

Leveraging Natural Language Processing to Identify Risk for Hospitalizations
Among Older Adult Home Healthcare Patients with Urinary Incontinence

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Abstract

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Background: Persistently elevated hospitalization rates in the home healthcare setting indicate the need to prioritize patients with undertreated conditions that can lead to negative outcomes. Urinary incontinence affects approximately 40% of older adults in home healthcare, yet often remains unaddressed. This leaves older adults with urinary incontinence at risk for potentially serious complications that can lead to emergency department visits, hospitalizations, and mortality. Multiple comorbidities, co-occurring symptoms, and disparities in care fuel the complexity of older adults in the home healthcare setting. The overall purpose of this dissertation was to leverage natural language processing to understand symptom clusters and factors associated with acute care utilization among older adults with urinary incontinence in home healthcare to improve comprehensive assessment, treatment, and outcomes. The aims of this dissertation were to: 1) identify relevant comorbidities among community-dwelling older adults with urinary incontinence; 2) develop and test a natural language processing algorithm to extract symptom information from home healthcare free-text clinical notes for older adults with urinary incontinence and analyze differences by race or ethnicity; 3) identify symptom clusters among older adults with urinary incontinence in home healthcare and examine differences by sociodemographic and clinical correlates; and 4) determine factors associated with the risk of emergency department visits or hospitalizations among older adults with urinary incontinence in home healthcare, including the impact of symptom clusters.

Methods: This dissertation comprised four studies: 1) a scoping review of the literature to identify comorbidities to broadly characterize community-dwelling older adults with urinary incontinence, 2) a secondary analysis of cross-sectional electronic health record data using natural language processing to extract symptoms from free-text clinical notes and analyze differences by race or ethnicity using Chi-square tests and logistic regression models, 3) a secondary analysis of cross-sectional electronic health record data using hierarchical clustering to analyze the natural language processing-extracted symptom variables and examine differences in sociodemographic and clinical correlates using Chi-square tests, and 4) a retrospective secondary analysis of electronic health record data to identify factors, including symptom clusters, associated with emergency department visits or hospitalizations using Chi-square tests and backward stepwise logistic regression.

Results: In the scoping review, we synthesized findings from 10 studies that identified comorbidities among community-dwelling older adults with urinary incontinence across neurologic, cardiovascular, respiratory, endocrine, genitourinary, musculoskeletal, and psychologic systems. In the natural language processing study, we identified eight symptoms of older adults with urinary incontinence (i.e., anxiety, constipation, dizziness, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, and vision impairment/blurred vision) that were extracted from free-text clinical notes from approximately 29% of home healthcare episodes. Compared to White patients, home healthcare episodes for Asian/Pacific Islander, Hispanic, and Black patients were less likely to have any symptoms documented in clinical notes. In the clustering analysis, we identified five distinct symptom clusters: *Cluster 1* (anxiety), *Cluster 2* (broadly symptomatic), *Cluster 3* (dizziness and anxiety), *Cluster 4* (constipation, anxiety, and dizziness), and *Cluster 5* (no symptoms) that correlate with

sociodemographic and clinical characteristics. Finally, in the retrospective analysis, we found that *Clusters 1-4* had higher odds of emergency department visits or hospitalizations, in addition to home healthcare episodes for Black and Hispanic patients, males, patients with an unhealed skin ulcer, and patients with a urinary tract infection 14 days prior to home healthcare admission.

Conclusion: Older adults with urinary incontinence in home healthcare have complex physical and psychosocial needs, increasing the risk of negative outcomes. Improving comprehensive assessment and treatment for older adults with urinary incontinence is an urgent priority, given high hospitalization rates in home healthcare. Leveraging natural language processing, this dissertation identified key symptom clusters and factors associated with emergency department visits or hospitalizations, providing valuable insight for multidimensional interventions. Findings provide preliminary evidence to inform improvements in clinical practice, healthcare policies, and future research to enhance the care of older adults with urinary incontinence and reduce negative outcomes in the home healthcare setting.

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Dedication

To all people with lower urinary tract symptoms
in need of better care.

Chapter 1: Introduction

1.1 Background

Focusing on Older Adults with Urinary Incontinence (UI) in the Home Healthcare (HHC)

Setting

Over three million older adults (65 years and older) receive HHC services annually in the United States (Medicare Payment Advisory Committee, 2023). HHC provides an opportunity for patients to manage health conditions in the community through skilled care, including nursing, medical, social work, physical, occupational, and speech therapy services (Medicare Payment Advisory Commission, 2023). Urinary incontinence (UI) is a condition that older adults in HHC may experience. UI is defined as the involuntary leakage of urine (Haylen et al., 2010) and affects approximately 40% of older adults receiving HHC services (Gorina et al., 2014). Despite this substantial prevalence, UI is often undertreated in the HHC setting (McCann et al., 2022). Although HHC agencies collect data on UI status upon admission using the Outcome and Assessment Information Set (OASIS) form (Centers for Medicare and Medicaid Services, 2017), UI is not necessarily addressed when formulating treatment plans (Albertson, 2018). Existing evidence suggests that community nurses may perceive UI as a minor issue that does not warrant treatment (McCann et al., 2022). Similarly, patients may perceive UI as a normal part of aging without any viable treatments available (Jung et al., 2015; Silay et al., 2016).

The significance of UI may not be immediately evident, as it typically does not directly result in major negative outcomes in HHC, such as acute care utilization (i.e., emergency department (ED) visits or hospitalizations). However, UI can directly contribute to complications that may lead to ED visits or hospitalizations. For example, prolonged or improper absorbent pad use related to UI can increase the risk of urinary tract infections, which may progress to more

severe infections, including pyelonephritis and sepsis (Larsen et al., 2023). Skin exposure to urine may lead to incontinence-associated dermatitis, a known risk factor for pressure ulcers (Kayser et al., 2019). In a large (n=56,209) retrospective analysis of adult patients across 818 inpatient facilities, patients with UI were 5.1 times more likely to develop a pressure ulcer and 5.8 times more likely to have a pressure ulcer become severe compared to patients without UI (Kayser et al., 2021). Patients with pressure ulcers are at increased risk for infections, including cellulitis, osteomyelitis, and sepsis (Jaul, 2010). This risk is even greater among older adults with UI due to mobility impairments, nutritional deficiencies, and multimorbidity; all of which impede skin healing (Jaul, 2010). In addition to serious infections, UI can increase the risk of falls among older adults due to urinary urgency, nocturia, unsteady gait, or limited mobility (Teo et al., 2006). Falls can be detrimental among older adults, leading to injuries, fractures (Brown et al., 2000), and increased risk of future falls (Whipple et al., 2018).

UI-related complications represent opportunities for preventable hospitalizations in the HHC setting. This is important as research has shown that patients with UI may have longer average hospital length of stays, higher incurred costs, and an increased likelihood of being readmitted to the hospital once discharged compared to patients without UI (Kayser et al., 2021). Despite attempts to prevent hospitalizations in HHC, hospitalization rates have not significantly improved (Siclován et al., 2021). Still, one in five patients is hospitalized during their time in HHC (Medicare Payment Advisory Commission, 2023). Reasons for this may include the undertreatment of UI, perpetuating complications that lead to hospitalizations. Therefore, improved identification and treatment of UI among older adults in HHC is an urgent priority.

Recognizing the Complexity of Older Adults with UI in HHC

Most older adults with UI who receive HHC services have multiple comorbid conditions (Murtaugh et al., 2009) and corresponding symptoms, making their clinical presentations increasingly complex for clinicians to navigate. Symptoms are defined as subjective experiences that elicit changes in physical, mental, or social functioning (Bender et al., 2017). Two or more co-occurring symptoms are referred to as symptom clusters (Barsevick, 2007; Dodd et al., 2004; Kim et al., 2005; Miaskowski et al., 2017), which can be more challenging to identify and treat compared to individually occurring symptoms (Kwekkeboom, 2016; Miaskowski et al., 2017).

Despite evidence supporting the interconnectedness of physiological systems and psychosocial factors linked with UI, patients with UI may not receive comprehensive assessments (Brady et al., 2022; Norton et al., 2022). Reasons for this may include challenges in prioritizing what to treat, as clinicians may perceive UI as less important to treat than other conditions (Brady et al., 2022). Additionally, clinical practice guidelines generally focus on individual conditions, promoting disjointed specialty-specific care (Salisbury et al., 2018; Valentijn et al., 2013). Further, knowledge deficits among community nurses regarding symptom identification and treatment strategies for UI may perpetuate suboptimal care (McCann et al., 2022). In a study of community nurses (n=72), less than half felt they had adequate knowledge to effectively care for patients with UI (Bignell & Getliffe, 2001). This is particularly concerning in the HHC setting where nurses are the predominant group of clinicians and, consequently, carry the primary responsibility of symptom assessment and UI treatment.

Inequities in Care Magnify the Undertreatment of UI

Existing evidence suggests disparities in UI care, with adults of racially or ethnically minoritized groups receiving lower quality and more delayed care than White adults (Anger et al., 2007; Gupta et al., 2016; Siddiqui et al., 2016; Willis-Gray et al., 2015). For example, prior

studies have shown that Black adults have undergone fewer surgical procedures for UI compared to White adults (Anger et al., 2007; Gupta et al., 2016). Further, these procedures to treat UI have been more delayed (Anger et al., 2007; Gupta et al., 2016). Specifically, among 4,401 men who underwent prostatectomy to treat prostate cancer, Black men received procedures to treat UI approximately nine months later than White men (Gupta et al., 2016). Additionally, prior studies suggest that Latina women have delays in care for UI due to deficient UI-related knowledge and shame in disclosing symptoms (Siddiqui et al., 2016). Symptom underreporting may stem from patients' prior experiences of implicit racial and ethnic biases in healthcare (Bazargan et al., 2021). These biases can influence clinicians' perception of patients' characteristics and result in formulating treatment plans that may not address all patient needs (Barcelona et al., 2023; Beach et al., 2021).

Further, the prevalence of UI among racially or ethnically minoritized populations warrants enhanced symptom recognition and treatment. Prior studies support high rates of UI among these groups (Akbar et al., 2021; Thom et al., 2006). For example, among 1,443 community-dwelling adults across six communities in the United States, non-Hispanic Black men were 62% more likely to have UI compared to non-Hispanic White men (Akbar et al., 2021). Additionally, a large population-based study of 2,109 community-dwelling women found UI prevalence to be highest among Hispanic women (36%) compared to non-Hispanic Black (25%) and non-Hispanic White (30%) women (Thom et al., 2006). Emerging evidence suggests that exposure to childhood adversity may be a risk factor for developing UI throughout the life course (Epperson et al., 2020). Given that some racially or ethnically minoritized groups may encounter childhood adversity at disproportionately higher rates (Turner & Lloyd, 2003), this may be a contributing factor to the increased prevalence of UI among these groups. Understanding

differences in symptoms by race or ethnicity can facilitate equitable care, improve symptom identification, and achieve better outcomes among diverse groups of older adults with UI.

HHC Nurses are Well-Positioned to Lead Efforts to Improve UI Care

Although UI is often normalized and concealed by those affected, existing evidence suggests that patients may be open to clinician-initiated screening (Hagglund & Wadensten, 2007). For example, a mixed methods needs assessment of 240 patients with overactive bladder and UI found patients prefer clinicians to initiate discussions about UI; however, these clinician-led discussions seldom take place (Filipetto et al., 2014). In a study of 969 patients with UI of which 55% were of racially or ethnically minoritized groups (i.e., Asian, Black, Hispanic, and Native American), only 3% indicated that clinicians initiated these discussions (Duralde et al., 2016). This represents a gap that can be addressed in the HHC setting, as nurses are uniquely positioned to assess and care for patients in their homes. Nurses' propensity to provide holistic care (i.e., recognize the person as a whole comprised of various interdependent aspects (Frisch & Rabinowitsch, 2019)) facilitates their ability to assess physiologic and psychosocial factors within patients' environments. Improving knowledge of symptoms of older adults with UI in the HHC setting can foster clinician-led assessments to improve UI identification and treatment.

Symptom clusters can contribute to the knowledge needed to build clinical phenotypes that can guide holistic assessments. Clinical phenotypes in nursing contexts are defined as groups of observable traits that diverge from typical physiology or behavior (Robinson, 2012). The complexity of older adults with UI in the HHC setting causes clinical phenotypes to remain poorly understood. Clinical phenotypes can comprise symptoms across physiological systems, underscoring the need for a holistic approach to care.

Data-driven characterization is essential to develop clinical phenotypes (Koleck, Topaz, et al., 2021) for older adults with UI based on patients' shared attributes. This can inform the understanding of interrelated symptoms to develop clinical practice guidelines for multiple conditions and co-occurring symptoms. Data-driven characterization requires a rich source of symptom information that captures symptom nuances. Existing evidence supports that most symptom information is documented in free-text clinical notes (Hobensack et al., 2022; Sockolow et al., 2014; Song, Hobensack et al., 2022). HHC clinicians typically function independently and communicate remotely with the healthcare team through the electronic health record (EHR) (De Vliegher et al., 2010). For these reasons, free-text clinical notes contain detailed descriptions of patients' health statuses, environments, and symptoms (Hobensack et al., 2022; Sockolow et al., 2014; Song, Hobensack et al., 2022). Leveraging symptom information in free-text clinical notes is essential for data-driven characterization to inform meaningful clinical phenotypes for older adult HHC patients with UI.

Using Natural Language Processing (NLP) to Leverage Symptom Information in Free-Text Clinical Notes

EHRs contain two types of data: structured (e.g., checkboxes, drop-down menus, flowsheets) and unstructured (e.g., free-text clinical notes) (Chen & Sarkar, 2014). Structured data forms use controlled vocabulary that may restrict what clinicians assess and document (Hobensack et al., 2022; Sockolow et al., 2014; Song, Hobensack et al., 2022). This may perpetuate narrow assessments contributing to the under-identification and undertreatment of older adults with UI. Unlike structured data forms, unstructured free-text clinical notes contain a range of symptom information, as clinicians can autonomously document what they deem necessary. Given variations in symptom reporting and clinician documentation styles, free-text

clinical notes contain different symptom descriptions, abbreviations, and misspellings that may represent the same concept (Forbush et al., 2013). Traditional methods used to identify symptom information in clinical notes involve manual extraction. This is time-consuming, costly, and cannot be applied to thousands or millions of notes (Koleck, Tatonetti, et al., 2021).

NLP can eliminate the challenges associated with manual extraction and automatically extract data on a large scale (Koleck, Tatonetti, et al., 2021; Mehta & Pandit, 2018; Topaz et al., 2021; Yim et al., 2016). NLP refers to computer-based algorithms used to identify and process language for further analysis (Yim et al., 2016) and can be applied to millions of free-text clinical notes to extract symptom information efficiently (Koleck, Tatonetti, et al., 2021; Topaz et al., 2021). This symptom information can be used to determine patterns and frequencies that comprise symptom clusters to generate clinical phenotypes for older adults with UI. This can provide a foundation to examine associations between symptom clusters and acute care utilization to inform comprehensive assessments and interventions aiming to reduce hospitalization rates in the HHC setting.

1.2 Overall Aim

The overall purpose of this dissertation was to leverage NLP to understand symptom clusters and factors associated with acute care utilization among older adults with UI in HHC to improve comprehensive assessment, treatment, and outcomes. This dissertation follows the publication format. Chapters 2-5 were developed as independent manuscripts to be submitted for publication. Chapter 2, entitled “Comorbidities of Community-Dwelling Older Adults with Urinary Incontinence: A Scoping Review” was published in *Geriatric Nursing* (Scharp et al., 2023). Chapter 3, entitled “Applying Natural Language Processing to Understand Symptoms Among Older Adult Home Healthcare Patients” was submitted the *Journal of Nursing*

Scholarship, Special Issue: Artificial Intelligence in Nursing (2024). Chapter 4, entitled “Characterizing Symptom Clusters for Older Adults with Urinary Incontinence in Home Healthcare,” and Chapter 5, entitled “Risk Factors for Emergency Department Visits or Hospitalizations Among Older Adults with Urinary Incontinence in Home Healthcare,” will be prepared as manuscripts and submitted for publication.

1.3 Specific Aims and Study Designs

This dissertation includes six chapters with four distinct aims:

Aim 1 (Chapter 2): Identify comorbidities among community-dwelling older adults with UI to inform symptom-based research and provide insights about relationships between health conditions.

Study Design: Scoping review of the literature reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (Tricco et al., 2018).

Aim 2 (Chapter 3): Develop and test an NLP algorithm to extract symptom information from free-text clinical notes for older adults with UI and analyze differences by race or ethnicity.

Study Design: Secondary analysis of cross-sectional EHR data collected between January 1, 2015, and December 31, 2017, using expert clinician-driven Delphi survey rounds, NLP, Chi-square tests, and logistic regression models.

Aim 3 (Chapter 4): Identify symptom clusters for older adults with UI in HHC and analyze differences in sociodemographic and clinical factors.

Study Design: Secondary analysis of cross-sectional EHR data collected between January 1, 2015, and December 31, 2017, using hierarchical clustering and Chi-Square tests.

Aim 4 (Chapter 5): Determine factors associated with the risk for ED visits/hospitalizations among older adults with UI in HHC, including the impact of symptom clusters.

Study Design: Retrospective secondary analysis of EHR data collected between January 1, 2015, and December 31, 2017, using Chi-square tests and logistic regression.

1.4 Theoretical Framework

This work was informed by the Theory of Unpleasant Symptoms (**Appendix A**), which accounts for physiologic, psychologic, and situational antecedents that affect symptom experience and subsequent outcomes (Lenz et al., 1997). This theory is underpinned by the assumption that overlapping symptoms occur synergistically, and the resulting symptom experience must be addressed holistically (Lenz et al., 1997). The specific dimensions within this theoretical framework include physiologic factors (i.e., normally functioning or pathologic processes influencing organ systems), psychologic factors (i.e., mental state or mood), and situational factors (i.e., aspects of the physical or social environment) that influence symptom experience and performance outcomes (Lenz et al., 1997). Within this framework, performance is defined as the outcome or effect of symptom experience and is conceptualized to include physical role performance (Lenz et al., 1997). Patients with a higher quantity or more severe symptoms generally have lower health status and ability to complete physical tasks (Lenz et al., 1997). Physical role performance indicators are experienced by patients and assessed by nurses to inform decision-making regarding transfer to a higher level of care (e.g., ED/hospital). Although this theory was originally conceptualized to study patient-level outcomes, the focus was extended to population-level outcomes by operationalizing performance as ED visits/hospitalizations. Integrating patient and population-level outcomes aligns with the need for healthcare to shift from siloed care models to focusing on the overall health of groups with

shared characteristics (Shahzad et al., 2019). The dimensions of this framework are not consecutive but rather interactive in how they foster symptom experience and outcomes. Further, resulting symptoms and outcomes mutually influence antecedent factors, which can prolong, perpetuate, or worsen symptom experience. This theory fosters consideration of interrelated symptoms and promotes the development of more comprehensive interventions than those directed toward addressing individual symptoms as separate entities (Lenz et al., 1997).

The Theory of Unpleasant Symptoms (Lenz et al., 1997) guided the variable selection process and informed the interpretation of study results. Variables mapped to the theoretical constructs were selected to examine symptom experience and performance outcomes through a holistic lens. This theory provided a comprehensive framework for understanding the complex interplay between symptoms of older adults with UI and factors associated with ED visits/hospitalizations in HHC. By drawing on this theory, clinical meaningful interpretations were generated that shed light on potential pathways linking multidimensional factors to symptom experience and outcomes.

1.5 Gaps and Potential Contributions

Chapter 2 (Aim 1): Fragmented assessment, treatment, and management of older adults with UI may be driven by clinical practice guidelines that typically focus on individual conditions. Lack of understanding of the directionality of relationships and shared mechanisms between comorbidities and UI may limit multidimensional symptom assessments needed to comprehensively identify and treat older adults with UI. This scoping review fills the literature gap by broadly characterizing community-dwelling older adults with UI to inform symptom-based research aiming to develop clinical phenotypes to guide holistic care.

Chapter 3 (Aim 2): UI is often under-identified and undertreated among older adults in the HHC setting, increasing the risk for negative outcomes and revealing disparities in care. Free-text clinical notes are an untapped data source illuminating symptom information that can be used to guide comprehensive care. This study generates new knowledge by identifying symptoms of older adults with UI to characterize these patients more specifically. Additionally, this study leverages NLP to extract symptom information from free-text clinical notes for older adults with UI and examine differences by race or ethnicity to identify potential gaps in care and inform more comprehensive assessments. A well-performing NLP algorithm can be applied to other data sources and in other clinical settings to uncover additional symptom information to inform holistic, equitable care.

Chapter 4 (Aim 3): Clinical phenotypes among older adults with UI remain an enigma, which can lead to missed opportunities to comprehensively assess and treat this population. This study addresses gaps in the literature by generating symptom clusters highlighting a range of symptom experiences among older adults with UI in HHC. Identifying subgroups with common characteristics can inform the development of tailored treatment strategies addressing co-occurring symptoms simultaneously rather than as individually occurring entities.

Chapter 5 (Aim 4): Despite efforts to leverage HHC to reduce acute care utilization, hospitalization rates have not significantly improved (Siclován et al., 2021). Although UI is a known risk factor for complications that can lead to negative outcomes, little is known about whether particular symptom clusters, sociodemographic, and clinical factors among older adults with UI are associated with ED visits or hospitalizations. Knowledge of these associations can enable closer monitoring and inform multidimensional interventions that can be developed, tested, and implemented to prevent ED visits, hospitalizations, and mortality.

1.6 Institutional Review Board Approval

This dissertation includes one scoping review and three studies using secondary data from a larger study (PI: Dr. Maxim Topaz, R01HS027742). The Institutional Review Board at VNS Health approved this dissertation work (IRB Reference #: I20-003). A de-identified subsample of the original VNS Health dataset was stored on secure password-protected networks within Columbia University School of Nursing. These studies had minimal risks to human subjects as there was no direct contact with human subjects, and all data were de-identified.

1.7 Conclusion

Improving care of older adults with UI in the HHC setting is an urgent priority to reduce negative outcomes, including ED visits, hospitalizations, and mortality. This dissertation will advance nursing science by characterizing older adults with UI, highlighting clinical phenotypes to guide holistic, equitable care. Findings will fill a critical gap by beginning to unravel complex clinical presentations to provide clinicians with a preliminary roadmap for evaluating and treating older adults with UI. The application of NLP in the context of older adults with UI in the HHC setting will provide a basis for future analyses of patient generated information, longitudinal data, and healthcare outcomes, fostering a comprehensive understanding of this important phenomenon.

Chapter 2: Comorbidities of Community-Dwelling Older Adults with Urinary Incontinence: A Scoping Review

Note. Chapter 2 is a manuscript published in *Geriatric Nursing*. It is published as:

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Keywords: comorbidities, older adult, scoping review, urinary incontinence

2.1 Introduction

Urinary incontinence (UI) (i.e., the involuntary leakage of urine (Haylen et al., 2010)) affects over 40% of community-dwelling older adults aged 60 years and older (Kozomara-Hocke et al., 2016; Milsom & Gyhagen, 2019); yet often goes untreated due to a lack of care seeking and screening (Jung et al., 2015; Norton et al., 2022; Silay et al., 2016). Most older adults do not report UI to clinicians due to embarrassment (Filipetto et al., 2014; Koch, 2006) or the belief that UI is part of normal aging (Jung et al., 2015; Silay et al., 2016). Clinician-initiated assessments of UI are preferred (Filipetto et al., 2014), however these assessments do not consistently take place (Duralde et al., 2016; Filipetto et al., 2014). UI can be associated with several negative outcomes, including urinary tract infections (Larsen et al., 2023), skin breakdown (Kayser et al., 2019), cognitive decline (Huang et al., 2007), falls (Moon et al., 2021), and fractures (Brown et al., 2000), all of which can be precursors to hospitalization and mortality (John et al., 2016). Despite these serious risks, UI may be perceived by clinicians as less important than other comorbid conditions (Brady et al., 2022). Most older adults with UI have chronic comorbid conditions (Coyne et al., 2013) that can initiate or exacerbate UI. For this reason, older adults with UI likely have symptoms affecting several physiological systems. This complicates the assessment of these patients as they present with co-occurring symptoms, which are more challenging to identify and treat compared to individually occurring symptoms (Kwekkeboom, 2016; Miaskowski et al., 2017). Given the interconnectedness of physiological systems, biological, and psychological factors that contribute to UI (Brady et al., 2022; Norton et al., 2022), a clear evaluation process that accounts for multiple co-occurring symptoms in a systematic way is warranted (Miaskowski, 2016).

