# Self-rated frailty, resilience, and mortality of old men: The Manitoba Follow-up Study

by

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#### Abstract

**Objectives:** Frailty has been described as an experience that results in an increased risk of disability, hospitalization, and mortality. Definitions of frailty have rarely included self-ratings of frailty. Older adults' self-rating of frailty may present new avenues of operationalizing frailty. The objectives are to (1) Assess the validity of self-rated frailty; (2) Examine the possibility of recovering from a frail state; and (3) Determine whether self-rated frailty relates to mortality. **Methods:** In 2015, we adapted the Clinical Frailty Scale to be used as a simple self-rating of frailty among 146 male participants of a cohort study of aging, the Manitoba Follow-up Study. Three years of follow-up have just become available. The Clinical Frailty Scale was asked yearly, and we compared ratings obtained on questionnaire responses in 2015 ( $T_1$ ), 2016 ( $T_2$ ), and 2017 (T<sub>3</sub>). **Results:** Self-ratings of "moderate-severe" frailty were associated with worse physical health and additional impairments in instrumental activities of daily living and basic activities of daily living at  $T_1$  and  $T_2$ , and worse mental and physical health at  $T_3$  (p $\leq 0.05$ ). These results have thus supported the validity of self-rated frailty (SRF). The proportion of men who reported an improvement in their self-rated frailty (i.e evidence for resiliency) was significant at  $T_2$ , and  $T_3$  (p $\leq 0.05$ ). Over the observation period, the Hazard Ratio for mortality was 3.3 (95%) CI: 1.5, 7.1) ( $p \le 0.05$ ) for those who rated themselves as "mildly to severely frail" vs "very fit or well, with no disease". Conclusion: Self-rated frailty has construct validity through its association with other measures of health and predicts mortality over a three-year period. Furthermore, some older men's self-rated frailty has improved over a one-year and two-year period.

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#### Introduction

Frailty has been described as an experience that is often associated with aging (Xue, 2011). Frailty has been considered to be a physiologic loss of reserve capacity and resistance to stressors (Buchner & Wagner, 1992; Fried et al., 2001). It has also been viewed as an increased vulnerability to adverse health outcomes resulting from the interactions of multiple factors related to age-related decline (Rodríguez-Mañas et al., 2013). Regardless of conceptualization, the implications of frailty can be insidious. This condition has been linked to dependency, institutionalization, and mortality (Bieniek, Wilczynski, & Szewieczek, 2016; Buckinx et al., 2015; Fried et al., 2001; Fried, Ferrucci, Darer, Williamson, & Anderson, 2004). It has been associated with an increased risk of adverse health outcomes including increased risk of falls, disability, hospitalization, and mortality (Chen, Mao, & Leng, 2014; Fried et al., 2001; Morley et al., 2013; Rodríguez-Mañas et al., 2013).

Frailty is also a growing public health concern. The Canadian older adult population is expected to comprise up to 25% of the population by 2036 (Statistics Canada, 2016). The fastest growing segment of this population, the oldest old (80+ years old), are at increased risk for the detrimental effects of frailty (i.e. increased risk of falls, disability, and delirium; Bronskill, Camacho, Gruneir, & Ho, 2011; Eeles, White, O'Mahony, Bayer, & Hubbard, 2012; Fried et al., 2001; Walston et al., 2006). Therefore the multifaceted clinical and societal consequences of frailty are expected to increasingly impact the provision and financial implementation of health policy and service provision (Buckinx et al., 2015)

It is thought that frailty may be responsive to prevention and remediation (Fried et al., 2004). Unfortunately, understanding frailty is often complicated by operational and conceptual challenges, impacting the development of appropriate and feasible responses to frailty (Fried et

al., 2004). The aim of this thesis is to address the limitations of the current approaches to frailty by expanding the understanding of frailty in relation to older adults' ability to self-rate frailty, resilience to frailty, and consequences of frailty.

#### **Literature Review**

#### **Defining Frailty**

Frailty definitions can be divided into two broad categories, depending upon their originators: researcher-generated definitions and lay definitions. There has been much diversity in researcher-generated definitions of frailty, since each definition is constrained by the specific areas of interest of the researcher(s) who created it (de Vries et al., 2011; Walston et al., 2006). Lay definitions of frailty, in contrast, can be much more all-encompassing and may include aspects of frailty that researcher-generated definitions have overlooked. The section that follows will describe some of the more popular researcher-generated frailty definitions, including their commonalities, their strengths, and what they may have overlooked. The possibility exists that some of the gaps in the researcher-generated frailty definitions could be addressed by considering lay-definitions of frailty instead.

**Researcher-defined frailty.** Definitions of frailty have evolved over time, incorporating numerous perspectives as to what this concept truly represents. According to Hogan et al. (2003), the term frailty was not used to describe older adults very frequently before the 1980s. However, a variety of other terms were utilized, such as "chronic sick", "debilitated", "disabled", "sedentary institutionalized", "incapacitated", or "functionally dependent elderly" (Hogan et al., 2003; Johnson & Shaw, 1966; Stamford, 1972; Stanford & Dolson, 1972; Warren, 1943, 1946). Even so, the term "frail" has appeared in some of these early texts within the term "frail ambulant" (E.g. Warren (1946) and Cosin (1947)) to "categorize those with disability yet who were still mobile, and required care in long stay annexes" (St. John, McClement, Swift, & Tate, 2019, p. 14).

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Hogan et al. (2003) indicated that the vast diversity of older adults became more readily acknowledged within the 1970s. The *Federal Council on Aging* had used the term "frail elderly" to draw focus to a particular group of older adults with special needs (Federal Council on the Aging, 1978). These individuals were described as "…older Americans with an accumulation of health, social, economic and environmental problems which impede their independent living to the extent that they need continuing personal assistance" (Federal Council on the Aging, 1978, p. v). Hogan et al. (2003) have indicated that reception to the task force's recommendations was limited, as the authors highlighted a single, anonymous response article to the Council's report that had labelled the term as technical vernacular ('Federal Council on Aging focuses attention on frail elderly', 1978).

Within the subsequent decades, researchers specified what "frailty" meant within their own publications (Hogan et al., 2003). For example, Stamford (1972) used the term "institutionalized" synonymously with frailty (Kauffman, Scott, Barr, & Moran, 2014; Van Kan et al., 2008). The early 1980s had several authors consider frailty to be functional dependence within the activities of daily living (Hogan et al., 2003; Rockwood, Fox, Stolee, Robertson, & Beattie, 1994; Woodhouse, Wynne, Baillie, James, & Rawlins, 1988). Similarly, Gillick (1989) considered frail older adults to be "…old, debilitated individuals who cannot survive without substantial care from others…" (p. 1998). Furthermore, Stone, Cafferata, and Sangl (1987) did not differentiate between the terms "frail elderly" and "disabled older individuals" when discussing the caregivers of older adults. The review by Hogan et al. (2003, p. 5) further indicated that there seemed to be "growing consensus that frailty was another term for disability in older individuals" in the early 1980s. However, by the late 1990s it was recognized that frailty was a distinctly separate concept from disability (Campbell & Buchner, 1997). Further

development acknowledged that there may be some overlap between disability, comorbidity and frailty (Fried et al., 2004).

Hogan et al. (2003) stated that within the 1990s a new theme emerged within the frailty research that sought to understand the underlying mechanisms and process behind how one became frail. A key model of frailty from this period included the "model of breakdown" introduced by Brocklehurst (Brocklehurst, 1985; Rockwood et al., 1994). This model proposed that factors contributing to good health were balanced against factors detrimental to one's health (Rockwood et al., 1994). The resulting "balance" of health factors determined whether one could successfully live in the community (Rockwood et al., 1994). This model was refined by Rockwood et al. (1994) into the "dynamic model of frailty", which introduced the concept of frailty as an "at-risk state" for increased disability and mortality (Rockwood et al., 1994; St. John et al., 2019).

The literature on defining and conceptualizing frailty grew exponentially after the 1990s, reflecting a multitude of perspectives (Kauffman et al., 2014; Van Kan et al., 2008). Currently, the most popular approaches to understanding frailty include the frailty phenotype (which considers frailty as a biological syndrome) and the frailty index (FI) (which views frailty as a state of risk determined by the quantity of factors of illness) (Morley et al., 2013; Theou, Brothers, Mitnitski, & Rockwood, 2013). Many other operationalizations of frailty have been developed but are typically based on one of these two theories (Buckinx et al., 2015; de Vries et al., 2011; Gill et al., 2002; Gill, Gahbauer, Allore, & Han, 2006; Morley et al., 2013; Theou et al., 2013; Theou & Kloseck, 2007). The paragraphs that follow will explore the conceptualization and operationalization of the most popular researcher-generated definitions of frailty, in addition to notable developments in the field.

*The frailty phenotype.* Fried et al. (2001) defined frailty as "A biological syndrome of decreased reserve and resistance to stressors, resulting from cumulative declines across multiple physiologic systems, and causing vulnerability to adverse outcomes" (p. M146). Using data from the *Cardiovascular Health Study*, Fried et al. (2001) operationalized frailty to be a clinical syndrome that included three or more of the following criteria:

- Shrinking: unintentional weight loss,  $\geq 10$  pounds in the past year;
- Weakness: poor grip strength within the lowest 20% when adjusted for gender and body mass index;
- Poor endurance and energy: as identified through self-reported exhaustion;
- Slowness: within the slowest 20% when adjusted for gender and standing height and based on walking speed during a 15 foot walk;
- Low physical activity: considered at the lowest quintile of physical activity of each gender.

Three stages of frailty were developed, based on the number of criteria experienced by the study participants: not frail (0 criteria met), pre-frail (1-2 criteria met), and frail (3-5 criteria met) (Op het Veld et al., 2015). This model presents a phenotype, or a set of observable traits, that illustrates the underlying physiologic state of vulnerability that frailty represents (as detailed by the conceptual definition proposed by Fried et al. (2001, 2004)). That is, frailty could be considered an aggregate expression of risk that becomes "visible" when individual losses of physiologic reserve accumulate to reach a threshold that creates a sizeable vulnerability that can be identified by observing clinical, functional, behavioural, and biological markers (e.g. cytokine IL-6; Fried et al., 2004; Walston et al., 2006).

The operational definition by Fried et al. (2001) is the most widely accepted definition of frailty (Garcia-Garcia et al., 2014; Romero-Ortuno, 2011), as this model includes primarily physical components that are easily measured (Sternberg, Schwartz, Karunananthan, Bergman, & Clarfield, 2011). Therefore the phenotype of frailty is often used as reference criteria or as a standard during research (Choi, Ahn, & Kim, 2015; Op het Veld et al., 2015; Theou et al., 2015).

*Deficit accumulation.* In the mid-1980s, Brocklehurst described frailty as a balance of biomedical and psychosocial factors to illustrate a "model of breakdown" that determined whether one could continue to live within the community (Brocklehurst, 1985; Rockwood et al., 1994). This model proposed that factors contributing to independence (deemed health "assets") were balanced against factors detrimental to one's independence (called health "deficits") (Rockwood et al., 1994). Examples of assets included factors such as health, functional capacity, and a positive attitude towards health and health practices (Rockwood et al., 1994). Examples of health deficits included illness (especially chronic disease), disability, dependence, and caregiver burden (Rockwood et al., 1994). This model was refined by Rockwood et al. (1994) into a "dynamic model of frailty", which emphasized frailty as an "at-risk state" for increased disability and mortality, resulting from the interaction between health assets and deficits within the biomedical and social spheres of health (Rockwood et al., 1994; St. John et al., 2019). Frailty is then considered by this model to be an at-risk state resulting from the accumulation of deficits related to age (Mitnitski, Mogilner, & Rockwood, 2001).

According to the deficit accumulation model, subjects whose assets outweighed their deficits were considered fit and subjects who exhibited a precarious balance (or imbalance in favour of deficits) were frail (Rockwood, Hogan, & MacKnight, 2000). Simply put, those who experienced more deficits than assets were considered frail (Rockwood et al., 2000; Rockwood

& Mitnitski, 2017). The vulnerability of this delicate balance of health assets and deficits has presented an intriguing perspective within the literature (Rockwood et al., 1994, 2000); that frailty as a vulnerable state could be subject to change (Rockwood et al., 1994).

The deficit accumulation model has measured frailty through a "frailty index" (FI) (Rockwood, Mitnitski, & MacKnight, 2002). The fundamental basis of the deficit accumulation theory is that the more deficits experienced the more likely one is to be frail (Rockwood et al., 2000; Rockwood & Mitnitski, 2017). Stemming from this principle, operationalization of frailty is achieved by counting the deficits in health experienced by the subject (Searle, Mitnitski, Gahbauer, Gill, & Rockwood, 2008). Deficits are represented by a variety of data including signs, laboratory abnormalities, diseases, and disabilities (Rockwood & Mitnitski, 2011). Deficits are given a score of 1 if present and 0 if absent (Rockwood & Mitnitski, 2017). There is also evidence to suggest that as long as enough variables are used in the FI, ordinal or continuous variables may also be transformed into intermediate scores (i.e. 0.25 or 0.5) (Peña et al., 2014). The frailty index is then derived as a ratio (or proportion) of the number of deficits present against the total number of deficit items considered (Searle et al., 2008). For example if 15 deficits were experienced by a subject out of which 40 deficits had been considered, the subject's frailty index would be 15/40 = 0.375 (Searle et al., 2008). This index is a continuous scoring system, with outcomes ranging from 0 to 1 (de Vries et al., 2011). The index is interpreted as the higher the score, the more likely the subject is to be at an increased risk to adverse health outcomes (Cesari & Theou, 2017; Rockwood & Mitnitski, 2011).

It is necessary to include at least 20 items in a FI, but a minimum of 30-40 deficits has been recommended to maintain estimate stability (Cesari & Theou, 2017; Moorhouse &

Rockwood, 2012). As exactly stated by Searle et al. (2008), proposed health deficits must satisfy five criteria:

- 1. The variables must be deficits associated with health status. Attributes such as graying hair, while age-related, are attributes and therefore not included;
- A deficit's prevalence must generally increase with age, although some clearly agerelated adverse conditions can decrease in prevalence at very advanced ages due to survivor effects;
- 3. Similarly, the chosen deficits must not saturate too early. For instance, age-related lens changes resulting in problems with accommodation (presbyopia) are nearly universal by age 55; in other words, as a variable, presbyopia saturates too early to be considered as a deficit here;
- 4. When considering the candidate deficits as a group, the deficits that make up a frailty index must cover a range of systems if all variables were related to cognition, for example, the resulting index might well describe changes in cognition over time, but would be a cognitive impairment index (Mitnitski & Rockwood, 2008) not a frailty index;
- 5. If a single frailty index is to be used serially on the same people, the items that make up the frailty index need to be the same from one iteration to the next (Rockwood, Mitnitski, Song, Steen, & Skoog, 2006). The requirement to use the same items need not apply to comparisons between samples i.e. samples that use difference frailty indexes appear to yield similar results (Mitnitski & Rockwood, 2008, p. 2).

There is evidence that some research further specified requirements. For example,

Moorhouse and Rockwood (2012) further required that each health deficit must have a minimum of 1% prevalence in the population during their study.

At the start, the frailty indices were used to count deficits in pre-existing databases (typically epidemiologic databases; Rockwood & Mitnitski, 2017). FIs can be constructed from any list of health deficits and do not need to be based on preset items (Moorhouse & Rockwood, 2012). FIs are then especially valuable for retrospective assessment of existing cohorts or databases (Cesari & Theou, 2017); as the factors included in the FI are not required to be predetermined prior to construction of the dataset, any available factors may be included (Cesari & Theou, 2017). As the deficit accumulation approach developed, prospective FIs were also created from comprehensive geriatric assessment (CGA) forms (Rockwood & Mitnitski, 2011, 2017) that typically have been used during clinical examinations (Jones, Song, & Rockwood, 2004). FIs have been used to investigate deficit accumulation in multiple different countries (Mitnitski et al., 2005), using many different samples sizes (Mitnitski et al., 2005), have considered subjects from a diverse range of communities (i.e. institutionalized, hospitalized older adults; Cesari & Theou, 2017; Mitnitski et al., 2005) and from a variety of data collection methods (i.e. only self-reported data, only objective data, combined methods; Rockwood & Mitnitski, 2011). Regardless of the size or construction of the FI, several characteristics have been observed across the studies that were notably similar (Cesari & Theou, 2017).

First, the index reflects the severity of illness and proximity to death (Mitnitski et al., 2001). This is because health deficits generally create a predisposition to death and hospitalization (Garcia-Garcia et al., 2014). A larger frailty index score indicates the presence of more health deficits and therefore a higher likelihood of experiencing frailty and ill health

(Rockwood & Mitnitski, 2011, 2017). However, there may be a limit to frailty. According to Rockwood and Mitnitski (2017) in an evaluation of a large number of datasets, less than 1% of subjects had a frailty index score that exceeded 0.7. This limitation has been reported several times in the literature (Rockwood & Mitnitski, 2017). Some authors have speculated that this limit has persisted because a FI score that exceeds 0.7 results in imminent death, before further accumulation of deficits (P. St. John and R. Tate, personal communication, January 9, 2019).

Second, in a study that compared deficit accumulation in community dwelling older adults across four Western countries (Canada, Australia, the United States, and Sweden) it was found that in each country, deficits accumulated at a rate of approximately 3% per year on a log scale (Rockwood & Mitnitski, 2011). This is particularly interesting as the FIs constructed from each unique dataset considered different variables and a different number of deficits were considered in each FI (Rockwood & Mitnitski, 2011).

*Multidimensionality*. A more recent development in researcher-generated definitions of frailty has considered frailty to be a multidimensional concept (including physical, psychological, and social aspects) (Chen et al., 2014; Fried et al., 2001; Gobbens, Luijkx, Wijnen-Sponselee, & Schols, 2010a; Gobbens, van Assen, & Schalk, 2014; Markle-Reid & Browne, 2003; Morley et al., 2013; Puts, Lips, & Deeg, 2005; Rodríguez-Mañas et al., 2013). This approach has gained support as compared to the single-domain definitions of frailty (de Vries et al., 2011; Gobbens et al., 2014; Markle-Reid & Browne, 2003; Puts et al., 2005), as researchers have reported concern that these definitions do not adequately address the complexity of frailty (Gobbens et al., 2010a). For example, as it has increasingly been recognized that frailty is more than a physical concept there has been concern that adopting a

purely physical approach to frailty could promote fragmentation of care (De Witte et al., 2013; Gobbens et al., 2010a; Markle-Reid & Browne, 2003; Walston et al., 2006).

