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ABSTRACT

Incontinence, falls and hip fractures are common public health problems, especially among older women. These conditions will increasingly burden the health care system as the population ages.

The aims of this thesis were to establish prevalence and incidence of urinary incontinence and its subtypes and double incontinence (i.e concurrent urinary and fecal incontinence) as well as their associated risk factors among older women with hip fracture. In addition, the studies sought to determine potential associations between incontinence and increased mortality, changes in living arrangements, and mobility.

The study population consisted of women aged ≥ 65 treated for their first hip fracture in the Seinäjoki Central Hospital between 2007 and 2019. Urinary and double incontinence were found to be highly prevalent and closely related to functional disability. Those women who reported double incontinence, were found to be an especially vulnerable group. Key modifiable risk factors included depressive mood and constipation associated with urinary incontinence, and delayed removal of urinary catheter and poor nutrition associated with double incontinence. Urgency urinary incontinence was the most common subtype of urinary incontinence, while mixed urinary incontinence was associated with most factors. Poor mobility and living in an institution at the time of the fracture predicted incident urinary and double incontinence, and respectively, both predicted decreasing mobility during 1-year follow-up. Double incontinence also predicted the need for more supported living arrangements. However, neither urinary nor double incontinence predicted increased mortality independently.

We found connection between incontinence and functional disability and other factors related to frailty repeatedly across all the studies. It is likely that incontinence serves as a marker for frailty in these patients and predicts possible challenges during the rehabilitation phase post-fracture. Incontinence should be actively screened and systematically managed in both primary and secondary prevention of falls, as well as part of rehabilitation programme after a hip fracture. Additional research is warranted to establish possible causality.

KEYWORDS: Incontinence, hip fracture, double incontinence, frailty

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Lääketieteellinen tiedekunta
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TIIVISTELMÄ

Inkontinenssi, kaatumiset ja lonkamurtumat ovat yleisiä erityisesti iäkkäiden naisten kansanterveydellisiä ongelmia, jotka tulevat edelleen lisääntymään väestön ikääntyessä.

Väitöskirjatutkimuksen tavoitteina oli selvittää virtsainkontinenssin ja sen alatyyppien sekä kaksoisinkontinenssin (virtsa- ja ulosteinkontinenssin esiintyminen yhtä aikaa) esiintyvyyttä sekä niiden riskitekijöitä iäkkäiden lonkkamurtuman sairastaneiden naisten keskuudessa. Lisäksi tutkittiin inkontinenssin sekä kuolleisuuden, palveluiden tarpeen ja liikuntakyvyn muutosten välisiä yhteyksiä.

Tutkimusaineisto koostui 65-vuotiaista tai tätä vanhemmista ensimmäisen lonkkamurtumansa sairastaneista naisista (n=1675), jotka hoidettiin Seinäjoen keskussairaalassa vuosina 2007–2019. Virtsa- ja kaksoisinkontinenssin todettiin olevan yleisiä ja kytköksissä potilaiden toimintakykyyn. Kaksoisinkontinenssia raportoivien naisten todettiin olevan erityisen hauraita. Muokattavissa olevia riskitekijöitä olivat mm. masentuneen mielialan ja ummetuksen yhteys virtsainkontinenssiin ja myöhäisen virtsakatetrin poistamisen ja heikon ravitsemustilan yhteys kaksoisinkontinenssiin. Pakkoinkontinenssi oli yleisin virtsainkontinenssityyppi, kun taas sekamuotoiseen virtsainkontinenssiin liittyi eniten riskitekijöitä. Lähtötilanteen heikentynyt liikuntakyky ja asuminen hoitolaitoksessa ennustivat uutena ilmenevää virtsa- ja kaksoisinkontinenssia, jotka toisaalta ennustivat heikkenevää liikuntakykyä vuoden seurannassa. Kaksoisinkontinenssi ennusti myös kasvavaa asumispalveluiden tarvetta. Kontinenssiongelmat itsessään eivät liittyneet lisääntyneeseen kuolleisuuteen.

Tutkimustuloksissa toistui virtsa- ja kaksoisinkontinenssin yhteys heikentyneeseen toimintakykyyn ja muihin gerasteniaan viittaaviin tekijöihin. Todennäköisesti inkontinenssi kertoo näiden potilaiden gerasteniasta ja odotettavissa olevista kuntoutuksen haasteista. Kontinenssiongelmia tulisi seuloa ja hoitaa systemaattisesti kaatumisten primaari- ja sekundaaripreventiossa ja osana lonkkamurtumapotilaiden kuntoutusta. Mahdollisen syy-yhteyden osoittaminen vaatii lisätutkimuksia.

AVAINSANAT: Lonkkamurtuma, virtsainkontinenssi, kaksoisinkontinenssi, gerastenia

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Abbreviations

ADL	Activities of Daily Living
ASA	The preoperative American Society of Anesthesiologists
AUR	Acute urinary retention
BMI	Body Mass Index
CGA	Comprehensive Geriatric Assessment
CI	Confidence interval
DI	Double incontinence
EMS	Elderly Mobility Scale
FI	Fecal incontinence
GDS-15	15-item Geriatric Depression Scale
HF	Hip fracture
HR	Hazard ratio
IADL	Instrumental Activities of Daily Living
ICS	International Continence Society
IQR	Interquartile range
MMSE	Mini Mental State Examination
MNA-SF	Mini Nutritional Assessment Short Form
MUI	Mixed urinary incontinence
OR	Odds ratio
PADL	Physical Activities of Daily Living
RCT	Randomized controlled trial
SPPB	Short Physical Performance Battery
SUI	Stress urinary incontinence
TUG	Timed Up and Go -test
UC	Urinary Catheter
UI	Urinary incontinence
UTI	Urinary tract infection
UUI	Urgency urinary incontinence

List of Original Publications

This thesis is based on the following publications, which are referred to throughout the text by their Roman numerals I–IV.

I Hellman-Bronstein AT, Luukkaala TH, Ala-Nissilä SS, Kujala MA, Nuotio MS. Factors associated with urinary and double incontinence in a geriatric post-hip fracture assessment in older women. Aging Clin Exp Res. 2022 Jun;34(6):1407–1418

II Hellman-Bronstein AT, Luukkaala TH, Ala-Nissilä SS, Nuotio MS. Associated factors of stress, urgency, and mixed urinary incontinence in a geriatric outpatient assessment of older women with hip fracture. Eur Geriatr Med. 2024 Jun;15(3):861–869

III Hellman-Bronstein AT, Luukkaala TH, Ala-Nissilä SS, Nuotio MS. Do urinary and double incontinence predict changes in living arrangements and mobility in older women after hip fracture? – a 1-year prospective cohort study. BMC Geriatr. 2024 Jan 26;24(1):100

IV Hellman-Bronstein AT, Luukkaala TH, Ala-Nissilä SS, Kujala MA, Nuotio MS. Urinary and double incontinence in older women with hip fracture – risk of death and predictors of incident symptoms among survivors in a 1-year prospective cohort study. Arch Gerontol Geriatr. 2023 Apr;107:104901

1 Introduction

Incontinence, falls and hip fractures affect women disproportionately compared to men, with well-established and long-lasting consequences on quality of life, loss of independence, and health care costs (Gibson & Wagg,2014; Guzon-Illescas et al., 2019). The impact of these common conditions on the health care system will further increase in the future as the population continues to age world-wide (United Nations, 2024; World Health Organization, 2007).

Urinary incontinence (UI), defined as any reported involuntary loss of urine (Haylen et al., 2010), is one of the most common geriatric syndromes first described in the 60s (Aharony et al., 2017). As opposed to a urogynecological condition in younger women, in older women UI is often precipitated by multiple comorbidities and functional limitations not related to the urinary tract (Gibson & Wagg, 2014; Sanses, Kudish and Guralnik, 2017). These factors are shared with other geriatric syndromes, such as falls (Chong et al., 2018). Older individuals suffering from UI are from 1.5 to 2.3 times more likely to fall than their continent peers (Gibson et al., 2018). Double incontinence (DI), defined as involuntary loss of both urine and feces (Sultan et al.,2017), is a more severe form of pelvic dysfunction, and strongly associated with disability (Matthews,2014). Hip fracture (HF) is one the most devastating consequences of a fall among older women, with high mortality rate during the first-year post-fracture and long-lasting impairments in mobility, functional ability and quality of life (Guzon-Illescas et al., 2019; Pajulammi et al., 2016).

Multiple geriatric syndromes often co-exist in the same patient increasing the risk of disability (Rosso et al., 2013). Given that patients sustaining HF are typically old and frail (Forssten et al., 2023), prevalence of incontinence is expected to be high in these patients. However, there is a paucity of literature concerning incontinence, related factors, and its impact on recovery and rehabilitation after HF.

This thesis was undertaken to establish prevalence and incidence of incontinence, identify risk factors of different types of incontinence, as well as the impact of incontinence on different outcomes in older women after HF. The data for the study was derived from the Seinäjoki hip fracture database.

2 Review of Literature

2.1 Epidemiology and subtypes of incontinence

2.1.1 Urinary incontinence

UI is defined as any involuntary loss of urine according to International Continence Society (ICS)(Haylen et al., 2010). UI is not a single disease entity, but rather a clinical manifestation of multiple pathophysiological mechanisms, especially in older patients. UI has been described as one of the geriatric giants, a term coined by Sir Bernard Isaacs in 1965 (Morley, 2004), and is still considered one of the most common geriatric syndromes today (Inouye et al., 2007; Parker-Autry et al., 2021). Despite this, UI remains underreported, -diagnosed and managed (Gibson & Wagg., 2014). Less than half of women experiencing UI seek treatment, and those who do often wait several years before doing so - commonly due to embarrassment or false belief that UI is a normal part of aging (Koch, 2006; LaPier et al., 2024). Up to 70% of older patients do not receive effective treatment. UI has been aptly referred to as “the frequently forgotten geriatric giant”. (Aharony et al., 2017)

The prevalence of UI increases with advancing age and is more common in women than in men. Reports on the prevalence of any UI have varied greatly due to differences in study populations, definitions and sampling. (Milsom & Gyhagen, 2019) According to a large recent meta-analysis of over 500,000 women, nearly 40% of older women aged 55 and over was affected by UI (Batmani et al. 2021). Reported prevalences are even higher in oldest age groups and settings of long-term care with estimations reaching up to 80% (Offermans et al., 2009).

UI can be further classified into the following subtypes: stress urinary incontinence (SUI), urgency urinary incontinence (UUI), and mixed urinary incontinence (MUI). According to ICS, SUI is defined as a complaint of involuntary loss of urine on effort or physical exertion such as coughing or lifting, UUI as complaint of involuntary loss of urine associated with a sense of urgency (a sudden desire to void), and MUI as concomitant symptoms of both SUI and MUI. (Haylen et al., 2010).

Risk factors for developing UI in older women differ from that of younger women who often develop UI as a urogynegologial condition and as a complication of pregnancy and childbirth (Matthews, 2014). In older women, maintaining continence is also contingent with factors outside the urinary tract, such as sufficient mobility, functional and cognitive ability, as well as accessible surroundings (Dubeau, 2007; Gibson & Wagg, 2014). Comorbidities and use of medications also increase significantly with age. Many neurogenerative diseases and diabetes have been established as risk factors for UI, as are medications such as psychotropics and diuretics. (Aharony et al., 2017) UI as a geriatric syndrome is discussed further in chapter 2.3.

2.1.1.1 Stress urinary incontinence

SUI is the most common UI subtype over-all among women, with a peak in prevalence in the 50th decade of life. However, its occurrence gradually decreases among older age groups, where advancing age is no longer a risk factor for SUI. (Minassian et al., 2008; Minassian et al., 2017) Smoking, chronic conditions such as COPD and diabetes, previous vaginal deliveries, using hormonal replacement therapy and being overweight or obese have been reported as correlates of SUI (Abufaraj et al., 2021). In a Finnish study by Nuotio et al, every fifth woman aged 70 and over was affected by SUI which was not associated with health and social indicators unlike MUI and UUI (Nuotio et al. 2003).

The pathophysiology of SUI is best understood among the three subtypes. Weakening connective tissue and supportive ligament around urethra have been stated as etiologic factors. SUI may be thought of as an outlet failure during times of increased bladder pressure. The pathophysiology of SUI explains why parity and vaginal deliveries are a clear predisposing factor for developing SUI whereas similar association has not been found with UUI. (Minassian et al., 2017; Parker & Griebling, 2015)

2.1.1.2 Urgency urinary incontinence

UUI is rarely diagnosed below the age 30 but the prevalence increases with age, and it becomes the predominant subtype along with MUI in the oldest groups of women. Additionally, increasing prevalence trends in women aged 60 and over has been reported in recent years. (Abufaraj et al., 2021; Minassian et al., 2008)

A key factor in UUI is the overactivity of the bladder muscle (detrusor) which causes involuntary bladder spasms and ensuing symptoms of urgency, frequency and incontinence. It can be idiopathic, or secondary with neurogenic or non-neurogenic causes. (Haylen et al., 2010) Especially in the oldest age groups the role of central nervous system is important. A widely accepted theory suggests that UUI arises from a loss of inhibitory control. The brain’s micturition center is normally capable of suppressing the urge to void as the bladder gradually fills. Disruption to this communication can result in UUI. (Minassian et al., 2017) UUI is very common in patients with cognitive disorders, usually occurring early in normal pressure hydrocephalus and frontotemporal and vascular dementia, and conversely in advanced stages of Alzheimer's and Parkinson's diseases. However, cognitive, behavioral and mobility issues are also key factors in maintaining continence in these patients. (Panicker, Fowler and Kessler, 2015) All the pathophysiological mechanisms of UUI are still not completely understood, and most likely underlying causes are multifactorial including many co-morbidities and medications as predisposing factors. For instance, acetylcholinesterase inhibitors commonly used for patients with cognitive disorders may increase detrusor contractility as a side effect. (Aharony et al., 2017; Minassian et al., 2017)

Urgency with or without UUI is significantly associated with lower quality of life, higher depression scores and lower quality of sleep compared to individuals without these symptoms (Stewart et al., 2003). UUI and SUI share several common risk factors such as smoking, obesity, and co-morbidities (Abufaraj et al., 2021). Due to differences in pathophysiology, parity has no effect on pure UUI (Minassian et al., 2017). Considering HF patients, most existing literature supports UUI as a risk factor for falls whereas similar association has not been found for SUI (Brown et al., 2000; Chiarelli, Mackenzie and Osmotherly, 2009; Teo et al., 2006).

2.1.1.3 Mixed urinary incontinence

Mixed urinary incontinence is the combined phenotype of both SUI and UUI. The prevalence of MUI increases gradually with advancing age and is the most prevalent subtype of UI in oldest age groups of women. (Minassian et al., 2017; Minassian et al., 2020). The prevalence of MUI has been on the rise in women aged over 60 largely due to population aging (Abufaraj et al., 2021). UI subtypes tend to remit and recur over long periods of time and transitions between different subtypes occur with trend towards progression into MUI (Komesu et al., 2016; Minassian et al., 2017).

Women with MUI tend to have more frequent UI episodes (Minassian et al., 2008; Qiu et al., 2022) with greater amounts of leakage and stronger impact on their daily life, physical activity and social relationships compared to SUI and UUI in isolation (Qiu et al., 2022). Different risk factors of SUI and UUI converge in MUI (Minassian et al., 2017). Importantly, MUI is strongly associated with functional and physical disability (Fritel et al., 2013; Komesu et al., 2016; Okumatsu et al., 2021), and among older frail women it has been associated with increased risk of falls (Takazawa & Arisawa, 2005).

2.1.2 Fecal incontinence

Fecal incontinence (FI) refers to a complaint of involuntary loss of feces according to the definition of ICS (Sultan et al., 2017). FI is a devastating condition which leads to social isolation and decline in the quality of life. It is more common in women than in men and highly correlated with depression and poor self-rated health. (Andy et al., 2016; Markland et al., 2008) Pathophysiology of FI is often multifactorial, involving both structural and nonstructural causes. Among women, one of the most common structural causes is obstetric injury during childbirth which may have long-lasting consequences. Other examples include complications of anorectal surgery and rectal prolapse. A frequent nonstructural cause is diarrhea which can be a consequence of infections, systemic diseases or adverse effects of medications or therapies. (Alavi et al., 2015) In addition, constipation can be an underlying cause of FI, either due to the overuse of laxatives or because of overflow resulting from fecal impaction (Andy et al., 2016; De Giorgio et al., 2015). FI has been reported to predict mortality among residents in long-term care. Advancing age is the strongest predictor of FI and it is particularly common among the cognitively impaired older individuals. (Bliss et al., 2018; Leung & Rao, 2009; Musa et al., 2019; Wald, 2018) In patients with cognitive disorders, disease progression itself is a known risk factor for FI, but other health- and care-related factors – such as mobility limitations, accessibility of toileting facilities and resources and awareness of nursing staff – also play important roles in continence maintenance (Emmanuel, 2019; Gibson & Wagg., 2014). Indeed, institutionalization itself has been cited as a risk factor for FI (Leung & Rao, 2009).

The reported prevalence rates have varied greatly from 2–20% in communal settings, up to 33% in hospitalized patients and up 70% in older people residing in long-term care. Studies with anonymous surveys tend to report higher prevalence rates compared to those using face-to-face interviews. (Sharma et al., 2016; Sharma & Rao, 2020) Botlero et al conducted a study using a postal questionnaire and reported a 20% prevalence rate of FI in women (mean age 60) living in the community. The strongest correlate of FI was coexisting UI which was reported by nearly two thirds of the women. (Botlero et al., 2011) FI is also frequently preceded by UI and associated with impaired functional ability and mobility, laxative use, constipation and diarrhea in long-term settings. (Bliss et al., 2018; Botlero et al., 2011; Musa et al., 2019)

2.1.3 Double incontinence

Double incontinence (sometimes named dual incontinence) (DI) refers to a condition in which a person suffers from UI and FI concurrently (Sultan et al., 2017). DI has received little attention in the field of incontinence research with a bulk of studies concentrating on UI, or UI and FI separately. DI is more common in women than in men and the prevalence increases with advancing age. It is also associated with a greater decrease in the quality of life compared to UI or FI in isolation. (Matthews, 2014; Matthews et al., 2013; Slieker-Ten Hove et al., 2010; Wu et al., 2015)

Prevalence rates of DI between 2.5-14.5% have been reported in community-dwelling older subjects (Markland et al., 2008; Slieker-Ten Hove et al., 2010; Wu et al., 2015). Unsurprisingly, the highest reported prevalence rates between 33% and 65% have been found in settings of long-term care (Bliss et al., 2018; Musa et al., 2019). However, given that especially FI component of incontinence is likely to be underreported due to embarrassment and still existing social stigma, true prevalence rates might be even higher (Matthews, 2014). According to a study by Cichowski et al, women with DI are far more willing to report UI compared to FI even in an outpatient clinic for pelvic floor disorders, and prefer written surveys compared to oral disclosure with a physician (Cichowski et al. 2014).