Despite this need, clinical assessment of UI is often limited to the urological system (Diaz et al., 2017). Clinical practice guidelines typically focus on individual conditions (Salisbury et al., 2018), which promotes fragmented specialty-specific healthcare (Valentijn et al., 2013). This may lead to missed opportunities to comprehensively assess and treat older adults with UI and other comorbid conditions (Brady et al., 2022; Norton et al., 2022). For example, current evidence-based recommendations for assessing and treating UI focus on evaluating voiding patterns, identifying the type of UI based on urinary symptoms, and reviewing medications that may affect the lower urinary tract (Diaz et al., 2017). Additionally, clinical assessment of patients with heart failure typically focuses on volume status and perfusion by evaluating for orthopnea, jugular venous distention, and edema (Thibodeau & Drazner, 2018). However, these recommendations only target symptoms related to one condition and do not reflect the holistic approach needed to care for patients with UI (Norton et al., 2022); such an approach recognizes the person as a whole, the context of the environment, and the mind-body connection (Frisch & Rabinowitsch, 2019). Evidence-based holistic care guidelines that account for several conditions and co-occurring symptoms can improve assessing and treating patients with multiple comorbidities. This holistic approach can improve UI and other comorbid conditions by facilitating earlier identification, prevention, and treatment strategies (Brady et al., 2022). Clinical phenotypes are essential to inform evidence-based holistic care. In medical and nursing contexts, clinical phenotypes are defined as groups of observable traits that deviate from normal physiology or behavior (Robinson, 2012). These traits can be operationalized as comorbidities or symptoms in research. Clinical phenotypes remain an enigma for community-dwelling older adults with UI, leading to delayed diagnosis, treatment, and worse outcomes. Identifying comorbidities of community-dwelling older adults with UI is a critical first step to

building clinical phenotypes by guiding future symptom-based research to improve assessment, treatment, and outcomes.

Community-dwelling older adults are unique as the experience and impact of UI differ from that of older adults in other settings, such as nursing homes and hospitals. UI in nursing homes is often related to dementia and mobility impairment (Leung & Schnelle, 2008), resulting in more severe symptoms and increased caregiver dependence compared to UI in the community (Offermans et al., 2009). Managing hospitalized older adults with UI typically focuses on containment strategies rather than treating the condition and promoting continence (Dingwall & McLafferty, 2006). Community-dwelling older adults with UI are often managing chronic conditions and living with the impacts of UI across personal (e.g., quality of life), interpersonal (e.g., intimate, familial, social, and workplace relationships), organizational (e.g., missed work, reduced productivity), community (e.g., stigma, social isolation), societal (e.g., increased health care utilization and costs), and ecosystem (e.g., increased water use from toilet flushing, increased waste from pad use) levels (Brady et al., 2022; Norton et al., 2022). Further, the cumulative aspect of comorbidities involves managing fluctuating symptoms in the community setting throughout the life course (Charmaz, 1991). A life course perspective supports that UI and other health conditions may develop at any point and the aggregate impact can increase over time (Brady et al., 2022); therefore, impacts are likely more significant with age. Community-dwelling older adults with UI and multiple comorbid conditions typically visit an increasing number of specialty-specific clinicians over time. This may lead to fragmented care and the formation of silos, in which the broader context of the entire clinical phenotype may be missed (Gordon et al., 2020). In the absence of well-defined clinical phenotypes and evidence-based holistic care guidelines, it is challenging for clinicians to navigate assessment and treatment

strategies for older adults throughout the life course. Given differences in health, functional status, and needs between institutionalized and community populations (Ostaszkiwicz et al., 2008), a study specific to community-dwelling older adults with UI is warranted.

The lack of understanding about comorbidities associated with UI among older adults, directionality of these relationships, and shared mechanisms inhibits the development of clinical phenotypes which may lead to fragmented assessment and treatment strategies (Brady et al., 2022). Existing evidence suggests the association of comorbidities outside the urinary tract and UI (Palmer et al., 2009; Roy et al., 2020; Tannenbaum et al., 2013; Troko et al., 2016); however, these studies were not specific to older adults with UI, leaving a gap in the literature for this study to address. The underreporting and undertreating of UI and its association with negative outcomes underscore the need for improved assessment and treatment strategies. Moreover, alarming evidence exists that many ill older adults consider UI a health state worse than death (Rubin et al., 2016), which further underpins this need.

Knowledge of comorbidities of community-dwelling older adults with UI can improve clinicians' ability to employ comprehensive assessments and timely interventions to reduce the risk of negative outcomes. Specifically, this knowledge can form a basis for developing clinical phenotypes and evidence-based holistic care guidelines that standardize assessments of multiple comorbidities and co-occurring symptoms. Further, this can increase clinicians' awareness of the need to screen for UI when patients present with certain comorbidities. This can lead to UI being more readily identified and treated before negative outcomes develop. Given the rising number of older adults with UI due to the growth of the aging population (Irwin et al., 2011), this study is well-timed to broadly characterize community-dwelling older adults with UI and provide a foundation for developing clinical phenotypes and evidence-based holistic care guidelines in

future research. Therefore, the objectives of this study were to: 1) review the literature to identify relevant comorbidities among community-dwelling older adults with UI to inform future symptom-based research, and 2) provide insights about relationships between comorbidities and UI to improve assessment and treatment strategies.

2.2 Methods

A scoping review was chosen instead of a systematic review as the purpose was to address a broad research question that aimed to identify significant comorbidities among community-dwelling older adults with UI and map existing evidence (Munn et al., 2018) by categorizing comorbidities by affected physiological system. Additionally, this review will enhance foundational knowledge specific to older adults to provide a basis for future symptom-based research involving this population (Munn et al., 2018). This scoping review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (Tricco et al., 2018) (**Appendix B**). This review involved the following phases: study retrieval, study selection, critical appraisal, data extraction, and data synthesis. Study selection, critical appraisal, and data extraction were performed using Covidence (www.covidence.org), a web-based tool designed to facilitate these processes.

A protocol for study eligibility was developed a priori and listed in the Open Science Framework database (<https://osf.io/a2xmw/>). The protocol was reported in accordance with the PRISMA-ScR statement (Tricco et al., 2018).

Eligibility Criteria

The search included studies from database inception through March 2023. There were no restrictions by publication date. Consistent with the World Health Organization's definition, older adults were defined as individuals aged 60 years and older (World Health Organization,

2023). Adults aged 60 years and older were selected as the population of focus because older adults have an especially high risk for negative outcomes secondary to UI and many older adults with UI have multiple chronic conditions (Murtaugh et al., 2009). UI was defined as the involuntary leakage of urine (Haylen et al., 2010). UI subtypes included stress (i.e., involuntary leakage of urine with physical exertion or effort, such as coughing, sneezing, or sporting activities), urgency (i.e., involuntary leakage of urine preceded by the sudden desire to pass urine which is difficult to defer), and mixed (i.e., involuntary leakage of urine associated with physical exertion or effort and urgency) (Haylen et al., 2010). Comorbidity was defined in the domain of clinical care as the co-occurrence of distinct diseases in any physiological system (Valderas et al., 2009). Inclusion criteria were: 1) quantitative study designs evaluating associations between comorbidities and UI among community-dwelling older adults (aged 60 years and older) that analyzed UI as either the exposure or outcome variable, 2) articles written in English or translated to the English language, and 3) full-text article is available. Studies were excluded if they: 1) took place in inpatient, nursing home, or post-acute care settings (i.e., long-term care, home healthcare, skilled nursing facility, or rehabilitation settings), 2) evaluated older adults with UI secondary to urinary tract infections, sexually transmitted infections, medication side effects, surgery, primary neurogenic lower urinary tract dysfunction (i.e., due to congenital neurological disorders and spinal cord injuries), or prostate cancer, 3) evaluated older adults with dual incontinence (i.e., UI and fecal incontinence), 4) focused on treatment and management of UI (e.g., medication or surgical interventions and outcomes), and 5) were review articles, qualitative studies, study protocols, dissertation studies, editorials, psychometric studies, case reports, and unpublished articles.

These criteria were established to only include studies specific to community-dwelling adults with UI without influence from acute conditions, medications, or surgery. Older adults with primary neurogenic lower urinary tract dysfunction were excluded because lower urinary tract dysfunction due to congenital neurological disorders or spinal cord injuries should be studied separately (Moussa et al., 2020). Older adults with prostate cancer were excluded because of medical complexity and increased frequency of UI secondary to management strategies (e.g., surgery) (Lardas et al., 2022). Additionally, older adults with dual incontinence were excluded because this is a severe type of pelvic floor dysfunction that affects individuals differently than UI or fecal incontinence in isolation (Fialkow et al., 2003; Matthews et al., 2013). Further, evidence suggests that comorbidities are more common among individuals with dual incontinence than UI alone (Matthews et al., 2013), which indicates that including this population in this study could overestimate comorbidities among older adults with UI.

Information Sources

Three databases were searched (PubMed, Cumulative Index of Nursing and Allied Health Literature (CINAHL), and Embase) in March 2023 to identify potentially relevant studies related to comorbidities among community-dwelling older adults with UI. Reference lists of included studies were manually searched for additional relevant studies.

Search Strategy

The author (DS) developed the search strategy which was revised in consultation with the co-authors (SH, MT) and the Columbia University School of Nursing and Health Sciences Library Informationist. Search terms that described the concepts of older adults, comorbidities, and UI included a combination of Medical Subject Heading (MeSH) vocabulary and keywords (**Table 2.1**). The terms used to operationalize these concepts in the literature were selected to

capture relevant studies focusing on comorbidities among community-dwelling older adults with UI. Full search strategies applied in PubMed, CINAHL, and Embase are presented in **Table 2.2**.

Selection of Sources of Evidence

All potentially relevant studies were imported to EndNote X9 software and deduplicated using the Bramer method (Bramer et al., 2016). To determine eligibility for inclusion, two reviewers (DS, SH) independently screened all studies by title and abstract using Covidence (www.covidence.org). The same two reviewers independently screened the full-text studies and documented reasons for exclusion. A third reviewer was consulted to resolve discrepancies (MT).

Data Charting Process

The author (DS) created the data extraction template, which was revised in consultation with the co-authors (SH, MT). The rationale and objectives of this current scoping review guided variable selection. The template was tested and continuously revised to include variables pertinent to the research question.

Data Items

The variables of interest for data extraction included authors, year of publication, country, study design, purpose, sample, type of UI studied, data source, significant comorbidities of community-dwelling older adults with UI, measurement of UI and significant comorbidities, and study outcomes. Data were summarized in tables to identify patterns and facilitate data synthesis.

Critical Appraisal of Individual Sources of Evidence

Methodological quality and risk of bias in design, implementation, and data analysis of each included study were assessed based on the Joanna Briggs Institute (JBI) Critical Appraisal

Checklist for Analytical Cross-Sectional Studies (for the 8 cross-sectional studies), JBI Critical Appraisal Checklist for Cohort Studies (for the one cohort study) and JBI Critical Appraisal Checklist for Case-Control studies (for the one case-control study) (Moola et al., 2020). The Critical Appraisal Checklist for Analytical Cross-Sectional Studies contains eight questions, the Critical Appraisal Checklist for Cohort Studies contains 11 questions, and the Critical Appraisal Checklist for Case-Control Studies contains 10 questions. Response options for each question are: “yes,” “no,” “unclear,” or “not applicable.” These tools were used to assess methodological quality and risk of bias in sampling, measurement, and data analysis. No studies were excluded based on results of the critical appraisal.

Synthesis of Results

Findings about significant comorbidities of community-dwelling older adults with UI were summarized and grouped based on the affected physiological system. Physiological system was extended to include “psychologic” to capture the impact of UI beyond the biological system. This summary also included information about samples, methods, and measurements used in each study.

2.3 Results

Selection of Sources of Evidence

A summary of the study selection process is provided in the PRISMA flow diagram (**Figure 2.1**). The initial literature search yielded 2,847 potentially eligible studies. After deduplication, 2,085 studies were included for the title and abstract screening. Thirty-eight studies were included for full-text review. Twenty-nine studies were excluded. Nine studies met eligibility criteria and were included for critical appraisal and data extraction. Reference lists of

the nine included studies were manually searched, and one study met inclusion criteria, for a total of 10 studies to be included in this scoping review.

Characteristics of Sources of Evidence

Ten studies met the inclusion criteria (Bresee et al., 2014; Brown et al., 1996; Buchman et al., 2017; Burti et al., 2012; Divani et al., 2011; Erdogan et al., 2019; Gerst et al., 2011; Park & Son Hong, 2016; Smith et al., 2010; Sohn et al., 2018) and represent data from 28,330 community-dwelling older adults with UI across several disease types (i.e., stroke, Parkinsonism, cerebrovascular disease, heart disease, hypertension, congestive heart failure, diabetes, chronic obstructive pulmonary disease, sarcopenia, arthritis, benign prostatic obstruction, depression, and anxiety). Characteristics of the ten included studies are presented in **Table 2.3**. The studies were published between 1996 and 2021 and were conducted across four countries (i.e., the United States (Bresee et al., 2014; Brown et al., 1996; Buchman et al., 2017; Divani et al., 2011; Gerst et al., 2011; Smith et al., 2010), Brazil (Burti et al., 2012), Turkey (Erdogan et al., 2019), and Korea (Park & Son Hong, 2016; Sohn et al., 2018)). Four studies (40%) included women and men (Buchman et al., 2017; Burti et al., 2012; Divani et al., 2011; Smith et al., 2010), four studies (40%) included women only (Bresee et al., 2014; Brown et al., 1996; Erdogan et al., 2019; Sohn et al., 2018), and two studies (20%) included men only (Gerst et al., 2011; Park & Son Hong, 2016). Of the studies that included women and men, samples ranged from roughly 55 to 90% women. Four studies (40%) solely focused on Mexican American men (Gerst et al., 2011), Latinx adults (Smith et al., 2010), Korean women (Sohn et al., 2018), and Korean men (Park & Son Hong, 2016). Of the remaining studies (n=6), all but two (Buchman et al., 2017; Erdogan et al., 2019) reported race or ethnicity data. Of the studies that reported these data, most samples mainly included (i.e., greater than 60%) White participants. Regarding type of UI

studied, four studies (40%) specified UI subtype and included older adults with stress (Burti et al., 2012; Erdogan et al., 2019; Park & Son Hong, 2016), urgency (Buchman et al., 2017; Erdogan et al., 2019; Gerst et al., 2011; Park & Son Hong, 2016), and mixed UI (Burti et al., 2012; Erdogan et al., 2019; Park & Son Hong, 2016).

Critical Appraisal Within Sources of Evidence

Details of the critical appraisal of the studies according to the JBI Critical Appraisal Checklists are provided in **Tables 2.4, 2.5, and 2.6**. Nine studies (Bresee et al., 2014; Brown et al., 1996; Burti et al., 2012; Divani et al., 2011; Erdogan et al., 2019; Gerst et al., 2011; Park & Son Hong, 2016; Smith et al., 2010; Sohn et al., 2018) (90%) examined comorbidities as the exposure and UI as the outcome. The only included prospective cohort study (Buchman et al., 2017) examined UI as the exposure and comorbidities (i.e., Parkinsonism) as the outcome. Most studies (n=6, 60%) (Bresee et al., 2014; Brown et al., 1996; Buchman et al., 2017; Divani et al., 2011; Gerst et al., 2011; Smith et al., 2010) received “yes” responses in most critical appraisal checklist domains, indicating that the criteria for methodological quality in that domain was met. The remaining studies (n=4, 40%) received “yes” responses in half (Burti et al., 2012; Erdogan et al., 2019; Park & Son Hong, 2016) and less than half (Sohn et al., 2018) of critical appraisal checklist domains.

Although critical appraisal revealed that most included studies had several strengths, weaknesses were identified across most studies in key areas. The measurement of UI was a notable weakness across most studies. Nine studies (Bresee et al., 2014; Brown et al., 1996; Buchman et al., 2017; Burti et al., 2012; Divani et al., 2011; Erdogan et al., 2019; Gerst et al., 2011; Park & Son Hong, 2016; Sohn et al., 2018) (90%) used self-report questions that were not psychometrically tested to assess UI. This can result in underreporting of UI and produce biased

estimates. Only one study (Smith et al., 2010) (10%) measured UI using the International Consultation on Incontinence Questionnaire, which has strong psychometric properties and generates valid and reliable scores (Avery et al., 2004). No studies confirmed UI with additional measurements.

The measurement of comorbidities was a similar weakness found among included studies. Seven studies (Bresee et al., 2014; Brown et al., 1996; Divani et al., 2011; Gerst et al., 2011; Park & Son Hong, 2016; Smith et al., 2010; Sohn et al., 2018) (70%) assessed comorbidities with self-report interviews or questionnaires. Only one study (Buchman et al., 2017) (10%) used measures that generate valid and reliable scores to assess comorbidities (i.e., the Unified Parkinson's Disease Rating Scale). Only two studies (Buchman et al., 2017; Erdogan et al., 2019) (20%) specified that clinicians performed a physical examination and used standardized instruments and validated protocols to assess comorbidities (i.e., Parkinsonism, sarcopenia). It remained unclear how one study (Burti et al., 2012) assessed comorbidities, as the authors reported that blood pressure, diabetes, and bone density measurements were taken at the hospital. Still, no details were provided about these measures (e.g., how blood pressure was taken, laboratory tests for fasting blood sugar or non-fasting blood sugar, hemoglobin A1C, fingerstick blood sugar, bone scan). Moreover, risk of measurement bias existed among these studies in that no study specified the qualifications of the individuals performing measurements. Studies described these individuals as professional interviewers (Bresee et al., 2014), trained professionals (Burti et al., 2012), trained nurses (Buchman et al., 2017), and geriatric physiotherapists (Erdogan et al., 2019); however, no further detail was provided.

The included studies exhibited some common strengths. In terms of sampling, all but one study (Sohn et al., 2018) had clearly defined inclusion and exclusion criteria. All but three

studies (Erdogan et al., 2019; Park & Son Hong, 2016; Sohn et al., 2018) described the participants and setting in detail. Included studies involved community-based samples, which decreased the risk of selection bias. All studies identified confounding factors, which mitigated the risk of history bias. Most studies (Bresee et al., 2014; Brown et al., 1996; Buchman et al., 2017; Divani et al., 2011; Gerst et al., 2011; Park & Son Hong, 2016; Smith et al., 2010) (n=7, 70%) accounted for confounding variables in adjusted analyses. The remaining three studies (Burti et al., 2012; Erdogan et al., 2019; Sohn et al., 2018) only adjusted for certain confounders and did not provide a rationale for variable selection. All studies used appropriate statistics to quantify the strength of the association between UI and comorbidities.

Relevant data that were extracted that relate to the current review objectives are presented in **Table 2.7**, including significant comorbidities of community-dwelling older adults with UI, study outcomes, and affected physiological system.

Comorbidities of Community-Dwelling Older Adults with UI

The included studies revealed significant associations between UI and comorbidities across seven physiological systems (i.e., neurologic, cardiovascular, psychologic, respiratory, endocrine, genitourinary, and musculoskeletal). Comorbidities affecting the neurologic and cardiovascular systems were found to be most commonly associated with UI. Associations between the psychologic, respiratory, endocrine, genitourinary, and musculoskeletal systems and UI were less frequent, but still meaningful.

Neurologic Comorbidities

Five studies (Bresee et al., 2014; Brown et al., 1996; Buchman et al., 2017; Divani et al., 2011; Sohn et al., 2018) (50%) found significant associations between comorbidities affecting the neurologic system and UI. Four of the five studies evaluated UI as the outcome variable and

found stroke (Bresee et al., 2014; Brown et al., 1996; Divani et al., 2011) and cerebrovascular disease (Sohn et al., 2018) to be associated with UI. The remaining study examined UI as the exposure variable and found an association with Parkinsonism (Buchman et al., 2017), suggesting that UI could be an early sign of the development of this disease.

Cardiovascular Comorbidities

Of the three studies (Bresee et al., 2014; Burti et al., 2012; Smith et al., 2010) (30%) that found significant associations between cardiovascular comorbidities and UI, two studies found a significant association between hypertension and UI (Burti et al., 2012; Smith et al., 2010). In one of these studies, approximately 40% of the sample was taking diuretics to treat hypertension (Burti et al., 2012), which can contribute to lower urinary tract symptoms (Ekundayo et al., 2009). Therefore, it was acknowledged that the association found may have been influenced by medications. The other study that found a significant association between hypertension and UI also found a significant association between congestive heart failure and UI (Smith et al., 2010). This finding suggests that UI may be associated with an aggregate effect of comorbidities rather than individual diseases. The remaining study found heart disease to be significantly associated with UI in multivariable analysis adjusting for age, race, ethnicity, and income (Bresee et al., 2014).

Psychologic Comorbidities

Only one study (Smith et al., 2010) (10%) found significant associations between psychologic comorbidities (i.e., anxiety and depression) and UI. These conditions were significantly associated with UI in bivariate analyses in which UI was examined as the outcome variable. This suggests that these mental health comorbidities may lead to the development of UI, although reasons for this remain poorly understood.

Respiratory Comorbidities

Only one study (Brown et al., 1996) (10%) found a significant association between respiratory comorbidities (i.e., chronic obstructive pulmonary disease (COPD)) and UI. COPD was identified as an independent factor associated with UI. This association remained significant after adjusting for smoking (Brown et al., 1996).

Endocrine Comorbidities

Of the two studies (Brown et al., 1996; Burti et al., 2012) (20%) that found significant associations between endocrine comorbidities and UI, both identified diabetes. One study found diabetes to be significantly associated with daily UI (Brown et al., 1996); the other study did not evaluate UI frequency (Burti et al., 2012).

Genitourinary Comorbidities

Two studies (Gerst et al., 2011; Park & Son Hong, 2016) (20%) found significant associations between prostate conditions (i.e., benign prostatic obstruction) and UI. One study included all UI subtypes (Park & Son Hong, 2016) and one study focused on the urgency UI subtype (Gerst et al., 2011). In both studies, prostate conditions were found to be independently associated with UI and remained significant when controlling for other confounding factors (Gerst et al., 2011; Park & Son Hong, 2016).

Musculoskeletal Comorbidities

Three studies (Erdogan et al., 2019; Smith et al., 2010; Sohn et al., 2018) (30%) found significant associations between musculoskeletal comorbidities and UI. One study found sarcopenia to be significantly associated with UI adjusted for weight (Erdogan et al., 2019). The other two studies found arthritis to be significantly associated with UI, which remained significant in adjusted analyses (Smith et al., 2010; Sohn et al., 2018).

2.4 Discussion

This scoping review included 10 studies identifying relevant comorbidities of community-dwelling older adults with UI across multiple physiological systems. The relatively small number of studies dedicated to UI and associated comorbidities among this population provides limited insight into causality, shared mechanisms, and directionality of relationships. Future research is needed to understand relationships between UI, comorbidities, and co-occurring symptoms to generate clinical phenotypes and improve the identification and treatment of UI.

Although connections between some comorbidities of community-dwelling older adults with UI identified in this review were not surprising (i.e., neurologic comorbidities, psychologic comorbidities, genitourinary comorbidities), others seemed less obvious. Approximately one-third of included studies identified musculoskeletal comorbidities (i.e., arthritis and sarcopenia) to be associated with UI. Reasons for this may include loss of muscle mass and skeletal malformations that can contribute to pelvic floor disorders. This can lead to UI if the pelvic floor muscles are weak. Additionally, cough and dyspnea related to COPD can increase intra-abdominal pressure which can put stress on the bladder and further weaken pelvic floor muscles leading to UI (Newman, 2014). These associations may not be known to clinicians, as evaluation of the pelvic floor is not routinely taught in clinical education (Gupta et al., 2015). Associations between UI and comorbid conditions such as hypertension, congestive heart failure, heart disease, and diabetes may also not be obvious. Underlying shared mechanisms may play a role, as well as other factors, including the aggregate effect of multiple comorbidities, how treatment for one condition affects another, and changes in physical and functional status throughout the life course. Understanding relationships between comorbidities and UI can improve clinicians'

awareness of the interconnectedness of physiological systems and facilitate holistic assessment strategies.

The directionality of relationships between comorbidities and UI remains elusive in the literature. Medications used to treat certain conditions (e.g., diuretics for hypertension or heart failure) may lead to UI (Burti et al., 2012). Only one study included in this review noted that diuretic use among participants might have influenced the association between hypertension and UI (Burti et al., 2012). However, a growing body of literature suggests that diuretic use is associated with other lower urinary tract symptoms, including frequency and urgency, but not with UI (Ekundayo et al., 2009; Miller et al., 2022; Palmer et al., 2009). Despite this evidence, the perception that diuretics may provoke or worsen UI may cause patients to avoid taking these essential medications to treat cardiovascular conditions (Hwang et al., 2013). Further research is needed to examine whether certain medications can initiate or exacerbate UI, or if shared mechanisms between certain comorbidities and UI may be the primary contributing factor.

Almost all studies in this review examined comorbidities as the exposure and UI as the outcome variable, indicating that certain comorbidities may lead to the development of UI. However, these relationships may be bidirectional (Brady et al., 2022). Mental stressors can influence health throughout the life course and increase the risk for lower urinary tract symptoms, including UI, through changes in stress physiology (Epperson et al., 2020). For example, evidence suggests that exposure to childhood adversity increases the risk for lower urinary tract symptoms and UI in adults (Epperson et al., 2020). Therefore, mental health conditions, such as anxiety and depression, may be risk factors for lower urinary tract symptoms, including UI. One study included in this review that investigated psychologic comorbidities examined anxiety and depression as exposure variables and found significant associations with

UI (Smith et al., 2010). Reasons for this may include alterations in stress physiology over time, although this was not the focus of this study. Conversely, stress, anxiety, and depression can be consequences of UI in terms of reduced quality of life, negative self-worth, loss of relationships, social isolation, financial distress, and stigma (Brady et al., 2022; Coyne et al., 2013). This evidence supports the need to screen for UI when older adults present with symptoms of anxiety or depression. This can be facilitated and standardized through the development of evidence-based holistic care guidelines that account for multiple conditions across physiological systems, as identified by this review.