As illustrated by the focus groups conducted by Gobbens et al. (2010a), this development has not been universally supported. This study involved the participation of 20 experts who had contributed scientific publications towards the definition of frailty within the existing literature (Gobbens et al., 2010a). Selected participants were from the United States, Canada, and the Netherlands (Gobbens et al., 2010a). The majority of the participants preferred the definition provided by Schuurmans et al. (2004), which viewed frailty as multidimensional: "Frailty is a loss of resources in several domains of functioning, which leads to a declining reserve capacity for dealing with stressors" (Schuurmans et al., 2004, p. 962). However some participants preferred to consider frailty as unidimensional, as they believed that the concept was already complicated enough when considered within a single domain (Gobbens et al., 2010a). Some experts also indicated that they viewed frailty as most closely defined by Fried et al.'s (2001) criteria, which primarily views frailty as a physical syndrome (Gobbens et al., 2010a). Gobbens et al. (2010a) concluded with the proposition of a new conceptual working definition that ultimately reflected the multi-dimensional nature of frailty: "Frailty is a dynamic state affecting an individual who experiences losses in one or more domains of human functioning (physical, psychological, social), which is caused by the influence of a range of variables and which increases the risk of adverse outcomes." (Gobbens et al., 2010a, p. 342).

*Critique*. There are several challenges exhibited by the literature defining frailty. The definitions and operationalizations presented in the literature are often plagued by ambiguity and a lack of consensus (Cesari, Gambassi, Van Kan, & Vellas, 2014; Clegg, Rogers, & Young, 2015; Conroy, 2009; Gobbens et al., 2010a, 2014; Malmstrom, Miller, & Morley, 2014;

Sternberg et al., 2011). Contributing to this issue, the definitions have remained divisive on which factors associated with frailty should be included by the definitions (Gobbens et al., 2010a, 2014). For example, the operational definition by Fried et al. (2001) has been recognized as the most widely accepted definition of frailty (Garcia-Garcia et al., 2014; Romero-Ortuno, 2011), as this model has included primarily physical components that are easily measured (Sternberg et al., 2011). Therefore the phenotype of frailty has been often used as reference criteria or as a standard during research (Choi et al., 2015; Op het Veld et al., 2015; Theou et al., 2015). However, as this model considers mostly physical aspects of frailty, the literature has noted that it then seems incomplete compared to the most recent and widely accepted multidimensional concept of frailty (i.e. having included physical, psychological, social domains) (Clegg, Young, Iliffe, Rikkert, & Rockwood, 2013; Ferrucci, Mahallati, & Simonsick, 2006; Fried et al., 2001; Sternberg et al., 2011). Consequently, research utilizing Fried et al.'s (2001) criteria has often altered the components defining frailty to fit the needs of the study. For example, recent research has had added mood, cognition, and other measures of mental health to research utilizing Fried et al.'s (2001) criteria (Ávila-Funes et al., 2009; Bergman et al., 2007; Rothman, Leo-Summers, & Gill, 2008). Unfortunately this has made comparison between studies difficult as they are not using the same definition of frailty once it has been altered. Therefore while there are operational differences between frailty definitions, there may also be differences between studies using the "same" criteria. The presence of several working definitions of frailty within the literature has made it difficult to compare and replicate results.

As the conceptual and operational definitions of frailty have not yet reached consensus a universal researcher-generated definition of frailty has yet to be achieved (Cesari et al., 2014; Clegg et al., 2015; Conroy, 2009; Gobbens et al., 2010a, 2014; Malmstrom et al., 2014;

Moorhouse & Rockwood, 2012; Sternberg et al., 2011), although the criteria by Fried et al. (2001) has been recognized as the most widely accepted definition of frailty (Garcia-Garcia et al., 2014; Romero-Ortuno, 2011). Efforts to reach consensus have had limited success (Gobbens et al., 2010a). For example, Rodriguez-Manas et al. (2013) gathered a variety of experts who were interested in frailty to form a working group focused on developing a complete and concrete definition of frailty. Interestingly, the experts involved exhibited a high degree of agreement on the concept of frailty (Rodríguez-Mañas et al., 2013). It was broadly agreed that frailty is "a multidimensional concept of decreased reserve and diminished resistance to stressors" (Rodríguez-Mañas et al., 2013, p. 65). However, there was no consensus on the specific factors involved in the operational definition, as there was no agreement on suitable measures and diagnostic paths (Rodríguez-Mañas et al., 2013).

According to Morley et al. (2013), part of the reason that efforts to achieve a clear definition of frailty have been frustrated is that the broad definitions of frailty have not been refined sufficiently. To address this barrier, these authors focused on physical frailty, considering it "as a specific medical syndrome within the broader context of frailty" (Morley et al., 2013, p. 393). The authors did acknowledge that frailty may incorporate other domains (i.e. psychological), but limited their approach to physical frailty. This action has further illustrated the lack of consensus on the definition of frailty (Morley et al., 2013).

Another limitation of the current approaches to frailty is the lack of tools and methods available for clinical use. It has been noted that the quantity of items required for constructing the FI is cumbersome, especially during index calculation in the clinical setting (Garcia-Garcia et al., 2014; Moorhouse & Rockwood, 2012; Theou et al., 2013). Clinicians have therefore reported concern about the feasibility of FIs for clinical use (Cesari & Theou, 2017; Moorhouse &

Rockwood, 2012; Theou et al., 2013). Some authors have indicated that the use of electronic medical records may improve feasibility by improving access to multiple areas of health information that are currently burdensome to incorporate in the clinical setting (Moorhouse & Rockwood, 2012; Theou et al., 2013).

The limited applicability of Fried et al.'s (2001) model has also been noted in clinical settings (Rockwood, 2005; Romero-Ortuno, 2011; Woo, Leung, & Morley, 2012), as the complex calculations required of the model are not feasible in the primary care environment (Romero-Ortuno, 2011). Additionally the diagnostic measures of Fried et al.'s (2001) model requires the subject to be well enough to complete the tests (which included a repeated 15 foot walk; Bieniek et al., 2016), which may limit the collection of accurate data.

Lay definitions of frailty. It may be that since frailty means different things to different people, the answer to the problem of trying to pin down a universal researcher-generated definitions of frailty may be to not do so at all. Instead, using a lay definition may provide additional insights. A lay perspective may be defined as one that has originated from "…people who are neither health care professionals nor health services researchers, but who may have specialized knowledge related to health. This includes patients, the general public, and consumer advocates." (Entwistle, Renfrew, Yearley, Forrester, & Lamont, 1998, p. 463).

This approach has been attempted before in the area of successful aging. Swift and Tate (2015) mapped prevalent researcher-generated theories of successful aging to lay definitions. This research revealed that several themes of successful aging from a lay perspective were not adequately covered, or even missing, from the dominant researcher-generated theories (Swift & Tate, 2015). In light of this parallel research in the area of successful aging, in which lay definitions of successful aging were found to be much more complete than researcher-generated

definitions (Swift & Tate, 2015), lay definitions of frailty may be much more comprehensive than are researcher-generated conceptualizations.

Unfortunately there is little evidence of lay definitions of frailty as examinations of older adult's own definitions of frailty were found to be lacking in the literature. It is not clear if lay definitions of frailty from the perspective of the subjects are similar to those of the researchers. For example, there is evidence to suggest that older adults do not use the term "frailty" to disseminate their experiences (Grenier, 2005; Kaufman, 1994). Grenier (2007) conducted a study exploring the lived experience of 12 English-speaking older women in Montreal, Quebec, which included how they "made meaning of their experiences of frailty, disability and decline in their everyday life" (Grenier, 2007, p. 433). Fifty percent were considered frail by the frailty criteria used in home-care sources in Quebec (Grenier, 2007). The older women expressed their experiences with frailty in several ways, including having viewed it as a social construct: "It's not something you say about yourself; it's something others say about you" (Grenier, 2007, p. 435). The women did not reject frailty as a concept, but rather, discussed times when they experienced vulnerability and uncertainty, thus "feeling frail" as opposed to elaborations of physical characteristics (Grenier, 2007). Physically, descriptions were centered around appearance and health, such as being small, skinny, weak, breakable, or wobbly (Grenier, 2007). The older women detailed frailty as a 'look', typically pairing weight loss or a sickly pallor with a lack of strength (Grenier, 2007). These women also related frailty to receiving health care services and a loss of control, in which the author discussed the practices of rationing health care according to the needs of the most frail (Grenier, 2007).

A recent article by St. John, McClement, Swift, and Tate (2019) explored older men's definitions of frailty and if these definitions aligned with any clinical definitions of frailty.

Responses of 147 men were analyzed. The mean age of the men was 93 (SD 2.7). The mean number of reported IADL impairments of the sample was 3.4 (SD 2.4), and the mean number of reported BADLs was 1.3 (SD 2.1). It was found that 56% of participants did not think that they were frail (St. John et al., 2019). A further 13% thought they were frail, 13% indicated their response to be "yes and no", and an additional 18% of participants responded with "don't know" or left the question blank.

The participants were also asked to provide their own definition of frailty (St. John et al., 2019). Thematic analysis of the men's answers indicated than most men defined frailty as related to BADL impairment (25%), as well as poor physical performance such as poor mobility, falls and fall risk, weakness and fatigue (St. John et al., 2019). When the authors attempted to match the older men's definitions to those used in clinical practice, it was found that 48% of the responses didn't really align with any clinical definition ("Other definition" (22%) plus "no existing theory" (26%); St. John et al., 2019). However of the responses that did align with a clinical definition, the most popular definition was "frailty as a disability" (Cosin, 1947; St. John et al., 2019). No further lay definitions of frailty from the perspective of the older adult were found by this review.

#### **Self-rated Frailty**

Considering the persistent ambiguity surrounding the concept of frailty and the limited success of efforts to reach consensus, perhaps a paradigm shift could yield further understanding. Self-rated health (SRH) has been well recognized as a valid indicator of health and an important predictor of mortality and well-being (Lucicesare, Hubbard, Searle, & Rockwood, 2010; Manor, Matthews, & Power, 2001; Martin, 2014; Mossey & Shapiro, 1982). Poor SRH has been associated with adverse health outcomes such as increased health service usage and increased

risk of mortality (Lucicesare et al., 2010). For example, Mossey and Shapiro (1982) found that the risk of early mortality for those whose self-rated health was poor was 2.92 times greater than of those whose self-rated health was excellent. Mossey and Shapiro (1982) also reported that self-rated health was the strongest predictor of early mortality. Furthermore, self-rated health is a popular and well established valid measurement used to indicate health states of older adults (DeSalvo, Bloser, Reynolds, He, & Muntner, 2006; Gijzel et al., 2017; Idler & Benyamini, 1997; Jylhä, 2009; Martin, 2014). In fact some authors have considered SRH to be the best single measure predictor of death, service use, institutionalization and hospitalization for this demographic (DeSalvo et al., 2006; Idler & Benyamini, 1997). Analogous to how self-rated health has a strong positive gradient with risk of mortality (Lucicesare et al., 2010; Manor et al., 2001; Martin, 2014; Mossey & Shapiro, 1982), it may be that self-rated frailty may also exhibit a relationship with mortality and well-being. In this sense, self-rated frailty may be an important reflection of efforts and interventions to alleviate the burden of frailty.

**Self-rated frailty in the literature.** The frailty literature indicated that using older adult's self-reported experience of frailty components was a popular method for gathering data. For example, a systematic review by de Vries et al. (2011) reported that 55% (11/20) of the frailty instruments reviewed were based on self-reported data. Similarly, a review by Bouillon et al. (2013) reported that 41% (11/27) instruments reviewed used only self-reported data. Selfreported data was also used in conjunction with performance tests and objective measures (i.e. grip strength tests), which was the method used by 35% (7/20) of the instruments reviewed by de Vries (2011). It should be noted that there was an overlap of 9 instruments reviewed between the reviews by Bouillon et al. (2013) and de Vries et al. (2011). Part of the appeal of using selfreported data in frailty research is that it might address the feasibility challenges of

operationalizing frailty frameworks in clinical settings (i.e. Fried et al.'s (2001) criteria; Johansen et al., 2014). More recent literature has explored if self-reported data could be used in lieu of performance measures (i.e. gait speed or grip strength tests), in order to improve the feasibility of frailty testing in clinical and research settings (Johansen et al., 2014; Painter & Kuskowski, 2013).

While there was evidence to support that older adults were often asked to report signs and symptoms related to frailty (i.e. difficulty walking or preparing meals), missing from the literature was older adult's self-assessment of frailty. In other words, literature asking older adults to ascribe a score to their own experience of frailty (e.g. a scaled rating, much like how self-rated health is determined), was not found by this review. However, St. John et al. (2019) did ask older men if they thought that they were frail. It was found that 56% of participants did not think that they were frail (St. John et al., 2019). A further 13% thought they were frail, 13% indicated their response to be "yes and no", and an additional 18% of participants responded with "don't know" or left the question blank.

#### **Resilience to Frailty**

One aspect of frailty that was not well understood is the older adult's capacity to adapt to challenges to their functional ability that occur throughout the aging process (Gijzel et al., 2017). Recently, frailty research had adapted the concept of resilience to describe this dynamic (Cohen, 2016). The aging literature had borrowed the term "resilience" from a variety of scientific fields, including psychology (Alfieri & Borgogni, 2010), physics (Conti & Conti, 2010; De Alfieri, Costanzo, & Borgogni, 2011), ecology (Witham & Sayer, 2015), and technology (Alfieri & Borgogni, 2010). In aging research, resilience has been conceptualized as the ability to "bounce back" or recover from adversity (Conti & Conti, 2010; Resnick, 2014; van Kessel, 2013) and has

been linked to concepts such as successful aging (Resnick, 2014). Alternately resilience had been viewed as an ability to adapt to significant challenges and life stressors (Conti & Conti, 2010; Wagnild & Young, 1990) and had been seen as a dynamic process affected by life experiences (Hardy, Concato, & Gill, 2004).

Several different types of resilience have been investigated by the literature, including health, physiological, emotional, dispositional, and psychological resilience (Resnick, 2014). For example, De Alfieri, Constanzo, & Borgogni (2011) focused on biological resilience, viewing resilience as "the ability to cope with stress and catastrophe and regain health by learning adaptation, a well-known capacity of the human mind" (p. 304). Alternately, research on psychological resilience had focused on identification of the protective factors and processes (Alfieri & Borgogni, 2010), which has included optimism and emotional well-being (Lamond et al., 2009).

Resilience has recently gained momentum in frailty research as a new area of interest (Rockwood & Mitnitski, 2015). The term "frailty" has often been used to refer to a negative construct, a measure of vulnerability (Witham & Sayer, 2015). This focus has aided risk assessment for adverse outcomes such as mortality and hospitalization (Witham & Sayer, 2015). However, the concept of frailty has been plagued by ambiguity (Witham & Sayer, 2015). Conceptual confusion has hampered operationalizations, obscuring determination of what factors would need to be altered to enact the desired changes (i.e. decreased frailty; van Kessel, 2013). "Resilience" has promoted the use of positive language, measuring resistance or recovery from challenges (Witham & Sayer, 2015). This perspective may provide a better basis on which to design interventions for older adults, drawing parallels between frailty research and how

resilience has been used to map interdependencies of organisms in the biological sciences (Witham & Sayer, 2015).

The emergence of resilience as an alternate concept for conceptualizing and operationalizing frailty has not been without its criticisms. Rockwood and Mitnitski (2015) questioned the rationality of moving from one ambiguous term to another. These authors also challenged Witham and Sayer's (2013) argument that resilience could present a more dynamic method of viewing and measuring deficits and decline (Rockwood & Mitnitski, 2015). These authors have conceded that language is important and that positive connotation is beneficial (Rockwood & Mitnitski, 2015). However, they concluded that words need to be feasible for clinical use and supported via mathematical evidence (Rockwood & Mitnitski, 2015). It has also been thought that as frailty and resilience share some overlap (De Alfieri et al., 2011; Witham & Sayer, 2015); these concepts may not be neatly oppositional (Rockwood & Mitnitski, 2015).

#### **Section Conclusion**

In summary, the literature has reflected many different understandings and operationalizations of frailty. While Fried et al.'s (2001) criteria and Rockwood and Mitnitski's (2011) FI have been popular approaches, no universal gold standard has been developed (Garcia-Garcia et al., 2014). Furthermore the literature has exhibited uncertainty as to which factors should be included during operationalization (Gobbens, Luijkx, Wijnen-Sponselee, & Schols, 2010b; Gobbens & van Assen, 2014). The field of successful aging experienced a similar lack of operational or conceptual consensus (Tate, Swift, & Bayomi, 2013). This field found that lay definitions, from the perspective of the older adult, were much more complete than researchergenerated definitions (Swift & Tate, 2015). Lay definitions of frailty may be much more

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comprehensive than are researcher-generated conceptualizations, but this approach has yet to be accepted.

Similar to lay definitions of frailty, asking older adults to rate their own experience of frailty could present a new perspective. Asking older adults to self-rate frailty on a likert or ordinal scale is akin to SRH, which has been considered as perhaps the best single measure predictor of death, service use, institutionalization, and hospitalization for older adults (DeSalvo et al., 2006; Idler & Benyamini, 1997). While there is evidence that self-reported components of frailty are often used by the literature, self-rated frailty has been minimally explored.

A recent turn of the literature has considered viewing "frailty" instead as "resilience". "Resilience" is a measure of the ability to "bounce back" (Conti & Conti, 2010; Resnick, 2014; van Kessel, 2013) or adapt to stressors (Conti & Conti, 2010; Wagnild & Young, 1990). This approach is fairly new to the field of frailty and requires further investigation.