DI has been described as the most severe manifestation of pelvic floor dysfunction. Besides advancing age, associated factors for DI in communal settings include functional limitations, decompensating medical conditions, depression, communication problems, impaired mobility, hysterectomy, multiparity, heavier fetal birth weight and diarrhea in older individuals. (Markland et al., 2008; Matthews et al., 2013; Stenzelius et al., 2004; Wu et al., 2015; Yuaso et al., 2018) Moreover, social isolation has been established as predictor for DI in older individuals living in the community. (Luo et al., 2020; Nakanishi et al., 1997)

The subtype of UI in patients with DI has been examined in general communal cohort of women (age range 45-85, mean 59). In this Dutch study utilizing postal questionnaires, women with UUI had a more than 4-fold risk of liquid FI and 1.6-fold risk of solid FI, and women with FI had a nearly 6-fold risk for UUI, suggesting shared pathophysiology. No association was found with SUI.(Slieker-Ten Hove et al., 2010)

Yuaso et al investigated also the incidence and risk factors for DI in older community-dwelling women. Incidence after four years of follow-up was found to be 7.4%. Incident DI was associated with impaired function in the instrumental activities of daily living (IADL) and falls in the previous 12 months. (Yuaso et al., 2018) Bliss et al examined correlates of incident DI in a long-term care setting and found pre-existing UI, functional and cognitive decline, as well as comorbidities to be strongest risk factors for incident DI (Bliss et al., 2018). The strong connection between DI and disability has been concluded to denote underlying frailty of these patients (Matthews, 2014; Stenzelius et al., 2004).

2.2 Hip fracture patients and incontinence

2.2.1 Falls and hip fractures

A fall is defined by the World Health Organization as an event where a person is "inadvertently coming to rest on the ground, floor or other lower level". Approximately every third older person above the age 65 falls each year, and the risk of recurring falls increases with age. (World Health Organization, 2007) HF is one of the most common serious injuries after a fall in an older person, and advancing age is one of the most important risk factors. Majority of patients hospitalized after sustaining HF are over 75 years of age.(Alpantaki et al. 2020) As the population ages, the proportion of older age groups among HF patients will grow, and by 2031, over 45% of HFs are projected to occur in patients aged 85 and over (Holt et al., 2009).

Women have a higher risk of falls compared to men (Gale, Cooper and Sayer, 2016), and sustain HF nearly three times more often than men (Alpantaki et al. 2020). Given that women also live longer and loose more bone mass than men in their lifetime, it is not surprising that three out of four HFs occur in women (Cummings & Melton, 2002). Two thirds of older women with HF are prefrail or frail (Forssten et al., 2023), making them vulnerable to perioperative complications, prolonged hospitalization and increased mortality (Yan et al., 2022).

Increased risk of mortality after HF is well-known. In a Finnish follow-up study, mortality rate among older women after HF was 20% 1-year post-fracture. (Tiihonen et al., 2022) Among survivors, increased morbidity, impaired mobility, and loss of independence often result in institutionalization and amount to approximately a third of the total costs first year following a HF. The strongest risk factors of institutionalization after HF are advancing age and cognitive impairment.(Hawley et al., 2022; Leal et al., 2016; Martinez-Reig, Ahmad and Duque, 2012)

2.2.2 Prevalence and incidence of incontinence

As stated above, both HFs and incontinence are common conditions both of which affect older women more frequently than men. A study by Gosch et al found that nearly 60% of older fragility fracture patients (58% of which were HFs) suffered from UI (Gosch et al., 2015). Sørbye and Grue reported a 49% prevalence of UI among older community-living HF patients (Sørbye & Grue, 2013). A recent study by Arroyo-Huidobro et al reported an even higher prevalence rate of UI in older patients with HF: 62% at baseline, 79% 30 days post-fracture and 77% 90 days post-fracture (Arroyo-Huidobro et al., 2024).

Two Spanish studies investigated recuperation of activities of daily living (ADL) in men and women at 90 days and up to 2 years after HF utilizing the Barthel index. Barthel index contains domains for bladder and bowel control: continent, occasional accident (max 1/week for FI and 1 for 24 hours for UI), and incontinent (Collin C et al., 1988). Gonzáles-Zabaleta et al recruited 100 consecutive HF patients and reported occasional bowel accidents in 14% of the patients at baseline and in 21% at 90 days. Occasional bladder accidents were reported in 20% of the patients at baseline and in 23% at 90 days. Prevalence rates of 13% for UI and 9% for FI before HF and 30% and 21% 90 days post-fracture were reported. Combining the two categories gives a prevalence of occasional or frequent UI 33% at baseline and 53% at 90 days. The respective prevalences for occasional or frequent FI are 23% and 44% in this study. (González-Zabaleta et al., 2015) Alarcón et al reported a 37% prefracture-prevalence for UI and 14% for FI. In this study, patients with occasional accidents with bladder or bowels were grouped with the continent. Bladder and bowel control were regained in 79% and 87% of the cases at six months. The probability of recovery increased only slightly after this, reaching 86% and 89% at 24 months after HF. (Alarcón et al., 2011) In an institutionalized setting in Spain, prevalence of UI among older residents aged 65 and over with a history of HF was 72%, compared to 49% in those without (Villanueva et al., 2011).

A few studies have examined incident UI after HF. Palmer et al established incident UI at 21% after HF in older women at the time of discharge from the surgical hospital (median length of stay 13 days), with impaired mobility and living in long-term care as risk factors (Palmer et al., 2002). Same authors had previously reported a 31% incidence for UI post-operatively among a small sample of both men and women with HF (Palmer, Myers and Fedenko, 1997). Arroyo-Huidobro et al examined both incidence of new-onset UI as well as worsening of existing UI with 62% of previously continent patients developing UI and 59% of patients with pre-fracture UI experiencing worsening of the symptoms at 30 days after HF. Acute urinary retention (AUR) and urinary tract infections (UTI) were established as predictors of both incident UI and deterioration of the condition post-fracture. (Arroyo-Huidobro et al., 2024)

Two randomized controlled trials (RCT) investigated if the incidence of UI could be decreased with intervention. Zusman et al used an in-hospital comprehensive geriatric assessment (CGA) with a consultation of a continence nurse, if necessary, in men and women aged 65 and over. Compared to the group receiving usual care, no significant change for UI was found between the groups at 12 months post-fracture. (Zusman et al., 2017) Córcoles-Jiménez et al conducted a multicenter RCT with a similar cohort. In this study, in-hospital "urinary habit training" group and a control group receiving usual care were followed for 6 months. At follow-up, the intervention group had half the incidence of UI compared to the controls. (Córcoles-Jiménez et al., 2021)

Previous publications examining HF patients and reporting either prevalence or incidence of incontinence have been outlined in Table 1. Reported prevalence rates are higher and likely more generalizable in studies including patients living in long-term care or having cognitive impairment.

2.2.3 Incontinence as a risk factor for hip fractures

A handful of publications have investigated UI as a predictor for fragility fractures or injurious falls, and the results have been inconsistent. Brown et al followed community-dwelling older women (n=6,049, mean age 78) up to 3 years and reported that more than half had fallen during the follow-up and 9% of the had had a fragility fracture. At least weekly occurring UUI was associated with 1.34-risk of fractures compared to women without any UI. (Brown et al. 2000) Wagner et al also reported a connection between urgency/UUI and injurious falls in a study of younger general population (mean age 54, 60% women). Subjects with urgency/UUI also tended to have more fractures compared to the continent, but this effect did not reach statistical significance. (Wagner et al., 2002) Johansson et al examined the association between UI and HF in an age-cohort of 85-old women (n=658) of which 70% were community-dwelling and 30% living in long-term care. Women with UI had more than twice the risk of HF compared to controls. (Johansson et al., 1996) Hasewaga et al conducted a 6-months follow-up study in a long-term setting (n=1,082, 70% women, mean age 82.5±8.5), in which UI was examined as a predictor for injurious falls (defined as fractures, joint dislocations head injuries or hospitalization-requiring soft tissue injuries) and recurrent falls. UI was a risk factor for recurrent but not injurious falls. (Hasegawa, Kuzuya and Iguchi, 2010) In a large cohort of older women receiving community care in New Zealand (n=42,032, mean age 83), UI was associated with falls but not with HFs (Schluter et al., 2018). A nationwide prospective cohort study of nearly 40,000 Korean older adults found that older women with UI had a significantly higher incidence of HFs (and other fragility fractures) compared to continent controls. However, in multivariate models adjusting for multiple comorbidities, cognitive impairment, mobility and other factors, UI did not reach statistically significant predictive value. (Kim et al., 2018) The association with incontinence and HFs is closely related to falls which is discussed in chapter 2.4.

Table 1. Previous studies reporting incontinence among hip fracture patients.

REFERENCE, YEAR, LOCATION	N	SETTING	PARTICIPANTS	OUTCOME AND RESULTS	CORRELATES
Palmer et al.,1997, USA.	100	A retrospective cohort study. Data collected in two surgical hospitals1992-1993.	Men and women aged ≥ 55, mean age 78± 7.7 years, 69% were women. Institutionalized were excluded.	31% incidence of UI postoperatively 22% prevalence of UI in women pre-fracture	Incident UI associated with cognitive impairment
Palmer et al., 2002, USA.	6,516	A retrospective cohort study with 30 days of follow-up. Data collected in 20 surgical hospitals 1983-1993.	Women aged ≥ 60 both from the community, retirement homes, and long-term care.	21% incidence of UI at discharge from the hospital.	Incident UI associated with non-independent ambulation pre-fracture, admission from a nursing home, confusion
Villanueva et al.,2011, Spain.	754	A cross-sectional study. Data collected in private and public facilities of long-term care 1998-1999. Prevalence and associated factors of UI investigated.	Institutionalized men and women ≥ 65, mean age 83,4 ± 7,3, 75% were women.	Residents with a history of HF had a 72% prevalence for UI vs 49% in residents who did not.	
Alarcón T et al., 2011, Spain.	509	A prospective cohort study with 2 years of follow-up. Data collected in one university hospital 2003-2005. Barthel index was used.	Men and women aged ≥ 64, mean age 84.5± 6.3 years, proportion of women not reported. Critically ill and being unable to walk were excluded.	The probability for regaining bladder control was 79% at 6 months and 82% a 12 month, and 87% and 89% for bowel control. Pre-fracture prevalence of 37% for UI and 14% for FI.	
Sorbye et al.,2013, Norway.	331	A prospective cohort study with 1 year of follow-up. Data collected in two acute surgical hospitals 2004-2006.	Men and women aged ≥ 65, mean age 84 years, 80% were women. Communal living patients with hearing/vision impairment. Critically ill, severely cognitively impaired and institutionalized excluded.	Outcomes associated with prolonged UC use and pre-fracture UI 12-months post-fracture. 49% prevalence of UI pre-fracture	Prolonged UC use associated with delirium, UTIs and cognitive decline. UI associated with decline in functional ability, mortality and institutionalization.

REFERENCE, YEAR, LOCATION	N	SETTING	PARTICIPANTS	OUTCOME AND RESULTS	CORRELATES
Gosch et al.,2014, Austria.	1,857	A retrospective cross-sectional study. Data collected in a post-acute care hospital 2005-2011.	Men and women aged ≥ 65, mean age of 81.7 ± 6.7 years, 81% were women. All in-hospital patients included. Study included all fragility fractures, 58,6% were HFs.	59% prevalence of UI	UI associated with lower ADL scores, higher rates of immobility, cognitive impairment and depression.
Gonzáles-Zabaleta et al.,2015, Spain.	100	A prospective cohort study with 90 days of follow-up. Data collected in one university hospital 2009-2011. Barthel index was used.	Men and women, mean age 82.5± 8.4 years, 83% were women. All patients operated on HF were included.	Occasional bowel accidents 14% at baseline, 23% at 90 days. FI 9.0% at baseline, 21% at 90 days. Occasional bladder accidents 20% at baseline, 23% at 90 days. UI 13% at baseline, 27% at 90 days.	Baseline ADL score predicts functional decline in ADL activities at 90 days post-fracture.
Zusman et al., 2017, Canada.	53	A randomized controlled trial conducted in 2010 with a follow-up time of 1 year. Participants were randomized to an intervention group including CGA and personalized management for geriatric syndromes and control group with usual care only. Regarding UI, a continence nurse was consulted if necessary, in the intervention group.	Men and women aged ≥ 65, mean age 79.6± 7.9 years, 65% were women. Patients unable to ambulate, having cognitive impairment or discharged to long-term care from the hospital were excluded.	44% prevalence of UI at baseline. At 12 months, no statistically significant change in UI between groups was found.	At six-months UI was associated with lower quality of life.

REFERENCE, YEAR, LOCATION	N	SETTING	PARTICIPANTS	OUTCOME AND RESULTS	CORRELATES
Córcoles-Jiménez et al.,2021, Spain.	109	A multicenter randomized controlled trial in Spain. Randomization to “urinary habit training” intervention group and usual care. Intervention was performed during hospital stay with a reinforcement by phone 10 days after discharge.	Men and women aged ≥ 65, mean age 80.6± 6.7, 71% were women. Patients living in the community who were continent pre-fracture were included. Cognitively impaired were excluded.	Incidence of UI at 6 months post-fracture was 26% in intervention group vs 49% in controls with a statistically significant difference.	
Arroyo-Huidobro et al.,2024, Spain.	248	A prospective cohort study with 90 days of follow-up. Data collected in three acute surgical hospitals between 2019-2021.	Men and women aged ≥ 75, Mean age 85.8± 6.8 years, 78% were women.	62% incidence of UI at 30 days and 52% at 90 days. 59% worsening of pre-existing UI at 30 days and 63% at 90 days	Incident UI and worsening of pre-fracture UI associated with AUR and UTIs.

2.2.4 The role of urinary catheters

Virtually all patients suffering HF undergo surgical procedure under general anesthesia with a routine use of urinary catheter (UC). Prolonged (>24 hours) and thus inappropriate use of UCs is widespread in hospitals with older women and surgical patients at highest risk of being exposed to its adverse outcomes such as iatrogenic UTIs and more serious ensuing complications such as bacteremia and delirium. (Gould et al., 2010; Fang-wen Hu et al., 2015) A recent nation-wide Taiwanese case-control study demonstrated that especially older female HF patients are at a higher risk of severe UTIs (i.e symptomatic UTI requiring hospitalization) compared to controls without HF (Lin et al., 2021). Use of UCs has been demonstrated to be associated with increased risk of UTIs, prolonged hospital stay, functional decline, increased mortality and institutionalization in hospitalized older adults (Bootsma et al., 2013; Fang-wen Hu et al., 2015). The association with increased mortality has also been demonstrated with HF patients in multivariable adjusted analyses (Pajulammi et al. 2016). Sørbye & Grue reported in their cohort of older HF patients including men and women that 11% of the patients still had indwelling UC 72 hours after surgery. After 1 year of follow-up these patients had a higher risk of falling, were less physically active and had more dependency in ADLs. (Sørbye & Grue, 2013)

The use of UCs has been shown to result in symptoms of urgency and bladder spasms in nearly every fourth patient after the removal of the UC (Saint et al., 2018). AUR is one of the most common perioperative complications affecting more than half of women with HF. AUR increases the risk of UTI itself and necessitates the use of UC. (Adunsky et al., 2015) Importantly, UC also inhibits free movement and may delay mobilization of the patient in the early stages of rehabilitation (Morri et al., 2018). In hospitalized settings, UTIs and AUR after HF (Arroyo-Huidobro et al., 2024) and prolonged use of UC and other continence aids (Morri et al., 2018; Zisberg et al., 2011) have been shown to predict incident UI and worse recovery in older adults.

2.3 Incontinence and other intertwining geriatric syndromes

Incontinence may be present in different stages during a woman's lifespan. A young woman may have transient UI symptoms caused by UTI. A middle-aged multiparous woman may develop UI as a condition which is then treated with medication or operatively. Among older women, UI may be present concomitantly with physical, functional and cognitive impairment as well as other comorbidities and polypharmacy, transforming it to geriatric syndrome. Unsurprisingly this kind of UI is more challenging to treat, often necessitates a multimodal approach, and likely is the most common phenotype of UI in oldest age groups of women. (Parker-Autry & Kuchel, 2021; Sanses, Kudish and Guralnik, 2017) This phenotype of UI is sometimes referred to as 'geriatric incontinence' (Parker-Autry et al., 2021).

Geriatric syndromes have been inconsistently defined, and the lists of different syndromes included also varies. Incontinence, falls, frailty, physical and functional decline have been commonly referred to as geriatric syndromes, as are e.g. pressure ulcers, syncope, depression, delirium, and cognitive impairment. These syndromes share common risk factors such as advancing age and impairment across different domains of function. They are all also associated with poor outcomes. (Chong et al., 2018; Inouye et al., 2007) Compared to other geriatric syndromes, UI (and clearly FI and DI) has received little attention in the field of geriatric research as seen in Figure 1.

Rosso et al conducted a large observational study of nearly 30,000 community-dwelling older women and found that nearly 80% had at least one geriatric syndrome and over 10% had a minimum of three. UI was the most common geriatric syndrome in this group. The more geriatric syndromes women had at baseline, the greater the risk of developing disability at follow-up. (Rosso et al., 2013)

In a hospitalized setting, Bell et al discovered that over 90% of older adults referred to long-term care at discharge had at least one geriatric syndrome and more than half had at least three. Incontinence (39%) and falls (39%) were the most common geriatric syndromes in these patients including both men and women. Recognition and documentation of geriatric syndromes by attending physicians were poor and varied by syndrome. Only 8% of cases with FI and 10% of UI were mentioned in discharge documents as opposed to two thirds of falls. (Bell et al., 2016)

An intricate interplay of links between incontinence and other geriatric syndromes and factors have been established and summarized in Figure 2. In the context of HF patients, the most relevant other geriatric syndromes connected to and often co-occurring with incontinence, namely falls, frailty, immobility and cognitive impairment are outlined in the next sections.

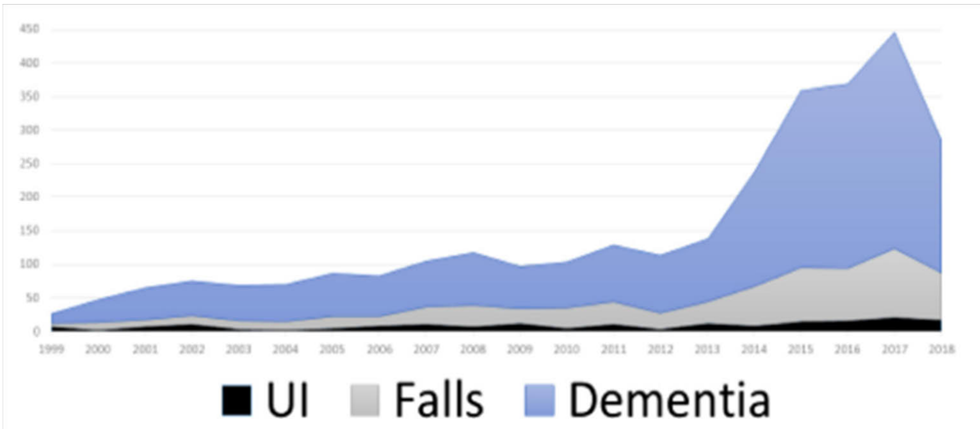

Figure 1. Review of publications between 1999-2018 on geriatric incontinence (black), in comparison to other geriatric syndromes of falls (gray) and dementia (blue). Reproduced from Parker-Autry C et al. 2021 with the permission of the copyright holder Elsevier.