In addition to the impact of mental stressors on physical health, physiologically, research has investigated the association between autonomic nervous system dysfunction and UI by measuring heart rate variability (Ben-Dror et al., 2012; Choi et al., 2005; Hsiao et al., 2014; Hubeaux et al., 2007; Im et al., 2010; Kim et al., 2010; Padilha et al., 2017). The autonomic nervous system regulates many involuntary body processes, including blood pressure, heart rate, respiration, blood sugar (Han et al., 2016), digestion, and bladder function (Ochodnický et al., 2013). Specific to bladder function, within the autonomic nervous system, the sympathetic nervous system controls bladder storage and the parasympathetic nervous system controls bladder emptying. Therefore, it is thought that dysfunction can lead to UI (Kim et al., 2010; Pietak & Rechberger, 2022). Measuring heart rate variability is a non-invasive way to assess the action of these systems and evaluate for dysfunction (Pietak & Rechberger, 2022). Prior research that used heart rate variability to evaluate the relationship between autonomic nervous system dysfunction and UI found differences in heart rate variability parameters among patients with urgency UI and overactive bladder syndrome (i.e., urinary frequency, urgency, nocturia) compared to patients without urinary symptoms (Ben-Dror et al., 2012; Choi et al., 2005; Hsiao

et al., 2014; Im et al., 2010; Padilha et al., 2017). Although this evidence supports a linkage between UI and autonomic nervous system dysfunction, these findings are limited to one UI subtype (i.e., urgency). The relationship between autonomic nervous system dysfunction and other UI subtypes (i.e., stress UI and mixed UI) remains unclear (da Silva et al., 2022). Given the physiology of the autonomic nervous system and the existing evidence, it is reasonable to posit a connection between autonomic nervous system dysfunction and UI. However, further research is needed to determine relationships between autonomic nervous system dysfunction and different UI subtypes, especially in the context of community-dwelling older adults. From a life course perspective, it is more common for older adults to have mixed UI than urgency or stress UI in isolation (Milsom & Gyhagen, 2019). Of the studies included in this review, more than half did not specify the type of UI studied (Bresee et al., 2014; Brown et al., 1996; Buchman et al., 2017; Divani et al., 2011; Smith et al., 2010; Sohn et al., 2018). Future research should clearly define the type of UI studied to understand the association with autonomic changes and the development of comorbidities throughout the life course.

Autonomic nervous system dysfunction has been linked to several comorbidities among community-dwelling adults with UI identified by studies in this review, including stroke (De Raedt et al., 2015), Parkinsonism (Zesiewicz et al., 2003), heart failure (Triposkiadis et al., 2009), hypertension (Burti et al., 2012; Smith et al., 2010), COPD (Brown et al., 1996), and diabetes (Brown et al., 1996; Burti et al., 2012). Although most studies in this review examined comorbidities as the exposure and UI as the outcome variable (i.e., indicating comorbidities precede UI onset), these relationships may not be one-directional. For example, UI can occur after stroke due to brain and nerve damage, impacting bladder control (Dumoulin et al., 2005). Other stroke-related factors can contribute to and worsen UI, such as functional limitations,

cognitive impairment, and caregiver dependence (Dumoulin et al., 2005). Conversely, UI may be an early indicator of declining health status (Wagg et al., 2015). In a study of hospitalized and clinic patients with heart failure (n=296), participants with late-stage heart failure were almost three times as likely to have UI compared to those in early-stage heart failure (Palmer et al., 2009). UI can occur early in the course of Parkinsonism, prior to developing motor symptoms, including gait disturbance and tremor (Buchman et al., 2017). Further, comorbidities often have overlapping signs and symptoms. For example, existing evidence supports heart failure and depression can have mutual signs such as decreased heart rate variability (Grippe, 2009; Johnson & Grippe, 2006) and symptoms of fatigue, sleep disturbance, and reduced mood. Other comorbidities such as stroke, Parkinsonism, COPD, and arthritis may also share these symptoms. Additionally, UI can be associated with these symptoms, as well as decreased heart rate variability (Choi et al., 2005) which supports potential shared mechanisms among these conditions. Therefore, autonomic nervous system dysfunction may be a shared mechanism between UI and several comorbidities. Further research is needed to investigate the influence of the autonomic nervous system on UI and comorbidities with analyses controlling for potential confounders such as sociodemographic characteristics, functional status, and medications. Including these confounders in analyses will build on knowledge gained through this review and generate detailed clinical phenotypes to guide assessment and management on a more granular level.

To advance the understanding of shared mechanisms between UI and comorbidities among community-dwelling adults with UI, research must continue to be done globally. Studies included in this review were conducted across four countries (i.e., the United States, Brazil, Turkey, and Korea). Although this highlights the worldwide prevalence of UI, this does not

capture the global impact. According to estimates from 2018, 423 million (21.6%) people worldwide were affected by UI (Irwin et al., 2011). This number has consistently increased over time and will continue to rise, especially given the growth of the older adult population (Irwin et al., 2011). The regional burden of UI was estimated to be greatest in Asia, with increasing incidence in Africa and South America (Irwin et al., 2011). Given differences in genetic and environmental risk factors across countries, differences in comorbidities are expected. Therefore, expanding knowledge of comorbidities among community-dwelling older adults with UI may identify these differences and generate implications for clinical practice on a global scale.

Many of the included studies did not include racially and ethnically diverse samples, as most studies that reported race or ethnicity data included samples of mostly White participants. Only two studies included participants of more than two races, with participants of racially or ethnically minoritized groups comprising only a small percentage of the samples (Bresee et al., 2014; Burti et al., 2012). Available evidence has shown that UI prevalence differs by race or ethnicity (Akbar et al., 2021; Thom et al., 2006) and racial and ethnic disparities exist in UI care in terms of quality and timing of care (Gupta et al., 2016; Siddiqui et al., 2016; Willis-Gray et al., 2015). Specifically, prior studies have shown that Black men received fewer and more delayed procedures to treat UI than White men (Gupta et al., 2016) and Latina women had the longest delays in care for UI compared to Black and White women (Siddiqui et al., 2016). Differences in UI prevalence and disparities in care give rise to the need for research with more diverse samples to examine comorbidities associated with UI by race or ethnicity to guide holistic, equitable care.

2.5 Implications

The results of this scoping review have several implications for research and clinical practice. Results of this review provide foundational knowledge for symptom-based research

aiming to develop clinical phenotypes for community-dwelling older adults with UI. Knowledge of comorbidities of community-dwelling older adults with UI illuminates what symptoms may comprise these patients' clinical phenotypes. Associated symptoms can be derived through clinical domain expertise or qualitative research involving key stakeholders including older adults with UI and clinicians caring for these patients.

In terms of clinical practice, knowledge about relationships between comorbidities and UI may prompt clinicians to employ routine screening for UI. Evidence supports UI as an early indicator of neurological disease (Buchman et al., 2017; Roy et al., 2020) and UI may also precede the onset of conditions affecting other physiological systems. Research has shown that patients prefer clinicians to initiate discussions about UI (Filipetto et al., 2014); however, these discussions seldom take place (Duralde et al., 2016). Knowledge generated from this review may allow clinicians to recognize patients with certain comorbidities at increased risk for UI to facilitate these conversations and ameliorate barriers to care.

Further, results of this review support the need for evidence-based holistic care guidelines, which can be implemented by clinicians caring for older adults with UI and multiple comorbid conditions. These guidelines may include referrals to specialists (e.g., mental health, neurology, cardiology, endocrinology, urology, physical therapy). If referrals are made, collaboration is essential to avoid fragmented care and promote holistic management of older adults with UI. Some countries (e.g., United Kingdom and the Netherlands) promote this collaboration through care models that involve a specialist continence nurse in the initial assessment and management of UI in primary care and specialty settings (Holtzer-Goor et al., 2015; Williams et al., 2000). These care models emphasize comprehensive assessments and have been found to be effective in improving symptoms (Williams et al., 2000) and reducing health

care costs (Holtzer-Goor et al., 2015). A specialist continence nurse can coordinate care between generalists and specialists. Results of this review support the need to integrate comorbidities into the assessment of older adults with UI and adopt these collaborative models globally.

Screening for UI when patients present with other conditions is an understudied area of research. Future research should investigate these underlying relationships to determine causal mechanisms and improve comprehensive care. To examine these relationships, future studies should assess UI in ways that produce more valid and reliable measurements. Bladder diaries, 24-hour pad testing, physical exam, and urodynamic testing can confirm and quantify UI (Drake, 2018) to mitigate the risk of biased reporting and produce more reliable estimates. Although bladder diaries are also self-reported, this method offers a more systematic way of collecting data on the day or week level, which can be more precise than recall over an unspecified period. Although objective data may be obtained through 24-hour pad testing, physical examination, and urodynamic testing, the practicality and utility of these measurements must be considered. These measurements may not yield accurate data as there is still a degree of subjectivity in 24-hour pad testing and physical examination. Additionally, it may not be feasible to perform urodynamic testing, especially in studies that involve large sample sizes. Future studies should consider using tools to assess UI that have strong psychometric properties (e.g., the International Consultation on Incontinence Questionnaire) in combination with bladder diaries to enhance the validity and reliability of UI measurement.

2.6 Limitations

This scoping review is not without limitations. In terms of the included literature, most studies used self-report questions that were not psychometrically tested to measure UI. Further, the definition of UI varied, and a range of terminology was used in self-report questions. Almost

all studies included in this review were cross-sectional, which limits the ability to infer causality. Only one included study employed a prospective cohort design and utilized longitudinal data to investigate the development of comorbidities among older adults with UI over time. Regarding sampling, included studies involved samples of mostly White female participants, which impedes generalizability to male and racially or ethnically diverse populations.

It is possible that some relevant studies may have been missed as the search was limited to three databases and excluded articles not published in English. Given that this review focused on community-dwelling older adults with UI, findings may not be generalizable to younger populations or older adults in other settings, such as nursing homes or hospitals. Lastly, this review focused on comorbidities associated with UI and not symptoms. Although studying symptoms may lead to a more granular analysis and robust understanding of the interdependence of physiological systems, current symptom-based literature involving patients with UI primarily focuses on urological symptoms (Aikawa et al., 2012; Hall et al., 2008; Hall et al., 2009). Therefore, studying comorbidities was more appropriate for this current scoping review's objectives to gain insight into comprehensive conditions affecting community-dwelling older adults with UI to provide a foundation for future symptom-based research.

2.7 Conclusion

With the growth of the aging population, it is expected that the number of community-dwelling older adults with UI will continue to rise (Irwin et al., 2011). There is an increasing need to shift from siloed specialty-specific health care to an integrated interdisciplinary approach (Norton et al., 2022). This approach warrants evidence-based holistic care guidelines informed by clinical phenotypes that account for multiple conditions. Results from this review highlight comorbidities of community-dwelling adults with UI across multiple physiological systems and

provide foundational knowledge for future symptom-based research to build clinical phenotypes. Additionally, comorbidities and UI are interrelated, and future research is needed to understand shared mechanisms and directionality of relationships throughout the life course. Increased knowledge of these relationships can increase clinicians' awareness of the need to screen for UI when patients present with other conditions. Future research should investigate the utility of routine screening among diverse populations and integrating comorbidities into collaborative care models to foster holistic, equitable care and improve outcomes.

Table 2.1*Concepts and Related Terms*

Concepts	Related terms for search
Older adults	Aged, older adult, elderly, geriatric
Comorbidities	Comorbidities, comorbidity, comorbid, chronic condition, chronic disease
Urinary incontinence	Urinary incontinence, urgency urinary incontinence, urge urinary incontinence, urge incontinence, stress urinary incontinence, stress incontinence, mixed urinary incontinence, mixed incontinence

Table 2.2*Search Strategies Used to Retrieve Articles*

Database	Search strategy	Publications retrieved
PubMed	(“Aged”[Mesh] OR “older adult”[tiab] OR “elderly”[tiab] OR “geriatric”[tiab]) AND (“Comorbidity”[Mesh] OR “comorbid*”[tiab] OR “chronic condition”[tiab] OR “chronic disease”[tiab]) AND (“Urinary Incontinence”[Mesh] OR “urinary incontinence”[tiab] OR “urgency urinary incontinence”[tiab] OR “urge urinary incontinence”[tiab] OR “urge incontinence”[tiab] OR “stress urinary incontinence”[tiab] OR “stress incontinence”[tiab] OR “mixed urinary incontinence”[tiab] OR “mixed incontinence”[tiab])	870 3/1/2023
CINAHL	((MH “Aged”) OR TI (“older adult” OR “elderly” OR “geriatric”)) OR AB (“older adult” OR “elderly” OR “geriatric”)) AND ((MH “Comorbidity”) OR TI (“comorbid*” OR “chronic condition” OR “chronic disease”) OR AB (“comorbid*” OR “chronic condition” OR “chronic disease”)) AND ((MH “Urinary Incontinence”) OR TI (“urinary incontinence” OR “urgency urinary incontinence” OR “urge urinary incontinence” OR “urge incontinence” OR “stress urinary incontinence” OR “stress incontinence” OR “mixed urinary incontinence” OR “mixed incontinence”) OR AB (“urinary incontinence” OR “urgency urinary incontinence” OR “urge urinary incontinence” OR “urge incontinence” OR	343 3/1/2023

“stress urinary incontinence” OR “stress incontinence” OR
“mixed urinary incontinence” OR “mixed incontinence”))

Embase	(‘aged’/exp OR ‘older adult’:ti,ab OR ‘elderly’:ti,ab OR ‘geriatric’:ti,ab) AND (‘comorbidity’/exp OR ‘comorbid*’:ti,ab OR “chronic condition”:ti,ab OR ‘chronic disease’:ti,ab) AND (‘urinary incontinence’/exp OR ‘urinary incontinence’:ti,ab OR ‘urgency urinary incontinence’:ti,ab OR ‘urge urinary incontinence’:ti,ab OR ‘urge incontinence’:ti,ab OR ‘stress urinary incontinence’:ti,ab OR ‘stress incontinence’:ti,ab OR ‘mixed urinary incontinence’:ti,ab OR ‘mixed incontinence’:ti,ab)	1,634 3/1/2023
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Table 2.3*Characteristics of Sources of Evidence*

Author, year	Country	Study design	Study purpose	Study sample	Type of UI studied	Data source	Measurement of UI	Measurement of significant comorbidities
Bresee et al., 2014	United States	Cross-sectional	To determine UI prevalence and associated factors (sociodemographic, overall health status, medical conditions) to quantify the burden of UI among older community-dwelling women.	5374 community-dwelling women aged 65 and older in California; 69.29% non-Hispanic White, 11.44% Asian, 10.61% Hispanic, 5.44% African American, 3.21% Other	Not specified	CHIS 2003	CHIS question: "In the past 30 days, have you been incontinent, that is unable to hold or control your urine more than once?"	Self-report of medical comorbidities
Brown et al., 1996	United States	Cross-sectional	To examine the prevalence of UI and associated factors among older women.	7949 community-dwelling women aged 69-101 years; excluded	Not specified	The Study of Osteoporotic Fractures	Questionnaire: "During the last 12 months have you ever leaked urine or lost control	Self-report questionnaire about comorbidities

				Black women due to low incidence of osteoporotic fractures; race and ethnicity data otherwise not specified			of your urine?"	
Buchman et al., 2017	United States	Prospective cohort	To determine if UI is associated with incident parkinsonism in community-dwelling older adults.	2617 women and men aged 65 and older without dementia who were Catholic nuns, priests, lay brothers, and residents of retirement communities and subsidized housing in Chicago; 73.5% women, 26.5% men; did not specify race	Not specified	The Religious Orders Study and the Rush Memory and Aging project	Self-report ordinal scale for frequency of UI episodes	26-item Unified Parkinson's Disease Rating Scale

				or ethnicity data				
Burti et al., 2012	Brazil	Cross-sectional	To determine the prevalence of UI and associated factors among low-income older adults.	388 community-dwelling women and men aged 65 years and older with no mobility or cognitive deficits living in low-income areas of Sao Paulo, Brazil; 63% women, 37% men; 62% White, 34% Black, 4% Asian	Stress UI, urgency UI, and mixed UI (stress and urgency UI)	Collaborative program developed by the 10/66 Dementia Research Group	Structured interview question: "Do you leak urine or have you lost control of your urine during the last 12 months?"	Blood pressure and diabetes measurements taken in the hospital
Divani et al., 2011	United States	Case-control	To determine the risk of developing post-stroke health problems, including UI.	Cases: 631 older adults age 68 years and older who had a first ever stroke from 1998-2006; 53% female,	Not specified	Health and Retirement Study database	Self-report (face-to face or telephone interview) of the involuntary loss of urine within the	Self-report (face-to face or telephone interview); asked participants if a physician has diagnosed them with

				75% Non-Hispanic White, 16% Black/Other race, 8% Hispanic Controls: 631 older adults who did not have a stroke 53% female, 79% Non-Hispanic White, 15% Black/Other race, 6% Hispanic			past 12 months	medical comorbidities
Erdogan et al. 2019	Turkey	Cross-sectional	To examine the relationship between stress and/or urgency urinary incontinence and sarcopenia among older women.	802 women aged 60 years and older who were seen at a geriatric outpatient university hospital clinic from 11/2012 – 11/2016; did not specify	Stress UI, urgency UI, mixed UI	Face-to-face interviews;	Interviews; self-report of UI defined as “the complaint of any involuntary leakage of urine in the past 12 months”	Geriatric physiotherapist performed all measurements related to sarcopenia; standardized stadiometer (to measure height and weight), bioimpedance analysis with body analysis

				race or ethnicity data				monitor (to measure body composition)
Gerst et al., 2011	United States	Cross-sectional	To investigate the prevalence, risk factors, and consequences of urge urinary incontinence among older Mexican-American men.	700 Mexican-American men aged 75 years and older from five Southwestern states (Texas, New Mexico, California, Arizona, Colorado)	Urgency UI	The fifth wave of the Hispanic Established Population for the Epidemiologic Study of the Elderly	Self-report question: "How often do you have difficulty holding your urine until you can get to a toilet?" with 5-point Likert-type response options (never, hardly ever, some of the time, most of the time, all of the time)	Self-report question asking participants if a healthcare provider had ever told them they had prostate problems.
Park & Son Hong, 2016	Korea	Cross-sectional	To identify the prevalence of UI and examine the association between UI and benign prostatic obstruction and functional ability (i.e., instrumental	6,185 community-dwelling Korean men age 60 years and older	Stress UI, urgency UI, mixed UI	Actual Living Condition of the Elderly and Welfare Need Survey conducted by the Korean Ministry of	Self report; asked participants "Do you have UI?"	Self report; asked participants "Do you have BPH which was diagnosed by doctor?"

			activities of daily living) in community-dwelling older men in Korea.			Health and Welfare		
Smith et al., 2010	United States	Cross-sectional	To evaluate the prevalence and correlates of UI among older community dwelling Latinx adults.	572 Latinx women and men 60 years and older from 27 community based senior centers; 77.1% women, 22.9% men	Not specified	Caminemos: a clinical trial of a behavioral intervention to increase walking levels	International Consultation on Incontinence Questionnaire	In-person survey; Charlson Comorbidity Index to quantify the number of comorbid conditions
Sohn et al., 2018	Korea	Cross-sectional	To examine the characteristics of patients with UI and evaluate the association of UI with other geriatric health problems.	2418 community-dwelling Korean women aged 65 years and older	Not specified	Korean Longitudinal Study of Aging	Self-report yes/no question: "Have you experienced urine leakage in the past 12 months?"	Self-report; asked participants if they were diagnosed by a doctor with specific chronic diseases

Note. UI, urinary incontinence; CHIS, California Health Interview Survey

Table 2.4

Critical Appraisal of Cross-Sectional Studies

Cross-sectional studies (n=8)								
Joanna Briggs Institute Checklist Questions	Bresee et al., 2014	Brown et al., 1996	Burti et al., 2012	Erdogan et al. 2019	Gerst et al., 2011	Park & Son Hong, 2016	Smith et al., 2013	Sohn et al., 2018
Were the criteria for inclusion in the sample clearly defined?	Yes Women aged 65 years and older living in California who completed the CHIS in 2003.	Yes Women aged 69-101 years in the Study of Osteoporotic Fractures. Women with bilateral hip replacement and those unable to walk were excluded.	Yes Adults aged 65 years and older with no mobility or cognitive deficits living without institutional support.	Yes Women aged 60 years and older without cognitive deficits who were seen at a geriatric outpatient clinic from 11/2012-11/2016. Excluded women with functional or overflow UI.	Yes Mexican American men aged 75 years and older from Wave five of the Hispanic Established Population for the Epidemiologic Study of the Elderly. Excluded men with a urinary catheter.	Yes 6,185 men aged 60 years and older who participated in the 2008 Actual Living Condition of the Elderly and Welfare Need Survey.	Yes Adults aged 60 years and older who self-identify as Latinx, speak English or Spanish, passed the six item cognitive screening with a score of 4/6 or higher, and exercise less than one hour/week.	No Provided vague information about inclusion criteria: women who responded yes to “have you had urine leakage in the past 12 months?”

Were the study subjects and the setting described in detail?	Yes Table 1 describes study subjects. Setting: California communities (stratified into 41 counties) from 8/2003 – 2/2004	Yes Table 1 describes study subjects. Setting: outpatient clinics in Maryland, Minnesota, Pennsylvania, and Oregon	Yes Table 1 describes study subjects. Setting: low-income areas of San Paulo, Brazil	No Table 1 describes sample age and prevalence of comorbid conditions but does not report sample race and ethnicity. Setting: geriatric outpatient clinic from 11/2012 – 11/2016	Yes Table 1 describes study subjects. Setting: five south western states (Texas, New Mexico, California, Arizona, Colorado)	No Table 1 describes the general attributes of participants including age, education, body mass index, comorbid conditions, number of limited instrumental activities of daily living, and walking speed in seconds. Setting was not described in detail	Yes Table 1 describes study subjects. Setting: 27 community based senior centers in the greater Los Angeles area	No Although Table 1 describes study subjects, setting is not described in detail
Was the exposure measured in a valid and	No Exposure: comorbidities (heart	No Exposure: comorbidities	Unclear Exposure: comorbidities (HTN,	Yes Exposure: comorbid-	No Exposure: comorbidities (MI,	No Exposure: comorbidities (BPO)	No Exposure: comorbidities (HTN,	No Exposure: comorbidities (HTN,

reliable way?	disease, any cancer diagnosis, cervical cancer, stroke)	(diabetes, stroke, COPD, asthma, CHF, Parkinson's disease)	diabetes, osteopenia, osteoporosis) Blood pressure, diabetes, and bone density measures were taken at the hospital. No detail provided about the training of who performed these measures or what these measures entailed (e.g., how blood pressure was taken, laboratory tests for fasting	ities (sarcopenia) Measures for the diagnosis of sarcopenia were taken by the same trained geriatric physiotherapist using standardized instruments and validated protocols.	stroke, HTN, cancer, arthritis, diabetes, hip fracture, prostate conditions) Measured by self-report by asking participants if a health care provider ever told them they had any of the specified conditions.	Measured by self-report by asking "Do you have BPO which was diagnosed by doctor?"	MI, CHF, stroke, diabetes, arthritis, hip fracture, asthma, emphysema, COPD, chronic bronchitis, cirrhosis or liver disease, cancer (other than skin), Parkinson's disease, Alzheimer's disease, depression, anxiety)	diabetes, chronic lung disease, cerebrovascular disease, arthritis). Measured by self-report by asking participants whether they were diagnosed by a health care provider with any of the specified conditions. Participants completed an in-person survey about health conditions and a brief physical
	Professional interviewers measured comorbidities by self-report using a computer assisted telephone interview system. No detail about training of the professional interviewers Data were collected and reported by one observer.	Participants completed a questionnaire about presence of comorbidities. No information about questionnaire items or validity and reliability of the questionnaire						

blood sugar
or non-
fasting
blood sugar,
hemoglobin
A1C,
fingerstick
blood sugar,
bone scan).

examination
Number of
comorbid-
ities was
quantified
with the
Charlson
Comorbidit
y Index. No
information
provided
about
survey
questions or
what the
physical
examination
entailed.

Were objective, standard criteria used for measurement of the condition?	No	No	No	No	No	No	No	No	No
	UI was measured by asking participants a self-report question from the CHIS: "In the past 30 days have	UI was measured by a questionnaire that included the questions: "During the last 12 months have you ever	UI was measured in interviews, during which participants were asked, "Do you leak urine or have you lost control	UI was measured in interviews, during which participants were asked if they had "any involuntary leakage of	UI was measured by asking participants a self-report question: "How often do you have difficulty holding your urine	UI was measured by self-report: "Do you have UI?"	UI was measured using an item from the ICIQ: "How often do you leak urine?" with six response options: never, less	UI was measured by self-report question: "Have you had urine leakage in the past 12 months?"	