Given these gaps in the knowledge, three areas of interest will be addressed by the proposed study:

- 1. Is self-rated frailty a valid measure of clinician assessed frailty?
- 2. Is there any evidence of resilience to frailty in older men?
- 3. Is there a relationship between self-rated frailty and mortality?

#### **Methods**

#### **Design and Cohort**

The present study is of prospective cohort design and has used primary data collected from the Manitoba Follow up Study. This study could be considered as the second part to a previous study, conducted by St. John, McClement, Swift, and Tate (2019). A detailed description of the methods of that study are available elsewhere (St. John et al., 2019). This section will describe the cohort selection and describe the datasets used by the current study.

**Data source**. The present study used data from the Manitoba Follow-up Study (MFUS). MFUS is the longest running prospective investigation of cardiovascular disease and aging in Canada. Currently in its 71<sup>th</sup> year, this prospective cohort study examines health and well-being in a cohort of World War II Royal Canadian Air Force aircrew recruits. The cohort was sealed on July 1, 1948 with 3,983 men (Tate, Cuddy, & Mathewson, 2015). Mean age at baseline was 31 years of age; 90% were 20-39 years of age (Tate et al., 2015). After 65 years of follow-up, to July 1, 2013, 429 men were alive at a mean age of 91 years (Tate et al., 2015).

As the cohort aged, the focus of MFUS was expanded to include measures of quality of life such as successful aging (Tate, Loewen, Bayomi, & Payne, 2009; Tate et al., 2013). In 1996, a quality of life survey was designed and mailed to study participants to ascertain core information about the cohort's mental, physical, and social functioning apart from physician diagnosed disease (Tate et al., 2015). Deemed the Successful Aging Questionnaire (SAQ), the self-administered questionnaire captured several aspects of health, well-being, and functional status (Tate, Lah, & Cuddy, 2003). Information of interest included living arrangements, limitations with basic activities of daily living (BADL), limitations with instrumental activities

of daily living (IADL), mental health, physical health, and the study member's perspective of aging and successful aging (Swift & Tate, 2015; Tate et al., 2015, 2003). The construction of the SAQ drew from several pre-existing sources, most notably including the RAND SF-36 (Ware & Sherbourne, 1992). Several open-ended qualitative questions were also added to the questionnaire (Tate et al., 2003).

**Sample**. The present study considered all members of the MFUS cohort who were alive and had a current address registered with MFUS as of the mailing date of the 2015 SAQ (May 11, 2015). Participants were included in the present study if they had returned a SAQ in 2015, 2016, or 2017. Cohort selection is further described in initial descriptive statistics.

**Datasets**. The data required for the present study was drawn from MFUS datasets. The original four files hosted by MFUS are described below.

- The demographic database: Contained vital demographic information such as date of birth, date of death, and date of last contact with study member. This file also included contact information (e.g. address, postal code, phone number), alternate contact information, date of last blood pressure, and date of last EKG. For the present study, access to only demographic information was obtained (MFUS ID number, date of birth, date of death, and date of last contact). No identifying information was accessed by this study.
- 2) The 2015 SAQ: This file is an electronic version of each member's response to the 2015 SAQ. The data in this file was used to inform the independent variables for objectives 1 and 3. The annual SAQ is described in greater detail in the next section. See Appendix 1 for a copy of the annual SAQ.

- The 2016 SAQ: This file is an electronic version of each member's response to the 2016 SAQ. It will be used to inform the independent and outcome variables for objectives 1 and 2.
- The 2017 SAQ: This file is an electronic version of each member's response to the 2017 SAQ. It will be used to inform the independent and outcome variables for objective 2.

In order to comply with ethical criteria set out by the University of Manitoba's Health Research Ethics Board (HREB) for working with personal health information, new data sets were created from each source dataset. These new datasets contained only the relevant variables required for analysis of the present study. Furthermore, the information was deidentified as participants were only represented by a numerical identifier unique to MFUS. Therefore the information received from MFUS did not contain personal information such as member's address, postal code, phone numbers, etc. Please see Figure 1 for a diagram depicting the creation of the new data sets.

	Demographics Database	2015 SAQ	2016 SAQ	2017 SAQ
MFUS Version	<ul> <li>Date of birth</li> <li>Date of death</li> <li>Date of last contact</li> <li>Contact information</li> <li>Alternate contact information</li> <li>Date of last blood pressure</li> <li>Date of last EKG</li> <li>MFUS unique ID</li> </ul>	• Responses to yearly SAQ	• Responses to yearly SAQ	Responses to yearly SAQ
Removal of identifying information, as per ethical criteria				
MSc Thesis Version	<ul> <li>Date of birth</li> <li>Date of death</li> <li>Date of last contact</li> <li>MFUS unique ID</li> </ul>	<ul> <li>Responses to yearly SAQ</li> </ul>	• Responses to yearly SAQ	Responses to yearly SAQ

Figure 1. Dataset creation and content exclusion. This figure illustrates how identifying information was removed from original dataset.

#### RAND 36-Item Short Health Survey (SF-36)

The RAND SF-36 (hereafter known as the SF-36) is a 36-item questionnaire developed to measure health-related quality of life across a diverse range of settings and populations (Ware & Sherbourne, 1992). This tool is used to evaluate a generic measure of health as the concepts considered are universally valued (Ware, Snow, Kosinski, & Gandek, 1993). Even more so, they are not concepts related to age, disease, or treatment specific experiences (Ware et al., 1993). By assessing such generic measures of health the SF-36 serves as a "common yardstick," able to evaluate a broad range of afflictions (Ware et al., 1993).

The SF-36 was included within the SAQ as it was the most applicable and accessible

index available that considered health-related quality of life at the time of creation (Barclay &

Tate, 2014). It also presented particular advantages to other options. The SF-36 was shorter than

those previously available (Ware et al., 1993), taking only 5-10 minutes to complete and can be self-administered (Jansen, Steultjens, Holtslag, Kwakkel, & Dekker, 2010; Ware et al., 1993).

The SF-36 evaluates mental and physical health across several components of well-being (Ware, 1987; Ware et al., 1993). It includes assessment across eight subscales: physical functioning, social functioning, role limitations due to physical health, role limitations due to emotional problems, mental health, bodily pain, vitality, and general health (Jansen et al., 2010). Each item is only used once, to calculate a score for one sub-scale (Ware & Kosinski, 2001). The responses are then aggregated and scored for each subscale. The raw scores can then be standardized into a score between 0-100 (Jansen et al., 2010). The scores are interpreted as higher scoring representing better health (Jansen et al., 2010). Therefore the health of the participant can be adequately represented by eight summary measures without losing too much information (Ware & Kosinski, 2001).

As previously stated, each of the 36 items on the SF-36 (except self-reported health transition) are used to score only one of the eight subscales (Ware & Kosinski, 2001). The eight subscales can then be used to form two higher-ordered clusters of scales, which are summarized by the SF-36 as two higher ordered summary measures: the Mental (MCS) and Physical Component Summary (PCS) measures (Ware & Kosinski, 2001). The following scales correlate most highly with the MCS measure (and are thereby summarized by the MCS measure): mental health, role limitations due to emotional problems, and social functioning (Ware & Kosinski, 2001). The scales that correlate most highly with (and are thereby summarized by) the PCS measure are the physical functioning, role limitations due to physical health, and bodily pain scales (Ware & Kosinski, 2001). Some of the scales correlate with both higher ordered summary measures. The vitality scale correlates notably with both the MCS and PCS summary measures

(Ware & Kosinski, 2001). The general health scale correlates with both, although does correlate more highly with the PCS summary measure (Ware & Kosinski, 2001). The social functioning scale also correlates with both summary measures, but correlates much more with the MCS summary measure (Ware & Kosinski, 2001). It should be noted that when the PCS and MCS summary measures are scored, the summarization considers the correlations exhibited by the individual SF-36 scales (Ware & Kosinski, 2001). Ware & Kosinski (2001) report that the physical and mental components have been found to "account for 81.5% of the reliable variance in SF-36 scales in the general US population" (Ware & Kosinski, 2001, p. 5). This is exciting because these two component scores represent information in the eight scales without fewer statistical comparisons but without significant loss of information (Ware & Kosinski, 2001). These two concepts are of particular interest, as they are utilized during analysis of the current study.

#### Variables

**Independent variables**. This section describes the independent variables included in this study.

**Age** was defined as the man's current age in years on the date the SAQ was completed by the MFUS member (in 2015, 2016, and 2017). It was derived from the demographic database merged with each SAQ.

**Self-rated health** was defined as the self-rated health score reported by the study member on the annual SAQ. Available ratings are "Excellent", "Very Good", "Good", "Fair", and "Poor/Bad". **Self-rated frailty** was defined as the self-rated score reported on the annual SAQ by the third question on the second last page. The corresponding question asked the members to, "Please rate YOUR frailty on this scale". A Likert-type scale was then provided, ranging from 1= very fit to 7= severely frail. Please see Appendix 1 for a copy of the SAQ sent in 2015.

This scale is a modified version of the 7-point Clinical Frailty Scale (CFS) created by the Canadian Study of Health and Aging (CSHA) (Cheung, Haas, Ringer, McFarlan, & Wong, 2017; Rockwood et al., 2005). The CSHA is a 5-year prospective cohort study of 10,263 Canadians aged 65 years and older (Rockwood et al., 2005). The CFS has demonstrated good construct validity, good predictive validity, and good reliability (Rockwood et al., 2005). The application of the CFS to elderly and aging individuals has demonstrated that increasing levels of frailty were associated with increased risk of mortality and institutionalization (Rockwood et al., 2005). However it should be noted that as the CSHA used clinical data and was based on physician assessment, it was created as a "measure of frailty based on clinical judgement" (Rockwood et al., 2005, p. 489). The present study asked MFUS members to rate their own frailty, therefore the present application of the CFS has been modified for self-report.

If a SAQ was not returned by the member, the member was excluded from analysis for that year. Responses to this question were coded as 'missing' if the SAQ was returned but this question was not answered, or if the given answer was not one of the options available (i.e. a written answer, question crossed out, or "see previous"). A questionnaire containing more than one indicated response was assigned the most severe rating (e.g. if both 4 and 5 were circled then 5 was assigned). Missing answers were excluded from analysis as indicated.

This variable was considered as the independent variable for objectives 1 and 3. This variable was also used as the independent and dependent variable for objective 2, depending upon the perspective. For example, a  $T_1/T_2$  comparison would mean that the CFS scores at  $T_1$  would be the independent variable and the CFS scores at  $T_2$  would be the dependent variable. **Marital status** was self-reported on that year's SAQ. Options included single, married/common law, widowed, and divorced/separated.
**Dependent variables.** This section describes the dependent variables included in this study.

**Time to death** was determined as date of death (or date of last contact) minus date of completion of the 2015 SAQ. It is used to determine the time under study, which is the follow up time. This variable was used as the dependent variable for objective three.

**Mental Component Score** (**MCS**) This is the higher ordered summary score yielded by the Mental Component Summary measure from the SF-36 embedded in the SAQ. Higher scores represent better reported mental health or well-being (Jansen et al., 2010). This variable was used as a dependent variable for objectives 1 and 2.

**Physical Component Score (PCS)** This is the higher ordered summary score yielded by the Physical Component Summary measure from the SF-36 embedded in the SAQ. Higher scores represent better reported physical health or well-being (Jansen et al., 2010). This variable was used as a dependent variable for objectives 1 and 2.

**Basic Activity of Daily Living (BADL):** This number is a score obtained by summing up the number of activities the participants report that they are not capable of doing without any help. The corresponding questions used to inform this score are the last 15 statements on page 5 of the SAQ. The activities are as follows: (a) going up and down the stairs, (b) getting about the house, (c) going out of door in good weather, (d) getting in and out of bed, (e) washing or bathing or grooming, (f) dressing and putting shoes on, (g) cutting your toenails, (h) eating, (i) taking medication or treatment, (j) using the toilet, (k) watching television or listening to radio, (l) reading or writing, (m) using the telephone, (n) buttoning a sweater, and (o) getting up out of a chair and walking 3 meters. As this score represents how many activities the participant cannot do, lower scores represent better functional ability. This variable was used as a dependent variable for objectives 1 and 2.

**Instrumental Activity of Daily Living (IADL):** This number is a score obtained by summing up the number of activities the participants report that they are not capable of doing without any help. The corresponding questions used to inform this score are the first 9 statements on page 5 of the SAQ. The activities are as follows: (a) doing light housework (washing up, dusting etc.), (b) doing heavy housework (cleaning floors, windows), (c) making a cup of tea or coffee, (d) preparing a hot meal, (e) shoveling and yard work, (f) shopping, (g) managing financial affairs (banking, paying bills), (h) laundry (household and personal), (i) major house or household repairs. As this score represents how many activities the participant cannot do, lower scores represent better functional ability. This variable was used as a dependent variable for objectives 1 and 2.

It should be noted that there are many ways of scoring BADLs and IADLs. One of the most well-known methods is the Katz Index of Independence in Activities of Daily Living. Commonly referred as the "Katz ADL" or the "Katz Index", this tool assesses the older adults performance across several areas of functional ability, providing objective data to form a baseline ability, so that a change in functional status may be observed (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963; Wallace & Shelkey, 2008). The assessment is made across six activities: bathing, dressing, toileting, transferring, continence, and feeding (Katz et al., 1963). Each task is scored dichotomously, with independence earning one point and dependence (full function), four indicates moderate impairment, and less than two points represents severe functional impairment (Wallace & Shelkey, 2008). Similar to this method, the SAQ sums up the dichotomous scoring to create an overall summary score. However, the SAQ's method differs in several ways. First, the activities chosen were based upon the tools available at the time of the SAQs creation (i.e. Katz

Index, Lawton Instrumental Activities of Daily Living Scale), and then edited upon the professional preferences of Professors Evelyn Shapiro and Betty Havens (originally, in 1996). The edited list of BADLs and IADLs used in the SAQ remained constant for the years considered in the present study (2015-2017). Second, page 5 of the SAQ asks the participant to indicate if they are *capable* of preforming the listed activities. Later, on page 7, the SAQ asks how much their health limits their participation in very similar activities.

#### **Data Analysis**

Data was analyzed using SAS (version 9.4) in a secure location on the University of Manitoba campus. Hypothesis testing was conducted at the  $p \le 0.05$  level of significance. Before testing the research hypotheses, descriptive statistics were conducted to describe the study cohort and variables of interest. These analyses included frequencies and percentages.

The study hypotheses were investigated following preliminary descriptive analysis. Objective 1 was addressed using ANOVA to assess the validity of using a self-rating as a measure to assess frailty. Specifically, the mean and standard deviation of the measures of health within the SAQ (MCS, PCS, IADL, and BADL) were calculated within the categories of self-rated frailty (levels 1-7). These means were then compared with ANOVA. It was expected that if self-rated frailty was a valid measure, then MFUS members with lower self-rated frailty scores would have better measures of health (higher MCS and PCS scores) and fewer limitations (lower BADL and IADL scores). This ANOVA was run for  $T_1$  (2015),  $T_2$  (2016), and  $T_3$  (2017). "Age" was also tested to see if it is significantly related to self-rated frailty.

Using ANOVA, the hypotheses were as follows:

H0: All populations share the same mean.

H1: All populations do not share the same means; or, at least 1 pair of means is not equal.

Objective 2 was addressed using binomial distribution. The self-rated frailty data from  $T_1$ ,  $T_2$ , and  $T_3$  was used for this test. If *p* is equal to the proportion of men showing improvement, the hypotheses were as follows:

H0: There are no men showing improvement; p = 0.

H1: There are men who have shown improvement; p > 0.

To test this hypothesis, a 95% confidence interval was constructed around  $\hat{p}$ , which was estimated from data collected at T<sub>1</sub>, T<sub>2</sub>, and T<sub>3</sub>. If the resulting confidence interval of  $\hat{p}$  crossed zero, sufficient evidence supporting resilience to frailty was not provided by this test. If the confidence interval did not cross zero, sufficient evidence would have been provided for resilience to frailty.

Objective 3 was addressed using the self-rated frailty score from  $T_1$  and mortality data at  $T_3$ . A Kaplan-Meier curve illustrated the survival of each grouping of the self-rated frailty scores. Cox proportional hazard modeling illustrated the contributions of self-rated frailty to mortality. Other factors included in the modeling included age, marital status, PCS, and MCS.

#### **Ethical Considerations**

Ethics approval for this thesis was received from the Health Research Ethics Board (HREB) at the University of Manitoba (HS21481 (H2018:041)). The datasets required were obtained from MFUS on a CD. The data on the CD will be destroyed after completion of the present project. The electronic databases created by this study were used and maintained only until completion for data analysis of the current research plus any articles for peer review. The data analysis was completed in the MFUS office, on a secure computer with no internet access. Card access is required to enter the MFUS office. Therefore, this study maintained the privacy

and confidentiality of the individuals whose data was reviewed in compliance with the HREBs data policies and the Personal Health Information Act (PHIA) of Manitoba.

#### Results

The three objectives of this study were 1) To assess the validity of self-rated frailty; 2) To examine the possibility of recovering from a frail state, thereby exhibiting evidence in favour of resilience to frailty; and 3) To determine whether and how self-rated frailty relates to mortality. To address these objectives, I will first describe the selection of the sample and several characteristics of interest. Then I will work through each objective before finally closing with a discussion and conclusion.

# Description of MFUS Sample

Selection of eligible MFUS members. Table 1 describes the characteristics of the men included in this study. The table shows that as of the date of the 2015 mailing, it was known that 3667 MFUS members were deceased. Among the 316 men assumed alive, 231 had current addresses and 85 were either too ill to continue with their participation or had no current address. The SAQ 2015 was mailed to 231 members. Follow-up reminders were sent in July and October, after which a response to the mailing had been received from 186 men. Of these responses, 23 returned surveys were blank. A survey response was considered a "blank" if a response was received (usually from family) indicating that the member was not well enough to complete the survey, or the post office had sent back the SAQ marked "moved" or "deceased." Of the 163 completed surveys received, 148 were filled out by the MFUS member himself without any outside assistance. Among the 148 men, 2 more were excluded because they sent back a response that was not pertinent (i.e. something other than the SAQ). Therefore, 146 men were included for this analysis at  $T_1$ . The responses to the 2016 ( $T_2$ ) and 2017 ( $T_3$ ) SAQ mailings were refined following a similar process. The final samples sizes used for analysis are 146 ( $T_1$ ), 123 (T<sub>2</sub>), 87 (T<sub>3</sub>).