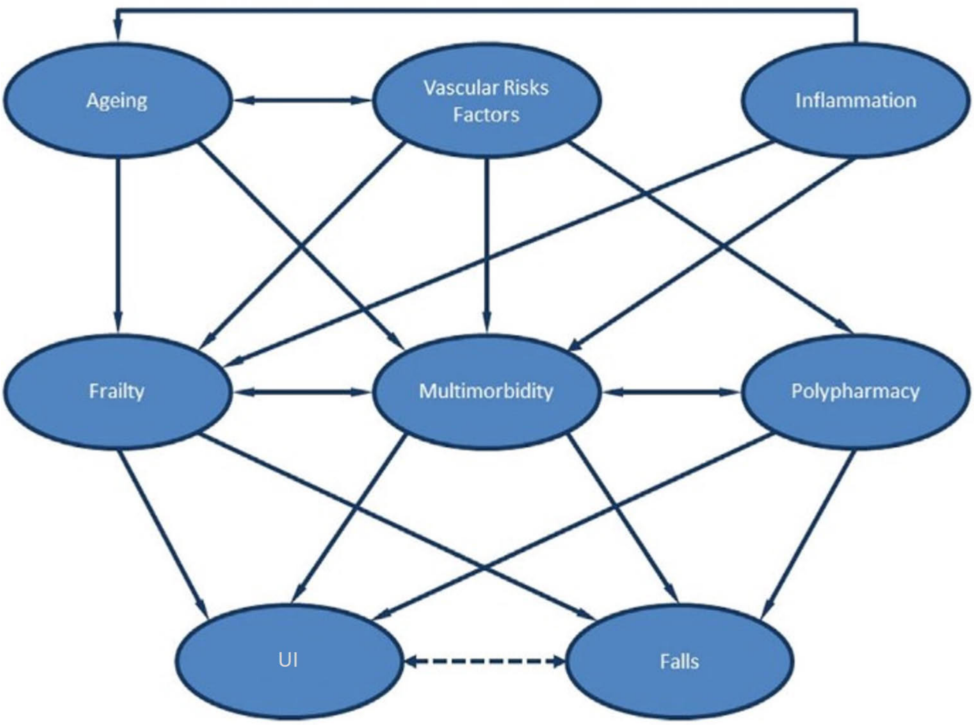

Figure 2. The network of links existing between UI and other geriatric syndromes and conditions. Reproduced and adapted from Gibson et al. 2018 with the permission of the copyright holder John Wiley and Sons.

2.3.1 Incontinence and falls

A considerable body of literature has concluded that older individuals with UI, predominantly UUI, have from 1.3- to 2.3-fold risk of falling compared to their continent peers. The risk is more pronounced in women than in men. (Chiarelli, Mackenzie and Osmotherly, 2009; Gibson et al., 2018; Szabo et al., 2018) In the English Longitudinal Study of Ageing, UI was found to be a risk factor for falls in women, but not in men (Gale, Cooper, and Sayer, 2016). A population-based Korean study discovered that UI was associated with falls and recurrent falls particularly in older individuals with cognitive and functional impairment (Moon et al. 2020). In a study by Schluter et al conducted in New Zealand, UI was an independent risk factor for falls in both men and women (Schluter et al., 2018).

Only a few studies have included subtypes of UI in their analysis when examining the association between UI and falls. Brown et al discovered that older women (n=6,049, mean age 78) living in the community with at least weekly UUI had an increased risk of falls compared to their continent peers. Respective risk was not found with SUI (Brown et al., 2000). Takazawa & Arisawa studied a selected cohort of older Japanese women who were users of day-care services (n=118, mean age 81). In this group of frail women with dependency on daily activities, MUI was associated with a three-fold risk of falling during 1-year follow-up. No association was found with UUI or SUI. (Takazawa & Arisawa, 2005) Foley et al conducted a cross-sectional study including both men and women aged $\geq$ 70 living in the community and found an association between both UUI and SUI and falls. Women had higher rates of both incontinence and falls, but the associations of UI and falls were not analyzed separately between the sexes. Individuals with physical limitations, urinary symptoms (e.g. pain while urinating) and larger volumes of leakage were more likely to fall. (Foley et al., 2012)

The mechanism behind the association between UI and falls, and particularly UUI and falls have raised speculation. Given that the main symptom is the sudden sense of urgency, rushing to the toilet has been proposed as a cause (Gale, Cooper and Sayer, 2016). However, Gibson et al demonstrated that sense of urgency in fact decreased gait velocity and stride length in a comparative way to a distracting task. Urgency might therefore increase the risk of falls by being a source of divided attention. (Gibson et al., 2021) A recent RCT supports this rationale. Mihaľová et al discovered that a 12-week program consisting of physical training three times per week combined with pelvic floor muscle training with dual cognitive tasks twice a week not only improved the symptoms of UI in older women with UUI but also reduced the risk of falls by approximately 20%. (Mihaľová et al., 2022) Indeed, there is emerging evidence that home-based integrated exercise and bladder training programs might have potential to target UI and falls, two commonly co-occurring geriatric syndromes, simultaneously and effectively thus decreasing morbidity and enhancing quality of life in older women. (Reaves et al., 2023)

The treatment of choice for UUI has for a long time been antimuscarinic drugs which alleviate the symptoms of urgency. Hypothetically, effective treatment of UUI might also reduce the risk of falls. However, antimuscarinic drugs have several adverse effects which are especially detrimental in older individuals: Dizziness, constipation, somnolence, cognitive impairment and AUR have been reported. In the frail older individuals these adverse effects can amount to delirium. The adverse effects of these drugs might therefore partly explain the connection between UUI and falls. Unfortunately, there is virtually no research on the subject and therefore there is not sufficient evidence to support either hypothesis. (Hunter et al., 2011)

Fisher et al demonstrated that increasing burden of comorbidities with co-existing symptoms of urgency, UI and nocturia correctly identified older women aged 65 and over who had increased risk of falling (Fisher et al. 2023). Given that UI has been linked with several specific comorbidities such as diabetes mellitus and neurological diseases which are also risk factors for falls, cumulative effects of these conditions may amount to increased risk of falling (Gibson et al. 2018). A strong link between impaired mobility, frailty and incontinence have been established (Veronese et al., 2018), as outlined in the next chapters. It is plausible that no causal link exists between incontinence and falls and rather both represent the vulnerability of the affected individual. Potential and known links between UI and falls are summarized in Figure 3.

Existing literature on FI or DI and falls is very limited. Yuaso et al found in their study of Brazilian women aged 65 and over that falls during previous year was a risk factor for incident DI (Yuaso et al., 2018). A retrospective cohort study by Kravitz et al found that women aged 65 or over with DI had a two-fold risk of falling compared to women with UI alone (Kravitz et al., 2024). In another study by Schluter et al, older women with any FI had a slightly higher risk of falling compared to their continent counterparts (Schluter et al., 2020).

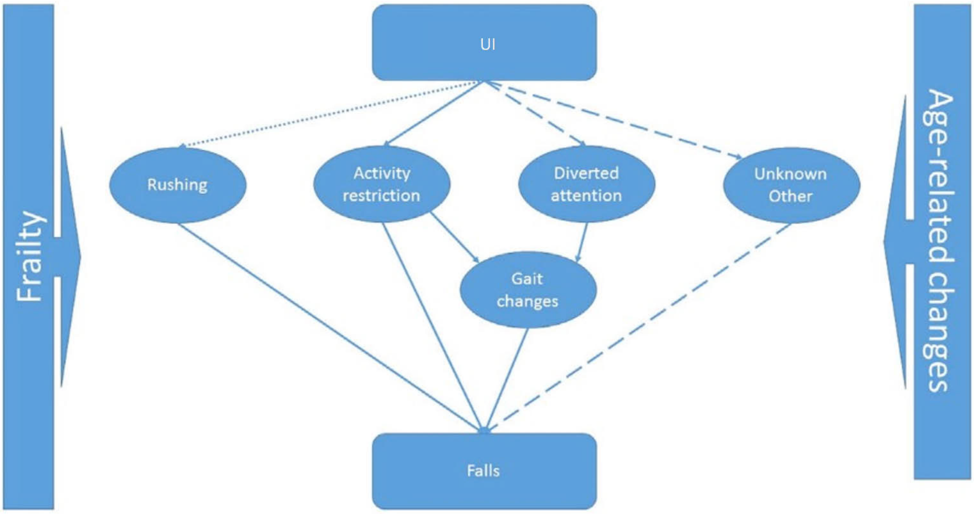

Figure 3. Potential (dashed line), known (solid line), suggested (dotted line) and likely incorrect links between UI and falls. Reproduced and adapted from Gibson et al. 2018 with the permission of copywrite holder John Wiley and Sons.

2.3.2 Incontinence and mobility

Incontinence has various negative impacts on the life of an older woman. One major factor is the individual's voluntary restriction of physical activity due to the fear of leakage. Women with frequent UI are more likely to be physically inactive compared to their peers with less symptoms or no UI. (Erekson et al., 2015) A strong link between UI and mobility problems have been demonstrated (Stenzelius et al., 2004).

Correa et al examined the association between self-reported UI and physical performance according to SPPB (Short Physical Performance Battery) after a follow-up of 2 years among older women (n=915, mean age 71) living in the community. Women with UI at baseline had a worse initial performance and steeper decline in the physical performance over two years compared to their continent peers. (Corrêa et al., 2019) Parker-Autry et al also utilized SPPB for the measurement of physical performance and discovered that older women (n=673, mean age 74) with incident UI after four years of follow-up had a significant decline in physical function during follow-up compared to the women who remained continent. This study also found that sarcopenia, defined as decline in skeletal muscle mass and function, developed at a higher rate in women with incident UI. (Parker-Autry et al., 2017)

Several studies have examined the association between physical activity and function between different subtypes of UI with inconsistent results. A prospective study by Okumatso et al followed 890 older community-dwelling women for four years and examined the association of lower extremity physical function and incident UI. Better lower extremity physical function had a protective effect against incident

UUI and MUI, but no such association was found with SUI. (Okumatsu et al., 2021) Bauer et al reached similar results in their large prospective cohort study of nearly 20,000 older women. Self-reported higher physical activity was significantly correlated with a lower risk of incident UUI and MUI, but not SUI. (Bauer et al., 2021) Fritel et al found a significant association with impaired mobility and balance skills and UUI, but not SUI, among community-dwelling women aged 75–85 (Fritel et al., 2013). Danforth et al found physical activity to be associated with around 20–25% risk reduction of developing any UI among older community-dwelling women (n=2,355, age 54–79). In subgroup analysis the association was stronger for SUI compared to UUI. (Danforth et al., 2007) In a similar setting, Suskind et al found declining muscle strength to be a risk factor for incident and persisting SUI but not for UUI in older women (n=1,475, age 70–79) living in the community (Suskind et al., 2017).

The current literature seems to support a bi-directional relationship between UI and decline in physical function and mobility in older women: Impaired mobility and physical function can amount to incident UI or exacerbation of existing UI through weakened over-all skeletal muscle and pelvic floor function, and women suffering from UI may voluntarily restrict their physical activity in fear of urine leakage which in turn leads to impaired mobility and physical function over time. (Gibson et al., 2018; Sanses, Kudish and Guralnik, 2017)

Although respective literature concerning FI and DI is thin, similar bidirectional assumptions can be made for these conditions, especially since patients with FI and DI are known to represent a frailer group compared to UI in isolation (Matthews 2014; Hassani, Arya, and Andy, 2020). Stenzelius et al demonstrated a link between mobility problems and DI among older women aged 75 and over (Stenzelius et al. 2004). Staller et al examined over 50,000 older women in the Nurse's health study and found higher levels of physical activity to result in 25% lesser risk of incident FI (Staller et al. 2018).

2.3.3 Incontinence and frailty

Frailty is a common and highly age-associated multifactorial syndrome in older adults and a harbinger of various adverse outcomes such as functional decline, institutionalization and death (Fried et al., 2001; Suskind, 2017; Veronese et al., 2018). Frailty has been presented as a phenotype with the following components: exhaustion, weight loss, low physical activity, slowness and weakness (Fried et al., 2001). Another approach is the accumulation of deficits related to ageing and combining these into a frailty index (Rockwood et al., 2007). Regardless of the conceptualization, frailty can be seen as a clinical state in which an individual has increased vulnerability to outer stressors resulting from multisystem physiological changes and diminished reserves

(Fried et al., 2001; Rockwood et al., 2007). According to a systematic review, approximately 11% of older adults living in the community can be considered as frail and another 42% prefrail, respectively (Collard et al., 2012). In acute hospitalized settings, up to half of older patients have been found frail (Chong et al., 2018). Among HF patients specifically, prevalence rates of frailty between 22 and 81% have been reported (Forssten et al., 2023; Yan et al., 2022).

According to a systematic review and meta-analysis, UI affects approximately 40% of frail older individuals making it twice as likely among the frail as compared to the robust. Causes and precipitating factors of UI in frail older adults tend to lie outside the urinary tract with impaired mobility, functional status and cognitive ability as well as polypharmacy listed as relevant factors. (Veronese et al., 2018) In a longitudinal study concerning men and women aged between 65-89 years (median age 73 years) found subjects with UI to have a 6.5-fold risk of being frail and a 2.3-fold risk of being prefrail compared to the continent subjects (Berardelli et al., 2013). Chong et al demonstrated a strong correlation between frailty and UI in hospitalized older (mean age 89.4±4.6 years, 70% women) adults. Moreover, frail subjects had a nearly three-fold risk of incident UI up to one year of follow-up. (Chong et al., 2018)

The relationship between frailty and UI is complex and likely resembles the cyclic association between UI and immobility/physical function. Cumulative adverse outcomes of UI, such as functional decline and impaired mobility, may amount to frailty over time. Conversely a frail individual may develop UI as a complication of advancing frailty, e.g. when exposed to outer stressors, such as an infection or a hospitalization. (Chong et al., 2018; Gibson, Johnson, et al., 2021; Suskind, 2017). Given that HF patients have very high prevalence rates of both frailty (Forssten et al., 2023; Yan et al., 2022) and incontinence (Arroyo-Huidobro et al., 2024), frailty is likely the common nominator for these conditions in this patient group. UI can be considered a marker for frailty (Gibson et al., 2018; Gibson, Johnson, et al., 2021; Suskind, 2017) which might be a clinically relevant factor in HF patients.

No studies examining the association between frailty and FI or DI directly were found. However, DI and FI are highly correlated with advancing age, functional and physical disability and comorbidities, which can be considered indicators of underlying frailty. Moreover, individuals with either FI or DI are considered frailer than those with UI in isolation (Matthews et al., 2013; Stenzelius, Westergren and Hallberg, 2007; Wu et al., 2015; Yuaso et al., 2018).

2.3.4 Incontinence and cognitive impairment

There is a well-recognized connection between incontinence and cognitive impairment with highest reported prevalences of incontinence occurring in populations with cognitive disorders (Offermans et al., 2009). Incontinence is multiple times more prevalent among cognitively impaired individuals than among those with intact cognition. Impaired cognition and apraxia disrupt normal toileting and self-hygiene, increasing dependency on caregivers as the disease progresses (Gibson et al., 2021). Furthermore, behavioral symptoms such as apathy or agitation may contribute to inappropriate voiding behaviors (Drennan et al., 2013). UI is considered a diagnostic feature in normal pressure hydrocephalus and dementia with Lewy bodies, where it usually emerges in early stages of the disease. In contrast, incontinence generally develops in later stages of Alzheimer's and Parkinson's diseases (Panicker, Fowler and Kessler, 2015).

Individuals with cognitive impairment are prone to develop other geriatric syndromes such as falls (Mecocci et al., 2005). The likely explanation for this is the close relationship between cognitive impairment and physical frailty which has been demonstrated repeatedly in literature. The term cognitive frailty has been coined to describe the co-occurrence of both conditions, although a clear and universally accepted definition has yet to be established.(Arai et al., 2018)

Cognitive impairment has been shown to be an independent risk factor for HF (Wang et al., 2014). Moreover, cognitive impairment has been shown to predict UI (Palmer, Myers and Fedenko, 1997) and is associated with prevalent UI (Gosch et al., 2015) among patients with HF. A recent meta-analysis reported that 37.0–50% of older surgical patients had unrecognized cognitive impairment (Kapoor et al., 2022). Similarly, among patients with HF, known or emerging cognitive impairment has been found in up to 50% of the cases (Jaatinen et al., 2020). Importantly, cognitively impaired patients with HF tend arrive at the emergency department later and in poorer clinical state and face higher risks of complications and mortality compared to patients with normal cognition (Birkner et al., 2025). High prevalence of cognitive impairment among HF patients (Jaatinen et al., 2020) likely is a contributing factor for the high prevalence of incontinence in these patients (Arroyo-Huidobro et al., 2024).

2.4 Incontinence and institutionalization

An estimated 10% of admissions of older women to long-term care have been attributed to UI (Morrison & Levy, 2006). Several studies have investigated whether UI is an independent predictor of institutionalization, and the results have been inconclusive (Luppa et al., 2009). Tilvis et al found UI to be a predictor of institutionalization after adjusting for age and gender in general aged population. After adjusting for cognitive impairment, the statistical significance was lost. (Tilvis et al., 1995) An earlier study by Drachman et al found UI to be a predictor of institutionalization among cognitively impaired older individuals alongside advancing stage of memory disorder and behavioral disorders (Drachman et al., 1992.). Incontinence significantly burdens formal and informal caregivers (Talley et al., 2021) which may in part explain the connection.

Thom et al found that older women with UI had a two-fold risk of institutionalization compared to their continent counterparts after adjusting for age, gender and multiple co-morbidities including cognitive impairment. The risk was over three-fold in men (Thom, Haan and Van Den Eeden, 1997). In two other studies, an independent association between UI and institutionalization was found in older men, but not in women. According to the authors, the gender difference might be explained by the fact that women are more prone to develop UI earlier in life and thus it might not have such a strong connection with disability and dependency in old age. (Matsumoto & Inoue, 2007; Nuotio et al., 2003)

A population-based cohort study following community-dwelling older women and men for two years found that subjects with UI were more likely to be institutionalized compared to the continent, but UI was not a predictor independently. Co-existing baseline morbidity and functional impairment were surmised to mediate the link between UI and institutionalization. (Holroyd-Leduc, Mehta and Covinsky, 2004)

The most recent study on the subject found that UI predicted a permanent placement to long-term care among older individuals (mean age 82.9±11.2, 70% women) in assisted living communities (Ajay et al. 2025). The only other study from 2020s is a Belgian study investigating predictors of institutionalization among community-dwelling men and women aged ≥ 65. Among several other predictors, UI was associated with a 1,5-fold of institutionalization over a median follow-up of 5 years. (Berete et al., 2022)

Sørbye and Grue observed that HF patients with pre-fracture UI had a four-fold risk of institutionalization 1-year post-fracture compared to the continent. However, UI was not evaluated as an independent predictor in multivariate modeling (Sørbye & Grue, 2013).

The association between FI and institutionalization has been investigated in a few studies. Schluter et al studied a general aged population receiving community care in New Zealand in a large cohort of over 30,000 people (mean age 82, 64% women) and found UI to be independent risk factor for more supported living arrangements whereas FI was not (Schluter et al., 2017). A Canadian study followed over 9,000 community dwelling older individuals aged ≥ 65 for 10 years and found individuals with FI to have higher risk of institutionalization after adjusting for age and sex, but the association lost its predictive value after adjusting for cognition, functional decline and self-reported health (Alameel, Andrew and MacKnight, 2010). Grover et al discovered that the presence of FI increased the likelihood of placing the subject to long-term care markedly more than UI. Strongest predictors were impaired mobility, cognitive decline and multimorbidity, but co-existing FI still increased the likelihood of referral further. (Grover et al., 2010)

Several authors have stated in their articles that DI is thought to be a frequent cause for institutionalization in older people (Matthews, 2014; Wu et al., 2015; Yuaso et al., 2018). However, no previous literature directly examining the association between DI and institutionalization was found in this review of literature.