<p>you been incontinent, that is, unable to hold or control your urine more than once?"</p>	<p>leaked urine or lost control of your urine?," "If yes, how often does this leakage of urine usually occur?"</p>	<p>of your urine during the last 12 months?" Participants answering "yes" were characterized by subtype: stress UI if leakage happened during effort, cough, or laugh, urgency UI if leakage was sudden/uncontrolled and mixed UI if leakage was reported in both conditions.</p>	<p>urine in the past 12 months." If yes, UI subtype was determined by asking "When does your leakage usually occur?" with response options: with coughing, lifting, standing up, or exercise, when you have the urge to urinate and cannot get to a toilet fast enough</p>	<p>until you can get to a toilet?" with 5-point Likert-type response options: never, hardly ever, some of the time, most of the time, or all of the time. The definition of UI is not consistent with standard criteria.</p>	<p>than one time per week, two to three times per week, once per day, several times per day, or all the time. Participants who responded anything other than "never" were classified as having UI.</p>
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<p>Were confounding factors identified?</p>	<p>Yes Age, gender,</p>	<p>Yes Age, menopausal</p>	<p>Yes Age, race, years of</p>	<p>Yes Age, fecal incontin-</p>	<p>Yes Whether or not the</p>	<p>Yes Age, education,</p>	<p>Yes Age, gender,</p>	<p>Yes BMI, education,</p>
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	race, ethnicity, citizenship status, primary language, education, employment income, health status, body mass index, fall in the past 12 months, HRT, smoking regular walking, medical visits.	years, number of live births, hysterectomy, body mass index, medications, coffee intake, smoking status, alcohol use, physical exercise, gait speed, muscle strength.	education, number of pregnancies, medications, body mass index.	ence, constipation height, weight, body mass index, functional status.	participant saw a physician in the last year, English or Spanish language, marital status, education, age, activities of daily living limitations.	body mass index, HTN, diabetes, stroke, depression, walking speed	marital status, level of education, income, smoking status, cognitive function, acculturation	marital status, smoking status, alcohol intake, social activity.
Were strategies to deal with confounding factors stated?	Yes Multi-variable logistic regression analysis; also considered interactions	Yes Multi-variable logistic regression analysis.	No Adjusted analysis was done with BMI and diabetes but no other adjusted analyses	No Multi-variable logistic regression analysis only adjusted for weight,	Yes Multi-variable regression models.	Yes Hierarchical logistic regression models adjusting for confounders	Yes Multi-variable logistic regression analyses (five models).	Unclear Unclear which covariates were used in adjusted logistic regression analyses.

between age, race, and ethnicity.

were done for other potentially confounding factors.

height, and BMI and did not adjust for other potential confounding factors.

Were the outcomes measured in a valid and reliable way?	No	No	No	No	No	No	Yes	No
	Outcome: UI	Outcome: UI	Outcome: UI	Outcome: UI	Outcome: UI	Outcome: UI	Outcome: UI	Outcome: UI
	UI was measured by self-report yes/no question. No information about the validity and reliability of the CHIS question.	UI was measured by self-report questionnaire No information about validity or reliability of the questionnaire	UI was measured during interviews conducted by a trained professional No information provided about training of the interviewers	UI was measured by self-report interview questions. No information about validity or reliability of the questions was provided. No detail about who conducted the	UI was measured by asking a self-report question with 5-point Likert-type response options. No discussion of interview procedure, training of interviewer, or validity or reliability of the question.	UI was measured by self-report question: "Do you have UI?"	UI was measured using an item modified from the ICIQ, a tool that generates valid and reliable scores.	UI was measured with a self-report yes/no question. No information about validity or reliability of the question.

interviews,
their
training.

Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Used Chi-square tests to test associations between UI and demographic and medical variables (categorical) Logistic regression to determine odds ratios.	Chi-square tests to evaluate factors potentially associated with UI (categorical variables).	Kruskal Wallis test was used when the variable did not meet the normality assumption. Fisher's exact test when > 20% of expected cell counts were less than 5, otherwise used Chi-square tests.	Used t-tests for continuous variables, Chi-square tests for categorical variables, Fisher's exact tests when > 20% of expected cell counts were less than 5.	Used t tests for continuous variables and Chi-square tests for categorical variables.	Hierarchical logistic regression analysis to determine odds ratios.	Used t-tests for continuous variables, chi-square tests for categorical variables, and multi-variable logistic regression models to estimate odds ratios.	Used t-tests for continuous variables, Chi-square tests for categorical variables, Fisher's exact test when >20% of expected cell counts were less than 5, and logistic regression.

Note. CHIS, California Health Interview Survey; UI, urinary incontinence; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; MI, myocardial infarction; HTN, hypertension; ICIQ, International Consultation on Incontinence Questionnaire; HRT, hormone replacement therapy; BMI, body mass index

Table 2.5*Critical Appraisal of Cohort Studies*

Joanna Briggs Institute Checklist Questions	Buchman et al., 2017
Were the two groups similar and recruited from the same population?	Yes Recruited from the Religious Orders Study and the Rush Memory and Aging Project. Inclusion/exclusion criteria were explicitly stated. Groups (no UI, n=1,370 and UI, n=1,247) had similar demographics, disability, cognition, and chronic health conditions.
Were the exposures measured similarly to assign people to both exposed and unexposed groups?	Yes Exposure: UI UI was measured using an ordinal scale; participants rated the frequency of episodes of UI during the previous year (0=never, 1= \leq 1 episode/month, 2=2-4 days/month, 3=2-4 days/week, 4=5=7 days/week).
Was the exposure measured in a valid and reliable way?	No UI was measured with a self-report scale.
Were confounding factors identified?	Yes Age, sex, years of education, hypertension, diabetes, MI, stroke, cancer, thyroid disorder, head trauma, BMI
Were strategies to deal with confounding factors stated?	Yes Examined crude associations of UI with confounders at baseline. Spearman's rank correlation was used to test associations with age and education. Cox proportional hazard ratios to test association with adverse health outcomes. Regression models which controlled for age and sex.

Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	Yes Outcome: comorbidities (Parkinsonism) At the start of the study participants did not have Parkinsonism.
Were the outcomes measured in a valid and reliable way?	Yes Trained nurses performed a clinical examination and administered the Unified Parkinson's Disease Rating Scale in which 26 items assessed four parkinsonian signs (gait or posture disturbance, bradykinesia, rigidity, tremor).
Was the follow up time reported and sufficient to be long enough for outcomes to occur?	Yes Eight-year follow up period was sufficient time to develop outcomes based on literature and clinical expertise.
Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	No Loss to follow up was briefly described: 261 (10%) did not follow up because they died before the first follow up or had not been in the study long enough. Specific reasons for loss to follow up were not explicitly described or explored. There was < 20% drop out rate which does not significantly impact the validity of the study.
Were strategies to address incomplete follow up utilized?	No 261 participants who were lost to follow up were excluded from analysis.
Was appropriate statistical analysis used?	Yes Used Cox proportional hazard ratios to test association with adverse health outcomes and regression models which controlled for age and sex.

Note. UI, urinary incontinence; MI, myocardial infarction; BMI, body mass index

Table 2.6*Critical Appraisal of Case-Control Studies*

Joanna Briggs Institute Checklist Questions	Divani et al., 2011
Were the groups comparable other than the presence of disease in cases or the absence of disease in controls?	No Although the groups were comparable in terms of most characteristics (age, race, ethnicity, living arrangements, and general health, stroke subjects had more pain (37% vs. 29%, $p = .002$), diabetes (29% vs. 17% $p < .0001$), and hypertension (71% vs. 49%, $p < .0001$) than non-stroke subjects.
Were cases and controls matched appropriately?	Yes 631 non-institutionalized individuals who had suffered a single stroke were matched with 631 controls based on age, gender and interview wave.
Were the same criteria used for identification of cases and controls?	Yes Stroke was defined as subjects who had a first-ever stroke in one of the interview waves between 1998 (4 th interview wave) and 2006 (8 th interview wave). Control subjects were randomly selected from a cohort matched for age (± 5 years), gender and interview wave.
Was exposure measured in a standard, valid and reliable way?	No Exposure: stroke Self report in telephone and face-to-face interviews as part of the Health and Retirement Study.
Was exposure measured in the same way for cases and controls?	Unclear

	Telephone and face-to-face interviews. No explanation on what the indicator for stroke was.
Were confounding factors identified?	Yes Age, gender, interview wave, diabetes, hypertension, living arrangements, alcohol consumption, ethnicity, psychiatric problems, proxy respondent, pain
Were strategies to deal with confounding factors stated?	Yes Binomial and Poisson distribution were used to model the frequencies of each of the health problem outcomes (motor impairment, UI, sleep disturbance) with classical covariance analysis using generalized linear modeling of each health condition
Were outcomes assessed in a standard, valid and reliable way for cases and controls?	No Outcome: UI Self report of the involuntary loss of urine within the past 12 months in telephone and face-to-face interviews
Was the exposure period of interest long enough to be meaningful?	Yes The longitudinal sampling strategy ensured that the health condition developed after the subject had suffered a stroke.
Was appropriate statistical analysis used?	Yes Chi-squared and/or t-tests were used to provide initial unadjusted comparisons between stroke and non-stroke subjects. Classical covariance analysis using generalized linear modeling of each health condition was used to estimate the effect of stroke on each health outcome.

Note. UI, urinary incontinence

Table 2.7*Results of Individual Sources of Evidence*

Author, year	Study outcomes related to comorbidities	Comorbidities of community-dwelling older adults with UI	Affected physiological system
Bresee et al., 2014	Heart disease (OR=1.87, 95% CI [1.51-2.31], $p < .0001$) and stroke (OR=1.57, 95% CI [1.18-2.08], $p = .0018$) had a higher prevalence of UI in unadjusted analysis. Heart disease remained significant in the adjusted analysis (OR=1.38, 95% CI [1.08-1.76], $p = .01$)	Heart disease	Cardiovascular
		Stroke	Neurologic
Brown et al., 1996	Stroke (OR=1.9, 95% CI [1.3-2.7]), diabetes (OR=1.7; 95% CI [1.2-2.4]), and chronic obstructive pulmonary disease (OR=1.4, 95% CI [1.1-1.9]) were associated with the prevalence of daily UI	Stroke	Neurologic
		Chronic obstructive pulmonary disease	Respiratory
		Diabetes	Endocrine
Buchman et al., 2017	UI was associated with incident parkinsonism (HR=1.07, 95% CI [1.02-1.12], $p = .008$)	Parkinsonism	Neurologic
Burti et al., 2012	UI was more common in individuals with diabetes ($p = .022$) and hypertension ($p = .008$)	Hypertension	Cardiovascular
		Diabetes	Endocrine
Divani et al., 2011	Stroke was significantly associated with UI (OR=1.56, 95% CI [1.17-2.08], $p < .01$) and remained significantly associated when accounting for time (OR=1.64, 95% CI [1.13-2.39], $p < .01$)	Stroke	Neurologic
Erdogan et al. 2019	Sarcopenia was significantly associated with UI when muscle mass was adjusted by weight	Sarcopenia	Musculoskeletal

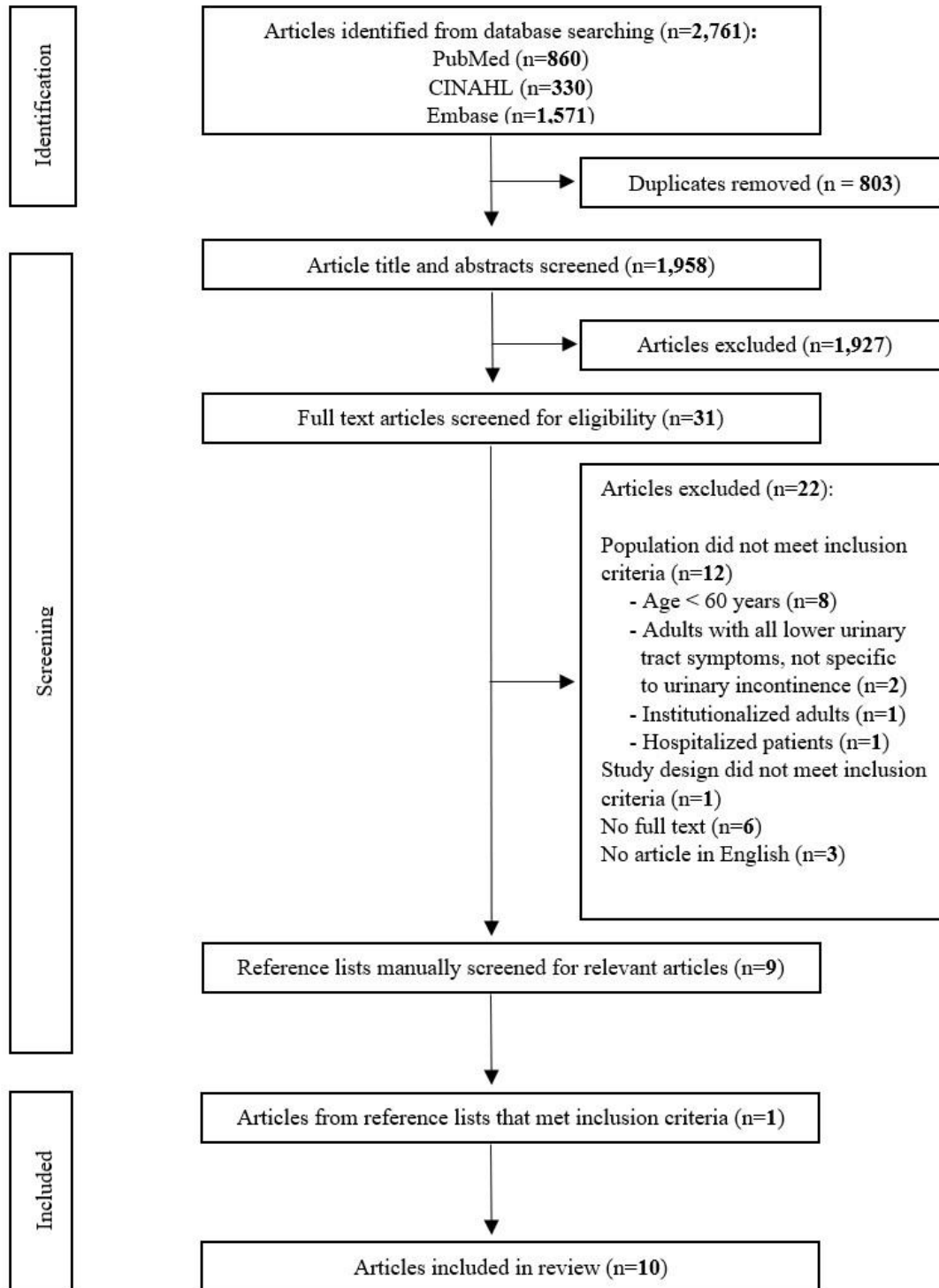
(OR=1.47, 95% CI [1.03–2.09], $p = .034$)

Gerst et al., 2011	Men with prostate conditions were more than twice as likely to report urgency UI compared to those without prostate conditions (OR=2.18, 95% CI = [1.52-3.14]; $p < .0001$)	Prostate conditions (benign prostatic obstruction)	Genitourinary
Park & Son Hong, 2016	Benign prostatic obstruction was significantly associated with UI in model 1 (OR=2.73, 95% CI [1.47–5.10]), model 2 which controlled for age, BMI, and education (OR=2.68, 95% CI, [1.42–5.07], and model 3 which controlled for HTN, DM, stroke, and depression (OR=2.58, 95% CI [1.36–4.90])	Benign prostatic obstruction	Genitourinary
Smith et al., 2010	HTN, congestive heart failure, arthritis, depression, and anxiety were associated with a higher prevalence of UI: medical comorbidity (OR=1.91 95% CI [1.57-2.32]; $p < .05$), depression (OR =2.35, 95% CI [1.58-3.48], $p < 0.05$)	Hypertension Congestive heart failure	Cardiovascular
		Arthritis	Musculoskeletal
		Depression Anxiety	Psychologic
Sohn et al., 2018	Cerebrovascular disease (OR=2.02; 95% CI [1.26-3.23]; $p = .003$) and arthritis (OR=1.44, 95% CI [1.18-1.77], $p < .001$) were significantly associated with UI	Cerebrovascular disease	Neurologic
		Arthritis	Musculoskeletal

Note. OR, odds ratio; CI, confidence interval; UI, urinary incontinence; HR, hazard ratio; BMI, body mass index; HTN, hypertension; DM, diabetes mellitus

Figure 2.1

PRISMA Flow Diagram of Article Selection Process



Chapter 3: Applying Natural Language Processing to Understand Symptoms Among Older Adult Home Healthcare Patients with Urinary Incontinence

Note. Chapter 3 is a manuscript submitted for publication in the *Journal of Nursing Scholarship, Special Issue: Transformative Role of Artificial Intelligence in Nursing*.

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Keywords: home healthcare, healthcare disparities, natural language processing, nursing informatics, older adults, symptom burden, urinary incontinence

3.1 Introduction

Urinary incontinence (UI) is a prevalent condition affecting approximately 40% of older adults (65 years and older) who receive home healthcare (HHC) services (i.e., skilled care including nursing, medical, social work, physical, occupational, and speech therapy) (Gorina et al., 2014). UI is defined as the involuntary leakage of urine (Haylen et al., 2010) and can lead to urinary tract infections (Moore et al., 2008), skin breakdown (Kayser et al., 2019), falls, and fractures (Brown et al., 2000). These sequelae can be detrimental among older adult HHC patients, resulting in emergency department visits, hospitalizations, and mortality (John et al., 2016). Despite being a potentially serious or serious condition, UI is often under-identified and undertreated. Patients may perceive UI as related to normal aging with no effective treatments available (Jung et al., 2015). Community nurses may perceive UI as less distressing for older adults compared to younger individuals and not serious enough to warrant treatment (McCann et al., 2022). For these reasons, patients often live with “hidden burdens” associated with UI, influencing more than only quality of life (Brady et al., 2022; Norton et al., 2022). UI can lead to increased healthcare utilization and costs incurred by patients and healthcare systems. Patients with UI may miss work or have decreased work productivity, leading to financial ramifications on the individual, organizational, and societal levels. Additionally, UI exerts impacts on the ecosystem level, in terms of increased waste generated from incontinence pad use (Brady et al., 2022; Norton et al., 2022). These multilevel impacts have made UI a public health priority (Brady et al., 2022; Norton et al., 2022), requiring improvements in healthcare to achieve better outcomes.

Care inequities magnify the under-identification and undertreatment of UI, particularly among racially or ethnically minoritized groups. Existing evidence suggests that Black and

Hispanic adults receive lower quality and more delayed UI care than White adults (Anger et al., 2007; Gupta et al., 2016; Siddiqui et al., 2016). For example, among 4,401 men who underwent prostatectomy for prostate cancer, Black men received fewer (2.1% versus 4.3%) and more delayed (28.3 months versus 19.9 months) procedures to treat UI than White men (Gupta et al., 2016). Similarly, in 215,060 women with stress UI, White women were more likely to undergo surgical sling procedures to treat UI than Black women (Anger et al., 2007). Among 113 Black, Latina, and White community-dwelling women, Latina women had the longest delays in care for UI due to a lack of UI-related knowledge and embarrassment about symptoms (Siddiqui et al., 2016). Expanding clinicians' knowledge of symptoms among patients with UI in the HHC setting can promote equitable care by improving UI identification, treatment, and outcomes.

Most older adults with UI who receive HHC services have multiple comorbid conditions (Murtaugh et al., 2009) and require comprehensive symptom evaluations. Existing evidence suggests that UI is associated with worsening status of common comorbid conditions in HHC (Murtaugh et al., 2009), such as diabetes (Lifford et al., 2005) and heart failure (Palmer et al., 2009). These relationships may be explained by shared mechanisms between UI, comorbidities, and autonomic nervous system dysfunction (Ben-Dror et al., 2012; Choi et al., 2005). The autonomic nervous system regulates many involuntary body processes, such as blood pressure, heart rate, blood sugar, digestion, and bladder function (Ochodnick et al., 2013).

Interconnections between disease processes and UI support the need for comprehensive evaluations to prevent complications that can lead to negative outcomes. This is especially important in the HHC setting, given the goal of managing healthcare at home and preventing hospitalizations. Despite this need, current recommendations for the assessment and treatment of UI are limited to the urological system (Diaz et al., 2017). This overlooks the holistic approach

(i.e., recognizes the person as a whole and considers the interdependence of various aspects of the whole (Frisch & Rabinowitsch, 2019)) that is needed for effective care (Norton et al., 2022).

Further, the design of electronic health records (EHRs) may restrict the scope of assessments that clinicians conduct (Hobensack et al., 2022; Sockolow et al., 2014; Song, Hobensack et al., 2022). In the EHR system, unstructured data (e.g., free-text clinical notes) can alleviate restrictions imposed by structured data (e.g., standardized assessment forms using controlled vocabulary). HHC agencies in the United States are mandated to complete standardized assessments for all patients admitted to HHC using a structured data form known as the Outcome and Assessment Information Set (OASIS) (Centers for Medicare and Medicaid Services, 2017). OASIS is a comprehensive assessment containing HHC patients' demographic information, clinical status, functional status, and service needs that is only completed upon admission, discharge, transfer (Centers for Medicare and Medicaid Services, 2017). OASIS uses controlled vocabulary; therefore, it does not capture variations in symptom expressions. Recent research indicates that clinicians are more likely to document patients' clinical characteristics, including symptom information, in unstructured free-text clinical notes (Hobensack et al., 2022; Sockolow et al., 2014; Song, Hobensack et al., 2022). Leveraging unstructured free-text sources of symptom information is essential to improve the identification and treatment of older adults with UI. However, this approach is limited due to manual data extraction challenges, including time, cost, and inability to review thousands or millions of notes (Koleck, Tatonetti, et al., 2021).

Natural language processing (NLP) can eliminate these challenges and automatically extract free-text data on a large scale (Yim et al., 2016). NLP refers to computer-based algorithms used to identify and process language for further analysis (Yim et al., 2016). Free-text clinical notes vary due to differences in symptom reporting and clinician documentation styles

and may contain diverse symptom descriptions that represent the same concept (Forbush et al., 2013). NLP extracts vocabularies of synonyms, including misspellings and abbreviations, from large corpora of free-text clinical notes (Yim et al., 2016). Data-driven characterization is essential to determine current symptom trends and future directions for research and clinical practice to promote holistic, equitable care.

Informed by the Theory of Unpleasant Symptoms (Lenz et al., 1997) (**Appendix A**), which asserts that symptoms occur synergistically, and the resulting symptom experience must be addressed with a holistic approach, we used NLP to investigate symptom information in free-text clinical notes for a racially and ethnically diverse cohort of older adults with UI in HHC. The dimensions of this theoretical framework include physiologic factors (i.e., normally functioning or pathologic processes affecting organ systems), psychologic factors (i.e., mood or mental state), and situational factors (i.e., attributes of the physical or social environment) that influence symptom experience and subsequent performance outcomes (Lenz et al., 1997). Symptom experience encompasses changes in usual physiological or behavioral patterns as perceived by an individual, posing health risks and increasing the probability of negative consequences (Lenz et al., 1997). Performance denotes the result or impact of symptom experience, encompassing physical role performance markers (Lenz et al., 1997). Individuals with higher symptom burdens often exhibit diminished capacity to carry out physical activities (Lenz et al., 1997). These individuals encounter physical role performance markers, which clinicians assess to guide decisions about potential escalation of care to a higher level (e.g., ED/hospital). We focused on multidimensional antecedents to characterize symptom experiences of older adult HHC patients with UI, providing a foundation to examine performance outcomes in later work. Therefore, this study aimed to develop and test an NLP algorithm to extract

symptom information from clinical notes for older adult HHC patients with UI and analyze differences in symptom documentation by race or ethnicity. Examining symptom documentation among HHC clinicians for older adults with UI is critical, providing implications for future research and practice to improve comprehensive assessment and outcomes.

3.2 Methods

Study Setting and Sample

We conducted a secondary analysis of cross-sectional EHR data collected between January 1, 2015, to December 31, 2017, from a large HHC agency in New York. Data were aggregated and summarized at the HHC episode level. A HHC episode is defined as the time period during which a patient receives HHC services, beginning with HHC admission and ending with discharge from HHC services, transfer to a higher level of care, or death. Each time a patient is enrolled in HHC, their sociodemographic and clinical characteristics may be different. For example, reason for admission, health status, caregiver availability, or housing attributes may be different among subsequent HHC episodes for an individual patient. Given that these characteristics influence symptom presentations, analyzing each HHC episode as a distinct entity can better capture symptom nuances and the breadth of symptom experiences.

The inclusion criteria for this study were HHC episodes for patients who were ≥ 65 years old and had a diagnosis of UI upon admission to HHC. Adults ≥ 65 years of age were selected for this study because older adults are at increased risk for negative outcomes secondary to UI, and many older adults with UI have multiple chronic conditions (Murtaugh et al., 2009). Exclusion criteria were HHC episodes for patients who were admitted to HHC with an indwelling urinary catheter and patients enrolled in hospice due to the complexity of documentation related to their terminal diagnosis and differences in treatment goals.