#### Table 1

Category	2015	2016	2017
Known Deceased	3667	3731	3803
Alive at mailing	316	252	180
Not sent (tracing/do not contact)	85	76	56
Mailed to	231	176	124
No Response	46	27	24
Response received	186	149	100
Blank/too ill/ moved/deceased	23	16	7
Completed	163	133	93
Filled out by man himself	148	123	87
Completed by proxy	15	10	6
Exclusions	2	0	0
Final sample size	146	123	87
Response Rate (%)	80.5	84.6	80.6
Completion Rate (%)	78.4	83.1	79.5

Response to Mailing of Three Successful Aging Questionnaires (SAQ)

**Personal characteristics of participants.** Table 2 describes the personal characteristics of the eligible MFUS members included in this study. This table shows that in 2015, about half of the men were married and just less than half were widowed. These proportions remained fairly stable across the follow up time. At all three times, at least 72.4% of men rated their self-rated health to be good or very good ( $T_1=72.7\%$ ,  $T_2=72.9\%$ ,  $T_3=72.4\%$ ). While the overall distribution of proportions experienced some variability during follow up, most men rated their life satisfaction to be very good or good ( $T_1=73.9\%$ ,  $T_2=63.3\%$ ,  $T_3=71.8\%$ ). However, 19.2% men did rate their life satisfaction as fair in 2016, which is 7.9 percentage points higher than the previous year.

# Table 2

Descriptive Characteristics of Men Included in Study

Variable	2015 (n=146)	2016 (n=123)	2017 (n=87)
Mean age (s.d.)	93.0 (2.7)	93.9 (2.6)	94.6 (2.7)
Marital status (%)			
Married/common law	50.7	47.2	50.6
Widowed	45.8	52.0	46.0
Self-rated health (%)			
Excellent	14.7	10.7	14.9
Very good	33.6	36.9	36.8
Good	39.2	36.1	35.6
Fair	10.5	14.8	11.5
Poor	2.1	1.6	1.1
Life Satisfaction (%)			
Excellent	14.8	15.8	12.9
Very good	42.3	34.2	43.5
Good	31.7	29.2	28.2
Fair	11.3	19.2	15.3
Poor/Bad	0.0	1.7	0.0

*Note.* Table complete with exclusions.

As illustrated by Table 3, there was some change in the cohorts BADL responses over time. In 2015, half of the participants indicated that they had no limitations in BADL. This fell over time, to 45.9% (T<sub>2</sub>) and then to 41.4% (T<sub>3</sub>). The percentage of men who reported 1 limitation rose over time from 20.8% (T<sub>1</sub>), to 23.8% (T<sub>2</sub>), and then 35.6% (T<sub>3</sub>). Overall, those who reported 1 or more limitation in BADL rose over time (T<sub>1</sub>=50.0%, T<sub>2</sub>=54.1%, T<sub>3</sub>=58.6%). The percentage of men that reported no limitations in IADL fell over time (T<sub>1</sub>=9.0%, T<sub>2</sub>=5.0%, T<sub>3</sub>=5.8%) while those reporting limitation in one IADL remained fairly stable. The percentage of men that reported 1 or 2 limitations experienced some variability. The percentage of that men

reported 3 or 4 limitations generally rose over time ( $T_1=36.1\%$ ,  $T_2=45.4\%$ ,  $T_3=37.9\%$ ). The

percentage of men that reported 5 or more limitations in IADL increased over time ( $T_1=24.3\%$ ,

 $T_2=26.0\%, T_3=26.4\%$ ).

#### Table 3

Limitation Category	2015 (n=146)	2016 (n=123)	2017 (n=87)
Limitations in BADL (%)			
None	50.0	45.9	41.4
One	20.8	23.8	35.6
Two	16.7	9.8	12.6
Three or more	12.5	20.5	10.3
Limitations in IADL (%)			
None	9.0	5.0	5.8
One	15.3	15.1	14.9
Two	15.3	8.4	14.9
Three	19.4	31.1	21.8
Four	16.7	14.3	16.1
Five or more	24.3	26.0	26.4

Basic Activities of Daily Living (BADL) and Activities of Daily Living (IADL) Characteristics of Men Included in Study

*Note*. BADL = Basic Activities of Daily Living, IADL = Instrumental Activities of Daily Living. **Living arrangements of study participants.** Table 4 details the living arrangements of

the study participants involved in this study. This table shows that the proportion of men who lived alone remained fairly equal to the proportion of men who lived with others at all three times. If the man lived with others, it was most likely to be a spouse. If it was not a spouse, then it was likely a grown-up child/children. Most men (>53% all at three times) lived in a house/townhouse/condominium townhouse. It should be noted that it is suspected that MFUS members that have significant symptoms of dementia, live in long term care, or have other such challenges do not complete the SAQ. Therefore, the percentage of men that reported living in a

personal care home, nursing home, long-term care, or extended care facility may be lower than

expected.

Table 4

Category	2015 (n=146)	2016 (n=123)	2017 (n=87)
Living Arrangement	n (%)	n (%)	n (%)
Live alone	71 (49.0)	62 (51.7)	43 (50.0)
Live with others	74 (51.0)	58 (48.3)	43 (50.0)
Of those who live with	Yes	Yes	Yes
others			
• Spouse/partner	67 (90.5)	51 (86.4)	38 (88.4)
Grown-up child/children	13 (17.6)	7 (11.7)	7 (16.3)
• One or more other adults not mentioned above	0	4 (6.5)	0
• One or more young children	0	0	0
Type of Residence (%)			
House/townhouse/condominium	57.9	57.0	53.5
townhouse			
Suite/apartment/condominium apartment	11.0	10.7	8.1
Suite in Senior Citizens'	13.1	13.2	17.4
housing/apartment with			
minimum age restriction			
Board &	0.7	0.8	1.2
room/hostel/commercial			
boarding	0.0	11.6	10.0
Assisted living facility	9.0	11.6	12.8
Personal care or nursing home	2.1	2.5	0.0
Long-term care/extended care facility	5.5	4.1	7.0
Other	0.7	0.0	0.0

Living Arrangement and Type of Residence of Men Included in Study

#### **Objective 1**

The first objective was to assess the validity of self-rated frailty (SRF). Comparing SRF to other measures of health would demonstrate if it made logical sense to use self-rated frailty to describe health (face validity). Tables 5-7 present the results of the ANOVA. This analysis is based on the returned SAQs of 146 men at  $T_1$ , 123 returned SAQs at  $T_2$ , and 93 returned SAQs at  $T_3$ . Responses were excluded if the self-rated frailty question (or that entire page) was unanswered/blank (marked as "Group 9. Blank – Don't know"). After exclusions, the remaining sample sizes were 132 responses at  $T_1$ , 108 responses at  $T_2$ , and 81 responses at  $T_3$ . Several health measures use smaller sample sizes because of missing data (i.e. unanswered questions throughout the SAQ); these instances have been indicated as such in Tables 5-7. Furthermore, group "6. Moderately Frail" and group "7. Severely Frail" were combined during analysis for  $T_1$  and  $T_2$ . This is because there were fewer than 5 members reported in group "7. Severely Frail". There were no eligible responses returned at  $T_3$  with a SRF score of 7.

Using ANOVA, the hypotheses were as follows:

H0: All populations share the same mean.

H1: All populations do not share the same means; or, at least 1 pair of means is not equal.

Analysis of  $T_1$  (2015). The ANOVA of the 2015 data reported a significantly small pvalue for PCS, IADL, and BADL, as shown in Table 5. Therefore, we reject the null hypothesis as at least one pair of means is not equal. To determine which means differ significantly, the Tukey test was utilized post hoc on the health indicators that had a significantly small ANOVA p-value. Please see Figure 2 for Tukey comparison illustrations.

It should also be noted that the men in Group "9. Blank – Don't know" reported health indicator scores that were similar to the rest of the sample at  $T_1$ . Descriptively, the men reported age, PCS, IADL, and BADL scores that were not significantly different from the other groups.

This group had a MCS score higher than most other groups, but as we failed to reject the null hypothesis for age and MCS (as in, all groups share the same means) we do not expect there to be a significant difference between groups.

Table 5

		, ,	SF-36 Functioning Score			
Self-rated Frailty Score	n (%)	Age (%) (n=132)	MCS (%) (n=114)	PCS (%) (n=114)	IADL (%) (n=131)	BADL (%) (n=131)
1. Very Fit	8 (5.5)	91.9 (4.2)	57.2 (7.6)	48.6 (8.6)	1.4 (2.2)	0.1 (0.4)
2. Well, with no disease	33 (22.6)	92.6 (2.2)	55.6 (7.9)	41.5 (8.2)	2.6 (2.0)	0.8 (1.8)
3. Well, with treated disease	33 (22.6)	93.4 (2.7)	58.3 (6.0)	37.7 (9.5)	2.9 (2.3)	1.1 (2.1)
4. Apparently vulnerable, "slowed up"	33 (22.6)	93.0 (2.6)	54.1 (7.8)	32.8 (8.7)	3.8 (2.0)	1.0 (1.0)
5. Mildly Frail	13 (8.9)	92.7 (2.1)	53.4 (8.6)	34.3 (5.9)	3.8 (1.9)	1.6 (2.3)
6 & 7. Moderately –Severely Frail	12 (8.2)	94.3 (4.0)	53.05 (8.4)	25.7 (8.4)	6.3 (2.7)	3.7 (3.7)
Blank – Don't know	14 (9.6)	93.1 (2.4)	56.4 (12.4)	30.7 (9.0)	3.5 (2.5)	1.8 (2.3)
ANOVA – p-value	` '	0.38	0.22	<.0001*	<.0001*	0.0005*

# Self-rated Frailty Scores vs. Measures of Functional Status (2015)

*Notes.* MCS=Mental Component Score, PCS=Physical Component Score, IADL=Instrumental Activities of Daily Living score, BADL=Basic Activities of Daily Living score. \*p≤0.05

Figure 2 illustrates the Tukey illustrations for the significant p-values at Time 1. These comparisons illustrate which group means differ by underlining the mean scores that do not differ. For example, the PCS mean of group 1 is significantly different from groups 3, 4, 5, and 6&7. The PCS mean of Group 1, however, is not significantly different from the PCS mean of group 2 is significantly different from the PCS means of group 4 and 6&7. However the PCS mean of group 2 is not significantly different from the PCS means of group 4 and 6&7. However the PCS mean of group 2 is not significantly different from the PCS means of groups 1, 3, or 5. The PCS mean of Group 3 is significantly different from the PCS means of group 1 and 6&7. The IADL mean of group 6&7 is significantly different from all other groups. The BADL group mean of 6&7 is significantly different from groups 1, 2, 3, & 4.

PCS

1 v. 3, 4, 5, 6/ 2 v. 4, 6/7 3 v. 1, 6/7	7					
Mean	48.6	41.5	37.7	34.3	32.8	25.7
SRF Group	1	2	3	5	4	6/7
IADL $\frac{6}{7}$ v. 1, 2, 3,	, 4, 5					
Mean	6.3	3.8	3.8	2.9	2.6	1.4
SRF Group	6/7	4	5	3	2	1
BADL $\frac{6}{7}$ v. 1, 2, 3,	, 4					
Mean	3.7	1.6	1.1	1.0	0.8	0.1
SRF Group	6/7	5	3	4	2	1

Figure 2. Tukey test results for T1 (2015). This figure illustrates the Tukey tests results for mean variable comparisons at T1.

Analysis of  $T_2$  (2016). The ANOVA of the 2016 data reported a significantly small pvalue for PCS, IADL, and BADL, as shown in Table 6. Therefore, we reject the null hypothesis as at least one pair of means is not equal. To determine which means differ significantly, the Tukey test was utilized post hoc on the health indicators that had a significantly small ANOVA p-value. Please see Figure 3 for Tukey comparison illustrations.

It should also be noted that the men in Group "9. Blank – Don't know" reported health indicator scores that were similar to the rest of the sample at  $T_2$ . Descriptively, the men reported age, PCS, IADL, and BADL scores that were not significantly different than the other groups. This group had a MCS score higher than most other groups, but as we failed to reject the null hypothesis for age and MCS (as in, all groups share the same means) we do not expect there to be a significant difference between groups.

Table 6

			SF-36 Functioning Score			
Self-rated Frailty Score	n (%)	Age (%) (n=108)	MCS (%) (n=92)	PCS (%) (n=92)	IADL (%) (n=104)	BADL (%) (n=107)
1. Very Fit	8 (6.5)	92.7 (4.0)	55.0 (15.7)	46.5 (7.6)	1.5 (1.1)	0.5 (0.8)
2. Well, with no disease	22 (17.9)	93.5 (2.8)	54.8 (9.1)	41.1 (9.0)	3.0 (2.3)	1.0 (1.7)
3. Well, with treated disease	22 (17.9)	93.8 (2.4)	53.9 (8.3)	36.5 (8.7)	2.6 (1.7)	0.4 (1.0)
4. Apparently vulnerable, "slowed up"	31 (25.2)	94.1 (2.5)	51.4 (10.8)	31.3 (9.3)	3.8 (2.0)	1.5 (1.7)
5. Mildly Frail	13 (10.6)	93.2 (2.9)	50.8 (9.1)	30.1 (5.5)	4.7 (2.0)	2.1 (3.2)
6 & 7. Moderately –Severely Frail	12 (9.8)	94.6 (2.5)	51.9 (10.4)	26.9 (4.1)	6.3 (2.8)	4.0 (3.5)
9. Blank – Don't know	15 (12.2)	94.7 (2.0)	57.2 (3.2)	35.0 (10.0)	3.5 (2.1)	1.5 (2.2)
ANOVA – p-value	. ,	0.59	0.81	< 0.0001*	< 0.0001*	0.0001*

Self-rated Frailty Scores vs. Measures of Functional Status (2016)

*Notes.* MCS=Mental Component Score, PCS=Physical Component Score, IADL=Instrumental Activities of Daily Living score, BADL=Basic Activities of Daily Living score.  $*p \le 0.05$ 

Figure 3 illustrates the Tukey illustrations for the significant p-values at  $T_2$ . This figure shows that at  $T_2$ , the PCS group means of groups 1 and 2 are both significant different from group 4, 5, 6&7, but not from each other. The mean PCS score of Group 3 is significantly different from only the mean PCS score of group 6&7. The mean IADL scores of group 6&7 is significantly different from the mean IADL scores of 1-4. The mean IADL scores of Group 5 is significantly different from groups 1 and 3. The mean BADL scores of group 6/7 is significantly different from only the BADL group means of groups 1-4.

PCS

1 v. 4, 5, 6/7 2 v. 4, 5, 6/7 3 v. 6/7 36.5 Mean 46.5 41.1 31.3 30.1 26.9 SRF Group 1 2 3 4 5 6/7 IADL  $\frac{6}{7}$  v. 1, 2, 3, 4 5 v. 1, 3 6.3 Mean 4.7 3.8 3.0 2.6 1.5 SRF Group 6/7 5 4 2 3 1 BADL  $\frac{6}{7}$  v. 1, 2, 3, 4 Mean 4.0 2.1 1.5 1.0 0.5 0.4 5 SRF Group 6/7 4 2 1 3

Figure 3. Tukey test results for T2 (2016). This figure illustrates the Tukey tests results for mean variable comparisons at T1.

Analysis of  $T_3$  (2017). The ANOVA of the 2017 data reported a significantly small pvalue for MCS and PCS, as shown in Table 7. Therefore, we reject the null hypothesis as at least one pair of means is not equal. To determine which means differ significantly, the Tukey test was utilized post hoc on the health indicators that had a significantly small ANOVA p-value. Please see Figure 4 for Tukey comparison illustrations.

It should also be noted that the men in the 9. Blank – Don't know category reported health indicator scores that were similar to the rest of the sample at  $T_3$ . Descriptively, the men reported age, PCS, IADL, and BADL scores that were not significantly different from the other groups. MCS score were higher than most other groups, but as it was equivalent to the mean of group 4, we do not expect there to be a significant difference between these men and the rest of the groups.

Table 7

# Self-rated Frailty Scores vs. Measures of Functional Status (2017)

			SF-36 Functioning Score			
Self-rated Frailty Score	n (%)	Age (n= 81)	MCS (n= 74)	PCS (n= 74)	IADL $(n=81)$	BADL $(n=81)$
1. Very Fit	9 (10.3)	94.3 (2.9)	57.5 (5.7)	46.5 (10.5)	2.9 (2.4)	0.9 (1.3)
2. Well, with no disease	21 (24.1)	94.2 (2.8)	57.9 (5.8)	39.2 (12.0)	3.3 (2.5)	1.5 (3.3)
3. Well, with treated disease	20 (23.0)	94.3 (2.1)	56.8 (5.4)	36.1 (9.2)	2.8 (1.9)	1.2 (2.1)
4. Apparently vulnerable, "slowed up"	13 (14.9)	94.8 (2.3)	49.6 (10.0)	30.8 (9.6)	4.2 (2.1)	2.1 (2.8)
5. Mildly Frail	8 (9.2)	94.5 (2.8)	48.4 (10.7)	34.3 (7.2)	4.4 (2.2)	1.3 (1.2)
6. Moderately Frail	10 (11.5)	96.0 (3.0)	47.6 (11.5)	26.5 (5.6)	4.4 (2.3)	2.0 (2.5)
9. Blank – Don't know	6 (6.9)	94.4 (4.6)	49.6 (6.6)	35.3 (4.0)	2.7 (1.5)	0.3 (0.5)
ANOVA – p-value		0.60	0.0017*	0.0009*	0.25	0.84

*Notes.* MCS=Mental Component Score, PCS=Physical Component Score, IADL=Instrumental Activities of Daily Living score, BADL=Basic Activities of Daily Living score.  $*p \le 0.05$ 

Figure 4 illustrates the Tukey illustrations for the significant p-values at  $T_3$ . This figure shows that the MCS means of groups 2 and 3 were both significantly different than the group mean of group 6. The PCS means of groups 1 and 2 were both significantly different than the group mean of group 6. Group 1's mean was also significantly different from group 4's PCS mean.