2.5 Incontinence and mortality

Research on the association between UI and mortality has produced inconsistent results over the years. According to a meta-analysis pooling the data of 38 studies and over 150,000 patients mainly in general geriatric populations found that individuals with UI had a two-fold risk of death compared to the continent. However, the hazard ratio (HR) was reduced to 1.3 when results of only adjusted models were pooled. Authors state that the association of UI and mortality is connected to advancing age, disability and comorbidities.(John et al., 2016) Another meta-analysis concentrating solely on older adults in long-term care also found UI to be a predictor of increased mortality (Huang et al., 2021).

Berardelli et al studied the connection between UI and mortality among two age groups of both men and women:65–89 (median age 73) and 90–107 (median 92). In the younger age group UI was not independently associated with mortality after controlling for age, sex and frailty status, not even when symptoms were severe. However, in the older age group of ultra-nonagenarians, severe UI was associated with increased mortality independently after adjusting for frailty. (Berardelli et al., 2013) Matta et al demonstrated that UI lost its association with mortality after adjusting for a comprehensive 45-item frailty index, thus explaining the difference in mortality between older men and women with and without UI.(Matta et al., 2020) Two older studies conducted in the 1990s followed over 6,000 community-dwelling older men and women for 9 years (Thom, Haan and Van Den Eeden, 1997) and two years (Holroyd-Leduc, Mehta and Covinsky, 2004) and found mortality rates to be higher in individuals with UI. However, after adjusting for comorbidities and functional impairments, no significant independent association was found, and frailty was thought to be the mediator of the connection.

Nakanishi et al found an association between severe incontinence and increased mortality among older home-dwelling individuals. Both UI and FI were elicited and analyzed together according to the severity of the symptoms. (Nakanishi et al., 1999) Jamieson et al conducted a retrospective analysis of a large cohort of over 40,000 older home-dwelling individuals with home care and analyzed UI and FI separately. After adjusting for confounders, FI remained independently associated with increased mortality whereas UI did not. (Jamieson et al., 2017) Nuotio et al discovered that in a cohort of both home-dwelling and institutionalized older individuals, FI and UI were not associated with increased six-year mortality after adjusting for comorbidities and functional disabilities. (Nuotio et al., 2009) No studies examining the association between DI and mortality were found.

The study by Sørbye and Grue was the only publication found to examine the association between UI and mortality in a cohort of HF patients. Patients with prefracture-UI had twice the mortality rate compared to those with no UI. These patients were also older, had more functional dependency and were institutionalized four times more often than their continent counterparts during one-year of follow-up. The analyses were descriptive; UI was not tested as an independent predictor of mortality. (Sørbye & Grue, 2013)

In all, current literature suggests that incontinence primarily reflects the disability and frailty of the affected individual. Even in studies where incontinence remained correlated with mortality after adjusting for comorbidities and frailty, the HRs were consistently small. (Berardelli et al., 2013; Huang et al., 2021; Jamieson et al., 2017; John et al., 2016; Matta et al., 2020; Nakanishi et al., 1999; Nuotio et al., 2009)

3 Aims

The primary aims of this thesis were to establish prevalence and incidence of incontinence and associated factors, predictors of incontinence and whether incontinence predicted different outcomes in older women with HF.

The specific aims were the following:

1. To establish the prevalence of UI and DI at the time of the fracture and six-months post-fracture and examine whether baseline variables and domains of the outpatient CGA were associated with incontinence six-months post-fracture. (I)
2. To further examine the prevalence and associated factors of different subtypes of UI six-months post-fracture. (II)
3. To examine whether UI or DI predicted changes in mobility or living arrangements 1-year post-fracture. (III)
4. To examine whether UI or DI predicted increased mortality, and which factors predicted incident symptoms 1-year post-fracture. (IV)

4 Materials and Methods

4.1 Study Population

The study data was obtained from the Seinäjoki Hip Fracture Database, which was established in 2007 as part of an orthogeriatric collaboration project. This database includes all patients aged 65 and older who experienced their first HF during the data collection period. (Pajulammi et al., 2017)

Data for the study was prospectively collected between September 2007 and January 2019 within the Hospital District of Southern Ostrobothnia, covering a population of approximately 200,000. All patients received treatment at Seinäjoki Central Hospital, the sole provider of surgical care in the region. The only exclusion criteria were pathologic and periprosthetic fractures.

This dissertation focuses exclusively on women aged 65 and older. While all studies (I–IV) used data from the same database, the study cohorts varied in size depending on the specific study design and follow-up duration.

4.2 Study design and data collection

A local hip fracture care pathway was established during the early years of data collection and stabilized as a permanent model of care 2009 onwards. It involved close collaboration between orthopedic surgeons and geriatricians and a multidisciplinary CGA during hospitalization. Special attention was given to early mobilization, nutrition, detection of complications such as delirium, prompt removal of UCs and review of medications. The care pathway included comprehensive instructions on peri- and postoperative care, the in-hospital-CGA as well as discharge criteria and post-discharge recommendations. Implementation of the orthogeriatric program has led to several quality improvements of care. (Pajulammi et al., 2017)

Observational prospective data was collected at several timepoints. During hospitalization, a trained geriatric nurse interviewed the patients or their proxies (next of kin or caregiver) and retrieved written informed consent. The perioperative interview was structured and contained detailed information on the circumstances of the fall, patient’s living arrangements, mobility, continence status (see below), level of assistance and services required before the fracture as well as known diagnosis of memory disorder. An assessment of nutritional state was carried out utilizing Mini Nutritional Assessment Short Form (MNA-SF)(Rubenstein et al., 2001) during the stay in the orthopedic ward. Data were also elicited from patients' medical records, and when necessary, the place of residence was contacted for additional or missing information. The preoperative American Society of Anesthesiologists (ASA) risk score represented general health at baseline with five classes: 1) healthy person, 2) mild systemic disease, 3) severe systemic disease, 4) severe systemic disease that is a constant threat to life, and 5) a moribund person not expected to survive without surgery (Sankar et al., 2014).

All patients were also invited to an outpatient-CGA 4-6 months after discharge from the hospital. A multidisciplinary team led by a geriatrician or a resident in geriatric medicine performed the outpatient-CGA. Patients were invited together with their next of kin or carer. A geriatric nurse conducted an initial interview and carried out different domains of the outpatient-CGA with instruments listed below.

- Cognition: Mini Mental State Examination (MMSE) (Folstein et al., 1975)
- Nutrition: Mini Nutritional Assessment Short Form (MNA-SF) (Rubenstein et al., 2001)
- Mood: 15-item Geriatric Depression Scale (GDS-15)(Brown et al., 2005)
- Functional ability: Instrumental Activities of Daily Living (IADL) (Lawton et al., 1969)

During the interview at the outpatient-clinic, patient's continence status was established using short survey-like questions which were predetermined by the study crew. Definitions of different types of incontinence based on these questions and used in the present study are listed in Table 1. The definitions align with the reports of ICS (Sultan et al. 2017a; Haylen et al. 2010). Information on new falls after fracture, constipation and currently used medications were also retrieved during the interview and BMI was measured.

Table 2. Definitions of incontinence types used in the study based on questions asked by the geriatric nurse during the patient interview.

Type of incontinence	Definition
UI	Any reported loss of urine (yes/no)
FI	Any reported loss of feces (yes/no)
DI	Yes to both questions on UI and FI
SUI	UI during physical exertion such as lifting or coughing
UUI	UI associated with sudden urge to void
MUI	Symptoms of both SUI and UUI reported

A physiotherapist assessed the patient's physical function using the following tools:

- Timed Up and Go -test (TUG) (Viccaro, Perera and Studenski, 2011)
- Elderly Mobility Scale (EMS) (Smith, 1994)
- Grip strength measured in the stronger hand with a Jamar dynamometer. Defined as weakened if less than 16 kg. (Alley et al., 2014)

The same geriatric nurse contacted the patients or their representatives by phone to collect follow-up data 1-year after the HF. During the telephone interview, the questions on continence, mobility and living arrangements were repeated. If the patient had died before the out-patient CGA or 1-year follow up call, the dates of death were retrieved from the National Population Register Center and extracted from the medical records. Mortality follow-up was complete with no data lost.

The data collected (I-IV) in all three time points have been summarized in Table 2. Most of the data was collected and saved in the original database in categorized form. Number of regularly taken medications was categorized into three classes of less than four, from four to ten, and more than ten medications. Similarly, mobility was categorized into the following levels: outdoors without help, indoors without help, indoors only with help, and unable to walk. Living arrangements categories were home without any services, home with organized home care, assisted living accommodation (no staff during the night) and institution (staff present at all times). The categories of mobility and living arrangements were adopted from the original British National Hip Fracture Database (FFFAP 2022). Removal of UC was split in two categories of "removed during the stay in central hospital" or "were discharged with indwelling UC". Data on cognitive disorder, incontinence, constipation and new falls was collected and saved with yes and no answers.

Table 3. Data collected after hip fracture.

At baseline	At the outpatient clinic 4-6 months after HF	1 year after HF
age	MMSE	living arrangements
fracture type	IADL	mobility level
ASA-score	GDS-15	continence status
living arrangements	EMS	
mobility level	TUG	
memory disorder	grip strength	
number of medications	number of medications	
MNA-SF	MNA-SF	
time of removal of UC	constipation	
continence status	continence status	
	new falls after HF	
	BMI	
date of death	date of death	date of death

4.3 Study methods and patients

4.3.1 General

For statistical purposes, all variables were categorical and most of them dichotomized. The categorization of variables used in studies I–IV are presented in tables 4–5 in the next chapter. In the original database, ADLs were evaluated using Physical Activities of Daily Living Index (PADL) introduced by Katz (Katz, 1976). However, as it includes a domain on incontinence, an issue with multicollinearity was encountered and EMS was used to present ADL instead in studies I and II.

A different cohort of women was generated for each study. The prevalence of isolated FI was found to be extremely small (n=18, 1% of the study cohort) and thus excluded from studies I, III and IV. In study II which investigates UI only, FI was added as an associated factor.

4.3.2 Study I

Study I included women who participated in the out-patient CGA and had data on continence status before HF and at the outpatient clinic 6 months post-fracture. After exclusion of missing data on baseline and at the outpatient clinic, the few women with FI only and those who were either deceased or didn't attend, a final sample of 910 women was reached. The outcomes were prevalent UI and DI 6-months post-fracture with the continent as a reference.

4.3.3 Study II

Study II was a cross-sectional examination of associations between outpatient domains and different subtypes of UI 6-months post-fracture. Of the 1,675 women, 307 had died and 262 did not attend the outpatient-CGA. A total of 1,106 women attended the CGA. Data on continence status or subtype of UI was missing from 194 patients, leaving 912 women with the data on continence at 6-month post-fracture. After further exclusions of patients with missing data on covariates, a final sample of 779 women was generated.

4.3.4 Study III

Study III investigated two outcomes: more supported vs same or less supported living arrangements and declined vs same/better mobility at 1-year post-fracture. The original categorization of mobility and living arrangements in the hip fracture database (see previous section 4.2). were dichotomized by using the change in levels of mobility/living arrangements between baseline and the end of 1-year follow-up time. For example, if the patient lived in own home without services before HF and had moved to assisted living by the end of first year after HF, the outcome was more supported living arrangements. Two separate study cohorts were generated for the mobility and living arrangements outcomes. For the mobility outcome, patients unable to ambulate at the time of the fracture were excluded. Similarly for the living arrangements outcome, patients already living in an institution at the time of the fracture were excluded.

In the mobility cohort, 21 women were unable to walk at baseline, and data was unavailable for 9 women, resulting in a cohort of 1,645 women. Among them, 375 passed away during follow-up, data was missing for 32, and 12 were affected solely by FI, leaving 1,226 women eligible for the analysis on change of mobility.

In the living arrangements cohort, 29 women were already institutionalized before HF, and data was missing for 8 women. An additional 270 women passed away within the first year, data was unavailable for 37, and 13 were affected only by FI, resulting in a final sample of 1,055 women eligible for analysis.

4.3.5 Study IV

Study IV had two different outcomes: mortality and incident UI or DI 1-year after HF. For the survival analysis, after exclusions of 189 women with missing data and 18 women with FI only, 1,468 women with the data on continence status at baseline were included. For the analysis of predictors of incident symptoms, a cohort of continent women at baseline was created. Out of 1,675 women, 614 were continent pre-fracture. Of these women, 78 died during follow-up and 96 had missing data on continence status 1-year post-fracture, leaving 436 women eligible for analyses.

4.4 Statistical analysis

Groupwise comparisons of characteristics of the different continence groups were examined using Pearson's Chi^2 or Fisher's exact tests. Adjusted analyses were performed using binary or multinomial logistic regression or Cox proportional hazards models. All tests were two-sided and p values < 0.05 were considered statistically significant. IBM SPSS Statistics versions 25.0 (I, III, IV) and 27.0 (II) for Windows software (SPSS Inc. Chicago, Illinois) was used for statistical analyses. Details on statistical analyses in each study are outlined below.

Study I. Distributions of baseline characteristics and outpatient domains between the continence groups were compared using Pearson's Chi^2-test or Fisher's exact test. Age- and multivariable-adjusted multinomial logistic regression analyses with odds ratios (OR) and 95% confidence intervals (CI) were conducted to examine the associations of both the baseline variables and outpatient domains with UI and DI at follow-up using the continent group as a reference.

Study II. Distributions of characteristics between the continent and different UI subtype groups were compared using Pearson's Chi2-test or Fisher's exact tests. Multivariable-adjusted multinomial logistic regression analysis with ORs and 95% CIs was conducted to examine the associations of the outpatient domains with SUI, UUI and MUI at follow-up using the continent group as a reference.

Study III. Age- and multivariable-adjusted logistic regression analyses with ORs and 95% CIs were conducted to evaluate the association of pre-fracture UI and DI and other baseline variables with the outcome variables of changes in mobility and living arrangements 1-year after HF.

Study IV. Age- and multivariable-adjusted Cox proportional hazard regression analyses with HRs and 95% CIs were conducted to examine associations of UI and DI and other baseline variables with 1-year mortality. Assumptions of Cox regression proportional hazard analysis were tested and confirmed. Age- and multivariable-adjusted multinomial regression analyses were also performed to identify predictors of incident UI or DI 1-year post-fracture.

4.5 Ethical Issues

The study design was approved by the Ethics Committee of the Hospital District of Southern Ostrobothnia. The study complies with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. All the participants or their representatives gave informed consent.

5 Results

5.1 Characteristics of the study population

In the entire cohort of 1,675 women, the mean age of the patients was 83.95±7.2 (range 65–105). Before the fracture, 31% of the women lived in an institution, 30% had a known cognitive disorder, 39% had a poor nutrition and 50 % could not ambulate without aid. The type of HF was intracapsular in 60% of the cases. In 46% of the women, UC was not removed before discharge from the central hospital. The median length of stay in the central hospital was 5 days (interquartile range [IQR] 2–8 days). The outpatient-CGA took place in a median time of 6 months (IQR 4–6 months) after HF.

5.2 Prevalence and incidence of incontinence (I, II, IV)

This dissertation presents prevalence rates of different types of incontinence among older women with HF a) before HF, b) 6 months post-fracture and c) 1 year after HF. Incidence of incontinence was established at one-year post-fracture.
Before HF, out of 1,486 women with data on continence status available, 614 (41%) were continent, 680 (46%) had UI and 174 (12%) had DI respectively. (I, IV)

Out of 910 surviving women evaluated at the outpatient clinic 4–6 months after HF, 343 (38%) remained continent, 469 (52%) had UI and 98 (11%) had DI. Continence status had improved (i.e. reverted from UI or DI to continent or from DI to UI) in 113 (12%) and got worse (i.e. advanced from continent to either UI or DI or from UI to DI) in 216 (24%) of the women (I). Among women with UI at the outpatient clinic, the prevalence of different UI subtypes was 117 (28%) for SUI, 183 (44%) for UUI and 119 (28%) for MUI when calculated from the smaller study cohort of 779 women (II).

After one year of follow-up, continence status was known from 1,000 (67% from the original 1,486 cohort) surviving women. Of these women, 374 (37%) were continent, 430 (43%) were affected by UI and 196 (20%) by DI respectively. During the first year after HF, continence status had improved in 120 (12%) and worsened in 256 (26%) women. Of the 614 women who were continent before HF, 128 (21%)

were affected by new-onset UI and 23 (4%) by new-onset DI by the end of follow-up. (IV)

5.3 Factors associated with urinary and double incontinence (I)

Distributions of baseline characteristics and outpatient-CGA domains across the different continence groups are presented in Tables 4 and 5. Women with incontinence, especially DI, were more likely to be older, more medicated, with poor nutrition, non-independent mobility and institutionalized than women without UI or DI. In age-adjusted univariate analyses, UI at follow-up was linked to several baseline factors, including being over 80 years old, taking 10 or more regular medications daily, having a cognitive disorder diagnosis, lacking independent mobility, residing in an institution, experiencing poor nutrition, delayed removal of UC, and pre-fracture UI or DI. Similarly, in age-adjusted univariate analyses, DI at follow-up was associated with baseline characteristics such as being between 80 and 89 years old, an ASA score greater than 2, taking at least four daily medications, a cognitive disorder diagnosis, impaired mobility, poor nutrition, delayed UC removal, and a history of UI or DI. All CGA domains except grip strength were associated with UI and DI at six months after adjusting for age. Additionally, observed constipation and new falls following the fracture were significantly correlated with both UI and DI at follow-up after adjusting for age.

In multivariate models of baseline factors, UI at follow-up was independently associated with being over 90 years old, a prior diagnosis of cognitive disorder, and pre-fracture history of UI or DI. Furthermore, in the outpatient CGA, UI was also independently linked to difficulties in IADL, depression according to GDS-15, abnormal EMS scores, and self-reported constipation in the multivariable-adjusted models. The multivariable-adjusted analyses for DI at follow-up identified independent associations with non-independent mobility, residing in long-term care, delayed UC removal, and prior UI or DI at baseline. Additionally, DI was independently linked to challenges in IADL, abnormal EMS scores, and poor nutrition as observed in the outpatient CGA. The results of the multivariable adjusted analyses are presented in tables 6 and 7.