Age and UI status were measured at the time of admission to HHC. Age was determined based on OASIS item M0066 noting the patient's age in years. UI was defined as the involuntary leakage of urine (Haylen et al., 2010). UI status was identified based on OASIS item M1610 indicating whether a patient had UI. Approval was obtained from the participating HHC agency's Institutional Review Board for this study.

Dataset

We used two types of data from the EHR: structured and unstructured. Structured data were defined as OASIS items completed by HHC clinicians, and for this study, these data were collected at the time of HHC admission. Unstructured data were defined as free-text clinical notes. Informed by the Theory of Unpleasant Symptoms (Lenz et al., 1997), we selected variables representing physiologic factors, psychologic factors, situational factors, and symptom experience to extract from the EHR. Additionally, we selected variables representing sociodemographic characteristics based on literature focused on nonbiologic factors that impact UI management (Norton et al., 2017). Patient-level nonbiologic factors, including physical ability, can affect symptom management in terms of healthcare decisions and behaviors (Norton et al., 2017). Therefore, it is important to consider variables reflecting these factors among older adults with UI. In **Appendix C**, we map each variable to the theoretical model dimensions, provide operational definitions, and specify measurement.

Structured Data

We extracted sociodemographic and clinical characteristics from structured OASIS items. Sociodemographic information included age, patient sex, race, ethnicity, insurance status, living arrangements, and functional status. We also extracted data on caregiver assistance with activities of daily living (ADLs), defined as help with grooming, dressing lower body, dressing

upper body, bathing, toilet transferring, toilet hygiene, transferring, ambulation, and eating. Clinical characteristics encompassed comorbid conditions, including cardiovascular disease, diabetes, depression, kidney disease, stroke, and risk factors for hospitalization, including history of two or more falls, taking five or more medications, and decline in mental or behavioral status.

Measures. Patient sex was determined based on OASIS item M0069 indicating if a patient was male or female. Race and ethnicity data were obtained from OASIS item M0140, indicating that the patient was American Indian or Alaskan Native (i.e., Native American), Asian, Black, Hispanic, Native Hawaiian or Pacific Islander (i.e., Pacific Islander), or White. We created an Asian/Pacific Islander category that included patients who were reported as Asian or Native Hawaiian or Pacific Islander. For patients with more than one race or ethnicity selected, we created a multi-racial category.

We characterized caregiver assistance with ADLs into three categories based on OASIS item M2100: caregiver(s) likely to provide assistance with ADLs, caregiver(s) not likely to provide assistance with ADLs, and no assistance needed. The middle category refers to patients that may require assistance with ADLs, but have caregivers who are not willing or able to provide the assistance needed. We assessed the patient's living arrangements using OASIS item M1100 and classified it as a binary variable indicating if a patient lived alone or with others. To measure functional status, we created a continuous variable which was the sum of nine binary fields (i.e., 0 indicates no issue, 1 indicates moderate/significant issue). These fields included OASIS items that described the patient's ability to perform ADLs: M1800: grooming, M1810: dressing lower body, M1820: dressing upper body, M1830: bathing, M1840: toilet transferring, M1845: toilet hygiene, M1850: transferring, M1860: ambulating, and M1870: eating.

We extracted data pertaining to comorbid conditions from OASIS item M1028 and created binary variables (diagnosis documented or not) to represent cardiovascular disease, diabetes, depression, kidney disease, and stroke. Finally, we characterized risk factors for hospitalization from OASIS item M1033 as three binary variables indicating history of two or more falls, taking five or more medications, and decline in mental or behavioral status.

Unstructured Data

We used free-text clinical notes from the EHR for the NLP process to investigate symptoms among older adult HHC patients with UI. There were two types of clinical notes: visit notes and care coordination notes. Clinical notes were documented by nurses, social workers, physical therapists, and occupational therapists. Visit notes were completed during HHC visits and contained information about the patient encounter (e.g., assessments, observations, and interactions with the patient). Care coordination notes were completed to record interdisciplinary communication, reasons for hospitalization, and other healthcare system navigation activities, such as referrals.

Approach for the Development and Implementation of the NLP Algorithm

The process of the NLP algorithm development, testing, and implementation is shown in **Figure 3.1** and included six steps: 1) identify symptoms, 2) create a language model to develop a preliminary vocabulary of synonyms for each identified symptom, 3) expand the preliminary vocabulary, 4) test the NLP algorithm, 5) evaluate the NLP algorithm performance and refine as needed, and 6) implement the NLP algorithm on the total study sample of clinical notes.

NLP Algorithm Development

We identified a set of symptoms among older adults with UI to develop a preliminary vocabulary for the NLP algorithm through a literature review and expert clinician-driven Delphi

survey rounds. The Delphi method was chosen because it is used to obtain subjective information and gain consensus from geographically diverse experts in a reliable way (McPherson et al., 2018). The expert panel included five geographically diverse nurses, each with more than 10 years of clinical experience: two academic PhD-prepared nurses with expertise in incontinence research, geriatric nursing, and urologic nursing (Pennsylvania, Tennessee), one HHC palliative care registered nurse with expertise in symptom management (Massachusetts), one registered nurse with expertise in inpatient medical-surgical care (Virginia), and one advanced practice nurse with expertise in intensive care (New York). Data were collated in Microsoft Excel and analyzed using R software version 4.2.2 (R Core Team, 2021).

We prepared for the Delphi survey rounds by first conducting a scoping review of the literature to identify comorbidities among community-dwelling older adults with UI (Scharp et al., 2023). Next, this list of comorbidities was compared to the most prevalent comorbidities among older adult HHC patients per a study of OASIS National Repository data for patients aged 65 years and older (Murtaugh et al., 2009). We found nine comorbidities in common between these two data sources and retained arthritis, benign prostatic obstruction, chronic obstructive pulmonary disease, diabetes mellitus, depression, heart disease, heart failure, hypertension, and stroke. The study lead developed a list of 38 symptoms related to these comorbidities based on clinical nursing expertise and then shared the list with the panel of expert nurses. We considered adding symptoms to the list when at least two expert nurses suggested adding a symptom to a particular category (Canto-Cerdan et al., 2020). At least two expert nurses recommended adding nausea to the hypertension category, chest pain to the heart disease category, and dysarthria to the stroke category, resulting in a total of 41 symptoms to begin round one of the Delphi survey.

In round one, experts independently labeled symptoms (i.e., yes/no) according to whether they could be associated with autonomic nervous system dysfunction. This classification was chosen because autonomic nervous system dysfunction may elicit shared mechanisms between UI and several comorbidities (Ben-Dror et al., 2012; Choi et al., 2005) given its influence on bladder storage by the sympathetic nervous system and bladder emptying by the parasympathetic nervous system (Grippio, 2009). Symptoms that were designated as “yes” by 51% or more of experts were retained (Canto-Cerdan et al., 2020).

In round two, experts independently quantified the relationship between symptoms and autonomic nervous system dysfunction using a closed answer questionnaire with response options on a scale from 1 (i.e., least related) to 5 (i.e., most related). We then calculated mean responses, and symptoms with a mean of 3 or higher were retained.

Round three involved a closed answer questionnaire in which experts independently rated whether each symptom could be related to autonomic nervous system dysfunction on a Likert scale with 5 response options (i.e., strongly disagree, disagree, neither agree nor disagree, agree, strongly agree). We calculated the median of Likert scale responses, and symptoms with the median in the level of strongly agree (i.e., 5) and all scores between neither agree nor disagree and strongly agree were retained (Canto-Cerdan et al., 2020). Lastly, results from the three Delphi survey rounds were presented to the expert panel of nurses to determine if any symptoms should be added. Symptoms were added when at least four expert nurses recommended adding a particular symptom (Canto-Cerdan et al., 2020).

After we determined symptoms of older adults with UI, we developed the preliminary vocabulary list. A comprehensive vocabulary tailored to healthcare allowed for a nuanced understanding of clinicians' notes. Relevant terms for each symptom domain were identified by

reviewing standardized terminologies, including the Synthesized Nomenclature of Medical Terms (SNOMED) (National Library of Medicine, 2023), International Statistical Classification of Diseases and Related Health Problems Version 10 (ICD-10) (World Health Organization, 2022), and International Classification for Nursing Practice (ICNP) (World Health Organization, 2019).

We developed the NLP algorithm using NimbleMiner (<https://github.com/mtopaz/NimbleMiner>), an open-source software that uses a word embedding approach for comparable term detection in clinical notes. Clinical notes in the HHC agency's dataset were used to generate large vocabularies of synonyms for the symptoms of interest through interactive vocabulary expansion. Then, we leveraged word embeddings, a form of language modeling, using R statistical software. These embeddings were generated using the word2vec and phrase2vec algorithms. Specifically, we applied the skip-gram model from word2vec to create vectors that predict contextual words from a target word, capturing semantic relationships in the text. This approach facilitated the construction of a vector space where semantically similar words are clustered, which allows for nuanced textual analysis and a deeper understanding of language patterns.

Two team members with expertise in nursing and informatics (DS, JS) inputted relevant symptom terms for each symptom domain into NimbleMiner and the software identified potential synonyms (i.e., words, phrases, misspellings, and abbreviations) from clinical notes based on the cosine distance from the skip-gram model. Additionally, NimbleMiner identified negations (e.g., "no symptom" or "denies symptom") and removed these expressions from consideration. The same two team members reviewed the synonyms identified by NimbleMiner and selected words and phrases that accurately reflected each symptom domain. Duplicates and

irrelevant terms were removed. Discrepancies were discussed until a consensus was reached. Once synonyms were selected, NimbleMiner identified additional terms for each word or phrase, team members reviewed the list, and additional relevant terms were selected. This iterative process was followed until NimbleMiner could not identify any additional relevant terms, and a vocabulary of synonyms for each symptom domain was finalized.

NLP Algorithm Testing

Traditionally, a gold standard testing set of clinical notes is created through expert human annotation to test whether the NLP algorithm can identify symptoms with accuracy similar to clinical experts. A random subsample of 1,000 clinical notes was independently annotated by two team members with expertise in UI, nursing, and informatics (DS, MH). Only approximately 2% of clinical notes in this random subsample were identified as containing relevant symptom information. Further, not all symptoms of interest were represented in this subsample. A gold standard testing set is needed to calculate performance metrics including recall and F-score (i.e., the weighted harmonic average of precision and recall). Precision is the ratio of true positives to the total number of predicted positives. Recall is the ratio of true positives out of the actual number of positives. Given sufficient evidence that recall and F-scores for symptom-based NLP algorithms using NimbleMiner in previous studies were high (Koleck, Tantonetti et al., 2021; Song, Ojo, et al., 2022; Topaz et al., 2019; Topaz et al., 2020; Topaz et al., 2021; Woo et al., 2021; Woo et al., 2022), we were confident that NimbleMiner would achieve similar performance in identifying the symptoms of interest in this study. Therefore, to maintain an appropriate allocation of time and resources in this study, we evaluated NimbleMiner's performance with precision. To do this, we applied the NLP algorithm to the study sample of clinical notes (n=1,098,419) and annotated a random subsample of 125 notes in each symptom

domain (n=1,000) to determine if NimbleMiner correctly identified each symptom. Given that visit notes are typically longer and contain more symptom information, notes were purposefully sampled to include up to 85% visit notes. We calculated precision for each symptom domain and overall. Then, we refined the NLP algorithm until precision was 0.85 or higher in all symptom domains.

NLP Algorithm Implementation

Following the development of a well-performing NLP algorithm, we applied the NLP algorithm on the total study sample of clinical notes (n=1,098,419). For each note, a binary indicator of symptom presence (coded as 1) or absence (coded as 0) was determined for each symptom domain.

Statistical Analyses

Binary symptom information was aggregated and summarized at the HHC episode level. Variables derived from structured and unstructured data were combined into a single analytic dataset. Descriptive statistics (i.e., means and standard deviations for continuous variables and frequencies and proportions for categorical variables) were used to summarize the sociodemographic and clinical characteristics of the sample. We used Chi-square tests to investigate differences in symptom documentation for each symptom domain by race or ethnicity. We employed logistic regression models to estimate the odds of any symptoms documented (any symptom/no symptoms documented) in the clinical notes by race or ethnicity. We only included HHC episodes for patients categorized as Asian/Pacific Islander, Black, Hispanic, or White in statistical comparisons of symptom presence due to small sample sizes of the other racial or ethnic groups. Confounding variables were selected based on the literature (Norton et al., 2017; Scharp et al., 2023) and domain expertise in nursing and HHC. We

identified age, patient sex, caregiver assistance with ADLs, living arrangements, cardiovascular disease, diabetes, depression, kidney disease, and stroke as confounders. We evaluated the risk of multicollinearity by calculating variance inflation factors and determined multicollinearity was not present if the variance inflation factor was less than five (Kim, 2019). All analyses were performed using R software version 4.2.2 (R Core Team, 2021).

3.3 Results

Identifying Symptoms of Older Adults with Urinary Incontinence

A summary of the comorbidity identification process, initial symptom list, and results of the Delphi survey rounds are provided in **Appendix D**. In round one, three or more expert nurses voted to retain 19 symptoms for round two of the Delphi survey. In round two, 12 symptoms had mean scores of three or higher and were retained for round three. In round three, ten symptoms had median ratings in the level of strongly agree and all ratings were between neither agree nor disagree and strongly agree and were retained. Results from the three Delphi survey rounds were presented to the expert panel of nurses. Four of the five nurses voted to add anxiety for a total of ten symptoms for the final symptom list: anxiety, constipation, dizziness, syncope, tachycardia, urinary frequency, urinary hesitancy, urinary retention, urinary urgency, and vision impairment/blurred vision. Due to similarities between concepts and relevant terms, we collapsed urinary frequency and urinary urgency into one category, and urinary hesitancy and urinary retention into another category for a total of eight symptom domains examined in this study: anxiety, constipation, dizziness, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, vision impairment/blurred vision.

Sample Characteristics

A summary of the sample selection process is provided in **Appendix E**. The final sample included 39,179 HHC episodes for 29,981 distinct older adults with UI at the time of admission to HHC. The mean number of HHC episodes per patient was 1.31 (standard deviation [SD]=0.67, median=1, range=1-10). These HHC episodes contained 1,098,419 free-text clinical notes (503,786 visit notes and 594,633 care coordination notes), which were used for the NLP portion of this study.

The sample included HHC episodes for patients with a mean age of 84 years (SD=9). Approximately 74% were female, and nearly 40% were from racially or ethnically minoritized groups (i.e., 18% Black, 14% Hispanic, 7% Asian/Pacific Islander, 0.3% multi-racial, 0.2% Native American). Additional sample characteristics are provided in **Table 3.1**.

NLP Algorithm Performance

Among the 1,000 randomly selected clinical notes, 835 (83.5%) were visit notes and 165 (16.5%) were care coordination notes. A total of 106 symptom expressions were detected in this subsample. The NLP algorithm's performance in identifying symptoms was excellent (average precision=0.92), with best performance for constipation (precision=0.98) and urinary frequency/urgency (precision=0.97), and poorest performance for anxiety (precision=0.86) and syncope (precision=0.86) (see **Table 3.2**).

NLP Algorithm Application on Total Study Sample of Clinical Notes

A total of 21,363/1,098,419 (2%) clinical notes were identified as containing symptom information from at least one of the eight symptom domains (i.e., anxiety, constipation, dizziness, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, vision impairment/blurred vision), representing approximately 29% of HHC episodes (11,183/39,179). Among the 21,363 notes that contained at least one symptom, most were visit notes (n=18,645,

87.3%), with the remaining notes being care coordination notes (n=2,718, 12.7%). In total, the NLP algorithm identified 2,300 unique symptom expressions: 1,439 synonyms for anxiety (e.g., afraid, anxious, fearful, nervous stressed out, overwhelmed, very worried about), 427 synonyms for dizziness (e.g., a bit dizzy, became dizzy, have dizziness, lightheadedness, presyncope), 116 synonyms for constipation (e.g., constipated, constipation [sic], experiencing constipation, fecal impaction), 131 synonyms for syncope (e.g., blacking out, collapsed, fainted, passed out, syncopal), 86 synonyms for tachycardia (e.g., elevated pulse rate, fast heart rate, heart racing, increased heart rate, rapid heartbeat, taccycardic [sic]), 49 synonyms for vision impairment/blurred vision (e.g., blurry vision, blurring of vision, cloudy vision, foggy vision, visual impairment), 30 synonyms for urinary hesitancy/retention (e.g., bladder distention, developed urinary retention, difficulty with urination, urinary hesitancy, urinary retension [sic]) and 22 synonyms for urinary frequency/urgency (e.g., freq urination, polyuria, urinary freq, urinating a lot, urgent urination).

The most common symptom in the total sample of 39,179 HHC episodes was anxiety (n=6,964, 17.8%), followed by dizziness (n=2,627, 6.7%), and constipation (n=1,628, 4.2%). The least common symptom in the HHC episodes was urinary hesitancy/retention (n=164, 0.42%), followed by urinary frequency/urgency (n=185, 0.47%), and vision impairment/blurred vision (n=358, 0.91%). Among the 11,183 HHC episodes with clinical notes containing symptom information, an average of 1.1 symptoms (SD=0.26) were detected per HHC episode. Frequencies and examples of symptom information documented in the clinical notes are provided in **Table 3.3**.

The majority of HHC episodes (n=10,506, 94%) containing clinical notes with symptom information had information about a single symptom. For the remaining 677 HHC episodes, 641

(5.7%), 29 (0.26%), and 7 (0.06%) contained information about two, three, and four symptoms, respectively. Among HHC episodes with information about two symptoms, the most common symptom combinations were anxiety and dizziness (n=146), anxiety and constipation (n=88), and dizziness and syncope (n=72). Few HHC episodes contained symptom combinations involving urinary symptoms, including urinary hesitancy/retention and anxiety (n=6), urinary frequency/urgency and anxiety (n=6), and urinary frequency/urgency and constipation (n=1). Among HHC episodes with information about three symptoms, the most common symptom combinations were anxiety, dizziness, and syncope (n=8) and anxiety, dizziness, and constipation (n=5).

Differences in Symptom Documentation by Race or Ethnicity

Among the 11,183 HHC episodes containing clinical notes with symptom information, most were for patients whose race was reported as White (n=7,342, 65.7%), followed by Black (n=1,597, 14.3%), Hispanic (n=1,524, 13.6%), or Asian/Pacific Islander (n=670, 6%).

Urinary symptoms (i.e., urinary frequency/urgency and urinary hesitancy/retention) were documented in less than 1% of HHC episodes for patients across all racial or ethnic groups, with the lowest frequencies being for Black patients. Urinary frequency/urgency was documented in approximately three times as many HHC episodes for White patients than Black patients and approximately two times as many HHC episodes for White patients than Asian/Pacific Islander or Hispanic patients.

We conducted bivariate pairwise analyses to compare symptom documentation by race or ethnicity. There were statistically significant differences in symptom documentation among HHC episodes for racially or ethnically minoritized groups compared to White patients. Lower proportions of HHC episodes for Asian/Pacific Islander (324/2,739, 11.8%, $p < .001$), Black

(857/6,870, 12.5%, $p < .001$), and Hispanic patients (873/5,351, 16.3%, $p < .001$) had anxiety documented compared to White patients (4,881/24,044, 20.3%). A lower proportion of HHC episodes for Black patients had constipation (223/6,870, 3.2%, $p < .001$), dizziness (391/6,870, 5.7%, $p < .001$), urinary frequency/urgency (14/6,870, 0.2%, $p < .001$), and urinary hesitancy/retention (17/6,870, 0.2%, $p < .05$) documented compared to White patients (constipation - 1,069/24,044, 4.4%; dizziness - 1,545/24,044, 6.4%; urinary frequency/urgency - 141/24,044, 0.6%; urinary hesitancy/retention - 109/24,044, 0.5%). Higher proportions of HHC episodes for Asian/Pacific Islander (233/2,739, 8.5%, $p < .001$) and Hispanic patients (446/5,351, 8.3%, $p < .001$) had dizziness documented compared to White patients (1,545/24,044, 6.4%). A higher proportion of HHC episodes for Black patients (89/6,870, 1.3%, $p < .001$) had vision impairment/blurred vision documented compared to White patients (201/24,044, 0.8%) (see **Table 3.4**).

Results of the logistic regression analyses are provided in **Table 3.5**. There were significant group differences in the odds of having any symptoms documented in the clinical notes in the unadjusted and adjusted models ($p < .001$). In the unadjusted model, HHC episodes for Asian/Pacific Islander patients were 26% less likely (OR=0.74, 95% CI [0.67 – 0.80], $p < .001$), Black patients were 31% less likely (OR=0.69, 95% CI [0.64 – 0.73], $p < .001$), and Hispanic patients were 9% less likely (OR=0.91, 95% CI [0.85 – 0.97], $p < .01$) to have any symptoms documented compared to White patients. These results remained significant in the adjusted model, after controlling for age, patient sex, caregiver assistance with ADLs, living arrangements, cardiovascular disease, diabetes, depression, kidney disease, and stroke. The variance inflation factor was less than five for all confounders, indicating that multicollinearity was not present in the adjusted model (see **Appendix F**).

3.4 Discussion

This study developed and tested a novel NLP algorithm to extract symptom information from clinical notes in the context of older adults with UI in HHC and analyze differences by race or ethnicity. The NLP algorithm performed very well (average precision=0.92), with comparable or better performance than symptom-based NLP algorithms applied in HHC (Topaz et al., 2021) and other (i.e., inpatient, outpatient, ED) (Koleck, Tatonetti, et al., 2021) clinical settings. Overall, 29% of HHC episodes had relevant symptom information, with anxiety, dizziness, and constipation most frequently documented, and urinary frequency/urgency, urinary hesitancy/retention, and vision impairment/blurred vision less frequently noted. Additionally, HHC episodes for Asian/Pacific Islander, Black, and Hispanic patients were less likely to have any symptoms documented compared to White patients. These results highlight the efficiency of applying NLP to free-text HHC clinical notes and underscore the need for future research to further characterize older adults with UI.

The NLP algorithm was innovatively developed using inputs from expert-driven Delphi survey rounds including geographically diverse nurses with a range of clinical expertise; thus, ensuring a broad and informed perspective in symptom identification. A recent scoping review identified that most studies applying NLP to clinical documentation in post-acute care settings (e.g., HHC) relied on literature review or team domain expertise to determine concepts for the NLP algorithm to extract (Scharp et al., 2024). We extended these methods of term identification to include experts separate from our research study team, providing quantifiable responses in three Delphi survey rounds. This novel approach mitigated the risks associated with group conformity and social desirability biases, common in traditional methods like focus groups (McPherson et al., 2018). This study demonstrated the feasibility of conducting Delphi survey

rounds with relevant geographically diverse experts and added rigor to developing and applying the NLP algorithm to clinician-generated data (i.e., free-text clinical notes).

To investigate symptoms among older adults with UI in this study, we invoked autonomic nervous system dysfunction, given the potential shared mechanisms between comorbidities and UI (Choi et al., 2005). Based on this understanding, we derived a comprehensive set of symptoms (i.e., anxiety, constipation, dizziness, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, vision impairment/blurred vision) classified as psychologic, gastrointestinal, neurologic, cardiovascular, and genitourinary. This holistic approach transcends the limitations of disease-specific clinical guidelines that often lead to fragmented care and increase the risk for adverse outcomes, including unresolved symptoms, complications, hospitalizations, and death (Salisbury et al., 2018). Although this approach was reasonable for this study, involving older adult HHC patients with UI in the symptom identification process could enhance clinical meaningfulness by capturing the lived symptom experience. This can facilitate developing patient-centered NLP algorithms that can be applied to free-text clinical notes and other important data sources, including patient-authored messages to clinicians (e.g., emails, patient portal messages), transcribed audio-recordings of patient-clinician communication, or electronic patient authored text (e.g., blogs, posts, comments). Given that many patients are reluctant to discuss UI and related symptoms with clinicians due to embarrassment or stigma (Jung et al., 2015), applying NLP to patient-generated data may reveal additional symptom information that can further describe older adults with UI.

In this study, our NLP algorithm identified 29% of HHC episodes containing relevant symptom information. Prior research that applied NLP to clinical documentation in the HHC setting to evaluate symptoms related to a urinary condition (i.e., urinary tract infection) found

similar frequencies (approximately 22%) of urinary-specific and non-specific (e.g., nausea, vomiting, fever, confusion) symptoms (Woo et al., 2021). Other symptom-based NLP studies in the HHC setting found higher frequencies of overall symptom presence in clinical notes, however these studies involved broader symptoms including pain, fatigue, anxiety (Topaz et al., 2021) depressed mood, and agitation (Topaz et al., 2020) for general HHC patient populations. We focused on more precise symptoms among a cohort of older adult patients with UI. Specifically, we analyzed both dizziness and syncope, which can be related, though are distinct symptoms. Additionally, we included two separate categories reflecting urinary symptoms referring to frequency/urgency and hesitancy/retention. Some frequencies of individual symptoms identified in our study were comparable to other studies. For example, in a study that applied NLP to a large corpus of clinical notes for 89,825 HHC episodes, 19% were found to contain concepts related to anxiety (Topaz et al., 2021) compared to 17.8% in our study. Another study that used NLP in the HHC setting identified 2% of 87,866 HHC episodes as containing information about genitourinary symptoms (Song, Ojo, et al., 2022) compared to approximately 1% in our study. This suggests that clinician documentation is a valuable source of symptom information, although it may not fully capture the breadth of symptoms patients experience. This may be due to patient underreporting of symptoms, which highlights the need for more proactive, clinician-led assessments. This is especially important considering potential underreporting in racially or ethnically minoritized groups (Bazargan et al., 2021).