It should be noted that the group means for variable MCS are not quite in order; group 1 and 3 have had their placement switched. This is because the sample sizes of groups 2 (n=21) and 3 (n=20) are twice as large as group 6 (n=10), which has implications for spread and variance. Therefore their placements were switched to maintain congruity with the Tukey illustrations.

48.4

30.8

4

5

47.6

26.5

6

6

MCS 2 vs. 6 3 vs. 6 Mean 57.9 56.8 57.5 49.6 SRF Group 3 1 4 2 PCS 1 vs. 4, 6 2 vs. 6 46.5 36.1 Mean 39.2 34.3 3 SRF Group 1 2 5

Figure 4. Tukey test results for T3 (2017). This figure illustrates the Tukey tests results for mean variable comparisons at T1.

### **Objective One Section Conclusion**

Upon consideration of the test results for objective one, several conclusions became apparent. In general, Figure 2 illustrates that higher ratings of frailty correspond with worse measures of health. For example, PCS was scored in such a way that a lower score indicates worse health. Therefore at T<sub>1</sub>, SRF group "1. Very Fit" had the highest mean PCS score at 48.6 while group "6&7. Moderately-Severely Frail" had the lowest mean PCS score at 25.7. Group 1 and group 2 mean PCS scores did not significantly differ from each other, but both were significantly different from the mean scores of groups 4 and 6&7, which had the lowest group mean scores (at 32.8 and 25.7, respectively). In this sense, the least frail men had reported significantly better physical health (had significantly higher mean PCS scores) than the most frail men (group "6&7. Moderately-Severely Frail"). Furthermore, the mean PCS scores of group 1 had a significant different mean from groups 3 and 5. This illustrated that the least frail group had reported significantly better physical health than men who had reported that they were "3. Well, with treated disease" or "5. Mildly frail". Additionally, the mean PCS score of group 3 were significantly different from the most frail and least frail men. In this sense, a gradient of physical health has been described: the least frail men had reported the best physical health and the most frail men had reported the worse physical health. Additionally, the men who reported a SRF in the middle of the scale had reported significantly worse physical health than the least frail but had reported better physical health than the most frail.

While the results of the other analyses at  $T_1$  were less clear than the PCS Tukey results, the results indicated that self-ratings of increased frailty correspond with increased limitations. Variables IADL and BADL were scored in such a way that a lower score indicated fewer limitations. Therefore group "1. Very Fit" had the least limitations at a group IADL mean of 1.4 and group "6&7. Moderately-Severely Frail" had significantly more IADL limitations than all

other groups (mean of 6.3). The IADL means of groups 1-5 did not significantly differ from each other. A similar conclusion can be drawn from the BADL T<sub>1</sub> Tukey test results. These results showed that while group 6&7 had significantly more BADL limitations than groups 1 through 4, the BADL mean of group 6&7 did not significantly differ from group 5. Also, the mean BADL scores of groups 1-4 did not differ significantly from each other. Therefore it can only be concluded that the most frail men (group "6&7. Moderately-Severely Frail") have reported significantly more limitations in their BADL and IADL activities than all other SRF groups, except the participants did not significantly differ from the number of BADL limitations reported by men in group "5. Mildly frail".

Figure 3 illustrated that at  $T_2$ , the PCS group means of groups 1 and 2 were both significant different from groups 4, 5, 6&7. Therefore, the least frail men reported significantly better physical health than the most frail men. Additionally, group 3 ("Well, with treated disease") reported significantly better physical health than group 6&7 (Moderately-Severely frail), but did not significantly differ from any other group. At  $T_1$ , group 3 had also reported significantly worse physical health than the least frail groups. Therefore while the most frail have reported worse physical health than the least frail, the gradient of physical health seen at  $T_2$  was not as clear as at  $T_1$ .

In general, the results of Figure 3 indicated that the mean IADL scores at  $T_2$  reported by the most limited men (group 6&7) differed from the means of groups 1-4, but not from the mean reported by group 5. Group 5 reported significantly more limitations than the least frail groups (1 and 3). As the results indicated, the IADL means of groups 1-4 were not significantly different from each other. Therefore, it could be concluded that the least frail reported fewer limitations than the most frail, but the evidence did not support that the men in groups 1-4 reported

significantly different number of limitations. Therefore while the least frail reported fewer limitations in their IADL activities than the most frail, a gradual increase in limitations as frailty increased was not observed.

The conclusions drawn from the BADL Tukey results of  $T_2$  were similar to the interpretation of BADL results at  $T_1$ . These results showed that while group 6&7 has reported significantly more BADL limitations than groups 1 through 4, the BADL mean of group 6&7 did not significantly differ from the mean of group 5. Also, the means of groups 1-4 did not differ significantly from each other. Therefore, conclusions could only state that the men who rated themselves as mildly, moderately, or severely frail (groups 5 and 6&7) reported significantly more limitations in their BADL activities than all other groups. Thus it could only be concluded that the most frail men (group "6&7. Moderately-Severely Frail") have reported significantly more limitations in their BADL and IADL activities than groups 1-4, as the participants did not significantly differ from the number of limitations reported by men in group "5. Mildly frail".

 $T_3$  (2017) presented slightly different results than the other time points, as it was the only time mean MCS scores were significantly different. Also, an adjustment had to be made while displaying the Tukey test results. The sample sizes of SRF Groups 2 (n=21) and 3 (n=20) were twice as large as group 6 (n=10), which had implications for spread and variance. The results of the Tukey test revealed that group 6 had reported significantly worse mental health than the MCS scores reported by groups 2 and 3. However, no other significant differences were reported. The mean PCS scores revealed that group 6 reported significantly worse physical health than the means of groups 1 and 2. Group 1 also reported significantly better physical health than group 4. Therefore, it could be concluded group "6. Moderately frail" reported significantly worse physical health than those of the least frail groups. It could further be

concluded that at  $T_3$ , the least frail men had reported better mental and physical health than the most frail men (group "6. Moderately frail"), but there was no evidence to distinguish the differences in health between increasing levels of frailty.

With these results, I conclude that the analyses show that increased ratings of SRF scores generally correspond with worse health and increased limitations as measured by other accepted measures of health (PCS, IADL, BADL). As illustrated most clearly by the analyses results at  $T_1$  and  $T_2$ , it makes logical sense to use SRF to describe health. Therefore there is significant evidence to support that SRF meets the criteria for face validity. Additionally, the analyses results at  $T_1$ ,  $T_2$ , and  $T_3$  have illustrated that PCS mean scores significantly decreased as SRF increased. Therefore, there is significant evidence to support that SRF fulfills the criteria for concurrent validity.

#### **Objective 2**

The second objective was to examine the possibility of recovering from a frail state, thereby exhibiting evidence in favour of resilience to frailty. For this study, resilience to frailty was considered as improvement in the SRF rating as compared to the score response from the previous time point. For example, if a man returned a SRF of "3. Well, with treated disease" at  $T_1$  and then returned a SRF of "2. Well, with no disease" at  $T_2$ , it was considered that the participant had shown resilience to frailty for the  $T_2/T_1$  time comparison.

Objective 2 was addressed using binomial distribution. The self-rated frailty data from  $T_1$ ,  $T_2$ , and  $T_3$  was used for this test. If is *p* equal to the proportion of men showing improvement, the hypotheses were as follows:

H0: There are no men showing improvement; p = 0.

H1: There are men who have shown improvement; p = 0.

To test this hypothesis, a 95% confidence interval was constructed around  $\hat{p}$ , which was estimated from data collected at T<sub>1</sub>, T<sub>2</sub>, and T<sub>3</sub>. If the resulting confidence interval of  $\hat{p}$  crossed zero, sufficient evidence supporting resilience to SRF was not provided by this test. If the confidence interval did not cross zero, sufficient evidence was provided for resilience to SRF. Resilience to SRF can be assessed retrospectively and prospectively. The prospective analysis of resilience to frailty is concerned with looking forward, and is similar to the concept of incidence. It provides a perspective of what we might expect to see, based on current data. The retrospective analysis presents what was seen according to the data and is similar to the concept of prevalence. We will start with the retrospective analysis.

#### **Retrospective analysis of frailty**

*Sample details.* Table 8 illustrates the details of the sample size of 2016/2015 retrospective comparison. Tables 8 and 9 illustrates the following process of exclusion. The analysis

comparing 2016/2015 data was run based on the return of 152 SAQs. Of these 152, 6 men did not return a 2015 SAQ but did return a 2016 SAQ. 29 returned a 2015 SAQ but did not return a 2016 SAQ. In total, 117 men returned both a 2015 SAQ and a 2016 SAQ.

## Table 8

Successful Aging Questionnaire (SAQ) Response Counts for T1 (2015) vs. T2 (2016)

2015	Y	Ν	Total
Y	117	29	146
Ν	6	-	6
Total	123	29	152

*Note.* Y=Returned a Successful Aging Questionnaire for that year. N=Did not return a Successful Aging Questionnaire for that year.

#### Table 9

SRF	SRF Scores (2016)									
Scores										
(2015)	NR	1	2	3	4	5	6	7	Invali	d Total
NR	0	0	1	0	0	2	1	0	1	5
1	2	2	1	1	2	0	0	0	0	8
2	4	1	13	3	6	0	0	0	6	33
3	5	3	2	9	6	3	0	1	4	33
4	7	0	2	5	10	1	4	1	3	33
5	1	0	0	3	3	5	0	1	0	13
6	6	0	0	0	2	1	1	0	0	10
7	2	0	0	0	0	0	0	0	0	2
Invalid	2	2	3	0	2	1	3	0	1	14
Total	29	8	22	21	31	13	9	3	15	152

All Self-rated Frailty (SRF) Responses for T1 (2015) vs. T2 (2016) Comparison

*Notes*. NR=Did not return a survey, Invalid=Survey returned without a valid Self-rated frailty score, SRF = Self-rated frailty.

However, not all 117 responses were eligible to be used for evidence for retrospective resilience. Some SAQs were returned without a useable response to the SRF question that can be used to assess evidence for resiliency. This is illustrated by the "Invalid" row and column of

Table 9. Therefore these responses were removed from consideration, as illustrated by Figure 10. After exclusions, the SRF responses of 92 men were eligible to be used for evidence for resilience for  $T_2/T_1$ .

Table 10

2015	Eligible 2016 Responses to SRF							
Responses	1	2	3	4	5	6	7	Total
1	2	1	1	2	0	0	0	6
2	1	13	3	6	0	0	0	23
3	3	2	9	6	3	0	1	24
4	0	2	5	10	1	4	1	23
5	0	0	3	3	5	0	1	12
6	0	0	0	2	1	1	0	4
7	0	0	0	0	0	0	0	0
Total	6	18	21	29	10	5	3	92

Eligible Responses for T1 (2015) vs. T2 (2016) Comparison

*Note*. SRF = Self-rated frailty

Table 11 illustrates the details of the sample size of 2017/2016 retrospective comparison. Tables 11 and 12 illustrates the following process of exclusion. This analysis comparing 2017/2016 data was run based on the return of 124 SAQs. Of these 124, 1 man did not return a 2016 SAQ but did return a 2017 SAQ. 37 returned a 2016 SAQ but did not return a 2017 SAQ. In total, 86 men returned both a 2016 SAQ and a 2017 SAQ.

Table 11

Successful Aging Questionnaire (SAQ) Response Counts for T2 (2016) vs. T3 (2017)

	201		
2016	Y	Ν	Total
Y	86	37	123
Ν	1	-	1
Total	87	37	124

*Note*. Y=Returned a Successful Aging Questionnaire for that year. N=Did not return a Successful Aging Questionnaire for that year.

## Table 12

SRF	SRF Scores (2017)								
Scores									
(2016)	NR	1	2	3	4	5	6	Invalid	Total
NR	0	0	1	0	0	0	0	0	1
1	1	3	1	1	0	1	1	0	8
2	3	2	11	1	1	1	2	1	22
3	7	0	3	8	1	0	1	2	22
4	10	3	1	6	6	1	3	1	31
5	4	0	1	1	3	2	1	1	13
6	6	0	0	0	0	2	1	0	9
7	2	0	0	0	0	0	1	0	3
Invalid	4	1	3	3	2	1	0	1	15
Total	37	9	21	20	13	8	10	6	124

All Self-rated Frailty (SRF) Responses for T2 (2016) vs. T3 (2017) Comparison

*Notes*. NR=Did not return a survey, Invalid=Survey returned without a valid Self-rated frailty score, SRF = Self-rated frailty.

However, not all 86 responses were eligible to be used for evidence for retrospective resilience. Some SAQs were returned without a useable response to the SRF question that can be used to assess evidence for resiliency, as illustrated by the "Invalid" row and column in Table 12. Therefore these responses were removed from consideration, as illustrated by Table 13. After exclusions, the SRF responses of 70 men were eligible to be used for evidence for resilience for  $T_3/T_2$ .

## Table 13

2016	Eligible 2017 Responses to SRF							
Responses	1	2	3	4	5	6	Total	
1	3	1	1	0	1	1	7	
2	2	11	1	1	1	2	18	
3	0	3	8	1	0	1	13	
4	3	1	6	6	1	3	20	
5	0	1	1	3	2	1	8	
6	0	0	0	0	2	1	3	
7	0	0	0	0	0	1	1	
Total	8	17	17	11	7	10	70	
Note SDE - Solf noted froilty								

Eligible Responses for T2 (2016) vs T3 (2017) Comparison

*Note*. SRF = Self-rated frailty

Table 14 illustrates the details of the sample size of 2017/2015 retrospective comparison. Tables 14 and 15 illustrates the following process of exclusion. This analysis comparing 2017/2015 data was run based on the return of 149 SAQs. Of these 149, 3 men did not return a 2015 SAQ but did return a 2017 SAQ. 62 returned a 2015 SAQ but did not return a 2017 SAQ. In total, 84 men returned both a 2015 SAQ and a 2017 SAQ.

Table 14

Successful Aging Questionnaire (SAQ) Response Counts for T1 (2015) vs. T3 (2017)

	201		
2015	Y	Ν	Total
Y	84	62	146
Ν	3	-	3
Total	87	62	149

*Note.* Y=Returned a Successful Aging Questionnaire for that year. N=Did not return a Successful Aging Questionnaire for that year.

## Table 15

SRF				SRF Sc	cores (20	<u>17)</u>			
Scores									
(2015)	NR	1	2	3	4	5	6	Invalid	Total
NR	0	1	2	0	0	0	0	0	3
1	2	3	3	0	0	0	0	0	8
2	8	2	9	7	1	1	2	3	33
3	12	1	2	9	4	2	2	1	33
4	15	2	2	2	6	3	2	1	33
5	8	0	0	2	0	1	1	1	13
6	8	0	0	0	1	0	1	0	10
7	2	0	0	0	0	0	0	0	2
Invalid	7	0	3	0	1	1	2	0	14
Total	62	9	21	20	13	8	10	6	149

All Self-rated Frailty (SRF) Responses for T1 (2015) vs. T3 (2017) Comparison

*Notes*. NR=Did not return a survey, Invalid=Survey returned without a valid Self-rated frailty score, SRF = Self-rated frailty.

However, not all 149 responses were eligible to be used for evidence for retrospective resilience. Some SAQs were returned without a useable response to the SRF question that can be used to assess evidence for resiliency, as illustrated by the "Invalid" row and column of Table 15. Therefore these responses were removed from consideration, as illustrated by Table 16. After exclusions, the SRF responses of 71 men were eligible to be used for evidence for retrospective resilience for  $T_3/T_1$ .

#### Table 16

2015	Eligible 2017 Responses to SRF						
Responses	1	2	3	4	5	6	Total
1	3	3	0	0	0	0	6
2	2	9	7	1	1	2	22
3	1	2	9	4	2	2	20
4	2	2	2	6	3	2	17
5	0	0	2	0	1	1	4
6	0	0	0	1	0	1	2
7	0	0	0	0	0	0	0
Total	8	16	20	12	7	8	71

Eligible Responses for T1 (2015) vs T3 (2017) Comparison

*Note*. SRF = Self-rated frailty

*Determining evidence for resiliency.* The frailty rating provided asks participants to rate their frailty on a 7-point scale (please see Appendix 1, p. 116 for a copy of the question). The ceiling and floor effects of this scale constrained the participant's opportunity to improve or decline. Participants who self-rated their frailty as a 1 at the base time did not have the opportunity to report improvement, as "1" is the upper limit of the frailty scale (i.e. ceiling effect). Similarly, participants who self-rated their frailty as a 7 at base time did not have the opportunity to report declination, as "7" is the lower limit of the frailty scale (i.e. floor effect). Therefore the upper and lower constraints of the scale affected the calculation of the proportions of who got better or got worse.

For example, 6 members rated themselves as a "1" in 2015 and returned a 2016 SAQ with a self-rating of frailty. These 6 participants had the opportunity to stay the same or become worse, but did not have a chance to improve as there is no room on the scale to improve from a SRF score of "1". As such, these 6 men were removed from calculation. Similarly, those who rated themselves as a "7" in 2015 and returned a 2016 SAQ with a self-rating of frailty had the

opportunity to improve or remain the same, but not to worsen. However there were no members in this category, so no additional men were removed from calculation. Similar calculations were used to determine the denominator for 2017/16 and 2017/15 data, please see Tables 17-19 for details.