Table 4. Distribution of the baseline indicators according to continence status (N=910) at 6 months post-fracture. Differences (p-value) between the continence groups were tested using Pearson chi-square test or Fisher's exact test.

		continent n=343		UI n=469		DI n=98		
	N	**n**	**(%)**	**n**	**(%)**	**n**	**(%)**	**p**
Age								<0.001
65–79	273	133	(39)	113	(24)	27	(28)	
80–89	504	177	(52)	274	(58)	53	(54)	
≥ 90	133	33	(10)	82	(18)	18	(18)	
Fracture type								0.038
Intracapsular	564	230	(67)	276	(59)	58	(59)	
Extracapsular	344	112	(33)	193	(41)	39	(40)	
Not known	2	1	(0)	0	(0)	1	(1)	
ASA								0.013
1–2	154	75	(22)	71	(15)	8	(8)	
3–5	742	264	(77)	390	(83)	88	(90)	
Not known	14	4	(1)	8	(2)	2	(2)	
Number of medications								0.001
< 4	171	84	(25)	80	(17)	7	(7)	
4–10	584	211	(62)	301	(64)	72	(74)	
> 10	155	48	(14)	88	(19)	19	(19)	
Cognitive disorder								<0.001
No	682	307	(90)	320	(68)	55	(56)	
Yes	227	36	(11)	148	(32)	43	(44)	
Not known	1	0	(0)	1	(0)	0	(0)	
Mobility								<0.001
Independent	567	270	(79)	267	(57)	30	(31)	
Non-independent	340	71	(21)	201	(43)	68	(69)	
Not known	3	2	(1)	1	(0)	0	(0)	
Living arrangements								<0.001
Home	707	309	(90)	353	(75)	45	(46)	
Institution	199	34	(10)	112	(24)	53	(54)	
Not known	4	0	(0)	4	(1)	0	(0)	
MNA-SF before HF								<0.001
Normal (12-14)	428	179	(52)	220	(47)	29	(30)	
Poor nutrition (< 12)	302	77	(22)	180	(38)	45	(46)	
Not known	180	87	(25)	69	(15)	24	(25)	
Removal of UC								<0.001
During hospital stay	530	228	(67)	263	(56)	39	(40)	
Later	372	113	(33)	200	(43)	59	(60)	
Not known	8	2	(1)	6	(1)	0	(0)	
Continence before HF								<0.001
Continent	431	268	(78)	149	(32)	14	(14)	
Urinary incontinent	406	71	(21)	282	(60)	53	(54)	
Double incontinent	73	4	(1)	38	(8)	31	(32)	

ASA, American Society of Anesthesiologists -risk score; MNA-SF, Mini Nutritional Assessment Short Form. Modified from Study I (Hellman-Bronstein et al 2021).

Table 5. Distribution of the outpatient domains according to continence status (N=910) at 6 months post-fracture. Differences between continence groups (p-value) were tested using Pearson chi-square test or Fisher's exact test.

		continent n=343		UI n=469		DI n=98		
	N	**n**	**(%)**	**n**	**(%)**	**n**	**(%)**	**p**
MMSE								<0.001
Normal (24–30)	323	164	(48)	144	(31)	15	(15)	
Abnormal (< 24)	555	176	(51)	308	(66)	71	(72)	
Not known	32	3	(1)	17	(4)	12	(12)	
IADL								<0.001
No difficulties (8)	154	98	(29)	54	(12)	2	(2)	
Difficulties (0–7)	742	239	(70)	407	(87)	96	(98)	
Not known	14	6	(2)	8	(2)	0	(0)	
GDS-15								<0.001
Normal (0–6)	703	301	(88)	345	(74)	57	(58)	
Depressed (> 6)	152	35	(10)	98	(21)	19	(19)	
Not known	55	7	(2)	26	(6)	22	(22)	
EMS								<0.001
Normal (14–20)	596	285	(83)	284	(61)	27	(28)	
Abnormal (< 14)	263	49	(14)	159	(34)	55	(56)	
Not known	51	9	(3)	26	(6)	16	(16)	
TUG								<0.001
Normal (1–2)	280	148	(43)	119	(25)	13	(13)	
Abnormal (3–5)	477	167	(49)	270	(58)	40	(8)	
Not known	153	28	(8)	80	(17)	45	(46)	
Grip strength, stronger hand								<0.001
Normal (≥ 16 kg)	186	86	(25)	90	(19)	10	(10)	
Abnormal (< 16 kg)	448	144	(42)	258	(55)	46	(47)	
Not known	276	113	(33)	121	(26)	42	(43)	
MNA-SF								<0.001
Normal (12–14)	371	179	(52)	180	(38)	12	(12)	
Poor nutrition (< 12)	524	158	(46)	285	(61)	81	(83)	
Not known	15	6	(2)	4	(1)	5	(5)	
Constipation								<0.001
No	307	137	(40)	143	(31)	27	(28)	
Yes	354	94	(27)	220	(47)	40	(41)	
Not known	249	112	(33)	106	(23)	31	(32)	
New falls after fracture								0.017
No	665	271	(79)	327	(70)	67	(68)	
Yes	244	71	(21)	142	(30)	31	(32)	
Not known	1	1	(0)	0	(0)	0	(0)	

MMSE, Mini Mental State Examination; IADL, Instrumental Activities of Daily Living; GDS-15, Geriatric depression scale; EMS, Elderly Mobility Scale; TUG, Timed Up and Go -test; MNA-SF, Mini Nutritional Assessment Short Form. Modified from Study I (Hellman-Bronstein et al 2021).

Table 6. Multivariable-adjusted associations of the baseline indicators with urinary or double incontinence after 6 months follow-up among hip fracture patients (N=910) were analyzed using multinomial regression. Reference group was no incontinence (n=343).

	UI (n=469)				DI (n=98)			
	n	**(%)**	**OR**	**(95% CI)**	**n**	**(%)**	**OR**	**(95% CI)**
Age								
65–79	113	(24)	1.00		27	(28)	1.00	
80–89	274	(58)	1.22	(0.84–1.78)	53	(54)	0.76	(0.41–1.43)
≥ 90	82	(17)	**1.78**	**(1.01–3.13)**	18	(18)	1.16	(0.49–2.74)
Fracture type								
Intracapsular	276	(59)	1.00		58	(59)	1.00	
Extracapsular	193	(41)	1.20	(0.85–1.68)	39	(40)	1.23	(0.71–2.13)
ASA								
1–2	71	(15)	1.00		8	(8)	1.00	
3–5	390	(83)	1.00	(0.63–1.53)	88	(90)	1.21	(0.50–2.92)
Number medications								
< 4	80	(17)	1.00		7	(7)	1.00	
4–10	301	(64)	1.20	(0.79–1.83)	72	(74)	2.08	(0.84–5.15)
> 10	88	(19)	1.13	(0.64–2.00)	19	(19)	1.40	(0.48–4.09)
Cognitive disorder								
No	320	(68)	1.00		55	(56)	1.00	
Yes	148	(32)	**2.06**	**(1.28–3.23)**	43	(44)	1.31	(0.67–2.62)
Mobility								
Independent	267	(57)	1.00		30	(31)	1.00	
Non-independent	201	(43)	1.38	(0.90–2.13)	68	(69)	**2.08**	**(1.05–4.15)**
Living arrangements								
Home	353	(75)	1.00		45	(46)	1.00	
Institution	112	(24)	1.10	(0.65–1.87)	53	(54)	**2.55**	**(1.27–5.15)**
MNA-SF before HF								
Normal (12–14)	220	(47)	1.00		29	(30)	1.00	
Poor nutrition (< 12)	180	(38)	1.09	(0.73–1.63)	45	(46)	1.52	(0.78–2.95)
Not known	69	(15)	0.71	(0.45–1.12)	24	(25)	1.44	(0.67–3.06)
Removal of UC								
During hospital stay	263	(56)	1.00		39	(40)	1.00	
Later	200	(43)	1.36	(0.96–1.94)	59	(60)	**2.33**	**(1.31–4.14)**
Continence before HF								
Continent	149	(32)	1.00		14	(14)	1.00	
Urinary incontinent	282	(60)	**5.76**	**(4.08–8.13)**	53	(54)	**11.80**	**(5.92–23.5)**
Double incontinent	38	(8)	**9.29**	**(3.12–27.6)**	31	(32)	**58.21**	**(16.8–201)**

Results are shown by odds ratios (OR) with 95% Confidence intervals (CI). Statistically significant ($p < 0.05$) ORs are in **bold**. ASA, American Society of Anesthesiologists -risk score; MNA-SF, Mini Nutritional Assessment Short Form. Modified from Study I (Hellman-Bronstein et al 2021).

Table 7. Multivariable-adjusted associations of outpatient domains with urinary or double incontinence after 6 months follow-up among hip fracture patients (N=910) were analyzed using multinomial regression. Reference group was no incontinence (n=343)

	Urinary incontinent (n=469)				Double incontinent (n=98)			
	n	**(%)**	**OR**	**(95% CI)**	**n**	**(%)**	**OR**	**(95% CI)**
Age								
65–79	113	(24)	1.00		27	(28)	1.00	
80–89	274	(58)	1.24	(0.85–0.81)	53	(54)	0.72	(0.37–1.40)
≥ 90	82	(17)	1.56	(0.89–2.74)	18	(18)	0.95	(0.39–2.31)
MMSE								
24–30	144	(31)	1.00		15	(15)	1.00	
< 24	308	(66)	1.12	(0.79–1.59)	71	(72)	1.25	(0.63–2.50)
IADL								
8	54	(12)	1.00		2	(2)	1.00	
0–7	407	(87)	**1.58**	**(1.00–2.51)**	96	(98)	**5.99**	**(1.28–28.0)**
GDS-15								
0–6	345	(74)	1.00		57	(58)	1.00	
> 6	98	(21)	**1.81**	**(1.16–2.84)**	19	(19)	1.64	(0.83–3.25)
EMS								
14–20	284	(61)	1.00		27	(28)	1.00	
< 14	159	(34)	**2.00**	**(1.29–3.12)**	55	(56)	**4.55**	**(2.19–9.48)**
TUG								
1–2	119	(25)	1.00		13	(13)	1.00	
3–5	270	(58)	1.28	(0.88–1.86)	40	(8)	0.67	(0.30–1.50)
Not known	80	(17)	1.66	(0.82–3.35)	45	(46)	1.92	(0.65–5.70)
Grip strength								
≥ 16 kg	90	(19)	1.00		10	(10)	1.00	
< 16 kg	258	(55)	0.94	(0.63–1.41)	46	(47)	1.13	(0.52–2.48)
Not known	121	(26)	0.62	(0.37–1.04)	42	(43)	0.81	(0.33–1.96)
MNA-SF								
Normal (12–14)	180	(38)	1.00		12	(12)	1.00	
Poor nutrition (< 12)	285	(61)	0.94	(0.67–1.31)	81	(83)	**2.31**	**(1.11–4.79)**
Constipation								
No	143	(31)	1.00		27	(28)	1.00	
Yes	220	(47)	**1.48**	**(1.02–2.13)**	40	(41)	0.84	(0.44–1.60)
Not known	106	(23)	0.93	(0.57–1.52)	31	(32)	0.84	(0.38–1.86)
New falls after HF								
No	327	(70)	1.00		67	(68)	1.00	
Yes	142	(30)	1.34	(0.94–1.90)	31	(32)	1.66	(0.94–2.93)

Results are shown by odds ratios (OR) with 95% Confidence intervals (CI). Statistically significant ($p < 0.05$) ORs are in **bold**. MMSE, Mini Mental State Examination; IADL, Instrumental Activities of Daily Living; GDS-15, Geriatric depression scale; EMS, Elderly Mobility Scale; TUG, Timed Up and Go - test; MNA-SF, Mini Nutritional Assessment Short Form. Modified from Study I (Hellman-Bronstein et al 2021).

5.4 Factors associated with different subtypes of urinary incontinence (II)

Table 8 presents the distribution of outpatient assessment domains across continent individuals and different UI subtypes. Women who were continent were generally younger, took fewer medications, had lower levels of disability and mobility impairment, experienced less depressive mood, and had a lower BMI compared to those with any form of UI. Women with MUI were typically older, had poorer physical function as indicated by EMS, took more medications, and had a higher prevalence of malnutrition and FI than other UI groups.

In the multivariable model, depressive mood (OR 3.53, 95% CI 1.99–6.23) based on GDS-15 and impaired mobility and functional ability (OR 2.74, 95% CI 1.48–5.09) measured by EMS were independently associated with SUI at six months after HF. UUI was independently linked to self-reported FI (OR 2.60, 95% CI 1.22–5.54) and a BMI over 28 (OR 1.80, 95% CI 1.15–2.81). MUI was independently associated with depressive mood (OR 2.11, 95% CI 1.15–3.87), impaired mobility and functional ability (OR 2.41, 95% CI 1.28–4.54), FI (OR 3.61, 95% CI 1.65–7.90), BMI over 28 (OR 1.62, 95% CI 1.62–4.88), and self-reported constipation (OR 1.78, 95% CI 1.05–3.03). Results of the multivariable-adjusted model are presented in Table 9.

Table 8. Distribution of the outpatient domains according to continence status (N=779) after 6-months of follow-up. Differences between continence groups were tested using Pearson chi-square test or Fisher's exact test.

	Continent n=360		**SUI n=117**		**UUI n=183**		**MUI n=119**		
	N	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**	**P**
Age									0.016
65–79	139	(39)	38	(33)	47	(26)	34	(29)	
80–89	186	(52)	67	(57)	109	(60)	63	(53)	
≥ 90	35	(10)	12	(10)	27	(15)	22	(19)	
ASA									0.013
1–2	83	(23)	12	(10)	37	(20)	15	(13)	
3–5	272	(76)	101	(87)	144	(79)	103	(87)	
Regular medication									<0.001
<4	46	(13)	8	(7)	14	(8)	4	(3)	
4–10	233	(65)	68	(58)	101	(55)	61	(51)	
>10	81	(23)	41	(35)	68	(37)	54	(45)	
MMSE									0.002
Normal (24–30)	172	(48)	50	(43)	79	(43)	33	(28)	
Abnormal (<24)	188	(52)	67	(57)	104	(57)	86	(72)	
IADL									<0.001
No difficulties (8)	104	(29)	19	(16)	28	(15)	13	(11)	

	Continent n=360		SUI n=117		UUI n=183		MUI n=119		
	N	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**	**P**
Difficulties (0–7)	256	(71)	98	(84)	155	(85)	106	(89)	
GDS-15									<0.001
Normal (0–6)	323	(90)	81	(69)	147	(80)	86	(72)	
Depressed (>6)	37	(10)	36	(31)	36	(20)	33	(28)	
EMS									<0.001
Normal (14–20)	318	(88)	80	(68)	142	(78)	68	(67)	
Abnormal (<14)	42	(12)	37	(32)	41	(22)	51	(43)	
TUG									<0.001
Normal (1–2)	157	(44)	33	(28)	70	(38)	36	(30)	
Abnormal (3–5)	192	(53)	78	(67)	102	(56)	69	(58)	
Not known	11	(3)	6	(5)	11	(6)	14	(12)	
Grip strength									<0.001
Normal (≥ 16 kg)	96	(27)	28	(24)	47	(26)	24	(20)	
Abnormal (>16 kg)	161	(45)	56	(48)	98	(54)	82	(69)	
Not known	103	(29)	33	(28)	38	(21)	13	(11)	
MNA-SF									<0.001
Normal (12–14)	191	(53)	55	(47)	96	(53)	35	(29)	
Poor nutrition (<12)	169	(47)	62	(53)	87	(48)	84	(71)	
Fecal incontinence									<0.001
No	346	(96)	105	(90)	163	(89)	98	(82)	
Yes	14	(4)	12	(10)	20	(11)	21	(18)	
Constipation									<0.001
No	151	(42)	45	(39)	61	(33)	38	(32)	
Yes	104	(29)	39	(33)	79	(43)	70	(59)	
Not known	105	(29)	33	(28)	43	(24)	11	(9)	
BMI									<0.001
23–28	167	(46)	55	(47)	79	(43)	41	(35)	
<23	110	(31)	22	(19)	37	(20)	28	(24)	
>28	83	(23)	40	(34)	67	(37)	50	(42)	
New falls after HF									0.012
No	280	(78)	81	(69)	121	(66)	80	(67)	
Yes	80	(22)	36	(31)	62	(34)	39	(33)	

ASA, American Society of Anesthesiologists -risk score; MMSE, Mini Mental State Examination; IADL, Instrumental Activities of Daily Living; GDS-15, Geriatric depression scale; EMS, Elderly Mobility Scale; TUG, Timed Up and Go -test; MNA-SF, Mini Nutritional Assessment Short Form; BMI, Body Mass Index. Small numbers of missing values (n<15) are not shown in the table. Modified from Study II (Hellman-Bronstein et al 2024).

Table 9. Multivariable-adjusted associations of outpatient domains with different types of UI six months post fracture among female hip fracture patients (n=779). Reference group in multinomial logistic regression analysis was no incontinence (n=360).

	SUI n=117				**UUI n=183**				**MUI n=119**			
	N	**(%)**	**OR**	**(95% CI)**	**N**	**(%)**	**OR**	**(95% CI)**	**N**	**(%)**	**OR**	**(95% CI)**
Age												
65–79	38	(33)	1.00		47	(26)	1.00		34	(29)	1.00	
80-89	67	(57)	1.00	(0.59–1.71)	109	(60)	1.59	(1.00–2.54)	63	(53)	0.85	(0.48–1.50)
≥90	12	(10)	0.77	(0.32–1.84)	27	(15)	2.00	(0.99–4.06)	22	(19)	1.01	(0.45–2.27)
ASA score												
1–2	12	(10)	1.00		37	(20)	1.00		15	(13)	1.00	
3–5	101	(87)	2.04	(1.00–4.19)	144	(79)	0.87	(0.52–1.45)	103	(87)	1.33	(0.66–2.67)
Medication												
< 4	8	(7)	1.00		14	(8)	1.00		4	(3)	1.00	
4–10	68	(58)	0.87	(0.37–2.03)	101	(55)	1.02	(0.51–2.04)	61	(51)	1.74	(0.56–5.42)
>10	41	(35)	1.02	(0.40–2.60)	68	(37)	1.54	(0.71–3.30)	54	(45)	2.48	(0.75–8.22)
MMSE												
24–30	50	(43)	1.00		79	(43)	1.00		33	(28)	1.00	
< 24	67	(57)	0.71	(0.43–1.19)	104	(57)	0.81	(0.53–1.25)	86	(72)	1.33	(0.76–2.33)
IADL												
8	19	(16)	1.00		28	(15)	1.00		13	(11)	1.00	
0–7	98	(84)	1.18	(0.58–2.41)	155	(85)	1.78	(0.99–3.22)	106	(89)	1.20	(0.53–2.70)
GDS-15												
0–6	81	(69)	1.00		147	(80)	1.00		86	(72)	1.00	
> 6	36	(31)	**3.53**	**(1.99–6.23)**	36	(20)	1.68	(0.97–2.90)	33	(28)	**2.11**	**(1.15–3.87)**
EMS												
14–20	80	(68)	1.00		142	(78)	1.00		68	(67)	1.00	
< 14	37	(32)	**2.74**	**(1.48–5.09)**	41	(22)	1.41	(0.80–2.49)	51	(43)	**2.41**	**(1.28–4.54)**
TUG												
1–2	33	(28)	1.00		70	(38)	1.00		36	(30)	1.00	
3–5	78	(67)	1.44	(0.81–2.56)	102	(56)	0.80	(0.50–1.26)	69	(58)	0.75	(0.41–1.35)
Not known	6	(5)	1.55	(0.47–5.14)	11	(6)	1.08	(0.39–2.96)	14	(12)	1.23	(0.42–3.67)
Grip strength												
≥ 16 kg	28	(24)	1.00		47	(26)	1.00		24	(20)	1.00	
< 16 kg	56	(48)	0.77	(0.42–1.39)	98	(54)	0.89	(0.55–1.45)	82	(69)	1.20	(0.65–2.21)
Not known	33	(28)	0.78	(0.35–1.74)	38	(21)	0.66	(0.33–1.34)	13	(11)	0.60	(0.23–1.55)
MNA-SF												
12–14	55	(47)	1.00		96	(53)	1.00		35	(29)	1.00	
< 12	62	(53)	0.84	(0.50–1.41)	87	(48)	0.79	(0.51–1.22)	84	(71)	1.68	(0.96–2.92)
FI												
No	105	(90)	1.00		163	(89)	1.00		98	(82)	1.00	
Yes	12	(10)	2.31	(0.97–5.50)	20	(11)	**2.60**	**(1.22–5.54)**	21	(18)	**3.61**	**(1.65–7.90)**
Constipation												
No	45	(39)	1.00		61	(33)	1.00		38	(32)	1.00	
Yes	39	(33)	0.82	(0.47–1.44)	79	(43)	1.49	(0.95–2.35)	70	(59)	**1.78**	**(1.05–3.03)**
Not known	33	(28)	0.80	(0.38–1.67)	43	(24)	1.21	(0.63–2.31)	11	(9)	0.51	(0.20–1.28)

	SUI n=117				UUI n=183				MUI n=119			
	N	**(%)**	**OR**	**(95% CI)**	**N**	**(%)**	**OR**	**(95% CI)**	**N**	**(%)**	**OR**	**(95% CI)**
BMI												
23–28	55	(47)	1.00		79	(43)	1.00		41	(35)	1.00	
<23	22	(19)	0.58	(0.31–1.05)	37	(20)	0.72	(0.44–1.19)	28	(24)	0.83	(0.45–1.53)
>28	40	(34)	1.39	(0.82–2.34)	67	(37)	**1.80**	**(1.15–2.81)**	50	(42)	**2.81**	**(1.62–4.88)**
New falls												
No	81	(69)	1.00		121	(66)	1.00		80	(67)	1.00	
Yes	36	(31)	1.08	(0.64–1.82)	62	(34)	1.37	(0.89–2.11)	39	(33)	1.11	(0.66–1.87)

Results are shown by odds ratios (OR) with 95% Confidence intervals (CI). Statistically significant ($p < 0.05$) ORs are in **bold.** ASA, American Society of Anesthesiologists -risk score; MMSE, Mini Mental State Examination; IADL, Instrumental Activities of Daily Living; GDS-15, Geriatric depression scale; EMS, Elderly Mobility Scale; TUG, Timed Up and Go -test; MNA-SF, Mini Nutritional Assessment Short Form; BMI, Body Mass Index. Small numbers of missing values (n<15) are not shown in the table. Modified from Study II (Hellman-Bronstein et al 2024).

