% C.I. [2]	p-value[3]
Time to new admission or wait-listing for NH placement [PRIMARY outcome]	3	7303 (43)	hazard ratio	3.01	2.42, 3.76	<0.0006
Mortality to 30 days after index procedure	3	7404 (57)	odds ratio	2.61	1.97, 3.44	<0.0006
Mortality from 90-180 days after index procedure	6	7293 (88)	hazard ratio	1.87	1.48, 2.35	<0.0006
Post-hospital outpatient physician visits, prorated to 180 days	6	7291	rate ratio	1.29	1.27, 1.31	<0.0006
Post-hospital Emergency Department visits, prorated to 180 days	6	7291	rate ratio	1.57	1.49, 1.67	<0.0006
Post-hospital hospital-days, prorated to 180 days	6	7344	rate ratio	nonlinear	nonlinear	<0.0006

1Indicates # of principal components of the covariates included in multivariable regression models; 2Numerical point estimates are provided when analysis indicated a linear association between pFI and the outcome, relevantly nonlinear relationship shown in e-Figure 1B; 3. Adjusted for covariates, and 6 outcomes via Bonferroni correction; NH, nursing home

a population-based study from a health region in a Canadian province over eight years, which assessed a range of relevant outcomes. Consistent with its underlying conceptual framework (14, 16), we analyzed frailty as a continuum, rather than the binary representation used in some prior studies. And finally, our analysis included robust adjustment for potential confounding variables, including patient demographics, socioeconomic status, and uniquely among existing studies, a measure of the degree of operative stress.

Our study also has limitations, of which foremost is the pFI frailty measure we used. Currently, the two principal clinical reference standard frailty constructs are the Frailty Phenotype (16), and deficit-counting method Frailty Index (14). As both require detailed clinical assessment, we instead used one of the claims-based measures that quantify frailty for large population-based datasets in which clinical assessment is infeasible. Such measures use diagnosis codes and health service claims, and like the clinical measures they relate to relevant outcomes (45). The pFI was developed in Canada for, and validated against, postoperative outcomes by McIsaac et al. (26). It is a composite including age, sex, living environment, socioeconomic status, comorbid conditions, prior hospitalizations and emergency department visits, certain medications, and characteristics of the index hospitalization. Though inclusion of homecare and some durable medical equipment improves correspondence of pFI with clinical frailty (46), pFI like other of its kind has differences from the clinical measures (46). While the few existing direct comparisons of claims-based with clinical measures have shown only modest correlations (45, 47), the correspondence between the Frailty Phenotype and Frailty Index is, in fact, only slightly higher (48). Nonetheless, we recognize the possibility that our findings would differ with use of an alternative measure. The main concern about using pFI, or any frailty measure that incorporates comorbid conditions, is that it misattributes effects of comorbidity to frailty. However, while clearly distinct, frailty and comorbidity have a complex bi-directional relationship, with some evidence that frailty may contribute to progression or even development of some comorbid conditions (49, 50). Indeed, it may be that much of the seemingly direct influence of comorbid conditions on some relevant outcomes is mediated by a common denominator of frailty.

Other limitations include the possibility that our findings might not generalize to other jurisdictions, and that as in all observational studies, residual confounding cannot be ruled out. Finally, although our conceptual basis for including OSS as a covariate in our analysis was the assumption that it, rather than the specific surgical procedure, is a main influence on our outcomes, bias could have entered our results if there is substantial variation in outcomes across different procedures with the same OSS.

In light of the high value that most people place on independence (2-5), and their associated aversion to living in a nursing home (8-11), our primary result has important implications for anesthesia and surgical practice. Strong arguments follow that surgical candidates be evaluated for their degree of frailty, and that their informed consent include discussion of the possibility of survival with loss of independence (51). Although the absolute rate of this outcome was only 6 per 1000 procedures, that is much higher than the approximate rate of 3 anesthesia deaths per 100,000 (52), for which informed consent is universal. Especially for elective surgeries, as we have studied, routine assessment of frailty in the preoperative clinic setting is feasible (53). However, the small literature on informed consent for surgery demonstrates important deficiencies (54, 55), and we were unable to find any published information relating to how often the possibility of ending up in a nursing home is included in discussions on informed consent.

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Ethical standard: This study, approved by the Health Research Ethics Board of the University of Manitoba (HS24056), did not require subject consent as it utilized existing, deidentified, data.

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