We found that HHC episodes for patients of racially or ethnically minoritized groups were less likely to have any symptoms documented compared to White patients. Further, HHC episodes for Black patients had lower proportions of most (five out of eight) symptoms documented compared to White patients. In contrast, a higher proportion of HHC episodes for

Black patients had vision impairment/blurred vision documented and higher proportions of HHC episodes for Asian/Pacific Islander and Hispanic patients had dizziness documented compared to White patients. Inconsistencies in symptom documentation across racial or ethnic groups may indicate that patients are not assessed in a systematic way. This may contribute to inequities in symptom recognition or reporting, which can lead to disparities in care delivery and outcomes.

Emerging evidence suggests clinicians may have biases that influence their perception and documentation of patient characteristics (Barcelona et al., 2023; Beach et al., 2021).

Research has shown that there is more stigmatizing language in clinical notes for Black patients compared to White patients (Beach et al., 2021; Himmelstein et al., 2022; Sun et al., 2022).

Further, evidence suggests deficiencies in assessing racially or ethnically minoritized patients (Duralde et al., 2016). For example, in a study of 969 patients with UI of which 55% of patients were reported as Asian, Black, Hispanic, or Native American, only 3% indicated that clinicians initiated assessments about UI-related symptoms (Duralde et al., 2016). Clinician biases based on patient characteristics such as race have been documented in other studies (Beach et al., 2021; Himmelstein et al., 2022; Sun et al., 2022), and patient race has been associated with a plethora of poor clinical outcomes in the literature (Anger et al., 2007; Gupta et al., 2016; Mossey, 2011; Siddiqui et al., 2016; Wilson & Sule, 2023). For example, evidence supports disparities in the detection of breast cancer, with Black women having a higher incidence of late-stage diagnosis and associated mortality than White women (Wilson & Sule, 2023). Additionally, prior research has shown that racially or ethnically minoritized groups receive less treatment for pain compared to non-Hispanic White individuals (Mossey, 2011). In addition to clinician biases, reasons for these negative outcomes may include symptom underreporting, driven by racism, discrimination, and stereotypes that perpetuate inequities in care (Mossey, 2011). Further research is needed to

examine potential biases specific to symptom assessment in the HHC setting and identify opportunities to dismantle these biases and facilitate equitable care.

Despite the importance of comprehensive clinician-led assessments, results of this study suggest that older adults with UI may not be comprehensively evaluated. Among our study sample, 26.8% of HHC episodes contained only one symptom. This finding is consistent with a prior study estimating symptom burden among community-dwelling older adults, in which 26.6% were found to have one symptom (Patel et al., 2019). Similarly, prior research that has used NLP to evaluate symptoms in the HHC setting found that 31% of HHC episodes had one symptom (Topaz et al., 2021). Although our results may provide an accurate portrayal of what older adult HHC patients are reporting, they may have concealed symptoms. The presence of these symptoms may warrant clinician-initiated screening for UI. Further work is needed to determine efficient ways of screening for UI among older adults in the HHC setting.

Computerized decisional analysis tools may be effective ways to facilitate assessment, however, digital maturity of HHC settings must be considered. Research suggests that there is value in using computerized decisional analysis tools to obtain information from patients about UI prior to clinician visits to promote efficient assessments and treatments (Nguyen et al., 2023). These tools can be comprehensive, including questions about symptoms across physiologic systems and flag pertinent areas for clinicians to address. These tools can coincide with holistic care guidelines to facilitate clinician-initiated assessments of multiple co-occurring symptoms to promote holistic care and reduce the risk of negative outcomes.

Despite current fragmented models of health care delivery, existing evidence suggests that older adults would prefer one clinician to manage their overall care (Bayliss et al., 2008) with integration of physiologic, psychological, and situational factors into individualized treatment

plans (Starfield et al., 2003). We used the Theory of Unpleasant Symptoms (Lenz et al., 1997) to inform this study to include variables representing influencing factors from these three domains. Each older adult embodies a unique portrayal of symptoms, comorbid conditions, environmental influences, and innate characteristics (Wilson et al., 2019). Given that we recognize race as a social construct founded on societal views and potential biases rather than discernable genetic differences (Helms et al., 2005), we mapped race or ethnicity to situational factors (i.e., attributes of the physical or social environment) (Lenz et al., 1997). This perspective can facilitate understanding differences in symptom documentation that can inform tailored assessments addressing the needs of diverse populations.

Results of this study underscore the multidimensionality of symptoms experienced by older adults with UI in HHC. Overall, anxiety was the most frequent symptom identified in HHC episodes, suggesting that the presence of anxiety may warrant screening for UI. The association between UI and anxiety has been supported in the literature (Reis et al., 2021), though less is known about this association among older adults. Emerging evidence suggests that anxiety may be a risk factor for the development of UI over the life course by way of exposure to childhood adversity (Epperson et al., 2020). Given that some racial and ethnic groups may experience childhood adversity at disproportionately higher rates (Turner & Lloyd, 2003), this may account for statistically significant differences in anxiety presence across racial and ethnic groups that we found. Anxiety was also predominant in symptom co-occurrence patterns that we identified. This finding provides an opportunity for further work to explore symptom clusters (i.e., two or more co-occurring symptoms (Miaskowski et al., 2017)) among older adult HHC patients with UI to better understand and address their healthcare needs.

3.5 Limitations

This study has some limitations. Relevant symptoms may have been missed, as this study analyzed symptoms documented by clinicians, and patients may report symptoms that are not documented. Further, clinical notes analyzed in this study were written by nurses, physical and occupational therapists, and social workers. Although clinicians of these disciplines have frequent contact with HHC patients and typically document symptom information, the absence of physician (e.g., generalist or specialist) authored notes may contribute to the low presence of symptoms noted in this sample. We addressed this by analyzing clinical notes from interdisciplinary clinicians which provides preliminary data for future research to investigate clinical notes from other disciplines and other data sources, such as patient-clinician audio-recorded conversations.

We operationalized UI as being present upon admission to HHC; therefore, we did not capture patients who may have developed UI during their HHC episode. Additionally, for some of these patients, UI may have resolved upon discharge from HHC. This can be addressed in future longitudinal analyses, by examining UI incidence, improvement, or resolution during HHC episodes and determining contributing factors. We excluded 175 patients reported as multi-racial (n=104) and Native American (n=71) from statistical analyses due to small sample sizes of these groups. As this study did not involve enough participants of these racial or ethnic groups to conduct meaningful statistical analyses, future research should purposefully include individuals of these groups to facilitate equitable research and care. We did not calculate other NLP performance metrics (e.g., recall and F-score). However, we are confident that NimbleMiner identified symptoms based on previous symptom-based NLP work using NimbleMiner (Koleck, Tantonetti et al., 2021; Song, Ojo et al., 2022; Topaz et al., 2019; Topaz et al., 2020; Topaz et al.,

2021; Woo et al., 2021; Woo et al., 2022) and our precision calculations. We analyzed data from 2015-2017, which may not reflect the current state of documentation. However, this eliminated the possibility of confounding effects due to the COVID-19 pandemic and provides a foundation for conducting future studies using more recent data. Finally, this study was limited to older adults receiving services from one HHC agency in New York and results may not be generalizable to other clinical settings or younger patients. However, this study provides important information on a diverse sample of HHC patients that will inform other, more geographically diverse studies.

3.6 Conclusion

This study generates new knowledge by developing, testing, and applying an NLP algorithm to HHC clinicians' free-text clinical notes to identify symptoms among older adults with UI. We identified eight symptoms across psychologic, gastrointestinal, neurologic, cardiovascular, and genitourinary domains. Results reveal multidimensional symptoms among older adults with UI in HHC, indicating potential gaps in comprehensive assessment. We identified differences in symptom documentation by race or ethnicity, particularly among minoritized groups, inferring disparities in care. Symptom co-occurrence patterns emerged, laying the groundwork for further research to investigate symptom clusters and identify older adult HHC patients with UI at high risk for negative outcomes. Future research should use NLP to extract symptom information from other data sources to determine symptom trends and inform holistic care strategies for diverse populations.

Table 3.1*Sociodemographic and Clinical Characteristics of Home Healthcare Episodes for Older Adults**with Urinary Incontinence (n=39,179)*

Characteristic	n (%)
Age (mean, SD)	84 (9)
Sex	
Female	29,041 (74%)
Male	10,138 (26%)
Race	
White	24,044 (61%)
Black	6,870 (18%)
Asian/Pacific Islander	2,739 (7%)
Multi-racial	104 (0.3%)
Native American	71 (0.2%)
Ethnicity	
Hispanic	5,351 (14%)
Insurance Status	
Medicare/Medicaid fee-for-service	35,340 (90%)
Dual eligibility	3,155 (8.1%)
Other	475 (1.2%)
Any managed care only	209 (0.5%)
Caregiver Assistance (ADLs) (e.g., transfer/ambulation, bathing, dressing, toileting, eating/feeding)	
Caregiver(s) likely to provide assistance	34,512 (88%)
Caregiver(s) not likely to provide assistance	3,903 (10%)
No assistance needed	764 (2%)
Living Arrangements	
Patient lives with others	23,969 (61%)
Patient lives alone	15,210 (39%)
Functional Status summary score [range: 0-9, mean (SD)]*	8 (1.0)
Comorbidities	

Diabetes	12,345 (32%)
Cardiovascular disease	6,671 (17%)
Depression	3,340 (8.5%)
Kidney disease	1,101 (2.8%)
Stroke	4,376 (11%)

Risk for hospitalization

Taking five or more medications	31,912 (81%)
History of falls (two or more)	10,506 (27%)
Decline in mental or behavioral status	8,379 (21%)

Note. *Functional status is continuous variable which was the sum of nine binary fields (i.e., 0 indicates no issue, 1 indicates moderate/significant issue) including OASIS items that described the patient’s ability to perform ADLs: M1800: grooming, M1810: dressing lower body, M1820: dressing upper body, M1830: bathing, M1840: toilet transferring, M1845: toilet hygiene, M1850: transferring, M1860: ambulating, and M1870: eating.

SD, standard deviation; ADLs, activities of daily living

Table 3.2

Natural Language Processing Algorithm Performance Evaluation

Symptom domain	Precision	Unique symptom expressions
Constipation	0.98	constip, constipa, constipat, constipated, constipating, constipation, constipation, nstipated
Urinary frequency/urgency	0.97	freq urination, frequency nocturia, frequent urination, frequenturgent urination, increased urination, polyuria, urgency frequency, urgency with urination, urgencyfrequency, urinary freq, urinary frequency, urinary

		uregencyfrequency, urinary urgency frequency, urinating a lot
Urinary hesitancy/retention	0.94	Bladder distention, bladder retention, developed urinary retention, difficulty in urination, difficulty urinating, difficulty voiding, hesitancy, retaining urine, retention foley catheter placed, retention of urine, trouble voiding, u_rinary retention, urin_ary retention, urin retention, urinary retension, urinary retention, urination difficulty, urine retention, uti retention
Dizziness	0.94	dizz, dizzy, dizzy, dizziness dizzines, dizziness, giddiness, lightheaded, lightheadedne, lightheadedness, vertigo
Tachycardia	0.91	achycardia, palpatation, palpations, palpit, palpitatio, palpitation, palpitations, tacchycardia, tacchycardic, tachicardia, tachy, tachycardia, tachycardic, tacky
Vision impairment/blurred vision	0.90	blur, blurred, blurr, blurre, blurred, blurrier, blurrier, blurriness
Anxiety	0.86	afraid, anxious, anxiety, distressed, distraught, excessive fear, fear,

		fearing, fearful, overwhelm, overwhelmed, overwhelming, paranoid, stress, stressed, stressful, worried, worries, worrying
Syncope	0.86	collapse, collapsed, faint, fainted, fainting, sync, synco, syncope, syncopal, syncope, Syncopey, Syncopecollapse
Average precision		0.92
Total unique expressions		106

Table 3.3

Frequencies and Examples of Symptoms Documented for Older Adults with Urinary Incontinence in Home Healthcare Episodes (n=39,179)

Symptom	Total frequency and proportion of documentation [n (%)]	Example sentences
Anxiety	6,964 (17.8%)	<p>“Patient reported fear of falling and <i>anxiety</i> while standing”</p> <p>“Pt <i>overwhelmed</i> with medical regimen, <i>anxious</i> re: being alone thru evening/night”</p> <p>“Pt describes financial situation as <i>stressful</i>”</p>
Dizziness	2,627 (6.7%)	<p>“Coming back [home] via cab probably dehydrated and while walking back to lobby <i>felt lightheaded</i> then fell on floor”</p> <p>“Pt with <i>dizziness</i> especially when first getting out of bed has someone with her 24/7”</p>

		“pt reports that her knees want to buckle today and still <i>dizzy</i> at times, pt requires caregiver for ambulation to prevent falls”
Constipation	1,628 (4.2%)	<p>“Has chronic <i>constip</i>, has bowel regimen”</p> <p>“Recent hospital stay was for hyponatremia and <i>constipation</i>, inst on hi fiber diet”</p> <p>“Patient co <i>constipation</i> with her pain meds and her laxative is not working”</p>
Syncope	1,097 (2.8%)	<p>“Pt lives alone elv bldg repts increased sob x1 week but did not call md, repts <i>passed out</i> in bathroom around 11pm, pressed lifealert admitted to [hospital]”</p> <p>“<i>Syncope episode</i> at home resulting in scalp laceration r parietal lobe has 2 staples in place area with minim swelling hematoma no ss of infection”</p> <p>“Patient most recently hosp for hypotension <i>syncope and collapse</i>”</p>
Tachycardia	555 (1.4%)	<p>“Pt presented with <i>tachycardia</i> at rest before treatment”</p> <p>“Pt reported not sleeping well at night and feeling under the weather pt presented with high bp and <i>elevated hr</i>”</p> <p>“Pt had 2 blood transfusion gout attack and episode of <i>tachycardia</i> in past 2 weeks and was not able to attend physical therapy”</p>
Vision impairment/blurred vision	358 (0.9%)	<p>“She mentioned that she cannot see out thru her left eye and has <i>blur vision</i> in her right”</p> <p>“Patient reported her <i>blurry vision</i> makes walking more challenging”</p> <p>“Pt requires assist with all ADLs is <i>visually impaired</i> and transfers with extensive assist, pt recommended for further OT intervention to improve transfers balance strength and endurance”</p>

Urinary frequency/urgency	185 (0.5%)	“Pt complains of difficulty urinating pain in lower abdomen and <i>frequent urination</i> ”
		“Patient reports <i>frequent urination</i> at times due to anxiety denies pain with urination”
		“Pt shared that she dislikes taking her water pill daily because she can’t tolerate the <i>frequent urination</i> and she does not want a commode”
		“Pt continues to use bedside commode occasionally due to <i>frequent urgent urination</i> ”
		“Patient stated that she has decreased fluid intake because she has <i>frequent urination</i> and urinary incontinence”
		“Pt was not drinking because of frequent urination”
Urinary hesitancy/retention	164 (0.4%)	“Pt had <i>urinary retention</i> which resulted in her need for foley catheter”
		“Pt had <i>difficulty urinating</i> , indwelling foley placed, urine clear”
		“Post hospital episode for <i>urinary retention</i> , now voiding well with adequate hydration. No Foley, incontinent”

Table 3.4*Bivariate Comparisons of Symptom Presence in Clinical Notes by Race or Ethnicity (n=39,004)*

Symptom	Race or Ethnicity	Symptom documentation frequency [n (%)]	Pairwise Chi-square comparison (p-value)
Anxiety	Asian/Pacific Islander	324 (11.8%)	< .001
	Black	857 (12.5%)	< .001
	Hispanic	873 (16.3%)	< .001
	White	4,881 (20.3%)	-
Constipation	Asian/Pacific Islander	110 (4%)	.322
	Black	223 (3.2%)	< .001
	Hispanic	217 (4.1%)	.220
	White	1,069 (4.4%)	-
Dizziness	Asian/Pacific Islander	233 (8.5%)	< .001
	Black	391 (5.7%)	< .001
	Hispanic	446 (8.3%)	< .001
	White	1,545 (6.4%)	-
Syncope	Asian/Pacific Islander	61 (2.2%)	.050
	Black	214 (3.1%)	.392
	Hispanic	149 (2.8%)	.660
	White	669 (2.8%)	-
Tachycardia	Asian/Pacific Islander	40 (1.4%)	.927
	Black	92 (1.3%)	.665
	Hispanic	82 (1.5%)	.568
	White	341 (1.4%)	-

Urinary frequency/urgency	Asian/Pacific Islander	7 (0.3%)	< .05
	Black	14 (0.2%)	< .001
	Hispanic	23 (0.4%)	.197
	White	141 (0.6%)	-
Urinary hesitancy/retention	Asian/Pacific Islander	14 (0.5%)	.784
	Black	17 (0.2%)	< .05
	Hispanic	24 (0.5%)	.990
	White	109 (0.5%)	-
Vision impairment/blurred vision	Asian/Pacific Islander	15 (0.6%)	.137
	Black	89 (1.3%)	< .001
	Hispanic	50 (0.9%)	.531
	White	201 (0.8%)	-

Note. Significant differences of proportions compared with HHC episodes for White patients as the reference group.

Full output of the Chi-square comparisons is presented in **Appendix G**.

Table 3.5*Logistic Regression Models Examining Symptom Documentation by Race or Ethnicity (n=39,004)*

Race or Ethnicity	Model 1: unadjusted			Model 2: adjusted		
	OR	95% CI	<i>p</i> -value	OR	95% CI	<i>p</i> -value
Asian/Pacific Islander	0.74	(0.67 – 0.80)	< .001	0.75	(0.69 – 0.92)	< .001
Black	0.69	(0.64 – 0.73)	< .001	0.66	(0.62 – 0.71)	< .001
Hispanic	0.91	(0.85 – 0.97)	< .01	0.88	(0.82 – 0.94)	< .01
White	Reference			Reference		

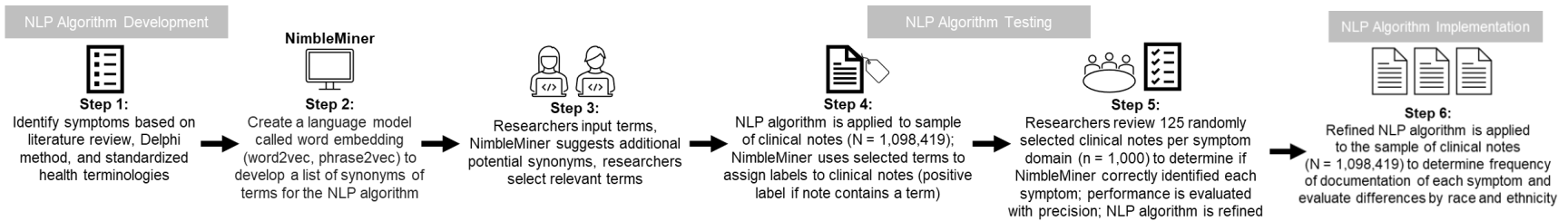
Note. Model 2 is adjusted for age, patient sex, caregiver assistance, living arrangements, cardiovascular disease, depression, diabetes, kidney disease, and stroke.

OR, odds ratio; CI, confidence interval

Full output of the logistic regression models is presented in **Appendix H**.

Figure 3.1

Overview of the Natural Language Processing Algorithm Development, Testing, and Implementation Process



Chapter 4: Characterizing Symptom Clusters for Older Adults with Urinary Incontinence in Home Healthcare

Keywords: home healthcare, nursing informatics, older adult, symptom clusters, urinary incontinence

4.1 Introduction

Most older adults receiving HHC services are medically complex with multiple comorbid conditions (Murtaugh et al., 2009). Among these conditions is urinary incontinence (UI), affecting approximately 40% of older adult HHC patients (Gorina et al., 2014). UI is defined as the involuntary leakage of urine (Haylen et al., 2010) and often remains unaddressed in the HHC setting (Albertson, 2018). Reasons for this may include patients' perception that UI is a normal part of aging (Jung et al., 2015; Silay et al., 2016) and clinicians' perception that UI is less important to treat and manage than other comorbid conditions (Brady et al., 2022). Failure to treat and manage UI in the HHC setting may contribute to persistently elevated hospitalization rates in HHC. Despite efforts to leverage HHC to reduce hospitalizations, recent reports indicate that approximately one in five patients is hospitalized during HHC (Medicare Payment Advisory Commission, 2023). A notable portion of these hospitalizations result from potentially preventable complications, including urinary tract infections, skin breakdown, and falls (Middleton et al., 2019). Although UI is not typically a direct cause of hospitalizations, UI increases the risk of these complications (Kayser et al., 2019; Larsen et al., 2023; Moon et al., 2021), which can lead to hospitalizations and mortality (John et al., 2016). Specifically, prolonged or improper absorbent pad use may increase the risk of urinary tract infections, which can progress to pyelonephritis and sepsis (Larsen et al., 2023). Skin exposure to urine can cause skin breakdown and wound infections (Kayser et al., 2019). Urinary urgency, nocturia, and mobility limitations can increase the risk of falls and injuries (Moon et al., 2021). Therefore, improved assessment and treatment of older adults with UI in HHC is an urgent priority.

Multimorbidity among older adults with UI in HHC suggests that these patients may exhibit symptom clusters (i.e., two or more co-occurring symptoms (Barsevick, 2007; Dodd et

al., 2004; Kim et al., 2005; Miaskowski et al., 2017)); yet symptom co-occurrence patterns remain poorly understood. Additionally, symptom clusters are more difficult to identify and treat compared to individually occurring symptoms (Kwekkeboom, 2016; Miaskowski et al., 2017). Symptom clusters can help build clinical phenotypes, defined as group characteristics that deviate from normal physiology or behavior (Robinson, 2012). Clinical phenotypes allow for classifying subgroups with common characteristics to inform tailored treatment strategies most likely to benefit each specific group (Robinson, 2012). Given the interconnectedness of physiological systems and psychosocial factors linked with UI (Brady et al., 2022), symptom clusters may correlate with sociodemographic characteristics and clinical attributes. Therefore, a clear evaluation process that accounts for multiple co-occurring symptoms and relevant sociodemographic and clinical factors is needed (Miaskowski, 2016).

Defining symptom clusters for older adult HHC patients with UI can enhance clinicians' understanding of the presentation of UI and related symptoms in clinical practice to inform comprehensive assessments and interventions. Few studies have assessed the effectiveness of interventions for predefined symptom clusters (Kwekkeboom et al., 2012; Lengacher et al., 2016; Lengacher et al., 2012; Sprod et al., 2015). For example, one study examined the efficacy of a patient-controlled cognitive behavioral intervention among patients with advanced cancer to treat a symptom cluster comprised of pain, fatigue, and sleep disturbance and found a reduction in symptom severity when reassessed at two weeks (Kwekkeboom et al., 2012). Another study evaluated the efficacy of a mindfulness-based stress reduction program for patients with breast cancer, targeting a cluster of psychologic (i.e., depression, anxiety, stress, and fear of recurrence) and physical (i.e., fatigue and pain) symptoms and found extended symptom improvement up to six weeks later (Lengacher et al., 2016). Reducing the overall symptom burden can also impact

population and systems level outcomes, including morbidity and mortality rates, health disparities, healthcare utilization, and costs.

This work was informed by the Theory of Unpleasant Symptoms (Lenz et al., 1997) (**Appendix A**), which posits that physiologic, psychologic, and situational factors synergistically affect the symptom experience. Within this framework, physiologic factors refer to normally functioning or pathologic processes affecting organ systems. Psychologic factors encompass mood or mental state. Situational factors include attributes of the physical or social environment. Symptom experience is defined as indicators of change in normal physiology or behavior as perceived by an individual, which pose threats to health and risks for adverse outcomes (Lenz et al., 1997). This theory assumes that symptoms overlap and perpetuate each other, underscoring the need for the resulting symptom experience must be addressed holistically (Lenz et al., 1997). This approach can facilitate more comprehensive assessments and improve the identification and management of UI among older adults in the HHC setting.

The goals of HHC encompass clinician-directed care to reduce symptom severity, achieve symptom maintenance, and prevent adverse outcomes (Andrade et al., 2017). HHC clinicians conduct assessments and treatments within patients' homes, enhancing their perception of physiologic, psychologic, and situational factors that affect health. Knowledge of symptom clusters highlighting clinical phenotypes can improve care and outcomes for older adults in the HHC setting. Therefore, this study aimed to identify symptom clusters among older adults with UI in HHC and analyze differences by sociodemographic and clinical correlates. This is essential to understand distinct symptom experiences and promote the development of comprehensive interventions tailored to patients' unique needs.