5.5 Factors associated with incident urinary and double incontinence (IV)

Of the 614 continent women at the time of HF, 128 (21%) developed new-onset UI and 23 (4%) DI within the first year post-HF. After adjusting for age, both incident UI and DI at follow-up were associated with the following baseline factors: age 80–89, age ≥90, known diagnosis of cognitive disorder, impaired mobility, living in long-term care, and delayed use of UC, with stronger ORs for DI. Poor nutrition was also linked to incident UI but not DI.

In the multivariable model, only non-independent mobility (OR 2.56, 95% CI 1.48–4.44) and living in an institution (OR 3.44, 95% CI 1.56–7.61) remained independently associated with incident UI at one-year follow-up. The respective results for DI revealed the same correlations with stronger ORs: non-independent mobility (OR 4.82, 95% CI 1.70–13.7) and living in an institution (OR 3.90, 95% CI 1.17–13.0). The multivariable-adjusted results are shown in Table 10.

Table 10. Multivariable-adjusted associations of baseline indicators of incident urinary and double incontinence after 1 year of follow-up among continent hip fracture patients at baseline (N=614) were analyzed using multinomial logistic regression. Reference group for both was no incontinence at follow-up (n=285).

	Urinary incontinent (n=128)				**Double incontinent (n=23)**			
	n	**(%)**	**OR**	**(95% CI)**	**n**	**(%)**	**OR**	**(95% CI)**
Age								
65-79	27	(21)	1.00		2	(9)	1.00	
80-89	75	(59)	1.42	(0.81–2.50)	14	(61)	2.52	(0.51–12.5)
≥ 90	26	(20)	2.13	(0.96–4.70)	7	(30)	4.51	(0.71–28.5)
Fracture type								
Intracapsular	78	(61)	1.00		12	(52)	1.00	
Extracapsular	50	(39)	1.07	(0.66–1.73)	11	(48)	1.44	(0.56–3.74)
ASA*								
1-2	21	(16)	1.00		2	(9)	1.00	
3-5	106	(83)	1.11	(0.59–2.09)	20	(87)	1.13	(0.21–6.10)
Medications								
<4	29	(23)	1.00		4	(17)	1.00	
4-10	86	(67)	1.01	(0.57–1.79)	13	(57)	0.80	(0.22–2.94)
>10	13	(10)	0.55	(0.23–1.30)	6	(26)	1.24	(0.27–5.69)
Cognitive disorder								
No	98	(77)	1.00		16	(70)	1.00	
Yes	30	(23)	1.55	(0.81–2.96)	7	(30)	2.00	(0.66–6.04)
Mobility								
Independent	74	(58)	1.00		8	(35)	1.00	
Non-independent	54	(42)	**2.56**	**(1.48–4.44)**	15	(65)	**4.82**	**(1.70–13.7)**
Living arrangements								
Home	102	(80)	1.00		16	(70)	1.00	
Institution	26	(20)	**3.44**	**(1.56–7.61)**	7	(30)	**3.90**	**(1.17–13.0)**
MNA-SF before HF								
Normal (12-14)	61	(48)	1.00		8	(35)	1.00	
Poor nutrition (<12)	46	(36)	1.38	(0.81–2.36)	9	(39)	1.54	(0.52–4.60)
Not known	21	(16)	1.46	(0.72–2.98)	6	(26)	2.40	(0.66–8.76)
Removal of UC*								
During hospital stay	74	(58)	1.00		11	(48)	1.00	
Later	53	(41)	1.41	(0.85–2.33)	12	(52)	1.71	(0.65–4.54)

Results are shown by odds ratios (OR) with 95% Confidence intervals (CI). Statistically significant ($p<0.05$) ORs are in **bold**. ASA, American Society of Anesthesiologists -risk score; MNA-SF, Mini Nutritional Assessment Short Form; HF, hip fracture; UC, urinary catheter. *Missing values (n=1-2) were not shown. Modified from Study IV (Hellman-Bronstein et al 2023).

5.6 Incontinence as a predictor of change in mobility (III)

Of the 1,226 women included in the study, 714 (58%) were able to ambulate independently before the fracture, 454 (37%) required assistance outdoors, and 58 (5%) needed assistance both outdoors and indoors. Among the 714 women who had been independent in mobility before HF, 209 (29%) required assistance outdoors, 35 (5%) needed help indoors as well, and 15 (2%) became unable to ambulate one-year post-fracture. Of the 454 women who had previously needed assistance outdoors, 31 (7%) regained independent mobility, 229 (50%) maintained their mobility level, 121 (27%) began requiring assistance indoors, and 73 (16%) became unable to ambulate. Among the 58 women who had only been able to ambulate indoors with assistance, mobility improved in 9 (16%), remained unchanged in 25 (43%), and deteriorated to complete immobility in 24 (41%) after one year. In summary, after the first year post-HF, 477 (39%) women had a declined mobility level compared to the time before the fracture. Changes in mobility according to pre-fracture continence status are presented in Figure 4.

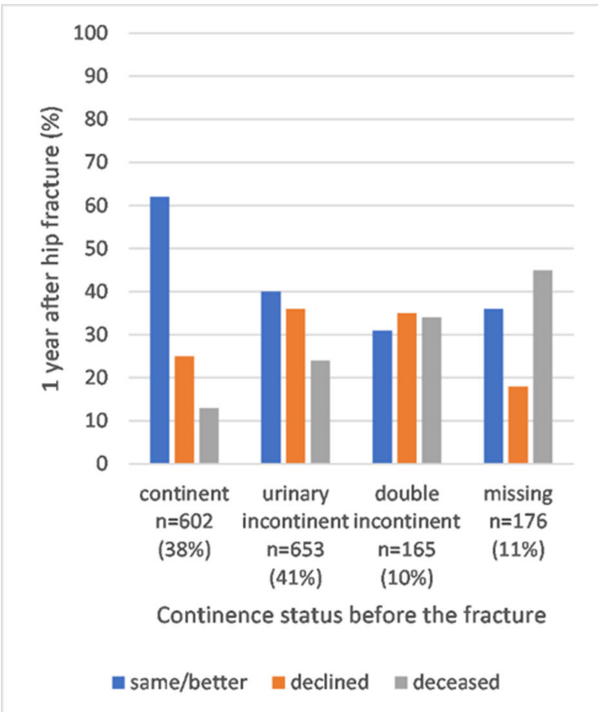

Figure 4. Changes in mobility in 1-year follow-up according to continence status before fracture (n=1596, 95% of the study population). Reproduced from Study IV (Hellman-Bronstein et al 2023). Copyright © The Authors. Published by Springer. Distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licences/by/4.0)

In age-adjusted logistic regression analyses, pre-fracture UI (OR 2.11, 95% CI 1.63–2.75) and DI (OR 2.63, 95% CI 1.72–4.03) were associated with declining mobility at one year, along with all other baseline variables except for pre-fracture mobility level. In multivariable-adjusted analyses, UI (OR 1.88, 95% CI 1.41–2.51) and DI (OR 1.99, 95% CI 1.21–3.27) remained significant predictors of mobility decline, as did age over 90 (OR 2.17, 95% CI 1.45–3.24), cognitive disorder diagnosis (OR 2.00, 95% CI 1.45–2.77), requiring organized home care or residing in assisted living (OR 1.77, 95% CI 1.29–2.43), living in an institution (OR 2.56, 95% CI 1.58–4.15), and late UC removal (OR 2.17, 95% CI 1.64–2.86). Additionally, being able to ambulate outdoors with assistance (OR 0.40, 95% CI 0.29–0.57) or indoors only with help (OR 0.24, 95% CI 0.12–0.47) was associated with a lower risk of further mobility decline. The multivariable-adjusted results are seen in Table 11.

Table 11. Multivariable-adjusted associations of baseline variables with changes in mobility (N=1,226) after 1-year of follow-up.

		same/better N=749		**worse n=477**		**multivariable-adjusted**	
	N	**N**	**(%)**	**N**	**(%)**	**OR**	**(95% CI)**
Age							
65-79	353	251	(34)	102	(21)	1.00	
80-89	662	399	(53)	263	(55)	1.23	(0.91–1.68)
≥ 90	211	99	(13)	112	(24)	**2.17**	**(1.45–3.24)**
Fracture type*							
Intracapsular	751	488	(65)	263	(55)	1.00	
Extracapsular	472	259	(35)	213	(45)	1.28	(0.99–1.66)
ASA							
1-2	186	140	(19)	46	(10)	1.00	
3-5	1021	597	(80)	424	(89)	1.39	(0.93–2.09)
Not known	19	12	(2)	7	(2)	1.37	(0.45–4.17)
Medications							
<4	239	162	(22)	77	(16)	1.00	
4-10	777	469	(63)	308	(65)	0.95	(0.67–1.35)
>10	210	118	(16)	92	(19)	0.97	(0.62–1.51)
Cognitive disorder*							
No	889	594	(79)	295	(62)	1.00	
Yes	335	153	(20)	182	(38)	**2.00**	**(1.45–2.77)**
Mobility							
Independently outdoors	714	455	(61)	259	(54)	1.00	
Independently indoors, outdoors with help	454	260	(35)	194	(41)	**0.40**	**(0.29–0.57)**
Indoors, only with help	58	34	(5)	24	(5)	**0.24**	**(0.12–0.47)**

		same/better N=749		worse n=477		multivariable-adjusted	
	N	N	(%)	N	(%)	OR	(95% CI)
Living arrangements*							
Home without services	552	400	(53)	152	(32)	1.00	
Home with organized home care/ assisted living accommodation	500	271	(36)	229	(48)	**1.77**	**(1.29–2.43)**
Institution	171	75	(10)	96	(20)	**2.56**	**(1.58–4.15)**
MNA-SF before HF							
Normal (12-14)	516	338	(45)	178	(37)	1.00	
Poor nutrition (>12)	419	223	(30)	196	(41)	1.29	(0.95–1.76)
Not known	291	188	(25)	103	(22)	0.86	(0.59–1.24)
Removal of UC							
During hospital stay	691	470	(63)	221	(46)	1.00	
Later	526	272	(36)	254	(53)	**2.17**	**(1.64–2.86)**
Continence before HF							
Continent	524	374	(50)	150	(31)	1.00	
Urinary incontinent	497	260	(35)	237	(50)	**1.88**	**(1.41–2.51)**
Double incontinent	109	51	(7)	58	(12)	**1.99**	**(1.21–3.27)**
Not known	96	64	(9)	32	(7)	0.98	(0.59–1.64)

ASA, American Society of Anesthesiologists -risk score; MNA-SF, Mini Nutritional Assessment Short Form. *Small numbers of missing values (n<10) were not shown in the table. Statistically significant results (p<0.05) were **bolded**. Modified from Study III (Hellman-Bronstein et al 2024).

5.7 Incontinence as predictor of changes in living arrangements (III)

Out of the 1,055 women in the living arrangements cohort, 551 (52%) lived independently in their own home without services before the fracture, while 504 (48%) lived at home with organized home care support or in assisted living. Among the 551 women who had previously lived independently, 177 (32%) required organized home care or moved to assisted living within one year, and 51 (9%) were institutionalized. Of the 504 women who already received services, 180 (36%) were institutionalized, while only 23 (2%) required fewer services. Overall, 408 (39%) of the women needed increased support after one year. Changes in living arrangements according to pre-fracture continence status are presented in Figure 5.

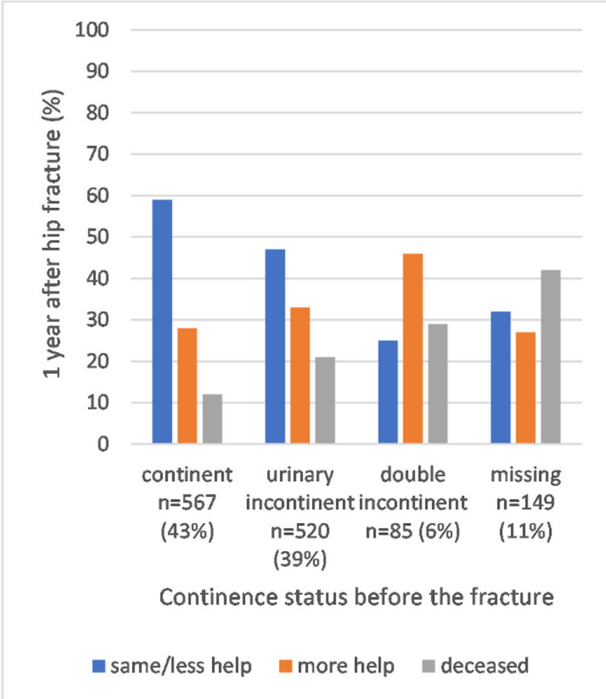

Figure 5. Changes in living arrangements in 1-year follow-up according to continence status before fracture (n=1321, 79% of the study population). Reproduced from Study IV (Hellman-Bronstein et al 2023). Copyright © The Authors. Published by Springer. Distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licences/by/4.0)

In age-adjusted logistic regression analyses, pre-fracture UI (OR 1.33, 95% CI 1.01–1.76) and DI (OR 3.77, 95% CI 2.12–6.70) predicted the need for increased assisted living support at one year, along with all other baseline factors except for fracture type and the number of regularly taken medications. In multivariable-adjusted analyses, pre-fracture DI (OR 2.40, 95% CI 1.22–4.75) remained an independent predictor of requiring more assisted living arrangements, whereas UI lost its predictive significance.

Other independent predictors for increased need of services at one year included age 80–89 (OR 2.00, 95% CI 1.42–2.82), age ≥90 (OR 4.30, 95% CI 2.65–6.98), cognitive disorder diagnosis (OR 2.87, 95% CI 1.95–4.22), requiring assistance to ambulate outdoors (OR 3.61, 95% CI 2.47–5.27) or indoors (OR 4.81, 95% CI 1.60–14.4), being unable to ambulate (OR 17.0, 95% CI 1.53–189), and late UC removal (OR 1.67, 95% CI 1.22–2.30). Conversely, having organized home care or already residing in assisted living (OR 0.16, 95% CI 0.10–0.23) was associated with a lower likelihood of requiring further assistance at one year. The multivariable-adjusted results are presented in Table 12.

Table 12. Multivariable-adjusted associations of baseline variables with changes in living arrangements (N=1,055) after 1-year of follow-up.

		same/less assisted n=647		more assisted n=408		multivariable-adjusted	
	N	**n**	**(%)**	**n**	**(%)**	**OR**	**(95% CI)**
Age							
65-79	325	241	(37)	84	(21)	1.00	
80-89	561	329	(51)	232	(57)	**2.00**	**(1.42–2.82)**
≥ 90	169	77	(12)	92	(23)	**4.30**	**(2.65–6.98)**
Fracture type*							
Intracapsular	658	403	(62)	255	(63)	1.00	
Extracapsular	394	243	(38)	151	(37)	0.91	(0.68–1.22)
ASA							
1-2	180	135	(21)	45	(11)	1.00	
3-5	860	501	(77)	359	(88)	1.67	(1.08–2.57)
Not known	15	11	(2)	4	(1)	0.87	(0.23–3.36)
Medications							
<4	230	147	(23)	83	(20)	1.00	
4-10	656	403	(62)	253	(62)	0.92	(0.64–1.34)
>10	169	97	(15)	72	(18)	1.12	(0.68–1.84)
Cognitive disorder*							
No	838	559	(86)	279	(68)	1.00	
Yes	215	86	(13)	129	(32)	**2.87**	**(1.95–4.22)**
Mobility							
Independently outdoors	699	498	(77)	201	(49)	1.00	
Independently indoors, outdoors with help	327	141	(22)	186	(46)	**3.61**	**(2.47–5.27)**
Indoors, only with help	21	6	(1)	15	(4)	**4.81**	**(1.60–14.4)**
Unable to walk	5	1	(0)	4	(1)	**17.0**	**(1.53–189)**
Living arrangements*							
Home without services	551	323	(50)	228	(56)	1.00	
Home with organized home care/ assisted living accommodation	504	324	(50)	180	(44)	**0.16**	**(0.10–0.23)**
MNA-SF before HF							
Normal (12-14)	490	333	(52)	157	(39)	1.00	
Poor nutrition (>12)	315	162	(25)	153	(38)	1.41	(0.99–1.99)
Not known	250	152	(24)	98	(24)	1.01	(0.67–1.53)
Removal of UC							
During hospital stay	607	404	(62)	203	(50)	1.00	
Later	439	236	(37)	203	(50)	**1.67**	**(1.22–2.30)**
Continence before HF							
Continent	497	337	(52)	160	(39)	1.00	
Urinary incontinent	411	242	(37)	169	(41)	1.26	(0.92–1.73)
Double incontinent	60	21	(3)	39	(10)	**2.40**	**(1.22–4.75)**
Not known	87	47	(7)	40	(10)	1.60	(0.96–2.90)

ASA, American Society of Anesthesiologists -risk score; MNA-SF, Mini Nutritional Assessment Short Form. *Small numbers of missing values (n<10) were not shown in the table. Statistically significant results (p<0.05) were **bolded**. Modified from Study III (Hellman-Bronstein et al 2024).

5.8 Incontinence as a predictor of death (IV)

Of the 1,468 women included in the cox proportional hazards model, 297 (20%) had died during the first year after HF. The mean survival for continent patients was 335 days (95%CI 328–342), and 303 (95% CI 293–312) and 276 (95% CI 255–296) for patients with UI and DI, respectively. The clear difference in mortality rates among the continence groups is presented in Figure 6.