Tables 17-19 present the number of men who got better, stayed the same, and got worse, by level of self-rated frailty. Sample calculations for the 95% CI are as follows:

 $\hat{p} = x/n$ 

Better = 22/(92-6) = 0.2558 Same = 40/92 = 0.4348 Worse = 30/(92-0) = 0.3261

Better Calculations:

$$SE = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} = \sqrt{\frac{0.26(1-0.26)}{86}}$$
$$= 0.0470 * 1.96 = 0.0922$$
$$95\% \text{ CI} = (0.26 - 0.09, 0.26 + 0.09)$$
$$(0.16, 0.35)$$

Figure 5. Calculation of retrospective Self-rated Frailty (SRF) for T2/T1 comparison. This figure provides sample calculations used to determine retrospective self-rated frailty.

Bin<sub>(86,22)</sub>,  $\hat{p} = 0.26$  (0.16, 0.35). The 95% CI did not cross zero; there is significant evidence in support of retrospective resilience. Therefore we reject the null hypothesis that there is no evidence for retrospective resilience to frailty for the T<sub>2</sub>/T<sub>1</sub> comparison.

Tables 17-19 show that none of the 95% CI crossed zero. Therefore it can be concluded that there is significant evidence in support of retrospective resilience. Therefore we reject the null hypothesis that there is no evidence for resilience to frailty.

#### Table 17

		SRF 2016		-
SRF 2015	Better	Same	Worse	_
1	-	2	4	
2	1	12	0	

Retrospective Self-rated Frailty (SRF) T1 (2015) vs. T2 (2016)

				_
SRF 2015	Better	Same	Worse	Denominator
1	-	2	4	6
2	1	13	9	23
3	5	9	10	24
4	7	10	6	23
5	6	5	1	12
6	3	1	0	4
7	0	0	-	0
Total (n)	22	40	30	92
Proportion	0.26	0.43	0.33	-
95% CI	(0.16, 0.35)	(0.33, 0.54)	(0.23, 0.42)	-
Matage CDE - Calf				

*Notes:* SRF = Self-rated Frailty

#### Table 18

Retrospective Self-rated Frailty (SRF) T2 (2016) vs. T3 (2017)

		SRF 2017		
SRF 2016	Better	Same	Worse	Denominator
1	-	3	4	7
2	2	11	5	18
3	3	8	2	13
4	10	6	4	20
5	5	2	1	8
6	2	1	0	3
7	1	0	-	1
Total (n)	23	31	16	70
Proportion	0.37	0.44	0.23	-
95% CI	(0.25, 0.48)	(0.33, 0.56)	(0.13, 0.33)	-

*Notes:* SRF = Self-rated Frailty

## Table 19

		SRF 2017		
SRF 2015	Better	Same	Worse	Denominator
1	-	3	3	6
2	2	9	11	22
3	3	9	8	20
4	6	6	5	17
5	2	1	1	4
6	1	1	0	2
7	0	0	-	0
Total	14	29	28	71
Proportion	0.22	0.41	0.39	-
95% CI	(0.12, 0.32)	(0.29, 0.52)	(0.28, 0.51)	-
95% CI	(0.12, 0.32)	(0.29, 0.52)	(0.28, 0.51)	-

Retrospective Self-rated Frailty (SRF) T1 (2015) vs. T3 (2017)

*Notes:* SRF = Self-rated Frailty

Table 20 summarizes the retrospective changes in SRF across all three time points.

#### Table 20

Retrospective Resilience to Self-rated Frailty (SRF)

Timeframe	Base year	Both	Better	Same	Worse	Unknown
2016→2015	123	92	22	40	30	6
2017→2015	87	71	14	29	28	3
2017→2016	87	70	23	31	16	1

*Notes*. Base year = number of SRF scores at base year time point. Both = number of surveys with valid SRF at both times. Unknown = Number of men who did not return a survey at the first chronological year, but did return a survey at the baseline year. As they did not return a survey at both years we cannot asses for resilience.

#### **Prospective analysis of frailty**

*Sample details*. Let us now analyze SRF prospectively. Table 8 illustrates the details of the sample size of 2015/2016 prospective comparison. Table 9 illustrates the following process of exclusion. The analysis comparing 2015/2016 data was run based on the return of 152 SAQs. Of these 152, 146 men returned a 2015 SAQ. However, 14 men returned a survey in 2015 without a valid SRF, as illustrated by the 2015 "Invalid" row in Table 9. This leaves us with 132 eligible

surveys from 2015. As illustrated by Table 9, 27 men had not returned a questionnaire in 2016, but had returned a survey with a valid SRF in 2015. This is calculated by summing the number of surveys that had a valid SRF in 2015 (a SRF score ranging 1-7) but did not return a survey in 2016 (sum of NR 2016 column of rows of SRF scores 1-7 in 2015). As also illustrated by Table 9, 13 questionnaires were returned in 2016 without a valid SRF, but were returned with a valid SRF in 2015. This is calculated by summing the number of surveys that had a valid SRF returned in 2016, but were returned without a valid SRF in 2016 (sum of the rows of 2015 SRF scores ranging 1-7 in 2016 "Invalid" column).

Numbers for the other two time comparisons are calculated similarly. Table 11 illustrates the details of the sample size of 2016/2017 prospective comparison. Table 12 illustrates the following process of exclusion. The analysis comparing 2016/2017 data was run based on the return of 124 SAQs. Of these 124, 123 men returned a 2016 SAQ. However, 15 men returned a survey in 2016 without a valid SRF, as illustrated by the 2016 "Invalid" row in Table 12. This leaves us with 108 eligible surveys from 2016. As illustrated by Table 12, 33 men had not returned a questionnaire in 2017, but had returned a survey with a valid SRF in 2016. This is calculated by summing the number of surveys that had a valid SRF in 2016). As also illustrated by Table 12, 5 questionnaires were returned in 2017 without a valid SRF, but were returned with a valid SRF in 2016. This is calculated by summing the number of surveys that had a valid SRF in 2016. This is calculated by summing the number of surveys that had a valid SRF, but were returned with a valid SRF in 2016. This is calculated by summing the number of surveys that had a valid SRF, but were returned with a valid SRF in 2016. This is calculated by summing the number of surveys that had a valid SRF in 2016. This is calculated by summing the number of surveys that had a valid SRF in 2016. This is calculated by summing the number of surveys that had a valid SRF in 2016. This is calculated by summing the number of surveys that had a valid SRF returned in 2016, but were returned without a valid SRF in 2017 (sum of 2017 "Invalid" column of rows of SRF 1-7 in 2016).

Table 14 illustrates the details of the sample size of 2015/2017 prospective comparison. Table 15 illustrates the following process of exclusion. The analysis comparing 2015/2017 data

was run based on the return of 149 SAQs. Of these 149, 146 men returned a 2015 SAQ. However 14 men returned a survey in 2015 without a valid SRF, as illustrated by the 2015 "Invalid" row in Table 15. This leaves us with 132 eligible surveys from 2015. 55 men had not returned a questionnaire in 2017, but had returned a survey with a valid SRF in 2015. This is calculated by summing the number of surveys that had a valid SRF in 2015 but did not return a survey in 2017 (sum of NR 2017 column of rows of SRF scores1-7 in 2015). As also illustrated by Table 15, 6 questionnaires were returned in 2017 without a valid SRF, but were returned with a valid SRF in 2015. This is calculated by summing the number of surveys that had a valid SRF returned in 2015, but were returned without a valid SRF in 2015 (sum of 2017 "Invalid" column of rows of SRF 1-7 in 2015).

*Determining evidence for prospective resiliency*. Resiliency was assessed using a similar method as it was for retrospective resiliency. However, the denominator was changed to reflect the change in perspective. Tables 21-23 present the number of men who got better, stayed the same, and got worse, by level of self-rated frailty. Sample calculations for the 95% CI are as follows:
Better = 22/(132-6) = 0.1746Same = 40/132 = 0.3030Worse = 30/(132-0) = 0.2273Better Calculations:

$$SE = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} = \sqrt{\frac{0.17(1-0.17)}{126}}$$
$$= 0.0338 * 1.96 = 0.0663$$
$$95\% \text{ CI} = (0.17 - 0.07, 0.17 + 0.07)$$
$$(0.11, 0.24)$$

Figure 6. Calculation of prospective Self-rated Frailty (SRF) for T2/T1 comparison. This figure provides sample calculations used to determine prospective self-rated frailty.

Bin<sub>(132,22)</sub>,  $\hat{p} = 0.17$  (0.11, 0.24). The 95% CI did not cross zero; there is significant evidence in support of resilience. Therefore we reject the null hypothesis that there is no evidence for resilience to frailty.

Tables 21-23 show that none of the 95% CI crossed zero. Therefore it can be concluded that there is significant evidence in support of prospective resilience. Therefore we reject the null hypothesis that there is no evidence for resilience to frailty.

### Table 21

		SRF 2016				
					No SRF	
				Dead or	at end	
SRF 2015	Better	Same	Worse	in LTC	time	Denominator
1	-	2	4	2	0	6
2	1	13	9	4	6	23
3	5	9	10	5	4	24
4	7	10	6	7	6	23
5	6	5	1	1	0	12
6	3	1	0	6	0	4
7	0	0	-	2	0	0
Total (n)	22	40	30	27	13	132
Proportion	0.17	0.30	0.23	0.20	0.10	-
95% CI	(0.11, 0.24)	(0.22, 0.38)	(0.16, 0.30)	-	-	-

Prospective Self-rated Frailty (SRF) T1 (2015) vs. T2 (2016)

*Notes.* SRF= Self-rated Frailty. Better = men who got better between time periods. Same = men who reported the same SRF score at both times. Worse = Men who reported a worse SRF score between time periods. No SRF at end time = SRF score not reported at end time.

#### Table 22

Prospective Self-rated Frailty (SRF) T2 (2016) vs. T3 (2017)

		SRF 2017				
				-	No SRF	
				Dead or	at end	
SRF 2016	Better	Same	Worse	in LTC	time	Denominator
1	-	3	4	1	0	7
2	2	11	5	3	1	18
3	3	8	2	7	2	13
4	10	6	4	10	1	20
5	5	2	1	4	1	8
6	2	1	0	6	0	3
7	1	0	-	2	0	1
Total (n)	23	31	16	33	5	108
Proportion	0.23	0.29	0.15	0.31	0.05	-
95% CI	(0.15, 0.31)	(0.20, 0.37)	(0.12, 0.18)	-	-	-

*Notes.* SRF= Self-rated Frailty. Better = men who got better between time periods. Same = men who reported the same SRF score at both times. Worse = Men who reported a worse SRF score between time periods. No SRF at end time = SRF score not reported at end time.

# Table 23

		SRF 2017				
				Dead	No SRF	
				or in	at end	
SRF 2015	Better	Same	Worse	LTC	time	Denominator
1	-	3	3	2	0	6
2	2	9	11	8	3	22
3	3	9	8	12	1	20
4	6	6	5	15	1	17
5	2	1	1	8	1	4
6	1	1	0	8	0	2
7	0	0	-	2	0	0
Total	14	29	28	55	6	132
Proportion	0.11	0.22	0.21	0.42	0.05	-
95% CI	(0.06, 0.17)	(0.15, 0.29)	(0.14, 0.28)	-	-	-

Prospective Self-rated Frailty (SRF) T1 (2015) vs. T3 (2017)

*Notes.* SRF= Self-rated Frailty. Better = men who got better between time periods. Same = men who reported the same SRF score at both times. Worse = Men who reported a worse SRF score between time periods. No SRF at end time = SRF score not reported at end time.

Table 24 summarizes the distribution of men in each category for prospective resiliency.

### Table 24

Prospective Resilience to Self-rated Frailty (SRF)

			At end of timeframe				
						Dead	No SRF at end
Timeframe	Base year	Both	Better	Same	Worse	or LTC	time
2015 →2016	146	132	22	40	30	27	13
2016→2017	123	108	23	31	16	33	5
2015→2017	146	132	14	29	28	55	6

*Notes.* Base year = number of SRF scores at base year time point. Both = number of surveys with valid SRF at both times. Dead or LTC = Members who are deceased or in LTC at end of timeframe. No SRF at end = A self-rated frailty score was not reported at end of time frame.

**Evidence for resilience summary**. The two perspectives presented by the present study provide different approaches to resilience to frailty. The prospective analysis of resilience to frailty is concerned with looking forward. It provides a perspective of what we might expect to see, based on current data. This is very similar to the concept of incidence and is useful for planning purposes (i.e. resource allocation). For example in 2015, 17% (95% CI: 11%, 24%) of the men will have shown resilience by 2016. The retrospective analysis presents what was seen according to the data. For example at  $T_2$  (2016), 26% (95% CI: 16%, 35%) of the men have shown resilience to frailty. This is very similar to the concept of prevalence, and therefore it can be used for describing the current epidemiology of resilience to frailty in the present sample. A summary of the proportions of resilience found is presented in Table 25.

### Table 25

### Resilience Summary

	Direction				
Year Comparison	Prospective (95%CI)	Retrospective (95%CI)			
2015-16	0.17 (0.11, 0.24)	0.26 (0.16, 0.35)			
2016-17	0.23 (0.15, 0.31)	0.37 (0.25, 0.48)			
2015-17	0.11 (0.06, 0.17)	0.22 (0.12, 0.32)			

**Significant characteristics**. Now that the analyses have shown significant evidence for resilience to self-rated frailty, I will explore what characteristics the resilient men may exhibit. The following three tables illustrate the output of an ANOVA investigating the characteristics that are significantly different between those who got better, stayed the same, or got worse across  $T_1/T_2$ ,  $T_2/T_3$ , and  $T_1/T_3$  comparisons.

Table 26 displays the ANOVA of the  $T_1/T_2$  data. This table shows that the ANOVA did not report a significantly small p-value for any health measure. Therefore, we fail to reject the null hypothesis as at least one pair of means is not significantly different.

# Table 26

		SF-36 Funct (20	ioning Score 116)		
Resilience Category	Ν	MCS	PCS	IADL	BADL
Better	22	53.7	37.4	3.4	1.2
Same	40	55.0	39.3	2.7	0.8
Worse	30	57.3	34.6	3.0	1.1
Missing	25	57.8	36.1	3.0	1.3
ANOVA – p-value		0.28	0.29	0.68	0.71

Resilience Category vs. Measures of Functional Status for T1 (2015) vs. T2(2016)

*Notes.* MCS=Mental Component Score, PCS=Physical Component Score, IADL=Instrumental Activities of Daily Living score, BADL=Basic Activities of Daily Living score. Better = men who got better between time periods. Same = men who reported the same SRF score at both times. Worse = Men who reported a worse SRF score between time periods. Missing = Invalid self-rated frailty score or SAQ not returned. \*p $\leq 0.05$ 

Table 27 displays the ANOVA of the 2016/17 data. This analysis reported a significantly small p-value for PCS. Therefore, we reject the null hypothesis as at least one pair of means is not equal. To determine which means differ significantly, the Tukey test was utilized post hoc on the health indicator that had a significantly small ANOVA p-value. Please see Figure 7 for Tukey comparison illustrations.

#### Table 27

		SF-36 Funct (20	ioning Score )17)		
Resilience Category	Ν	MCS	PCS	IADL	BADL
Better	23	53.7	30.4	3.7	1.8
Same	31	52.5	40.6	2.5	0.6
Worse	16	51.8	34.8	3.3	0.9
Missing	16	56.8	36.5	3.1	0.5
ANOVA – p-value		0.63	0.0055*	0.21	0.07

Resilience Category vs. Measures of Functional Status for T2 (2016) vs. T3(2017)

*Notes.* MCS=Mental Component Score, PCS=Physical Component Score, IADL=Instrumental Activities of Daily Living score, BADL=Basic Activities of Daily Living score. Better = men who got better between time periods. Same = men who reported the same SRF score at both times. Worse = Men who reported a worse SRF score between time periods. Missing = Invalid self-rated frailty score or SAQ not returned. \*p $\leq$ 0.05

Figure 7 illustrates the Tukey illustrations for the significant PCS p-values comparing the health characteristics of men between 2016/17. These comparisons illustrate which group means differ by underlining the mean scores that do not differ. There is a difference of 10.2 (2.8, 17.5) units between the group means of "Same" and "Better".

PCS

Same vs. Better

Mean40.636.534.830.4GroupSameMissingWorseBetter

Figure 7. 2016/17 Tukey Test. This figure illustrates the Tukey tests results for mean variable comparisons at T2/T3.

Table 28 displays the ANOVA of the 2015/17 data. The ANOVA reported a significantly small p-value for PCS. Therefore, we reject the null hypothesis as at least one pair of means is not equal. To determine which means differ significantly, the Tukey test was utilized post hoc on the health indicator that had a significantly small ANOVA p-value. Please see Figure 8 for Tukey comparison illustrations.

### Table 28

		SF-36 Functi (20	ioning Score 17)		
Resilience Category	Ν	Mental	Physical	IADL	BADL
Better	14	55.5	35.6	2.9	1.0
Same	29	56.4	42.7	1.9	0.3
Worse	28	56.8	34.6	2.8	0.8
Missing	13	49.5	37.0	3.2	1.5
ANOVA – p-value		0.15	0.01*	0.12	0.08

Resilience Category vs. Measures of Functional Status for T1(2015) vs. T3(2017)

*Notes.* MCS=Mental Component Score, PCS=Physical Component Score, IADL=Instrumental Activities of Daily Living score, BADL=Basic Activities of Daily Living score. Better = men who got better between time periods. Same = men who reported the same SRF score at both times. Worse = Men who reported a worse SRF score between time periods. Missing = Invalid self-rated frailty score or SAQ not returned. \*p $\leq$ 0.05

Figure 8 illustrates the Tukey illustrations for the significant PCS p-values comparing the health characteristics of men between 2015/17. These comparisons illustrate which group means differ by underlining the mean scores that do not differ. There is a difference of 8.1 (1.3, 15.0) units between the group means of "Same" and "Worse".

PCS

Same vs. Worse

Mean	42.7	37.0	35.6	34.6
Group	Same	Missing	Better	Worse

Figure 8. 2015/17 Tukey Test. This figure illustrates the Tukey tests results for mean variable comparisons at T1/T3.