4.2 Methods

Study Setting and Sample

We conducted a secondary analysis of cross-sectional electronic health record (EHR) data collected between January 1, 2015, and December 31, 2017, from one large HHC agency in New York. Data were aggregated and summarized at the HHC episode level. A HHC episode is defined as the time period in which a patient receives HHC services, commencing with HHC admission and concluding with discharge, transfer to a higher level of care, or death. Patients' sociodemographic and clinical characteristics may be different each time they are enrolled in HHC. For example, health status, medication regimen, caregiver support, housing conditions, or access to other healthcare resources may vary between subsequent HHC episodes for a single patient. Given that these factors influence symptom presentations, analyzing each HHC episode as a unique entity can better capture the full range of symptom experiences.

The inclusion criteria for this study were HHC episodes for patients who were ≥ 65 years old and had a diagnosis of UI upon admission to HHC. Adults ≥ 65 years of age were selected for this study because older adults are particularly vulnerable to adverse outcomes associated with UI, compounded by multiple chronic conditions and co-occurring symptoms (Murtaugh et al., 2009). Exclusion criteria included HHC episodes for patients who were admitted to HHC with an indwelling urinary catheter and patients enrolled in hospice due to the intricacies of documentation related to their terminal diagnosis and differences in treatment objectives.

Age and UI status were assessed at the time of HHC admission using a structured data form known as the Outcome and Assessment Information Set (OASIS) (Centers for Medicare and Medicaid Services, 2017). Structured data forms are standardized assessments using controlled vocabulary, often containing check boxes, drop-down menus, or flowsheets. HHC

agencies in the United States are mandated to complete OASIS for all patients admitted to HHC (Centers for Medicare and Medicaid Services, 2017). OASIS contains information about patients' demographics, clinical characteristics, functional status, and service needs (Centers for Medicare and Medicaid Services, 2017). Age was determined through OASIS item M0066, which specifies the patient's age in years. UI was defined as the involuntary leakage of urine (Haylen et al., 2010). UI status was ascertained by referencing OASIS item M1610, which indicates whether a patient had UI. Approval was obtained from the participating HHC agency's Institutional Review Board for this study.

Dataset

This study used two types of data from the EHR: structured and unstructured. Structured data were defined as OASIS items completed by HHC clinicians at the time of HHC admission. Unstructured data were defined as free-text clinical notes. Guided by the Theory of Unpleasant Symptoms (Lenz et al., 1997), we selected variables representing physiologic factors, psychologic factors, situational factors, and symptom experience to extract from the EHR. In **Appendix C**, we align each variable to the theoretical model dimensions, specify operational definitions, and denote measurement.

Structured Data

We extracted sociodemographic and clinical characteristics from structured OASIS items. We selected sociodemographic and clinical characteristics based on a review of the literature identifying patient-level non-biologic factors that impact UI management (Norton et al., 2017) and comorbidities of older adults with UI (Murtaugh et al., 2009; Scharp et al., 2023). Sociodemographic variables included age, patient sex, living arrangements, race, and ethnicity. Clinical characteristics comprised relevant comorbid conditions and risk factors for

hospitalization. Comorbid conditions included cardiovascular disease, diabetes, depression, kidney disease, and stroke. Risk factors for hospitalization included taking five or more medications, a history of two or more falls, and a decline in mental and behavioral status.

Measures. Patient sex was determined based on OASIS item M0069, indicating whether a patient was male or female. Race and ethnicity data were extracted from OASIS item M0140, specifying that the patient was American Indian or Alaskan Native (i.e., Native American), Asian, Black, Hispanic, Native Hawaiian or Pacific Islander (i.e., Pacific Islander), or White. We created an Asian/Pacific Islander category that included patients reported as Asian or Native Hawaiian or Pacific Islander. For patients with more than one race or ethnicity selected, we created a multi-racial category. We determined living arrangements using OASIS item M1100 and classified it as a binary variable indicating if a patient lived alone or with others.

We extracted data pertaining to comorbid conditions from OASIS item M1028 and created binary variables to represent cardiovascular disease, diabetes, depression, kidney disease, and stroke. We classified risk factors for hospitalization from OASIS item M1033 as three binary variables indicating if the patient was taking five or more medications, had a history of two or more falls, or had a decline in mental or behavioral status.

Unstructured Data

We extracted symptom information from unstructured free-text clinical notes documented by nurses, social workers, physical therapists, and occupational therapists. In previous work (Scharp et al., unpublished data, **Chapter 3**), we identified symptoms of older adults with UI based on a literature review (Murtaugh et al., 2009; Scharp et al., 2023) and expert-driven Delphi survey rounds with five geographically diverse nurses. The following

symptoms were identified: anxiety, dizziness, constipation, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, and vision impairment/blurred vision.

Next, we applied natural language processing (NLP - computer-based algorithms used to extract and process language for further analysis) using NimbleMiner software (<https://github.com/mtopaz/NimbleMiner>) to extract these eight symptom domains from free-text clinical notes. To evaluate NLP algorithm performance, we calculated precision (i.e., the ratio of true positives to the total number of predicted positives) by annotating a random subset of 1,000 clinical notes (125 notes per symptom domain). The NLP algorithm achieved excellent performance (average precision=0.92), indicating high symptom identification accuracy. For each note, a binary indicator was assigned to indicate each symptom's presence (coded as 1) or absence (coded as 0). Details of the NLP process are described in **Chapter 3**.

Statistical Analyses

Descriptive statistics (e.g., means and percentages) were calculated to summarize the sample characteristics. Hierarchical clustering was performed to characterize symptom co-occurrence patterns and identify subgroups with comparable symptom co-occurrence patterns. This clustering method was chosen because it is based on the assumption that symptoms cluster together because they may share common underlying mechanisms (Cleeland et al., 2003; Everitt et al., 2011; Miaskowski et al., 2004). Specifically, agglomerative hierarchical clustering was performed because this analysis starts with all symptoms individually and groups symptoms into clusters of related symptoms (Everitt et al., 2011; Woo et al., 2018). We used the Jaccard distance as the dissimilarity measure since the eight symptoms were coded as binary indicators (Real & Vargas, 1996). The Jaccard distance is calculated as the ratio of the number of observations in both sets to the number of observations in either set and ranges from 0 to 1 (i.e.,

0 indicates complete similarity, and 1 indicates complete dissimilarity) (Real & Vargas 1996). We used the elbow method (Higgins et al., 2023; Syakur et al., 2018), NbClust function within the R package ‘NbCluster’ (Charrad et al., 2014), and domain expertise to determine the optimal number of clusters. The elbow method involves calculating the total sum of square error for each number of clusters and plotting these values on a curve (Higgins et al., 2023). The point at which the total sum of square error reduces significantly (i.e., where the curve appears most pronounced) suggests the optimal number of clusters (Syakur et al., 2018). Hierarchical clustering of symptoms was performed in a stepwise approach until the number of clusters had clinical meaning and interpretability (Everitt et al., 2011). Clinical meaning was evaluated by three team members (DS, JS, MT) with expertise in UI, geriatric care, HHC, and nursing to determine the final number of clusters.

To understand cluster characteristics, we calculated the frequency of each symptom within each cluster. To include all racial and ethnic groups despite the small sample sizes of some groups, we created a binary variable to reflect race or ethnicity (White and Other [includes HHC episodes for Asian/Pacific Islander, Black, Hispanic, multi-racial, and Native American patients]) in statistical analyses. We used Chi-square tests to investigate differences among clusters compared to the reference group (*Cluster 5*: [no symptoms]) by sociodemographic and clinical correlates. All analyses were performed using R software version 4.2.2 (R Core Team, 2021).

4.3 Results

Sample Characteristics

A summary of the sample selection process is provided in **Appendix E**. The final sample included 39,179 HHC episodes containing 1,098,419 free-text clinical notes for 29,981 unique

patients. The mean number of HHC episodes per patient was 1.31 (standard deviation [SD]=0.67, median=1, range=1-10). This sample included HHC episodes for patients with a mean age of 84 years (SD= 9). Approximately 74% were female, and nearly 40% were from racially or ethnically minoritized groups (i.e., 18% Black, 14% Hispanic, 7% Asian/Pacific Islander, 0.3% multi-racial, 0.2% Native American). The most common comorbidities were diabetes (32%) and cardiovascular disease (17%). Additional sample characteristics are provided in **Table 4.1**.

Symptom Characteristics

Approximately 29% (11,183/39,179) of HHC episodes had at least one of the eight symptoms (anxiety, dizziness, constipation, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, and vision impairment/blurred vision) extracted from clinical notes using NLP. In the remaining 27,996 HHC episodes, none of these symptoms were extracted. Symptom frequencies are presented in **Table 4.2**.

Symptom Clusters

We identified five clusters to be the optimal number of clusters showing different symptom co-occurrence combinations among the sample. The frequency of each symptom within each identified cluster is depicted in **Figure 4.1**. *Cluster 1* (n=5,423) is characterized by anxiety (100%). *Cluster 2* (n=2,268) is classified as broadly symptomatic, as all symptoms are represented (syncope 48%, anxiety 25%, tachycardia 24%, dizziness 20%, vision impairment/blurred vision 16%, urinary frequency/urgency 8%, constipation 8%, urinary hesitancy/retention 7%). *Cluster 3* (n=2,044) is denoted by dizziness (100%) and anxiety (27%). *Cluster 4* (n=1,448) is characterized by constipation (100%), anxiety (29%), and dizziness (9%). *Cluster 5* (n=27,996) is classified by no symptoms, as no symptoms are represented.

Associations Between Sociodemographic/Clinical Characteristics and Symptom Clusters

We performed bivariate pairwise analyses to compare sociodemographic and clinical characteristics across symptom clusters. Statistically significant differences were observed in several sociodemographic and clinical characteristics among clusters compared to the reference group (*Cluster 5* [no symptoms]) (see **Table 4.3**).

In terms of sociodemographic characteristics, *Cluster 1* (anxiety) had a significantly higher proportion of HHC episodes for females compared to *Cluster 5* (no symptoms) (79% versus 73%). Additionally, *Cluster 1* (anxiety) had a significantly lower proportion of HHC episodes for patients of racially or ethnically minorized groups (i.e., Asian/Pacific Islander, Black, Hispanic, multi-racial, and Native American) compared to *Cluster 5* (no symptoms) (30% versus 40%). *Cluster 3* (dizziness and anxiety) had a significantly higher proportion of HHC episodes for patients who lived alone compared to *Cluster 5* (no symptoms) (46% versus 38%). (all $p < .001$).

Regarding comorbidities, *Cluster 2* (broadly symptomatic) had a significantly higher proportion of HHC episodes for patients with cardiovascular disease compared to *Cluster 5* (no symptoms) (25% versus 16%). *Cluster 1* (anxiety) had a significantly higher proportion of HHC episodes for patients with depression compared to *Cluster 5* (no symptoms) (13% versus 7%) (all $p < .001$).

In terms of risk for hospitalization, *Cluster 3* (dizziness and anxiety) had a significantly higher proportion of HHC episodes for patients with a history of two or more falls compared to *Cluster 5* (no symptoms) (33% versus 25%). *Cluster 4* (constipation, anxiety, and dizziness) had a significantly higher proportion of HHC episodes for patients taking five or more medications compared to *Cluster 5* (no symptoms) (85% versus 81%) (all $p < .001$).

4.4 Discussion

This study contributes novel insights into symptom clusters among older adults with UI in HHC, highlighting five distinct symptom experiences with observed differences in sociodemographic and clinical factors. Leveraging NLP, we were able to analyze symptoms extracted from approximately one million HHC free-text clinical notes, promoting robust data-driven characterization of older adults with UI. Findings revealed anxiety, dizziness, and constipation as predominant co-occurring symptoms. Additionally, findings revealed a complex cluster in which all eight co-occurring symptoms across neurologic, cardiovascular, gastrointestinal, genitourinary, and psychologic domains were present. Notably, the reference group was the largest cluster representing 71% of HHC episodes, which may be due to symptom underreporting, under-documenting, or symptom resolution by the time of admission to HHC. Findings provide preliminary evidence for how older adults with UI may present in HHC, emphasizing the importance of assessing for associated symptoms and addressing symptom clusters concurrently. Further research is warranted to elucidate relationships among symptoms, informing comprehensive assessment strategies and tailored interventions to reduce UI-related complications and hospitalizations in HHC.

Anxiety was the most frequently documented symptom in the clinical notes and was present in four of the five clusters we identified. This finding is not surprising, as high rates of anxiety among older adults are supported in the literature (Curran et al., 2020; Lu et al., 2023) and prior studies have demonstrated associations between anxiety and UI (Bogner et al., 2011; Elstad et al., 2010; Felde et al., 2012; Milsom et al., 2012; Reis et al., 2021; Smith et al., 2010). All HHC episodes in *Cluster 1* had anxiety, and no other symptoms. Of note, *Cluster 1* (anxiety) had a significantly higher proportion of HHC episodes for women compared to *Cluster 5* (no

symptoms). This finding is concordant with prior studies that estimated the prevalence of anxiety to be higher among women than men (Howell et al., 2001; McLean et al., 2011). Reasons for this may include latent gender-specific biological factors that predispose women to developing anxiety, including genetic predispositions and hormonal influences (Howell et al., 2001; McLean et al., 2011). Societal and cultural gender-specific expectations for the expression of anxiety may also contribute to higher rates of anxiety among women (McLean & Anderson, 2009).

Understanding these gender-specific patterns can inform treatment approaches tailored to the unique needs of older adult women with UI and anxiety.

Additionally, *Cluster 1* (anxiety) had a significantly higher proportion of HHC episodes for patients with depression compared to *Cluster 5* (no symptoms). This was an expected finding, as interconnections between anxiety, depression, and UI have been documented in other studies (Coyne et al., 2009; Huang et al., 2017; Milsom et al., 2012). These anticipated findings add validity to the utilization of NLP and free-text clinical notes to examine symptoms and symptom clusters among older adults with UI. Although expected, our findings highlight the importance of addressing anxiety, depression, and UI concurrently among older adults, especially women.

Although anxiety and depression have been acknowledged as consequences of UI due to related stigma, social isolation, and functional impairment (Bogner et al., 2011; Elstad et al., 2010; Felde et al., 2012; Reis et al., 2021), less is known about anxiety and depression as risk factors for UI over the life course. Existing evidence suggests that UI, anxiety, and depression may be linked through shared physiological pathways involving the hypothalamic-pituitary-adrenal axis and neurotransmitters, including corticotrophin-releasing factor, serotonin, and dopamine given impacts on mood regulation, stress response (Nemeroff, 2004; Pecina et al., 2017; Wang et al., 2016), and urinary control (Ramage, 2006; Seki et al., 2001; Smith et al., 2016). These

relationships may be bidirectional, though few studies have investigated this reciprocal connection simultaneously (Felde et al., 2017; Huang et al., 2017). The predominance of anxiety that we found in this study provides an opportunity to investigate the directionality of relationships between symptoms and conditions through longitudinal analyses. Further research examining physiological pathways linking symptoms and conditions can guide the development of targeted interventions aimed at addressing shared mechanisms underlying these interconnected health issues.

Anxiety, dizziness, and constipation emerged as predominant symptom co-occurrence patterns, which is a novel finding in this context. Prior studies have examined associations between UI and dizziness or constipation as distinct entities (Murukesu et al., 2019; Stenzelius et al., 2004), or UI with concurrent anxiety and depression (Felde et al., 2012). Traditional clinical approaches often consider what may be causing each symptom individually and map symptoms to disease-specific care guidelines. This promotes fragmented care, incurring additional burdens on patients and healthcare systems (Salisbury et al., 2018). Understanding how symptoms across physiological systems may be interrelated can promote a shift towards a more integrated and holistic approach to care. In addition to dysfunction of the hypothalamic-pituitary axis, existing evidence suggests that dysfunction of the autonomic nervous system can manifest various symptoms, given this system's influence on involuntary body processes including bladder function, digestion, respiration, blood pressure, and heart rate (Han et al., 2016; Ochodnický et al., 2013). Therefore, autonomic nervous system dysfunction may represent shared physiological pathways between UI and several symptoms, underscoring the need to explore interventions that target this underlying cause. It is possible that symptoms may not stem from distinct conditions, but rather broad dysregulations influenced by external stressors, biologic factors, and attributes

of the physical and social environment. These factors can encompass lifestyle elements such as diet, exercise, and sleep patterns, as well as structural racism-level factors that contribute to systemic inequalities and stressors experienced by marginalized communities. These influences can alter physiological processes over time (Epperson et al., 2020; Gartside et al., 2003), manifesting various symptoms that may seem unrelated, but may have deeply rooted etiologies. This represents a need for a shift in healthcare to focus on these complex origins, considering how early life may affect the current health of older adults.

The predominance of constipation in *Cluster 4* (constipation, anxiety, and dizziness) may be explained by pelvic floor dysfunction, which can be influenced by lifestyle factors including diet, low fluid intake, exercise, and medications. Pelvic floor dysfunction refers to hypertonic or hypotonic pelvic musculature, which may influence bowel and bladder function (Quaghebeur et al., 2021). Age-related factors, including alterations in muscle tone and contractility, and post-menopausal hormonal changes in women may contribute to an increased risk of pelvic floor dysfunction older adults (Chen, 2007; Quaghebeur et al., 2021). Although this is known, the influence of the musculoskeletal system on symptom manifestations among older adults with UI may be overlooked. Prior studies have cited increased intra-abdominal pressure related to constipation as the driver of UI (Eshkoo et al., 2017; Murukesu et al., 2019); however, the etiology is likely more complex. Although HHC typically involves care delivery by an interdisciplinary team, including nurses and physical therapists, primary goals of care are often focused on functional and mobility improvement (LeDoux et al., 2020). The predominance of constipation in *Cluster 4* (constipation, anxiety, and dizziness) highlights a need to broaden the scope of HHC to include comprehensive pelvic floor assessments and interventions. This can

promote symptom improvement, enhance overall well-being, and reduce the risk of complications which may lead to hospitalizations.

Another novel finding was *Cluster 2* (broadly symptomatic), comprised of eight co-occurring symptoms: anxiety, constipation, dizziness, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, vision impairment/blurred vision. In prior work (Scharp et al., unpublished data, **Chapter 3**), we identified these eight symptoms as essential to investigate among older adults with UI based on a literature review and expert clinician-driven Delphi survey rounds. The emergence of *Cluster 2* (broadly symptomatic) with all eight co-occurring symptoms confers validity to the identification of these symptoms as important among older adults with UI. However, future research is needed to further validate this set of symptoms or identify new symptoms. Standardizing the assessment and evaluation of symptoms in both research and clinical practice is critical for improving care and outcomes among older adults with UI. This can be achieved by engaging groups of key stakeholders, including patients, clinicians, and caregivers, through participatory research methods and triangulating their perspectives to identify a core set of symptoms.

Cluster 2 (broadly symptomatic) had a significantly higher proportion of HHC episodes for patients with cardiovascular disease compared to *Cluster 5* (no symptoms). Consistent with this finding, the most frequent symptom in *Cluster 2* (broadly symptomatic) was syncope, followed by anxiety, tachycardia, and dizziness. Although these symptoms are expected with cardiovascular disease, less expected symptoms, including urinary frequency/urgency and urinary hesitancy/retention, were also present within this cluster. Existing evidence suggests that urinary symptoms may be prevalent among patients with some cardiovascular conditions, such as heart failure (Palmer et al., 2009). Further, urinary symptoms may be more common in the

later stages of the disease. For example, in a study of 296 adults (mean age 62.2 years), patients with late-stage heart failure were nearly three times more likely to have urinary symptoms compared to patients with early-stage heart failure (Palmer et al., 2009). For these reasons, it is reasonable to postulate that urinary symptoms may have been more pronounced in this cluster. This discordance may be attributed to the underreporting of urinary symptoms by patients or the under-documenting of urinary symptoms by clinicians. Future research should explore additional sources of symptom information, such as audio-recorded patient-clinician conversations or electronic patient authored text, to target the breadth of symptom experiences and further delineate symptom clusters.

Most HHC episodes (71%) were grouped into the reference group (*Cluster 5*, [no symptoms]), as the clinical notes did not have any of the eight symptoms documented. Reasons for this may pertain to a variety of clinical scenarios including symptom underreporting by patients, under documenting by clinicians, or symptom resolution. In previous work (Scharp et al., unpublished data, **Chapter 3**), symptom frequencies in the clinical notes were similar to those found in other symptom-based NLP studies in HHC (Song, Ojo, et al., 2022; Topaz et al., 2021; Woo et al., 2021), indicating that clinician documentation may be a reliable source of symptom information. Although some symptom frequencies were low, concordance with prior studies supports the use of the eight NLP-extracted symptoms from free-text clinical notes as the basis of our clustering analysis. Given the prevalence of HHC episodes without any of these symptoms documented, it is important to investigate reasons for this and discern other valuable sources of symptom data in HHC. Such analyses may contribute to improving data accuracy and enhancing the effectiveness of symptom-based NLP studies in HHC.

Notably, *Cluster 5* (no symptoms) included 40% HHC episodes for patients of racially or ethnically minoritized groups. In addition to symptom underreporting and under documenting, conscious or unconscious clinician biases may contribute to this finding. Existing evidence suggests that clinician biases based on patient race are associated with reduced symptom identification, disparities in disease detection, and limited treatments (Duralde et al., 2016; Mossey 2011; Wilson & Sule, 2023). Further, assumptions about racial or ethnic labels have been misused in healthcare to generalize particular groups (Dordunoo et al., 2022). These generalizations fuel healthcare disparities that may be underpinned by clinician biases transmitted through clinical documentation (Beach et al., 2021; Himmelstein et al., 2022; Sun et al., 2022). Researchers have recommended tailored clinician education in other clinical settings involving antiracism education and recurrent self-assessments of individual beliefs to begin to unravel these potential biases (Barcelona et al., 2023; Himmelstein et al., 2022). Future research is needed to examine potential biases in the HHC setting, accounting for clinicians' exposure to patients' home environments, which may introduce biases linked to factors at the domestic level.

Cluster 3 (dizziness and anxiety) had a significantly higher proportion of patients living alone compared to *Cluster 5* (no symptoms). *Cluster 3* reflected dizziness as the predominant symptom. This raises clinical concern, as *Cluster 3* also had a significantly higher proportion of HHC episodes for patients with a history of two or more falls compared to *Cluster 5* (no symptoms). The association between UI and falls is supported in the literature, with contributing factors including urinary urgency, nocturia, and mobility impairments (Moon et al., 2021). The addition of dizziness may heighten the risk of falls among older adults with UI. Additionally, *Cluster 3* reflected anxiety as a co-occurring symptom. The co-occurrence of dizziness and anxiety in a cluster with a high proportion of HHC for patients with a history of falls may be

explained by a fear of falling. Prior research has demonstrated associations between living alone and fear of falling with increased fall rates among older adults (Elliott et al., 2009). Although the presence of anxiety as a co-occurring symptom in this cluster may be linked to fear of falling, it is also possible that it is linked to UI (Bogner et al., 2011; Elstad et al., 2010; Felde et al., 2012; Milsom et al., 2012; Reis et al., 2021; Smith et al., 2010). Further, emerging evidence has shown comparable patterns of brain activity in response to fear between patients with dizziness and those with anxiety, supporting a neurobiological connection between these symptoms (Maywald et al., 2023). Although this may support the symptom co-occurrence that we found in *Cluster 3* (dizziness and anxiety), further research is needed to investigate etiology and understand underlying relationships to design interventions that address these interconnections holistically.

The identification of five distinct symptom clusters in this study raises clinical awareness of potential clinical phenotypes among older adults with UI. Clinicians are encouraged to take the lead in eliciting information from patients about UI and its related symptoms, and not solely rely on what patients report. This is particularly important regarding older adults with UI, as patients may not readily disclose some symptoms due to embarrassment, cultural stigma, or perceiving certain symptoms as irrelevant (Wang et al., 2015). The clinical relevance of the full context of patient presentations is supported by our findings, highlighting a spectrum of symptom experiences, ranging from no symptoms to eight co-occurring symptoms. Clinicians should consider how symptoms across physiological systems may be interrelated, accounting for potential psychosocial and structural influences. Our findings provide a preliminary roadmap for clinicians to navigate complex assessments considering the broader context of older adults with UI, promoting improved symptom recognition and a more holistic approach to care. Future

research is needed to explore underlying mechanisms between symptoms and develop multidimensional interventions that support a shift away from siloed clinical care.

Further, our findings lay the groundwork for future research investigating whether these symptom clusters are associated with outcomes. Outcomes of interest may include acute care utilization (i.e., emergency department visits or hospitalizations), quality of life years, and healthcare costs. These outcomes are particularly important in the HHC setting, given the goals of managing patients' health conditions at home through cost-efficient care and improving quality of life (Andrade et al., 2017). Knowledge of associations between symptom clusters and outcomes may further enhance their applicability to clinical practice by drawing attention to ways to improve outcomes for older adults with UI in HHC.