In the Cox proportional hazards model adjusted for age, UI (hazard ratio [HR] 1.72, 95% confidence interval [CI] 1.31–2.26) and DI (HR 2.61, 95%CI 1.86–3.66) were associated with one-year mortality, along with all the other baseline variables apart from fracture type.

However, in the multivariable-adjusted analysis, UI and DI lost their predictive significance. Instead, factors that remained independently associated with one-year mortality included age over 90 (HR 2.32, 95% CI 1.57–3.44), being institutionalized (HR 1.36, 95% CI 1.04–1.77), impaired mobility (HR 2.13, 95% CI 1.52–2.97), poor nutrition (HR 2.09, 95% CI 1.52–2.86), taking between 4 and 10 medications (HR 1.98, 95% CI 1.18–3.32) or more than 10 medications (HR 2.64, 95% CI 1.53–4.53), and delayed removal of a UC (HR 1.58, 95% CI 1.23–2.02). The results of the multivariable-adjusted analysis are presented in table 13.

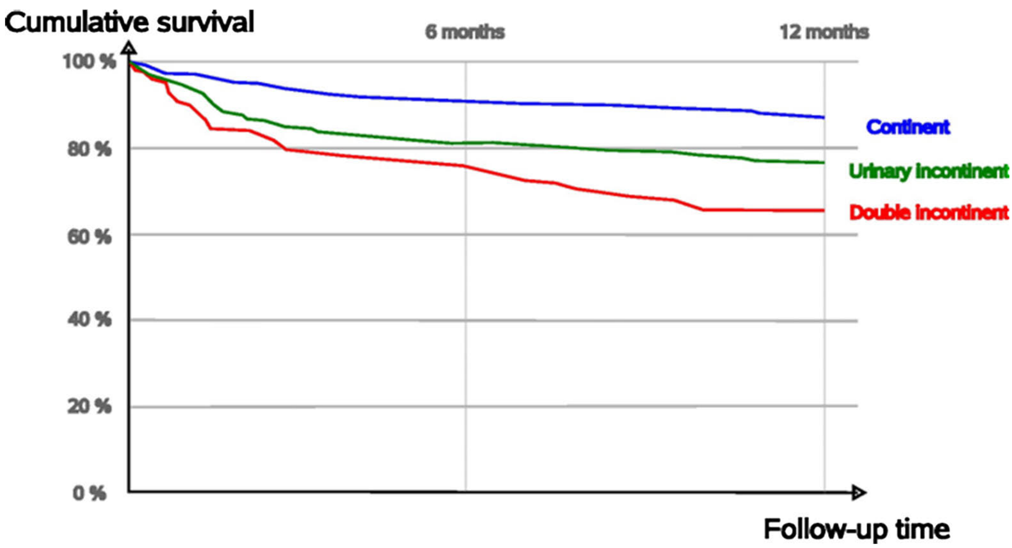

Figure 6. Cumulative survival curves utilizing Kaplan-Meier among the different continence groups (N=1468).

Table 13. Distribution of the baseline indicators between alive and deceased individuals (N=1468) after 1 year follow-up. Multivariable-adjusted survival with hazard ratios (HR) and 95% confidence intervals (CI) were calculated using Cox regression.

		Deceased n = 297		Alive n = 1171		Multivariable–adjusted	
	N	**n**	**(%)**	**n**	**(%)**	**HR**	**(95% CI)**
Age							
65–79	376	36	(12)	340	(29)	1.00	
80–89	770	141	(48)	629	(54)	1.33	(0.91–1.93)
≥ 90	322	120	(40)	202	(17)	2.32	(1.57–3.44)
Fracture type*							
Intracapsular	883	164	(55)	719	(61)	1.00	
Extracapsular	583	133	(45)	450	(38)	0.95	(0.75–1.21)
ASA							
1–2	196	10	(3)	186	(16)	1.00	
3–5	1248	281	(95)	967	(83)	1.82	(0.94–3.50)
Not known	24	6	(2)	18	(2)	2.53	(0.90–7.08)
Medications							
< 4	246	17	(6)	229	(20)	1.00	
4–10	925	184	(62)	741	(63)	1.98	(1.18–3.32)
> 10	297	96	(32)	201	(17)	2.64	(1.53–4.53)
Cognitive disorder							
No	1030	181	(61)	849	(73)	1.00	
Yes	436	115	(39)	321	(27)	0.78	(0.60–1.01)
Mobility*							
Independent	786	65	(22)	681	(58)	1.00	
Non–independent	719	232	(78)	487	(42)	2.13	(1.52–2.97)
Living arrangements*							
Home	1023	143	(48)	880	(75)	1.00	
Institution	441	154	(52)	287	(25)	1.36	(1.04–1.77)
MNA–SF before HF							
Normal (12–14)	583	59	(20)	524	(45)	1.00	
Poor nutrition (< 12)	614	197	(66)	417	(36)	2.09	(1.52–2.86)
Not known	271	41	(14)	230	(20)	1.01	(0.66–1.54)
Removal of UC							
During hospital stay	813	122	(41)	691	(59)	1.00	
Later	631	160	(54)	471	(40)	1.58	(1.23–2.02)
Not known	24	15	(5)	9	(1)	8.18	(4.68–14.3)
Continence before HF							
Continent	614	78	(26)	536	(46)	1.00	
Urinary incontinent	680	159	(54)	521	(45)	1.15	(0.86–1.54)
Double incontinent	174	60	(20)	114	(10)	1.19	(0.82–1.74)

ASA, American Society of Anesthesiologists -risk score; MNA-SF, Mini Nutritional Assessment Short Form. *Small numbers of missing values (n=1–4) were not shown in the table. Modified from Study IV (Hellman-Bronstein et al 2023).

6 Discussion

This dissertation addresses the gap of knowledge regarding incontinence among older women with HF. Both UI and DI were established to be very common and associated with functional and physical disability. Several modifiable risk factors such as constipation, prolonged use of UCs, depressive mood, and poor nutrition were identified. Regarding subtypes of UI, UUI was the most prevalent while MUI was associated with most factors. Women with DI were found to be especially vulnerable. Impaired mobility before HF predicted incident symptoms of UI and DI, both of which also predicted declining mobility levels during the first year after HF. Notably, DI – but not UI – was associated with a higher likelihood of transitioning to more supported living arrangements after one-year post-fracture. Despite higher mortality rates compared to the continent, neither UI nor DI predicted mortality independently.

6.1 Prevalence and incidence of incontinence

In this patient population, the prevalence of UI fluctuated between 43% and 52% during the first year after HF. Prevalence of DI fluctuated between 11–20%. It is noteworthy that our study investigated both UI and DI. Because women with concurrent UI and FI were categorized in a separate group, the prevalence of isolated UI was lower than it would have been if reported prevalences of isolated UI and FI had been used. Bearing this in mind, our findings are in accord with previous publications in which prevalence of UI before HF have ranged between 44% and 62% (Arroyo-Huidobro et al., 2024; Sørbye & Grue, 2013; Zusman et al., 2017). No previous studies were found regarding DI, but two studies reported 9–14% prevalence of FI at the time of HF among men and women.(Alarcón et al., 2011; González-Zabaleta et al., 2015).

The prevalence of UI increased slightly at six months but returned to baseline level at 1-year post-fracture. (I, IV) UI is known to remit and recur frequently in older women (Komesu et al., 2016). In our study population, the increase in prevalence in first months after HF is in accord with the results of Arroyo-Huidobro et al who reported gradually increasing prevalence of UI up to 90 days after HF (Arroyo-Huidobro et al., 2024). The increase in prevalence is likely attributed to the worsened physical condition after the fracture. The effects of rehabilitation might conversely explain the decrease in prevalence back to baseline level which is an encouraging thought. According to Alarcón et al, majority of HF patients regain their pre-fracture continence status during the first year after HF(Alarcón et al., 2011).

The most common UI subtype at the outpatient clinic was UUI, followed by MUI and SUI with equal prevalences (II). We found no previous studies examining UI subtypes on HF patients. However, in studies including older women living in the community, prevalence rates close to ours have been reported (Abufaraj et al., 2021; Fritel et al., 2013; Lee et al., 2021; Schreiber Pedersen et al., 2017) with UUI and MUI being prominent in oldest age groups. Given that half of our study population had a known or emerging cognitive disorder (IV, Jaatinen et al. 2020), which is known to be a significant risk factor for UUI (Panicker, Folwer and Kessler, 2015), our finding of high prevalence of UUI is not surprising.

Prevalence of DI remained stable till six months but nearly doubled at 1-year post-fracture. Given that DI is highly correlated with advancing age and disability (Bliss et al., 2018; Matthews et al., 2013; Musa et al., 2019), the increasing prevalence of DI in our study population during first year after HF likely reflects the high age and vulnerability of our patients and represents those who could not rehabilitate successfully to their pre-fracture functional level and were further afflicted by the cascade of frailty.

One in five women who were previously continent developed UI within the first year following HF. Previous publications have reported UI incidence rates ranging from 21 to 62% within six months after HF (Arroyo-Huidobro et al., 2024; Palmer et al., 2002; Zusman et al., 2017). The higher incidence rates observed in these studies can likely be attributed to their shorter follow-up periods which focus on the initial months after the fracture, when patients are typically in their most vulnerable condition. This was the first study to our knowledge to examine incidence of DI among HF patients. Among community-dwelling older women, a 4-year incidence of 7,4% has been previously reported (Yuaso et al., 2018). A significantly longer follow-up period likely explains the higher incidence in their study compared to ours.

6.2 Factors associated with incontinence

6.2.1 Modifiable risk factors

6.2.1.1 Functional disability and reduced mobility

Functional disability and reduced mobility were highly associated with incontinence in our study. Women with difficulties in basic ADLs and mobility according to EMS scores were twice as likely to report any UI and five times more likely to report DI while women with difficulties in IADL were almost twice as likely to report any UI and six times more likely to report DI than their continent counterparts. Moreover, women with non-independent mobility before HF had a two-fold risk of DI at the outpatient clinic. (I) Our findings reinforce the findings of several previous studies. Gosch et al discovered that UI was associated with lower ADL scores and higher rates of immobility in older men and women with fragility fractures (Gosch et al., 2015). Palmer et al found older women with HF who had non-independent ambulation at baseline to have higher likelihood of incident UI at discharge (Palmer et al., 2002). Sørbye and Grue reported that older HF patients with UI had a steeper decline in functional ability during the first year after fracture compared to their continent peers (Sørbye & Grue, 2013).

When examining UI subtypes, women with low EMS scores were nearly three times and two and half times more likely to report SUI and MUI compared to continent women whereas no association was found with UUI. (II) In two previous studies directly examining UI and functional ability, a strong correlation was found between functional disability and UUI and MUI in older general geriatric populations (Komesu et al., 2016; Nuotio, Jylhä, et al., 2003). Higher physical activity and function have also been found to protect against incident UUI and MUI, but not SUI (Bauer et al., 2021; Okumatsu et al., 2021), and impaired mobility and balance skills have been shown to associate with UUI but not SUI (Fritel et al., 2013). These results contradict our findings. However, higher physical activity - which can be interpreted as better mobility – has been shown to protect from developing SUI in older women (Danforth et al., 2007). Additionally, declining muscle strength has been established as a risk factor for SUI bot not UUI (Suskind et al., 2017). Existing literature on the connection with physical and functional disability and UI subtypes seems to be conflicting, possibly due to differences in study populations and designs. Considering that UI is predominantly a geriatric syndrome in oldest age groups (Parker-Autry & Kuchel, 2021), differentiation between UI subtypes might not be as relevant as in younger women in this instance.

Although no studies concerning DI among HF patients were found, difficulties in IADLs (Yuaso et al., 2018) and ADLs (Luo et al., 2020; Matthews et al., 2013) have been found to be associated with DI among older communal living women before. The close association between functional and physical disability and incontinence underlines the vulnerability of our study population, especially women with DI.

6.2.1.2 New falls

Our study included data on new falls after fracture. New falls after HF were more common among women with any UI and DI compared to the continent women

(I,IV). However, in multivariable analyses, new falls were not significantly associated with neither any UI (or its subtypes) (I, II) nor DI (I), although the association was not far from significant with DI. Although UI, predominantly UUI, has been associated with increased risk of falls (Chiarelli, Mackenzie and Osmotherly, 2009) the underlying cause for the connection has raised speculation. Given that both incontinence and falls are considered markers of frailty (Chong et al., 2018; Gibson et al., 2018; Moon et al., 2020; Veronese et al., 2018), it is possible that it mediates the observed association between incontinence and falls without causal relationship. Our findings support this hypothesis especially since our models were adjusted with a considerable number of factors, most of which were indicators of frailty.

6.2.1.3 Depression

In our study, women having depression based on the GDS-15 were nearly twice as likely to report UI at the outpatient clinic 6-months post-fracture compared to those without incontinence (I). When examining UI subtypes, the association was strongest for SUI with a 3,5-fold risk. Women with MUI had a two-fold risk, while no significant association was found with UUI (II). The association between depression and any UI has been demonstrated before in older women living in the community (Felde, Bjelland and Hunskaar, 2012; Lim et al., 2018; Melville et al., 2005). Furthermore, depression is a recognized risk factor for HFs (Shi et al., 2019), and individuals recovering from HF are at heightened risk of developing depression (Lenze et al., 2007).

Different explanations for the link between depression and UI have been proposed. First, the burden of chronic UI may have an impact on the onset of depression through social isolation, decreased activity and ensuing disability. Second, neurotransmitters in the central nervous system, particularly serotonin, are associated both with voiding function and mood. Thus, low serotonin levels in depression can affect continence, producing symptoms of especially UUI (Vrijens et al., 2015). Two studies have reported the association between UUI and MUI and depression while no association was found with SUI (Felde, Bjelland and Hunskaar, 2012; Melville et al., 2005). Our findings contrast with previous studies with SUI having the strongest correlation with depression. Some unknown factors in our selected study population might explain this, calling for further studies with longitudinal settings. Given that the risk of depression is greatest immediately after HF and ensuing first weeks (Lenze et al., 2007), it is quite possible that depressive mood post-fracture might contribute to worsening of UI or even incident UI during the first months after HF. Due to our cross-sectional setting, we cannot establish causality. Screening both UI and depression are warranted as a part of CGA among older women with HF.

6.2.1.4 Fecal incontinence and constipation

The majority of women with FI in our study population also experienced concurrent UI (I, III, IV), consistent with previously published findings (Botlero et al., 2011). FI was independently associated with UUI and MUI, but not SUI (II), also aligning with previous studies (Coyne et al., 2011; Slieker-Ten Hove et al., 2010). These findings suggest that, among women with DI in our cohort, the UI component was predominantly either UUI or MUI.

Constipation was associated with any UI (I) and specifically MUI (II). There is robust evidence supporting constipation as a risk factor for UI, with the anatomical proximity of rectum and bladder, as well as their shared innervation as etiological factors (Lian et al., 2019). Additionally, insufficient hydration and immobilization – both of which HF patients are susceptible to during hospitalization – are known risk factors for constipation (De Giorgio et al. 2015). A considerable amount of missing data on constipation in our dataset limits the reliability of these findings. Notably, previous research has demonstrated significant overlap between FI, constipation and UUI (Coyne et al., 2011) which may be partially explained by the shared pathophysiological mechanisms. Furthermore, the overuse of laxatives to manage constipation, as well as overflow incontinence resulting from severe constipation, may also contribute to the observed associations (Andy et al., 2016; De Giorgio et al., 2015). UUI and MUI are also often treated with anticholinergic medications which can cause constipation as a side effect (Parker & Griebling, 2015).

6.2.1.5 BMI

BMI greater than 28 was associated with UUI and especially with MUI (II). Obesity has been established as a risk factor for all subtypes of UI (Marcelissen et al., 2019; Minassian et al., 2008). Obesity increases the risk of UI by several mechanisms: it increases intra-abdominal pressure and intravesical pressure, exerts increased force on the pelvic floor, and often exacerbates mobility problems and functional disability. Additionally, increased visceral adipose tissue increases the risk of UI metabolically by inducing systemic inflammation and oxidative stress. (Marcelissen et al., 2019) Two previous studies have found that high BMI predicts incident MUI and lower remission rates during a two-year (Komesu et al., 2016b) and four-year follow-up periods (Pang et al., 2022).

Although moderate weight loss has been proven to significantly improve symptoms of UI in women (Wing et al., 2010), it remains a complex clinical issue in this patient population. A high rate of poor nutrition has been established in patients with HF with significant links to poor mobility and grip strength, implying an association with protein-energy malnutrition and sarcopenia. (Helminen et al., 2017) Overweight and obese HF patients also carry the risk of sarcopenic obesity and poor outcomes (Bell et al., 2021). Weight reduction in HF patients might therefore accelerate muscle and bone mass loss and the cascade of frailty. Nevertheless, emerging evidence suggests that these adverse effects can be mitigated through comprehensive therapeutic interventions which integrate caloric restriction with both aerobic and resistance training, resulting in improved physical function and over-all health in older adults (DiMilia et al., 2019). Given the complex interplay between obesity, nutrition and sarcopenia and UI in this vulnerable population, a clinical trial specifically targeting HF patients with incontinence is warranted.

6.2.1.6 Nutrition

Poor nutrition according to MNA-SF at the outpatient clinic was independently associated with DI at six months post-fracture. Poor nutrition was common in our study population with a tendency to further deteriorate during the first months after HF (I). As stated above, poor nutrition is correlated with sarcopenia, but it also predicts all-cause mortality, declining mobility and increasing dependency (Helminen et al., 2017; Helminen et al., 2017). Poor nutrition has been found to be associated with FI among older adults who were either hospitalized or attended an outpatient CGA (Saka et al., 2010). Moreover, a correlation between the severity of UI and malnutrition, as well as impaired mobility and cognitive function has been shown in long-term care settings, reflecting the advancing cascade of frailty (Rose et al., 2013). Poor nutrition can be considered as an indicator of frailty (Soysal et al., 2019) which likely is the underlying cause for the connection with DI.

6.2.1.7 Use of Urinary catheter

Prolonged use of UC was independently associated with DI at six-months, but the association didn’t quite reach statistical significance with UI (I). Inappropriate use of UC may precipitate the onset or worsen existing UI through infections (Arroyo-Huidobro et al., 2024), bladder-related complications such as spasms and urgency (Saint et al., 2018), as well as through inhibition of free movement, early mobilization and normal voiding strategies (Morri et al., 2018). Importantly, prolonged UC use has also been shown to lead to prolonged hospital stays, worse recovery and functional decline among several other poor outcomes (Bootsma et al., 2013; Fang-wen Hu et al., 2015; Zisberg et al., 2011). Among HF patients, UC use over 72 hours has been associated with higher frequency of delirium, UTIs, cognitive impairment and mood issues (Sørbye & Grue, 2013).

We cannot establish causality or its direction. It is plausible however, that the adverse effects of UC use may have had an impact on the deterioration of continence status in our patients, or women with pre-fracture DI were subjected to prolonged UC use more often compared to women with UI or no incontinence due to their frailer state. Given that women with DI exhibited highest rates of functional disability and the poorest performance in the domains of CGA, they were particularly vulnerable to inappropriate use of UCs and its compounding effects on functional decline and delayed recovery. It should also be borne in mind that our definition of prolonged UC use was crude, dichotomized only before and after discharge from the hospital when, according to international guidelines, inappropriate UC use is defined as a duration over 24 hours (Gould et al., 2010). A longitudinal study examining thoroughly the duration of UC use and its potential contribution to the development of UI, FI and DI among HF patients is called for. Considering the use of UCs represents a care-related modifiable factor in clinical practice, further research is necessary for evidence-based interventions to improve patient outcomes.