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#### **Objective Two Section Conclusion**

In review of the results, there is sufficient evidence to support that it is possible to recover from a frail state, therefore expressing evidence in favour of resilience to frailty. Retrospectively, none of the 95% CIs calculated for any of the time comparisons crossed zero. The weakest support was given by the group of men who reported getting better at  $T_1/T_3$  at 22% (12%, 32%), as the lower limit of this CI is the closest to zero. Prospectively, none of the CIs calculated for any of the time comparisons crossed zero. The weakest support was given by the group of men who reported y none of the CIs calculated for any of the time comparisons crossed zero. The weakest support was given by the group of men who reported y. None of the CIs calculated for any of the time comparisons crossed zero. The weakest support was given by the group of men who reported getting better at  $T_1/T_3$ , 11% (95% CI: 6%, 17%).

When investigating the significant characteristics that men resilient to frailty may exhibit, it was revealed that for the  $T_1/T_2$  comparison none of the health measures had a significantly small p-value. Therefore we fail to reject the null hypothesis and conclude that none of the men who got better, stayed the same, or got worse reported health measures that were significantly different from one another. At the  $T_2/T_3$  comparison the mean PCS score reported by men who got better was 10.2 (2.8, 17.5) units significantly higher than men who reported the same SRF score. At the  $T_1/T_3$  comparison, the mean PCS score between men who reported they stayed the same was 8.1 (1.3, 15.0) units better than those who reported a worse SRF score. In conclusion of the second objective, there is significantly was the PCS score comparisons at  $T_2/T_3$  and  $T_1/T_3$ .

### **Objective 3**

The third objective was to determine whether and how self-rated frailty relates to mortality. Figure 9 displays a Kaplan-Meier curve displaying the survival of each grouping of the self-rated frailty scores (log rank  $\chi^2$  test: 16.2, 3 df, p<0.001). It shows that groups 1&2, 3, 4 were not significantly different from each other. However, group 6&7 was significantly different from from groups 1&2, 3, and 4.



Figure 9. Survival Probability by Self-rated Frailty Group. This figure displays the Kaplan-Meier curve survival of each self-rated frailty grouping.

Cox proportional hazard modeling was used to illustrate the contributions of self-rated frailty to mortality. Table 29 shows that the hazard of dying for men who reported a SRF of 5, 6,

or 7 at  $T_1$  (group "5&6&7. Mildly-severely frail") was 3.7 (95% CI: 1.7, 8.0) times than that of men who reported a SRF of 1 or 2. Groups 3 and 4 did not have a significantly different risk of mortality than that of group 1&2.

Table 29

Mazara Ranos Munou Majusineni						
Parameter	p-value	Hazard Ratio	95% CI			
3. Well, with treated	0.7	1.2	(0.5, 2.8)			
disease						
4. Apparently vulnerable,	0.3	1.5	(0.7, 3.5)			
"slowed up"						
5,6,7. Mildly-severely	< 0.01*	3.7	(1.7, 8.0)			
frail						
* p<0.05						

Table 30 illustrates that the hazard of dying for men who reported a SRF of 5, 6, or 7 at  $T_1$  (group "5&6&7. Mildly-severely frail") was 3.3 (95% CI: 1.5, 7.1) times than that of men who reported a SRF of 1 or 2, when adjusted for age. Groups 3 and 4 did not have a significantly different risk of mortality than that of group 1&2.

Table 30

Parameter	p-value	Hazard Ratio	95% CI
3. Well, with treated	0.9	1.1	(0.5, 2.6)
disease			
4. Apparently vulnerable,	0.4	1.4	(0.6, 3.3)
"slowed up"			
5,6,7. Mildly-severely	< 0.01	3.3	(1.5, 7.1)
frail			
Age	0.02	1.1	(1.0, 1.3)
* p≤0.05			

Hazard Ratios Adjusting for Age

### **Objective Three Section Conclusion**

In review, the Kaplan-Meier curves illustrate that the mortality experience for men in Group 6&7 was significantly different from groups 1&2, 3, and 4 (log rank  $\chi^2$  test: 16.2, 3 df, p<0.001). After adjusting for age, Cox proportional hazard modeling revealed that the hazard of dying for men who reported a SRF of 5, 6, or 7 at T<sub>1</sub> (group "5&6&7. Mildly-severely frail") was 3.3 (95% CI: 1.5, 7.1) times faster than men who reported a SRF of 1 or 2. Groups 3 and 4 did not have a significantly different risk of mortality than that of group 1&2. Therefore, I conclude that the analyses provided evidence to support that increased ratings at category 5, 6, or 7 of self-rated frailty are associated with increased mortality. In other words, frail men have a significantly increased risk of mortality than non-frail men.

#### **Discussion and Conclusion**

To the knowledge of the author, the present study was the first to explore the validity of using SRF to measure frailty in older adults, the prevalence of resilience to SRF, and the association between SRF and mortality. Overall the main findings of the current study were: 1) The analyses show that increased ratings of SRF scores generally correspond with worse health and increased limitations as measured by other accepted measures of health (PCS, IADL, and BADL). As illustrated most clearly by the analyses results at  $T_1$  and  $T_2$ , it makes logical sense to use SRF to describe health. Therefore there is significant evidence to support that SRF meets the criteria for face validity. Additionally, the analyses results at T<sub>1</sub>, T<sub>2</sub>, and T<sub>3</sub> illustrated that PCS mean scores significantly decreased as SRF increased. Therefore, there is significant evidence to support that SRF fulfills the criteria for concurrent validity. 2) There is sufficient evidence to support that it is possible to recover from a frail state, therefore expressing evidence in favour of resilience to frailty. However, the only health measure that differed significantly was the PCS score comparisons at  $T_2/T_3$  and  $T_1/T_3$ . 3) There is sufficient evidence to suggest that frail men have a significantly increased risk of mortality than non-frail men (log rank  $\chi^2$  test: 16.2, 3 df, p<0.001). Specifically, after adjusting for age the hazard of dying for men who reported a SRF of mildly-severely frail (group "5&6&7. Mildly-severely frail") was 3.3 (1.5, 7.1) times faster than men who reported a SRF of 1 or 2. This section will discuss the results of each objective and connect the findings to the literature. It will also discuss the strengths, limitation, and implications of the present study before ending with a conclusion.

#### **Objective One**

Objective one sought to assess the face validity and concurrent validity of SRF. Significant evidence to support this hypothesis is most clearly illustrated by the post hoc Tukey

results of the mean PCS scores at T<sub>1</sub>. These results indicated that the least frail men (groups 1 and 2) reported significantly better physical health than the most frail men (group 6&7). The least frail and most frail men also reported significantly different physical health than group "3. Well, with treated disease", which is one of the mid-range SRF options. Therefore a gradual gradient of physical health is observable at T<sub>1</sub>. While not as clear as the PCS results at T<sub>1</sub>, this gradual change in reported health and limitations can also be seen within the PCS and IADL variables at T<sub>2</sub>. Additionally, the results of IADL and BADL at T<sub>1</sub>, BADL at T<sub>2</sub>, and PCS at T<sub>3</sub> illustrate that worse ratings of health and increased limitations were reported by men who reported increased SRF. As such, it appears that increased SRF had some association with worse self-rating of health and increased functional limitations, supporting the face validity of SRF. Furthermore, as the results indicated that an increase in SRF is associated with adverse changes in other reported health measures, there is evidence to support that SRF has shown concurrent validity. This association is most clearly illustrated by the gradient in reported mean PCS scores at T<sub>1</sub>, but can also be seen within the PCS and IADL variables at T<sub>2</sub>.

The findings supporting the validity of SRF, as a derivative of SRH, is congruent with the literature. The literature stated that self-rated health is a popular and well established valid measurement used to indicate health states of older adults (DeSalvo et al., 2006; Gijzel et al., 2017; Idler & Benyamini, 1997; Jylhä, 2009; Martin, 2014). In fact some authors considered it to be the best single measure predictor of death, service use, institutionalization and hospitalization for this demographic (DeSalvo et al., 2006; Idler & Benyamini, 1997).

SRF also connects with a particular subset of SRH: single item general self-rated health. This approach uses a single question to assess SRH. While the exact phrasing of this question varied within the literature (Jylhä, 2009), within the SF-36, this question asks: "In general, would

you say your health is...". Response options include (1) Excellent; (2) Very Good; (3) Good; (4) Fair; and (5) Poor. Although this question depends on the subjective perspective of the participants own health, it has often been used within the literature to investigate the association of the participant's response with mortality, hospitalization, or other objective health measures (DeSalvo et al., 2006). Similar to single item general self-rated health, the present study asked participants to self-rate their frailty via a single item of general self-rated frailty. Similar to the literature, participants provided their subjective assessment of their own frailty while the present study compared their SRF with several observable measures of health (PCS, MCS, IADL, BADL). Therefore the present study extends the literature in this area to explore SRF as a subset of SRH.

A limitation identified in the literature was that the current definitions and operationalizations of frailty were often plagued by ambiguity and a lack of consensus (Cesari et al., 2014; Clegg et al., 2015; Conroy, 2009; Gobbens et al., 2010a, 2014; Malmstrom et al., 2014; Sternberg et al., 2011). Contributing to this issue, the definitions remained divisive on which factors associated with frailty should be included by the definitions (Gobbens et al., 2010a, 2014). The results of the current study may lend some clarity to these concerns. PCS was the only health measure to have significantly different SRF group means at all three time points. Also, the gradient in physical health as SRF increased was most clearly illustrated by the mean PCS scores at T<sub>1</sub>. However, the SRF group means of IADL and BADL were significantly different at T<sub>1</sub> and T<sub>2</sub>. In general, the analysis results of these health measures did support that men who reported themselves as being the most frail did have significantly more limitations than the other groups. In comparison, significant mean MCS scores between the SRF groups was only found at T<sub>3</sub>. The dominance of the physical measures of health as seen in the present study seems

to be similar to that within the literature, as the operational definition by Fried et al. (2001) was the most widely accepted definition of frailty (Garcia-Garcia et al., 2014; Romero-Ortuno, 2011). However, the phenotype of frailty includes primarily physical components that are easily measured (Sternberg et al., 2011). If then, the physical components of frailty are easily measured, then perhaps this explains why the results of the present study have favored the physical measures of frailty.

The analyses results also aligned with the lay definitions of frailty as investigated by St. John et al. (2019). The analyses results at  $T_1$ ,  $T_2$ , and  $T_3$  illustrated that PCS mean scores significantly decreased as SRF increased and the SRF group means of IADL and BADL were significantly different at  $T_1$  and  $T_2$ . St. John et al. (2019) asked participants to provide their own definitions of frailty. Thematic analysis of the men's answers indicated that most men defined frailty as related to BADL impairment (25%), as well as poor physical performance such as poor mobility, falls and fall risk, weakness and fatigue (St. John et al., 2019). Therefore the importance of physical health and functional ability in the BADLs has been recognized by both the health measures considered by the present study and the participants own definitions of frailty. The results of the present study did not align with the experiences of the older women who participated in the study by Grenier (2007), however, as the participants in that study discussed times when they experienced vulnerability and uncertainty as opposed to discussing physical characteristics.

As the mean IADL and BADL scores were significantly different between SRF groups at  $T_1$  and  $T_2$ , some support for frailty as a multidimensional concept may be provided by these results (Clegg et al., 2013; Ferrucci et al., 2006; Fried et al., 2001; Sternberg et al., 2011). However, as MCS was only significant at  $T_3$ , the results of this analysis only provide limited

support that frailty includes mental components of health. Additionally, as the results of objective 1 support that the most frail men reported increased limitations as compared to the least frail men, there is some support for the frailty index perspective that frailty is an at-risk state resulting from the accumulation of deficits related to age (Mitnitski et al., 2001).

### **Objective Two**

The current study investigated retrospective and prospective resilience to frailty. The results of the analyses of objective 2 have provided evidence for resilience to frailty. Retrospectively, it was found that the proportion of men that showed evidence of resilience was as follows:  $T_2$  vs.  $T_1$ : 0.26 (95%CI: 0.16, 0.35);  $T_3$  vs  $T_2$ : 0.37 (95%CI: 0.25, 0.48);  $T_3$  vs  $T_1$ : 0.22 (95%CI: 0.12, 0.32). Prospectively, it was found that the proportion of men that showed evidence of resilience was as follows:  $T_1$  vs.  $T_2$ : 0.17 (95%CI: 0.11, 0.24);  $T_2$  vs  $T_3$ : 0.23 (95%CI: 0.15, 0.31);  $T_1$  vs  $T_3$ : 0.11 (95%CI: 0.06, 0.17). These results indicate that there was sufficient evidence to support that it is possible to recover from a frail state, therefore expressing evidence in favour of resilience to frailty. Retrospectively, none of the 95% CIs calculated for any of the time comparisons crossed zero. The weakest support was given by the group of men who reported getting better for the  $T_1/T_3$  comparison at 0.22 (95%CI: 0.12, 0.32), as the lower limit of this CI is the closest to zero. Prospectively, none of the 95% CIs calculated for any of the time comparisons crossed zero. The weakest support was given by the group of men who reported getting better at the  $T_1/T_3$  comparison, at 0.11 (95%CI: 0.06, 0.17).

When investigating the characteristics associated with the men who showed resilience, it was found that at the  $T_2/T_3$  comparison the mean PCS score reported by men who got better was 10.2 (95% CI: 2.8, 17.5) units significantly higher than men who reported the same SRF score. At the  $T_1/T_3$  comparison, the mean PCS score between men who reported they stayed the same was 8.1 (95% CI: 1.3, 15.0) units better than those who reported a worse SRF score. Therefore, the

only health measure that differed significantly was the PCS score comparisons at  $T_2/T_3$  and  $T_1/T_3$ .

The present study has considered resilience to be the ability to "get better," as measurable through SRF. Results have indicated that resilience may also be indicated through change in mean PCS scores. As the concept of resilience is new to the field of aging, little information is available for comparison. However, the findings of the present study are partly consistent with those of Gijzel et al. (2017). Gijzel et al. (2017) found that frail participants had increased variability in self-rated physical, mental and social domains. The finding of the present study are consistent in the fact that mean self-reported physical health (PCS) was higher in resilient men as compared to those who got worse and those who got better. However, the present study differs from Gijzel et al. (2017) as only PCS was found to differ between groups.

As the only health measure that differed significantly between SRF groups was the mean PCS scores, support is provided for physical concepts of frailty. These results could be considered to have then provided support for Fried et al. (2001)'s model of frailty, as the phenotype of frailty purports a mostly physical understanding of frailty (Fried et al., 2001). It has not provided support for the multidimensional view of frailty that has recently emerged in the literature, as PCS was the only health measure that differed significantly between SRF groups. Significant evidence was found to support resilience to frailty at all time comparisons for both perspectives explored. This finding connects with Rockwood et al.'s (1994) perspective of frailty as a dynamic vulnerable state that was subject to change. However, as only mean PCS scores were found to differ this finding could only provide support for inclusion of physical factors in a frailty index.

Several additional conclusions may be drawn from the analyses of the second objective. First, the two perspectives presented by the present study provide different approaches to resilience to frailty. The prospective analysis of resilience to frailty is concerned with looking forward. It provides a perspective of what we might expect to see, based on current data. This is very similar to the concept of incidence and is useful for planning purposes (i.e. resource allocation). For example in 2015, 0.17 (95% CI: 0.11, 0.24) men will have shown resilience by 2016. The retrospective analysis presents what was seen according to the data. For example at  $T_2$ , 0.26 (95% CI: 0.16, 0.35) men have shown resilience to frailty. This is very similar to the concept of prevalence, and therefore it can be used for describing the current epidemiology of resilience to frailty in the present sample.

Second, a count of all men who were alive at the start time were in included within the prospective denominator. The denominator of the retrospective analysis has not included the SRFs that were ineligible for analysis ("Invalid" column of Tables 9, 12, and 15) or the responses of men who died or moved to long term care ("NR" column of Tables 9, 12, 15). This accounts for why the proportion of men who showed resilience was so much larger within the retrospective analysis. If none of the men had died, moved to long term care, or returned ineligible SRF responses, it would be expected that the  $T_1/T_2$  and  $T_1/T_3$  comparisons would be very similar proportions across the two perspectives, as both time comparisons are 1 year time differences. However, they are very different; this means that a lot of men died.

Third, the present study has assumed the most extreme situation, as we have not included any men that may have been resilient within the prospective analyses. Men who completed survey with help were excluded. Even so, the prospective analyses have still provided significant

support for resilience to frailty. The real-world proportion is likely to be somewhere in the middle of the prospective and retrospective proportions.

Fourth, the grouping of men that reported the most deaths were not from the most frail SRF groups. In fact, for the  $T_1/T_2$  comparison most come from groups 4 & 6 (Table 21), for the  $T_2/T_3$  comparison most come from groups 3 & 4 (Table 22), and for the  $T_1/T_3$  comparison, most come from groups 3 & 4 (Table 23). This could indicate limitations of our sample. Perhaps all of the men who would have been included in the SRF group 7 were already in long term care, as men in this category are very unlikely to fill out the survey without assistance (which was part of the eligibility criteria for the present study). Or, perhaps men in this category filled out the survey with assistance, and as such were excluded from analysis. Perhaps it means that those in SRF groups 1-4 were still living in the community and either die more often or were not receiving the support needed. Or, perhaps the men at home did not stay resilient.

Lastly, according to Table 24 the number of men in category "No SRF at end of time" has decreased over time. One interpretation of this result is that perhaps at  $T_1$ , it was the first time that sample participants had been asked to consider if they were frail. Another interpretation is that those who had left the question blank or returned an otherwise ineligible SRF score were no longer part of the eligible sample at  $T_2$  or  $T_3$ .

### **Objective Three**

In review, the Kaplan-Meier curves illustrate that Group 6&7 are significantly different from groups 1&2, 3, and 4 (log rank  $\chi^2$  test: 16.2, 3 df, p<0.001). After adjusting for age, Cox proportional hazard modeling revealed that the hazard of dying for men who reported a SRF of 5, 6, or 7 at T<sub>1</sub> (group "5&6&7. Mildly-severely frail") was 3.3 (1.5, 7.1) times faster than men who reported a SRF of 1 or 2. Groups 3 and 4 did not have a significantly different risk of mortality than that of group 1&2. Therefore, I conclude that the analyses provided evidence to

support that increased ratings of self-rated frailty were associated with increased mortality. In other words, frail men had a significantly increased risk of mortality than non-frail men.