6.2.2 Non-modifiable risk factors

High age over 90 and history of cognitive disorder were independently associated with a two-fold risk of any UI and living in an institution was associated with a 2,5-fold risk of DI at six-months post-fracture (I). Advancing age is a known risk factor for both UI and DI with highest prevalence rates reported in oldest age groups (Gibson et al., 2021; Minassian et al., 2008; Minassian et al., 2017; Stenzelius et al., 2004). The lack of association between age and DI in our study might be due to our limited sample size. Residents of institutions of long-term care constitute typically the oldest and frailest individuals of society. Thus, the link between baseline institutionalization and DI is logical and supported by previous literature (Bliss et al., 2018; Musa et al., 2019). In addition, a connection between residence in long-term care and incident UI has been discovered before among patients with HF (Palmer et al., 2002). Cognitive disorders are a known risk factor for UI in general older populations (Gibson et al., 2021) and established also in a small previous study of men and women with HF (Palmer et al., 1997).

History of UI or DI before fracture were the strongest predictors of incontinence also at the outpatient clinic six-months post-fracture (I). Considering the follow-up time of six months and the fact that significant changes in continence status occurred only in minority of the women, this association is very logical. DI is also often preceded by UI in isolation (Bliss et al., 2018; Botlero et al., 2011). Studies with longer follow-ups of several years have shown that incontinence history is the strongest predictor of recurrence in older women with UI (Komesu et al., 2016; Minassian et al., 2017).

6.3 Factors associated with incident incontinence

Every fifth continent woman developed a new-onset UI and 4% new-onset DI during the first-year post-fracture (IV). In multivariable analysis, non-independent mobility and living in long-term care emerged as independent predictors of both incident UI and DI. Continent women with non-independent mobility had a 3-fold risk of developing UI and a 5-fold risk of developing DI. Women living in long-term care had a 3- and 4-fold risks of developing UI and DI, respectively.

This study corroborates previous findings from Palmer et al who found that non-independent mobility and living in long-term care were predictors of incident UI at the time of discharge from the hospital (Palmer et al., 2002). In our findings the association reaches up to one-year post-fracture and includes DI. In community-dwelling older women, declining physical function and sarcopenia have been shown to predict incident UI (Parker-Autry et al., 2017; Suskind et al., 2017), and conversely higher physical activity and better physical function have had a protective effect against incident UI (Danforth et al., 2007; Okumatsu et al., 2021). Likewise, higher physical activity has been shown to have a protective effect against incident FI (Staller et al., 2018), and falls – often seen as a sign of mobility issues – has been established as a predictor of incident DI (Yuaso et al., 2018) among older women living in the community. Prevalence of incontinence and HFs is highest in long-term care facilities (Bliss et al. 2018; Gibson & Wagg, 2014; Fangke Hu et al. 2012; Musa et al. 2019), reflecting the multimorbid and frail condition of the residents.

Our findings underline the close association between physical function and the onset of incontinence among women in old age. Older women with HF are especially susceptible to incident incontinence for several reasons: First, being hospitalized after major trauma leads to several days of immobilization. Older hospitalized patients spend majority of their time in bed rest. Immobilization quickly leads to significant loss of muscle mass and function, and disability. (Fazio et al., 2020; Loyd et al., 2020) Second, virtually all HF patients have an indwelling UC after surgery, and prolonged use is still widespread mainly for convenience of care. Use of UC further hinders mobilization, prevents normal voiding and affects bladder health. (Bootsma et al., 2013; Gould et al., 2010; Fang-wen Hu et al., 2015) Implementing strategies that promote mobilization as fast as possible post-surgery and progressive physical activity during hospital stay while also minimizing the use of UCs would likely promote the maintenance of continence in these patients. Patient education on urinary habit training after UC removal, as part of usual care, would likely also promote bladder health. This rationale is supported by one RTC in which urinary habit training halved the incidence of incontinence at six-months post-fracture (Córcoles-Jiménez et al., 2021).

6.4 Association between incontinence and changes in mobility

Women with pre-fracture UI or DI had a two-fold risk of declining mobility level during the first year after HF (III). A significant proportion of HF patients lose their independence in mobility post-fracture with the number of independent mobilizers cut in half at 90 days (González-Zabaleta et al., 2015). Approximately 40% of HF patients continue to have declined mobility level compared to the time before HF at after one-year of follow-up (III) (Pajulammi et al., 2015). For this reason, any precipitating factors of declining mobility are important to establish in this patient group.

As opposed to research on the role of baseline mobility/physical performance on incident incontinence, fewer studies have explored the role of incontinence as a predictor of changes in physical function and mobility in a longitudinal setting. Sørbye & Grue reported that among older men and women with HF, individuals with pre-fracture UI were more likely to experience decline in ADL during first year after HF compared to the continent. Mobility is a domain of ADL but it was not reported separately in this study. (Sørbye & Grue, 2013) Correa et al found that older community-living women with UI had a steeper decline in physical performance compared to women with no UI during two years of follow-up (Corrêa et al., 2019). In two follow-up studies, older women with UI at baseline were also more likely to fall (i.e. had mobility issues) than controls (Brown et al., 2000; Takazawa & Arisawa, 2005). This association has now been confirmed among older women with HF.

Furthermore, a bidirectional relationship between UI and DI and mobility has been established: older women with limited mobility prior to fracture were more likely to develop UI and DI one-year after HF (IV), while those with pre-fracture UI and DI were at increased risk of declining mobility over the same period (III). This creates a cycle in which reduced mobility, along with overall muscle and pelvic floor weakening, contributes to the development of incontinence. In turn, incontinence can lead individuals to voluntarily limit physical activity due to fear of leakage, ultimately accelerating the decline of mobility over time. (Hassani, Arya and Andy, 2020; Sanses, Kudish and Guralnik, 2017)

6.5 Association between incontinence and changes in living arrangements

Women with pre-fracture DI had more than a two-fold risk of needing more supported living arrangements after one-year of follow-up whereas no association was found with UI (III). Most previous studies have examined incontinence as a predictor of institutionalization, i.e. placement of participants in long-term care facilities. This study had a broader definition of the outcome (as explained in chapter 4.3.4) which should be borne in mind when interpreting the results. HF patients have a high risk of institutionalization following the increase in disability and dependency after the injury. Oldest age groups and individuals with cognitive impairment bear the greatest risk. (Hawley et al., 2022; Martinez-Reig, Ahmad and Duque, 2012)

Sørbye and Grue examined older men and women with HF and found that participants with pre-fracture UI were four times more likely to institutionalize compared to their continent counterparts. However, UI was not tested as an independent predictor (Sørbye & Grue, 2013). In previous publications concerning general geriatric populations, a significant association between UI and institutionalization has been demonstrated mostly in men. Authors of these studies have hypothesized that women tend to develop UI earlier in life, have better coping skills with it and thus, UI might not lead to same degree of disability among women compared to men in older age. (Matsumoto & Inoue, 2007; Nuotio et al., 2003; Thom, Haan and Van Den Eeden, 1997) In a more recent study involving both older men and women, UI was found to be a predictor of institutionalization in individuals living in the community. However, being female had a protective effect against long-term care placement (Berete et al. 2022). In two studies on older individuals living in own home with organized community care (Schluter et al., 2017), and living in assisted living accommodations (Ajay et al., 2025) UI predicted the need for a placement in long-term care with no reported differences among sexes.

Our findings - that UI does not predict the need for more supported living arrangements among older women with HF – are consistent with most of the existing literature which highlights the risk primarily in men. Considering that many women experience varying degrees of UI for decades and are accustomed to using menstrual pads from a young age, it is conceivable that UI might not cause the same level of dependency in women as it does in men. In one study, UI had a lowering impact on the quality of live in older women but increasing leakage steepened the decline only slightly (Krhut et al., 2018). In another study, UI was not associated with significantly lower quality of life compared to continent peers whereas FI was (Eloranta et al., 2019). FI is known to lead to social isolation, poor quality of life and self-rated health (Andy et al., 2016; Markland et al., 2008; Stenzelius, Westergren and Hallberg, 2007). It is plausible that FI component is the stronger determinant of disability and dependency among the women with DI in our study population.

In a study concerning older men and women receiving home care, UI was marginally associated with institutionalization whereas FI was not. In this study, FI lost its predictive value after adjusting for cognitive impairment and functional ability. Authors noted that cognitive impairment and functional disability, which are common among individuals with FI, likely mediate the connection of FI with institutionalization. (Schluter et al., 2017) This finding is in accord with the study by Alameel et al in which FI did not predict institutionalization after adjusting for confounders such as cognitive impairment and functional decline among community-dwelling older adults (Alameel, Andrew and MacKnight, 2010).

In our study population, women with DI were found to be especially vulnerable with poorer physical and functional performance compared to women with UI or no incontinence (I) and had the highest mortality rate compared to other continence groups (IV). In our analysis, DI predicted the need for more supported living arrangements even after adjusting for cognitive impairment and other factors denoting functional decline. It is likely that DI serves as a marker of greater frailty and functional impairment than UI or FI in isolation in our study population, which mediates the connection with the more need for more supported living arrangements.

6.6 Association between incontinence and mortality

Although a clear difference in mortality rates was observed between women with UI, DI and no incontinence, neither UI nor DI had independent prognostic significance in our study (IV). Instead, several other predictors remained independently associated with mortality. Our findings that advanced age, being institutionalized and having impaired mobility predicted increased 1-year mortality in older women with HF, is consistent with previous literature on HF patients (Guzon-Illescas et al. 2019; Fangke Hu et al. 2012).

Taking between 4 and 10 or over 10 regular medications were independent predictors of mortality. Individuals with multiple comorbidities typically take more medications than those in better health, making polypharmacy a marker of the overall health status of the individual. In older adults living in the community, polypharmacy has been associated with increased risk of falls, hospitalizations, and mortality. These outcomes are likely driven by side effects, drug–drug interactions, and inappropriate prescribing. (Fried et al., 2014; Li et al., 2022) Polypharmacy has also been previously established as a predictor of mortality in men and women with HF (Pajulammi et al., 2016).

The prolonged use of UC was an independent prognostic factor in our study. Our findings concur with previous studies on hospitalized older adults (Bootsma et al., 2013; Fang-wen Hu et al., 2015) and after HF (Pajulammi et al., 2016). Indwelling UC predisposes the patient to infections and delirium while also hindering mobilization (Bootsma et al., 2013; Gould et al., 2010; Fang-wen Hu et al., 2015) and thus the early stage of rehabilitation in patients with HF. However, this study could not confirm the direction of causality.

Women with poor nutrition according to MNA-SF had a two-fold risk of death compared to women with normal nutrition in our study which concurs with an earlier study on malnutrition and mortality among HF patients (Helminen et al., 2017).

All the predictors of mortality mentioned above reflect the poor general health, as well as the functional and physical impairment and high dependency of our study population and suggests underlaying frailty. Although our study did not include a validated frailty tool, MNA-SF has been proven to be useful in detecting frailty with similar cut-off values (Soysal et al., 2019). Considering this, the high prevalence of poor nutrition mirrors a high prevalence of frailty in our study population. At six-month post-fracture, nearly half of the women in our study (I) had poor nutrition/frailty, which is in accord with previous reports on the prevalence of frailty among HF patients (Forssten et al., 2023). The higher mortality rate observed in groups with incontinence can be attributed to the higher levels of disability and frailty compared to the women without incontinence. Our findings are in accordance with several similar studies conducted in general geriatric populations, in which UI lost its association with mortality after adjusting for comorbidities and functional impairments (Holroyd-Leduc, Mehta and Covinsky, 2004; Nuotio et al., 2009; Thom, Haan and Van Den Eeden, 1997) and frailty status (Berardelli et al., 2013; Matta et al., 2020).

However, an earlier study on both men and women with HF found that UI and/or FI (Guzon-Illescas et al., 2019) were independent predictors of mortality at 1-year post-fracture. The differing results may be explained by variations in inclusion criteria, adjustment methods, and importantly, the inclusion of male participants, who have a significantly higher mortality rate than women with HF. In Seinäjoki Hip Fracture Database, the 1-year mortality rate of men with HF was 34% (Pajulammi et al., 2015).

6.7 Strengths and limitations

This study involved a prospectively collected, large cohort of older women with HF. The study population closely reflects real-world female HF patients, as the only exclusion criteria were pathological and periprosthetic fractures. All eligible patients were invited to participate, regardless of their place of residence or cognitive status.

Notably, one-third of the participants had a cognitive disorder or were institutionalized at baseline. In contrast to several previous studies (see Table 1), where referral from or to long-term care and cognitive impairment were common exclusion criteria, our inclusive approach enhances the generalizability of the findings. Data collection was conducted systematically by a trained geriatric nurse - almost exclusively by a single individual - strengthening the reliability of the dataset. Furthermore, there was no loss to follow-up in mortality data. Another key strengths are the use of well-established and validated tools in our outpatient-CGA and thorough adjustments of our statistical models.

Although the data was collected prospectively, the study design for this dissertation was retrospective, which accounts for many of its limitations. Some relevant data that would have been beneficial for this study were not recorded. Incontinence symptoms were assessed using simple, survey-style questions rather than validated questionnaires. This approach was partly chosen to maximize response rates, given the anticipated high levels of frailty and cognitive impairment in the study population. However, the frequency and severity of incontinence symptoms were not documented, nor was the precise duration of UC use. Similarly, other less common subtypes of urinary incontinence such as postural and overflow incontinence were not identified.

ASA score is the only indicator of general health in the data. Pre-fracture comorbidities or a comorbidity index were not recorded, and thus possible pre-existing urogynecological disorders were not known. However, ASA score has been established to correlate relatively well with Charlson comorbidity index among HF patients (Ek et al., 2022). Additionally, a validated frailty screening or assessment tool was absent from the original database. Given that multiple frailty indicators were consistently linked to incontinence in this study, the inclusion of a validated frailty tool would have strengthened the findings. Nevertheless, the MNA-SF was recorded both during hospitalization and at the outpatient clinic. This tool has been validated for identifying frailty (Soysal et al., 2019). Based on MNA-SF results, nearly half of the women at the outpatient clinic (I) were found to have poor nutritional status or frailty, aligning with previously reported prevalence rates of frailty among HF patients (Forssten et al., 2023).

The inclusion of DI in the study design is a strength as it addresses a gap of previous knowledge regarding DI in HF patients. However, DI groups in the studies (I, III, IV) of this dissertation were relatively small, which reduces the statistical power and the reliability of the results. In study II, SUI and MUI groups were equally small which raises the same concerns. FI in isolation manifested in so few patients that meaningful analysis was not feasible.

The data collection period spanned over a decade, during which time some degree of secular changes likely occurred and may have affected the results. For example, in the early years of data collection the orthogeriatric treatment model was in its pilot phase as opposed to later years when it was a stabilized part of standard care. Another noteworthy secular change was a gradual shift from long-term institutional care toward supporting older individuals to remain in their own homes as long as possible with the assistance of organized home care services. Moreover, due to differences in the structure and availability of care for older adults, our results on changes in living arrangements may not be directly generalizable to other societies. Survival and selection biases should also be considered. Mortality rate among the entire study population of 1,675 women was 18,5% during the first 6 months and 23,2% during the first-year post-fracture (unpublished result). These women were likely to be in poorest health with a high prevalence of frailty and incontinence which might lead to underestimated prevalence and incidence rates of incontinence. Similarly, among surviving women, those in worst condition were the most likely to drop-out or not answer the questions concerning incontinence.

7 Conclusions

Based on the findings of this dissertation, the following conclusions can be drawn:

1. Self-reported incontinence is highly prevalent among older women with HF and closely associated with disability. Women with DI were found to be the most vulnerable. Both UI and DI were associated with several patient- and care-related factors which can be targeted in orthogeriatric care, e.g. early mobilization, prompt UC removal, screening of depression, and effective prevention and treatment of constipation both in orthopedic wards and during rehabilitation.

2. UUI is the predominant subtype of UI, reflecting high age and multimorbidity of our patient population. MUI is associated with most factors. Discerning the specific subtype of UI maybe less clinically relevant than in younger women; CGA remains key.

3. UI and DI predict declining mobility levels, while DI – but not UI – predicts also the need for more supported living arrangements within first-year post-fracture. DI likely indicates more marked vulnerability and burden to both the patient and possible formal and informal caregivers.

4. Neither UI nor DI predict 1-year mortality independently. Underlying frailty likely accounts for the difference between mortality rates among the continence groups. Impaired mobility and living in an institution predict incident UI and DI one-year after HF, highlighting the importance of physical function in the development of incontinence in these frail women. Furthermore, a bidirectional relationship between UI and DI, and mobility has been established in this patient population. Focusing on re-gaining pre-fracture mobility level is essential not only for overall recovery but also for maintaining and regaining continence.

8 Future Considerations

The orthogeriatric care model has been shown to enhance the quality of care and outcomes for hip fracture patients. Extensive knowledge exists on optimal treatment strategies for these patients (Pajulammi et al., 2017). This dissertation adds to the body of knowledge on older women with HF. Incontinence is often noted as a part of CGA in orthogeriatric care, but understanding of its significance for patient outcomes, as well as active management, remains lacking. Pre-fracture incontinence can be a marker for frailty and a risk factor for poor outcomes. A significant number of patients also develop incident incontinence exposing them to further cascade of frailty after HF.

In clinical practice, incontinence should be assessed perioperatively to determine pre-fracture continence status and monitored regularly throughout rehabilitation as a regular part of the orthogeriatric model of care. Ongoing education for healthcare personnel on the risks associated with UC use is essential, along with the implementation of protocols for timely catheter removal and urinary habit training as part of standard care. Prevention and management of constipation is likewise essential, as is recognizing women with depressive symptoms. Early and progressive mobilization and sufficient nutrition play a crucial role both in restoring pre-fracture physical and functional levels while also supporting continence maintenance and improvement.

In research, further longitudinal studies on incontinence in this patient population are needed. Since approximately half of HF patients experience some degree of incontinence, a more detailed assessment – considering symptom severity and frequency – is necessary to better understand its impact on patient outcomes. Additionally, larger RTCs are needed to evaluate a variety of interventions aimed at reducing new-onset incontinence and improving existing continence problems and outcomes in HF patients. Equally important is the exploration of strategies that support successful aging, including the maintenance of physical function, mobility, and nutrition. Identifying interventions that help mitigate frailty, reduce fall risk, and prevent the onset of incontinence could play an important role in decreasing the incidence of injurious falls.

The implementation of orthogeriatric care, as well as the resources allocated for rehabilitation and falls prevention, continue to vary significantly across different regions in Finland. In 2023, Finland initiated a historic reform of its social welfare and healthcare service structure. The responsibility for organizing these services shifted from municipalities to 21 wellbeing services counties. However, the reform is still in progress, with an adjustment period expected to last several years. In its early stages, the focus was on cost-saving measures, leading to reductions in services for older adults. Now is the time to strive for wide-spread implementation of scientifically proven and cost-effective treatment models nationwide. A standardized orthogeriatric care model, including evaluation and management of incontinence, should be made accessible to everyone, regardless of their place of residence.

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