The current literature generally agrees that frailty is associated with and can somewhat predict mortality (Fried et al., 2001; Rockwood & Mitnitski, 2011; Rockwood, Theou, & Mitnitski, 2015). The present study is consistent with this literature, as the findings indicate that men with increased SRF died at a faster rate than the men who had rated themselves as the least frail. However, the present study is also consistent with literature on the predictive ability of SRH on mortality. In general, the literature supported that SRH is a predictor of subsequent mortality (Heistaro, Jousilahti, Lahelma, Vartiainen, & Puska, 2001).

### Strengths

There are several strengths to this study. First, to the best of the authors knowledge, it was the first study to examine the validity of SRF, resilience to frailty, and the association between SRF and mortality. Additionally, the present study has presented a unique contribution to the literature with a novel application of the Clinical Frailty Scale. Second, the SAQ used by the present study has been in use at MFUS since 1996, using the same methodology with few deviations since its implementation (Tate et al., 2013). Furthermore, as indicated by St. John et al. (2019), the men involved with MFUS are familiar with the questionnaire and answering open ended questions. Therefore the consistency of the information is appreciated (Swift & Tate, 2015). Third, the SAQ is a self-administered questionnaire that has captured several aspects of health, well-being, and functional status (Tate et al., 2003). Information of interest included living arrangements, BADLs, IADLs, mental health, physical health, and the study member's perspective of aging and successful aging (Swift & Tate, 2015; Tate et al., 2015). Furthermore the

data provided by MFUS was unique as studies with participants over the age of 90 are unusual (St. John et al., 2019; Tate et al., 2015). The present study has used well-established measures, such as the SF-36. The validity of this tool has been generally well accepted and it is one of the most popular tools used to measure health-related quality of life across a diverse range of settings and populations (Ware & Sherbourne, 1992).

### Limitations

There are several limitations to the present study. First, the sample was made of very old, predominantly white, Canadian men (Tate et al., 2015, 2009). As mentioned by St. John et al. (2019) experiences of frailty may include factors that have a cultural or gendered perspective, impacting the applicability of the present study's results to older women and to older men from other cultures. Secondly these men were born within only a few years of each other, have resided mostly within Canada for most of their lifespan, and have had the common experience of having served in the Royal Canadian Air Force during World War II (St. John et al., 2019; Tate et al., 2013). This may limit the generalizability of results to populations outside this demographic.

#### Implications

As the Canadian population ages, an increasing proportion of older adults are expected to be affected by frailty (Buckinx et al., 2015). Furthermore as frailty increases the risk of adverse outcomes, the societal and personal costs of this condition have prompted the involvement of the medical and scientific communities (Buckinx et al., 2015). However, the operational and conceptual definitions in the literature exhibit lack of consensus, limiting the effectiveness of our approach. The present study has provided evidence in support of the face validity of SRF, as increased SRF has been shown to correspond with increased imitations and decreased reported physical health. The present study has also provided evidence of the concurrent validity of SRF, as a gradual gradient in reported physical health from most frail to frail participants has been

observed. Together, these results provided support that SRF is most closely associated with factors of physical health. Additionally, the present study has provided evidence in support of resilience to self-rated frailty. However, the only health measure that differed significantly was the PCS score comparisons at  $T_2/T_3$  and  $T_1/T_3$ . Therefore the implications of the present study support that SRF is most closely associated with physical factors or experiences of frailty. In this manner the present study has provided evidence to support operational or conceptual approaches to frailty that consider factors of physical health, such as Fried et al.'s (2001) phenotype of frailty or the use of physical components of health in frailty indices (Rockwood & Mitnitski, 2011).

The results of objective three revealed that the hazard of dying for men who reported a SRF of 5, 6, or 7 at  $T_1$  (group "5&6&7. Mildly-severely frail") was 3.3 (95% CI: 1.5, 7.1) times faster than men who reported a SRF of 1 or 2, when adjusted for age. Thus the author has concluded that the analyses have provided evidence to support that increased ratings of self-rated frailty were associated with increased mortality. In other words, frail men had a significantly increased risk of mortality than non-frail men. In this manner the results of the present study support the utilization of SRF, as a derivative of SRH, within health assessments. Furthermore as the analyses found evidence to support resilience to SRF, the author urges the scientific community to continue consideration of this new area in aging research.

As identified by St. John et al. (2019), the British Geriatrics Society *Fit for Frailty* report has acknowledged the importance of identifying the impact frailty has on care provision (British Geriatrics Society, 2017). However, a hesitancy to use the term when engaging with older adults has been noted (St. John et al., 2019). This discomfort may be due to fear of offence thereby impacting the physician-patient relationship, the displeasure of delivering bad news, or concern that the patient might internalize a sick role (P. John, personal communication, January 9, 2019).

However, according to Table 24 the number of men in category "No SRF at end of time" has decreased over time; perhaps older adults may not be displeased or harmed by pursuing discussion on if they believe they are frail (St. John et al., 2019). This study has shown that SRF was a valid measure, that there was evidence that some older adult men are resilient to frailty, and that the hazard of dying for men who reported a SRF of 5, 6, or 7 at T<sub>1</sub> (group "5&6&7. Mildly-severely frail") was 3.3 (95% CI: 1.5, 7.1) times faster than men who reported a SRF of 1 or 2 (when adjusted for age). As such, the consequences of becoming frail warrant a reconsideration on the discussion of SRF with older adults.

The findings of the present study are important for several other reasons. According to the deficit accumulation model of frailty, frailty is a vulnerable state that could be subject to change (Rockwood et al., 1994). Frailty is also considered to be amenable through prevention and remediation (Fried et al., 2004). Future research could ask if resilient men are able to continue to "get better" or at least stay "the same". Furthermore, additional future research could also investigate which characteristics are associated with getting better, staying the same, or getting worse. These questions are valuable to determining which factors maximize the time spent at the best possible quality of life. Future research could also identify men who are resilient at  $T_2$  from  $T_1$  and examine the trajectories of their survival until the end of the follow up time. This research could investigate if resilient men have better survival, or a better trajectory at end of life. As in, do resilient men spend more time at better health followed by a terminal drop, presenting a better quality of death?

### **Knowledge Translation**

The results of the present study have been presented as a poster presentation at the Canadian Association on Gerontology (CAG) 2018 conference in Vancouver. The results of this

thesis will also be disseminated through publication in relevant academic journals and future poster/conference presentations.

### **Study Conclusion**

In closing, the growing impact of frailty has far reaching implications on the provision and financial implementation of health policy and service provision (Buckinx et al., 2015). While several definitions and operationalizations of frailty have been developed, the current researchergenerated definitions of frailty might not fully address the issue. Analogous to self-rated health, using older adult's self-ratings of frailty may present new avenues of operationalizing frailty. Additionally, frailty may be responsive to prevention and remediation (Fried et al., 2004). Therefore, there is interest to determine if there is evidence to suggest resilience to frailty. The present study addressed these issues through investigation of the utility of self-rated frailty using data collected from the Manitoba Follow-up Study.

The main findings of the study were: 1) The analyses showed that increased ratings of SRF scores generally correspond with worse health and increased limitations as measured by other accepted measures of health (PCS, IADL, BADL). As illustrated most clearly by the analyses results at  $T_1$  and  $T_2$ , it makes logical sense to use SRF to describe health. Therefore there was significant evidence to support that SRF meets the criteria for face validity. Additionally, the analyses results at  $T_1$ ,  $T_2$ , and  $T_3$  illustrated that PCS mean scores significantly decreased as SRF increased. Therefore, there was significant evidence to support that SRF fulfills the criteria for concurrent validity. 2) There was sufficient evidence to support that it is possible to recover from a frail state, therefore expressing evidence in favour of resilience to frailty. However, the only health measure that differed significantly was the PCS score comparisons at  $T_2/T_3$  and  $T_1/T_3$ . 3) There was sufficient evidence to suggest that frail men have a significantly increased risk of mortality than non-frail men.

The implication of these results is that SRF may provide an alternative method that may not be as affected by feasibility concerns during clinical application. Additionally, this project adopted the perspective of the older adult, which was lacking from the current literature. In addition, the current study has addressed the possibility of resilience to frailty. This was an exploratory endeavor, as the field of frailty has only recently considered how frailty may relate to resilience (Rockwood & Mitnitski, 2015). The implication of this effort is that it may help shape the discussion on how these two concepts are related. Furthermore, frailty has been considered to be amenable through prevention and remediation (Fried et al., 2004). The evidence provided by the current study in support of resilience to frailty could open up additional avenues to combating the impact that frailty has upon the Canadian health care system.

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Appendices

# Appendix 1: 2015 SAQ

UNIVERS	SITY OF MANITOBA FOLLOW-UP STUDY QUESTIONNAIRE, 2015
What is t	today's date? day month year
Whose opi	inions or answers will be presented in this
question	naire?
1.	MFUS Member, unassisted
2.	MFUS Member, assisted by relative or friend
	By whom and why?
3.	Relative or friend (MFUS Member unable to fully
	understand and answer the questions)
	By whom and why?
How would	d you describe your health compared to others your age?
1.	Excellent
2.	Very Good
3.	Good
4.	Fair
5.	Poor/Bad
What is y	your <u>current</u> marital status?
1.	Single, for years
2.	Married/Common-law, for years
3.	Widowed, for years
4.	Divorced/Separated, for years

Please check  $\underline{\checkmark}$  if you live alone \_\_\_\_ or live with others \_\_\_\_. If "live with others", I live with ... My spouse/partner ..... Yes No My grown-up child/children (18 years of age or older) .. Yes No One or more other adults not mentioned above .....Yes \_\_\_\_Yes \_\_\_\_ No One or more young children (under 18 years of age) ..... Yes No What type of residence do you currently live in? House or townhouse or condominium townhouse 1. 2. Suite or apartment or condominium apartment 3. Suite in Senior Citizens' housing unit or other apartment with a minimum age restriction 4. Board & Room, hostel, commercial boarding 5. Assisted living facility 6. Personal care or nursing home 7. Long-term care or extended care facility Other, specify 8. How long have you lived in your current place of residence?

- 1. 0-2 years 4. 11-25 years
- 2. 3-5 years 5. 26-50 years
- 3. 6-10 years 6. 50 years or more

#### How long have you lived in your community?

1.	0-2 years	4.	11-25 years
2.	3-5 years	5.	26-50 years
3.	6-10 years	6.	50 years or more

-2-

In looking at YOUR own personal life, how important are the following items in determining YOUR present quality of life?

	Very	Moderately	Not
	Important	Important	Important
Good physical health			
Being mentally aware			
Having a positive attitude			
Being happy			
Absence of mental illness			
(eq Alzheimer's depression	)		
Living to an old ago	/		
Veeping physically active			
Reeping physically active			
Reeping mentally active			
Keeping busy (eg, hobbies)			
Volunteering			
Having goals/making plans			
Helping family/friends			
Acceptance of/coping with			
life changes			
Adapting to changes in life			
Being spiritual/having faith .			
Relationship with spouse/famil	У		
Friendships			
Pets			
Being socially active			
Being independent (eg, driving			
being mobile, financially)			
Still working			
Being retired			
Good lifestyle/needs are met .			
-	-3-		

# Do you ... (please circle all that apply)

- 1. walk unassisted
- 2. walk with the use of a cane / walker
- 3. use a scooter
- 4. use a wheel chair
- 5. cannot walk at all
- 6. other, please specify \_\_\_\_\_

# Following are some questions about how you spend your time. In the past month, have you participated in these activities?

1. Visited with family or relatives	Yes	No
2. Visited with friends or neighbours	Yes	No
3. Hobby work, including collecting or handiwork	Yes	No
4. Played sports or games (bowling, skiing, etc)	Yes	No
5. Other social group activity(cards, bingo, etc).	Yes	No
6. Church related activities	Yes	No
7. Music, art, theatre	Yes	No
8. Service, fraternal or Legion organizations	Yes	No
9. Community volunteer work	Yes	No
10.Working for pay (including self-employment)	Yes	No
11.Used a computer (e-mail, Internet, typing)	Yes	No
12.Attended classes, workshops, lectures	Yes	No
13.Home maintenance (indoor and/or outdoor)	Yes	No
14.Travel/Vacation	Yes	No
15.Reading and/or writing	Yes	No
16.Watching television	Yes	No
17.Outdoor nature activities	Yes	No
18 Exercise (swimming, cycling, walking, etc.)	Yes	No
19.Pet care	Yes	No
20.Flying	Yes	No
21.0ther		

Which of the above activities are the most important to you?

Now I have some questions about your ability to carry on different activities. I am interested in your <u>capability</u>, not whether or not you actually do them.

#### Are you capable of ..... without any help from anyone else?

Doing light housework (washing up, dusting etc.).	Yes	No
Doing heavy housework (cleaning floors, windows).	Yes	No
Making a cup of tea or coffee	Yes	No
Preparing a hot meal	Yes	No
Shovelling and yard work	Yes	No
Shopping	Yes	No
Managing financial affairs (banking,paying bills)	Yes	No
Laundry (household and personal)	Yes	No
Major house or household repairs	Yes	No
Going up and down the stairs	Yes	No
Getting about the house	Yes	No
Going out of doors in good weather	Yes	No
Getting in and out of bed	Yes	No
Washing or bathing or grooming	Yes	No
Dressing and putting shoes on	Yes	No
Cutting your toenails	Yes	No
Eating	Yes	No
Taking medication or treatment	Yes	No
Using the toilet	Yes	No
Watching television or listening to radio	Yes	No
Reading or writing	Yes	No
Using the telephone	Yes	No
Buttoning a sweater	Yes	No
Getting up out of a chair and walking 3 meters	Yes	No

In general, would you say your health is ...

- 1. Excellent
- 2. Very Good
- 3. Good
- 4. Fair
- 5. Poor

Compared to one year ago, how would you rate your health in general now?

- 1. Much better now than one year ago
- 2. Somewhat better now than one year ago
- 3. About the same as one year ago
- 4. Somewhat worse now than one year ago
- 5. Much worse than one year ago

During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

a.	Cut down the <i>amount of time</i> you		
	spent on work or other activities	Yes	No
b.	Accomplished less than you would like	Yes	No
с.	Were limited in the <i>kind</i> of work		
	or other activities	_Yes	No
d.	Had difficulty performing the work		
	or other activities (for example,		
	it took extra effort)	_Yes	No

The following questions are about activities that you might do during a typical day. Does *your health now limit you* in these activities? If so, how much?

	ACTIVITY	Yes,	Yes,	No, Not
		Limited	Limited	Limited
		A Lot	A Little	At All
a.	<i>Vigorous activities</i> , such as running, lifting heavy objects, participating in strenuous sports			
b.	Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf			
с.	Lifting or carrying groceries			
d.	Climbing <i>several</i> flights of stairs			
e.	Climbing one flight of stairs			
f.	Bending, kneeling, or stooping			
g.	Walking more than a mile			
h.	Walking several blocks			
i.	Walking one block			
j.	Bathing or dressing yourself.			

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During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

a.	Cut down the <i>amount of time</i> you		
	spent on work or other activities	Yes	_No
b.	Accomplished less than you would like	Yes	_No
с.	Didn't do work or other activities		
	as carefully as usual	Yes	No

During the *past 4 weeks*, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours or groups?

- 1. Not at all
- 2. Slightly
- 3. Moderately
- 4. Quite a bit
- 5. Extremely

How much bodily pain have you had in the past 4 weeks?

- 1. None
- 2. Very mild
- 3. Mild
- 4. Moderate
- 5. Severe
- 6. Very severe

During the *past 4 weeks*, how much did *pain* interfere with your normal work (including both work outside the home and housework)?

- 1. Not at all
- 2. A little bit
- 3. Moderately
- 4. Quite a bit
- 5. Extremely

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These questions are about how you feel and how things have been with you *during the past 4 weeks*. For each question, please give the one answer that comes closest to the way you have been feeling.

How much of the time during the past 4 weeks ....

		All of the time	Most of the time	A good bit of the time	Some of the time	A little of the time	None of the time
a.	Did you feel full of pep?						
b.	Have you been a very						
	nervous person?						
c.	Have you felt so down in						
	the dumps that nothing						
	could cheer you up?						
d.	Have you felt calm						
	and peaceful?						
e.	Did you have a						
	lot of energy?						
f.	Have you felt						
	downhearted and blue?						
g.	Did you feel worn out?						
h.	Have you been a						
	happy person?						
i.	Did you feel tired?						

During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

- 1. All of the time
- 2. Most of the time
- 3. Some of the time
- 4. A little of the time
- 5. None of the time

#### How TRUE or FALSE is each of the following statements for you?

		Definitely	Mostly	Don't	Mostly	Definitely
		true	true	know	false	false
a.	I seem to get sick					
	a little easier than					
	other people					
b.	I am as healthy					
	as anybody I know $\dots$ _			<u> </u>		
с.	I expect my health					
	to get worse					
d.	My health					
	is excellent					

# How would you describe your satisfaction with life in general at present?

- 1. Excellent
- 2. Very Good
- 3. Good
- 4. Fair
- 5. Poor/Bad

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What	is	YOUR	defi	nition	of	successful	aging?
					<u> </u>		
Would	a yo	DU sa	y you	have	"AGE	D SUCCESSF	ULLY"?

Like successful aging, frailty is an important topic in contemporary Geriatric Medicine. Please share your views on frailty with us.

What is YOUR definition of frailty?

Do you think that YOU are frail? \_\_\_\_\_

Please rate YOUR frailty on this scale.

- 1. Very fit
- 2. Well, with no disease
- 3. Well, with treated disease
- 4. Apparently vulnerable "slowed up"
- 5. Mildly frail
- 6. Moderately frail
- 7. Severely frail

Is the notion of frailty important to YOU? Why or why not?

Do you think that people can accurately rate their frailty level?

Why or why not?

Thank you very much for completing this lengthy questionnaire.

Feel free to use this page if you have any suggestions or wish to comment on your experience with The Manitoba Follow-up Study