4.5 Limitations

Study limitations include using clustering analysis on symptoms identified from clinical notes using NLP, which may have resulted in missing symptoms not documented or reported. Further, HHC clinicians may only document focused assessments limited to the reason for the visit. However, we identified a comprehensive set of symptoms across several physiological systems aiming to capture a range of symptom experiences in our analyses. We examined symptom clusters using binary symptom data (i.e., present or absent) and did not account for the number of times a symptom was documented or include measures of symptom severity. Additionally, UI was measured at admission to HHC; therefore, we did not include patients who developed UI during their time in HHC. However, this study provides a basis for future longitudinal analyses investigating symptom trends and how they map back to comorbid diagnoses and influence future outcomes.

Given the small sample sizes of some racially and ethnically minoritized groups, we included race or ethnicity as a binary variable (i.e., White and Other [includes HHC episodes for Asian/Pacific Islander, Black, Hispanic, multi-racial, and Native American patients]) in statistical analyses. Although this was appropriate for this study, future research should purposefully sample individuals of racially and ethnically minoritized groups to examine symptom differences more closely by race or ethnicity. We did not account for healthcare literacy or cultural variations that may impact patient-clinician communication. Future research should include community partnerships offering patient involvement to understand the breadth of symptom experiences underscored by patient insight. We analyzed data from 2015-2017, which may not exhibit the current state of documentation. However, we chose to study this timeframe to mitigate the potential for confounding effects of the COVID-19 pandemic and provide a foundation for future studies using more recent data. We identified a cluster with one symptom (*Cluster 1*, [anxiety]) and *Cluster 5* (no symptoms) as the reference group. Although this provided a clinically interpretable clustering solution for these data, future investigation is needed to identify clusters that all reflect two or more co-occurring symptoms. Finally, this study's scope was confined to older adults receiving services from a single HHC agency in New York; therefore, the findings might not be generalizable to different clinical settings, geographic locations, or younger patients. However, this study's diverse sample offers valuable insights that can guide more geographically diverse studies.

4.6 Conclusion

This study generates new evidence identifying five distinct symptom clusters for older adults with UI in HHC derived from approximately one million free-text clinical notes. The five symptom clusters illuminate potential clinical phenotypes of older adults with UI in the HHC

setting, which can guide comprehensive assessment and treatment strategies. Anxiety, dizziness, and constipation emerged as predominant co-occurring symptoms. Significant differences in sociodemographic and clinical characteristics were observed across clusters. Disparities in symptoms among racially or ethnically minoritized groups underline the importance of addressing potential biases among HHC clinicians. This work provides preliminary findings to support future research examining associations between symptom clusters and outcomes, to identify at-risk patients requiring tailored interventions to reduce health complications and hospitalizations in the HHC setting.

Table 4.1*Sociodemographic and Clinical Characteristics of Home Healthcare Episodes for Older Adults**with Urinary Incontinence (n=39,179)*

Characteristic	n (%)
Age (mean, SD)	84 (9)
Sex	
Female	29,041 (74%)
Male	10,138 (26%)
Race	
White	24,044 (61%)
Black	6,870 (18%)
Asian/Pacific Islander	2,739 (7%)
Multi-racial	104 (0.3%)
Native American	71 (0.2%)
Ethnicity	
Hispanic	5,351 (14%)
Living Arrangements	
Patient lives with others	23,969 (61%)
Patient lives alone	15,210 (39%)
Comorbidities	
Diabetes	12,345 (32%)
Cardiovascular disease	6,671 (17%)
Depression	3,340 (8.5%)
Stroke	4,376 (11%)
Kidney disease	1,101 (2.8%)
Risk for hospitalization	
Taking five or more medications	31,912 (81%)
History of falls (two or more)	10,506 (27%)
Decline in mental or behavioral status	8,379 (21%)

Note. SD, standard deviation

Table 4.2*Frequencies of Symptoms Documented for Older Adults with Urinary Incontinence in Home**Healthcare Episodes (n=39,179)*

Symptom	Total frequency and proportion of documentation [n (%)]
Anxiety	6,964 (17.8%)
Dizziness	2,627 (6.7%)
Constipation	1,628 (4.2%)
Syncope	1,097 (2.8%)
Tachycardia	555 (1.4%)
Vision impairment/blurred vision	358 (0.9%)
Urinary frequency/urgency	185 (0.5%)
Urinary hesitancy/retention	164 (0.4%)

Table 4.3*Bivariate Comparisons of Sociodemographic and Clinical Characteristics of Home Healthcare Episodes by Symptom Cluster**(n=39,179)*

	Cluster 1: Anxiety (n=5,423)	Cluster 2: Broadly symptomatic (n=2,268)	Cluster 3: Dizziness and anxiety (n=2,044)	Cluster 4: Constipation, anxiety, and dizziness (n=1,448)	Cluster 5: No symptoms (n=27,996) [Reference]
Sex (female)	4,279 (79%)*	1,637 (72%)	1,531 (75%)	1,119 (77%)*	20,474 (73%)
Race (Other)	1,627 (30%)*	862 (38%)	858 (42%)	492 (34%)*	11,198 (40%)
Living arrangements (alone)	2,239 (41%)*	937 (41%)*	933 (46%)*	547 (38%)	10,552 (38%)
Cardiovascular disease	861 (16%)*	569 (25%)*	423 (21%)*	203 (14%)	4,615 (16%)
Diabetes	1,586 (29%)*	724 (32%)	684 (34%)	388 (27%)	8,962 (31%)
Depression	684 (13%)*	194 (9%)	195 (10%)*	179 (12%)*	2,088 (7%)
Kidney disease	128 (2%)*	60 (3%)	66 (3%)	26 (2%)*	821 (3%)
Stroke	585 (11%)	272 (12%)	234 (11%)	147 (10%)	3,138 (11%)
Taking five or more medications	4,410 (81%)	1,880 (83%)*	1,727 (84%)*	1,234 (85%)*	22,660 (81%)
History of falls (two or more)	1,687 (31%)*	729 (32%)*	670 (33%)*	407 (28%)*	7,018 (25%)
Decline in mental/behavioral status	1,407 (26%)*	485 (21%)	366 (18%)*	295 (20%)	5,816 (21%)

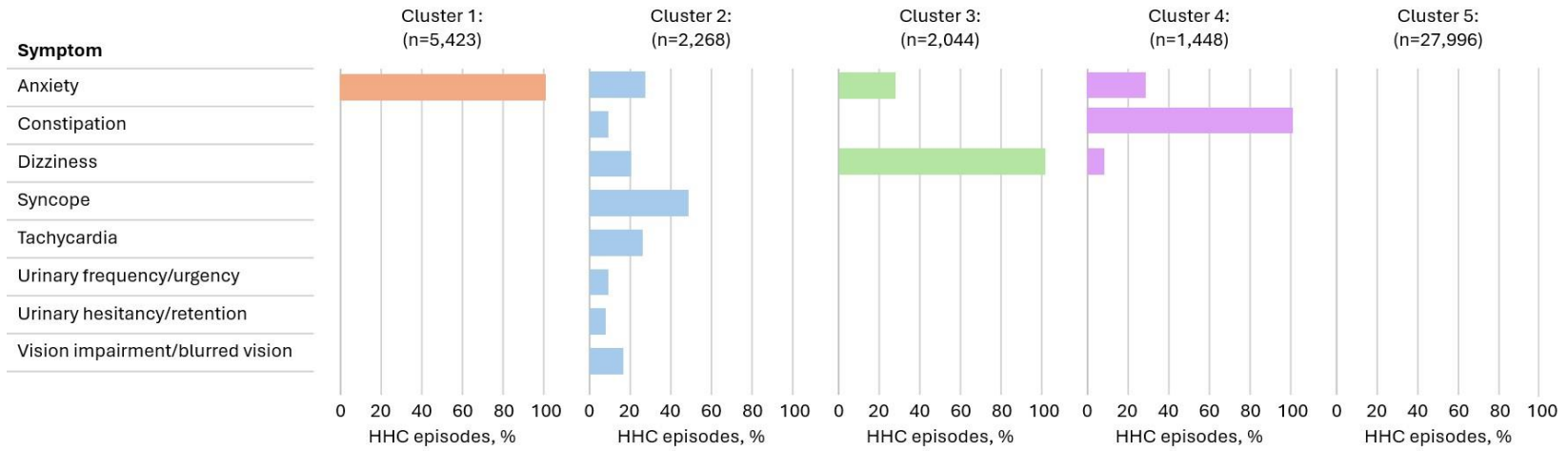
Note. Significant differences of proportions compared with the reference group (*Cluster 5* [no symptoms]) determined by Chi-square tests. ‘Other’ race category includes HHC episodes for Asian/Pacific Islander, Black, Hispanic, multi-racial, and Native American patients. * $p < .05$, ** $p < .01$, *** $p < .001$

Full output of the Chi-square comparisons is presented in **Appendix I**.

Figure 4.1

Frequency of Each Symptom Within Clusters Among Home Healthcare Episodes for Older Adults with Urinary Incontinence

(n=39,179)



**Chapter 5: Risk Factors for Emergency Department Visits or
Hospitalizations Among Older Adults with Urinary Incontinence
in Home Healthcare**

Keywords: acute care utilization, home healthcare, older adult, symptom clusters, urinary incontinence

5.1 Introduction

More than three million older adults (65 years and older) receive home healthcare (HHC) services annually in the United States (Medicare Payment Advisory Commission, 2023). HHC involves skilled care including nursing, medical, social work, physical, occupational, and speech therapy services (Medicare Payment Advisory Commission, 2023). Despite efforts to utilize HHC to prevent emergency department (ED) visits and hospitalizations, hospitalization rates have not significantly improved (Siclovan et al., 2021). Recent reports show that approximately one in five patients visit the ED or are hospitalized during their time in HHC (Medicare Payment Advisory Commission, 2023). Further, many of these hospitalizations are due to potentially preventable causes (Middleton et al., 2019).

A prevalent condition among older adult HHC patients that may lead to potentially preventable hospitalizations is urinary incontinence (UI) (Albertson, 2018). UI is defined as the involuntary leakage of urine (Haylen et al., 2010) and affects approximately 40% of older adults in HHC (Gorina et al., 2014). Despite being a prevalent condition, UI is often undertreated in the HHC setting (Albertson, 2018). Possible explanations for this may include patients' perceptions that UI is a normal part of aging (Jung et al., 2015; Silay et al., 2016) and clinicians' perceptions that UI is less critical to address compared to other health conditions (McCann et al., 2022). Failure to address UI in the HHC setting heightens the risk of potentially serious complications, including urinary tract infections (Larsen et al., 2023; Moore et al., 2008), skin breakdown (Kayser et al., 2019), and falls (Moon et al., 2021), which can lead to ED visits, hospitalizations, and mortality (John et al., 2016; Thom et al., 1997). Notably, a retrospective cohort study of over one million older adults receiving HHC services identified urinary tract infections and skin breakdown as the most common reasons for potentially preventable hospitalizations in HHC

(Middleton et al., 2019). Therefore, UI in the HHC setting represents an opportunity for improved identification and treatment to prevent complications before patients are hospitalized.

Symptom management is a priority in HHC and a core tenet of nursing practice (Corwin et al., 2014). Symptoms are defined as subjective experiences that provoke changes in physical, mental, and social functioning (Bender et al., 2017). HHC's objectives include providing nurse-directed care to mitigate the intensity of symptoms and attain ongoing symptom maintenance (Andrade et al., 2017). These initiatives prevent exacerbations, complications, and keep patients in the community and out of the hospital. However, symptom management in HHC is challenging, especially among older adults who often have multiple comorbid conditions and co-occurring symptoms (Ma et al., 2018; Murtaugh et al., 2009). Two or more co-occurring symptoms are referred to as symptom clusters (Barsevick, 2007; Dodd et al., 2004; Kim et al., 2005; Miaskowski et al., 2017), which are more difficult to identify and treat compared to individually occurring symptoms (Kwekkeboom, 2016; Miaskowski et al., 2017). Symptom clusters illuminate clinical phenotypes, defined as subgroups of patients with sets of features that diverge from normal physiology or behavior (Robinson, 2012). Clinical phenotypes can be integrated with physiologic and environmental factors to guide clinical practice by informing diagnosis, treatment, and risk assessment strategies. Classifying subgroups with shared characteristics can enable the development of customized treatment approaches, ensuring that interventions are most likely to be effective for each specific group (Robinson, 2012).

This work was informed by the Theory of Unpleasant Symptoms (Lenz et al., 1997) (**Appendix A**). This theory asserts that physiologic (i.e., normally functioning or pathologic processes affecting organ systems), psychological (i.e., mood or mental state), and situational factors (i.e., attributes of the physical or social environment) affect symptom experience and

performance outcomes. Symptom experience refers to alterations in typical physiological or behavioral patterns as perceived by an individual, carrying potential health risks and the likelihood of adverse outcomes (Lenz et al., 1997). Performance is defined as the outcome or effect of the symptom experience, including physical role performance indicators (Lenz et al., 1997). Patients with greater symptom burdens typically have a reduced ability to complete physical tasks (Lenz et al., 1997). Patients encounter physical role performance indicators, which clinicians evaluate to inform decisions regarding potential transfer to a higher level of care (e.g., ED/hospital). This theory posits that interconnected symptoms co-occur and reinforce each other, emphasizing the necessity of holistically addressing the resulting symptom experience (Lenz et al., 1997). Failure to address the symptom experience comprehensively can result in adverse health outcomes.

High hospitalization rates in the HHC setting require a closer examination of actionable factors. To improve the understanding of different symptom presentations among older adults with UI in HHC, prior work has identified symptom clusters that correlate with sociodemographic and clinical characteristics (Scharp et al., unpublished data, **Chapter 4**). Although UI is a known risk factor for complications that can lead to ED visits, hospitalizations, and mortality (John et al., 2016; Thom et al., 1997), little is known about whether certain symptom clusters are associated with these outcomes. Further, understanding factors linked to the risk of ED visits or hospitalizations among older adults with UI in HHC can enhance clinical awareness, enabling closer monitoring and timely interventions for at-risk patients. Therefore, this study aimed to determine factors associated with the risk for ED visits or hospitalizations among older adults with UI in HHC, including the impact of symptom clusters, to inform comprehensive assessments and interventions to prevent potentially avoidable hospitalizations.

5.2 Methods

Study Setting and Sample

We conducted a retrospective secondary analysis of electronic health record (EHR) data collected between January 1, 2015, and December 31, 2017, from one large HHC agency in New York. Data were aggregated and summarized at the HHC episode level. A HHC episode is defined as the timeframe during which a patient receives HHC services, starting with HHC admission and ending with discharge, transfer to a higher level of care (e.g., ED/hospital), or death. Sociodemographic, clinical, and symptom characteristics may be different each time a patient is enrolled in HHC. For example, admitting diagnoses, health status, caregiver availability, living arrangements, or access to healthcare resources may change between subsequent HHC episodes for an individual patient. Given that these variations could impact symptom experiences, approaches taken for treatment, and outcomes, analyzing each HHC episode as an individual entity can better capture potential factors associated with ED visits/hospitalizations.

The inclusion criteria for this study were HHC episodes for patients who were ≥ 65 years old and had a diagnosis of UI upon admission to HHC. Adults ≥ 65 years of age were chosen for inclusion in this study due to their heightened risk for unfavorable outcomes related to UI, which is further exacerbated by the presence of multiple chronic conditions and concurrent symptoms (Murtaugh et al., 2009). Exclusion criteria were HHC episodes for patients who were admitted to HHC with an indwelling urinary catheter or were on hospice due to the intricacies of documentation related to their terminal diagnosis and differences in treatment objectives.

Age and UI status were assessed at the time of admission to HHC by using a structured data form known as the Outcome and Assessment Information Set (OASIS) (Centers for

Medicare and Medicaid Services, 2017). OASIS is a standardized assessment form using controlled vocabulary and checkboxes to denote patients' sociodemographic and clinical characteristics (Centers for Medicare and Medicaid Services, 2017). Age was determined through OASIS item M0066, denoting the patient's age in years. UI was defined as the involuntary leakage of urine (Haylen et al., 2010). UI status was assessed with OASIS item M1610, which indicates whether a patient had UI. Approval was obtained from the participating HHC agency's Institutional Review Board for this study.

Dataset

This study used two types of EHR data: structured and unstructured. Structured data were defined as OASIS items recorded by HHC clinicians upon HHC admission. Unstructured data were defined as free-text clinical notes. In **Appendix C**, we align each variable to the theoretical model dimensions, specify operational definitions, and denote measurement.

Structured Data

We extracted sociodemographic and clinical characteristics from structured OASIS items. We selected variables based on the Theory of Unpleasant Symptoms (Lenz et al., 1997), literature pertaining to comorbidities of older adults with UI (Murtaugh et al., 2009; Scharp et al., 2023), patient-level non-biologic factors that impact UI management (Norton et al., 2017), and potential risk factors for hospitalization (Kayser et al., 2019; Larsen et al., 2023).

Sociodemographic variables included age, patient sex, race or ethnicity, living arrangements, and caregiver assistance with activities of daily living (ADLs), defined as help with grooming, dressing lower body, dressing upper body, bathing, toilet transferring, toilet hygiene, transferring, ambulation, and eating. Clinical characteristics included relevant comorbid conditions, risk factors for hospitalization, and the outcome variable, ED visits/hospitalizations.

Comorbid conditions included cardiovascular disease, diabetes, depression, kidney disease, and stroke. Risk factors for hospitalization included taking five or more medications, history of two or more falls, decline in mental and behavioral status, presence of an unhealed skin ulcer, and urinary tract infection within the past 14 days prior to HHC admission.

Measurement of Sociodemographic Characteristics. Patient sex was determined based on OASIS item M0069, which indicated whether a patient was male or female. Race and ethnicity data were extracted from OASIS item M0140, noting that the patient was American Indian or Alaskan Native (i.e., Native American), Asian, Black, Hispanic, Native Hawaiian or Pacific Islander (i.e., Pacific Islander), or White. We created an Asian/Pacific Islander category that included patients reported as Asian or Native Hawaiian or Pacific Islander. For patients with more than one race or ethnicity selected, we created a multi-racial category. We determined living arrangements based on OASIS item M1100 and created a binary variable indicating if a patient lived alone or with others. We classified caregiver assistance with ADLs into three categories based on OASIS item M2100: caregiver(s) likely to provide assistance with ADLs, caregiver(s) not likely to provide assistance with ADLs, and no assistance needed. The second category refers to patients that may require assistance with ADLs, but have caregivers who are not willing or able to provide assistance.

Measurement of Clinical Characteristics. We extracted data reflecting comorbid conditions from OASIS item M1028 and generated binary variables representing cardiovascular disease, diabetes, depression, kidney disease, and stroke. We characterized risk factors for hospitalization from OASIS item M1033 as three binary variables indicating a history of two or more falls, taking five or more medications, and a decline in mental or behavioral status. We determined the presence of an unhealed skin ulcer from OASIS item M1306 and classified it as a

binary variable. We characterized urinary tract infections in the past 14 days prior to HHC admission as a binary variable based on OASIS item 1600, indicating if a patient had been diagnosed and treated for a urinary tract infection.

Measurement of the Outcome: ED visits/hospitalizations. We created a composite binary variable from two OASIS items to indicate whether a HHC episode resulted in an ED visit or hospitalization. HHC episodes for patients who had an ED visit were determined based on OASIS item M2300 indicating having received emergent care. Similarly, we identified HHC episodes for patients who were hospitalized based on OASIS item M0100, noting a transfer to an inpatient facility. A composite binary variable was selected because a patient could have had an ED visit and hospitalization within the same HHC episode.

Unstructured Data

We extracted symptom information from unstructured free-text clinical notes. These notes were written by nurses, social workers, physical therapists, and occupational therapists. In prior work (Scharp et al., unpublished data, **Chapter 3**), we identified symptoms of older adults with UI based on a literature review (Murtaugh et al., 2009; Scharp et al., 2023) and expert clinician-driven Delphi survey rounds. The following symptoms were identified: anxiety, dizziness, constipation, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, and vision impairment/blurred vision.

Next, we applied natural language processing (NLP) using NimbleMiner software (<https://github.com/mtopaz/NimbleMiner>) to extract these eight symptom domains from free-text clinical notes for older adults with UI. NLP uses computer-based algorithms to recognize and process language for further analysis (Yim et al., 2016). We annotated a random subsample of 1,000 clinical notes (125 per symptom domain) to determine NLP algorithm performance and

calculated precision. Precision is the ratio of true positives to the total number of predicted positives. Then, we refined the NLP algorithm to achieve precision of 0.85 or higher in all symptom categories. Finally, we applied the refined NLP algorithm to the full study sample of clinical notes (n=1,098,419). The NLP algorithm performed very well (average precision=0.92), indicating high symptom identification accuracy. A binary indicator was generated to denote each symptom's presence (coded as 1) or absence (coded as 0). Details of the NLP process are described in **Chapter 3**.

In previous work, (Scharp et al., unpublished data, **Chapter 4**), we used hierarchical clustering to identify symptom clusters for older adults with UI in HHC derived from NLP-extracted symptoms. We used Chi-square tests to examine cluster differences by sociodemographic and clinical correlates. Details of the clustering methods are described in **Chapter 4**.

Statistical Analyses

Descriptive statistics (e.g., mean and percentages) were calculated to summarize the overall sample characteristics and sample characteristics by cluster. We conducted bivariate analyses (Chi-square tests) to identify sociodemographic and clinical variables that were significantly associated with ED visits/hospitalizations ($p < .05$). Next, we employed backward stepwise logistic regression to estimate the odds of ED visits/hospitalizations by significant sociodemographic and clinical factors, including symptom clusters, in which only variables with p -values $< .05$ were retained in the final model (Peng et al., 2001). We assessed the risk of multicollinearity by calculating variance inflation factors and determined multicollinearity was not present if the variance inflation factor was less than five (Kim, 2019). All analyses were performed using R software version 4.2.2 (R Core Team, 2021).

5.3 Results

Sample Characteristics

A summary of the sample selection process is provided in **Appendix E**. The final sample included 39,179 HHC episodes containing 1,098,419 free-text clinical notes for 29,981 distinct patients. The mean number of HHC episodes per patient was 1.31 (standard deviation [SD]=0.67, median=1, range=1-10).

Overall sample characteristics are provided in **Table 5.1**. This sample included HHC episodes for patients with a mean age of 84 years (SD=9), and approximately 74% were female. Nearly 40% were from racially or ethnically minoritized groups (i.e., 18% Black, 14% Hispanic, 7% Asian/Pacific Islander, 0.3% multi-racial, 0.2% Native American). The most prevalent comorbidities were diabetes (36%) and cardiovascular disease (17%). About 27% had a history of two or more falls and most were taking five or more medications (81%). Approximately 18% had an unhealed skin ulcer, and 10% had a urinary tract infection that was diagnosed and treated within 14 days prior to HHC admission. Approximately 16% of HHC episodes resulted in an ED visit/hospitalization.

Symptom Characteristics

Approximately 29% (11,183/39,179) of HHC episodes contained relevant symptom information from one of the eight symptom domains (i.e., anxiety, dizziness, constipation, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, and vision impairment/blurred vision) extracted from free-text clinical notes using NLP. No symptoms were extracted from the remaining 27,996 HHC episodes (71%). Details of the NLP results, including symptom frequencies, are presented in **Chapter 3**.

Symptom Clusters

Using agglomerative hierarchical clustering, we identified five distinct symptom clusters for older adults with UI in HHC. *Cluster 1* (n=5,423) is characterized by anxiety (100%). *Cluster 2* (n=2,268) is described as broadly symptomatic, representing all eight symptoms (syncope 48%, anxiety 25%, tachycardia 24%, dizziness 20%, vision impairment/blurred vision 16%, urinary frequency/urgency 8%, constipation 8%, urinary hesitancy/retention 7%). *Cluster 3* (n=2,044) is classified by dizziness (100%) and anxiety (27%). *Cluster 4* (n=1,448) is denoted by constipation (100%), anxiety (29%), and dizziness (9%). *Cluster 5* (n=27,996) is characterized by no symptoms, as none of the eight symptoms are represented. Details of the clustering results are presented in **Chapter 4**.

Sample characteristics by symptom cluster are provided in **Table 5.2**. *Cluster 1* (anxiety) (n=5,423) had the highest proportion of HHC episodes for females (n=4,279, 79%), White patients (n=3,794, 70%), and patients with depression (n=684, 13%). *Cluster 2* (broadly symptomatic) (n=2,268) had the highest proportion of HHC episodes for patients who had an ED visit/hospitalization (n=553, 24%), patients with cardiovascular disease (n=569, 25%), and patients diagnosed and treated for a urinary tract infection (n=285, 13%). *Cluster 3* (dizziness and anxiety) (n=2,044) had the highest proportion of HHC episodes for patients who lived alone (n=933, 46%), patients with a history of two or more falls (n=670, 33%), and patients with diabetes (n=684, 33%). *Cluster 4* (constipation, anxiety, and dizziness) (n=1,448) had the highest proportion of HHC episodes for patients taking five or more medications (n=1,234, 85%). *Cluster 5* (no symptoms) (n=27,996) had the highest proportion of HHC episodes for patients with an unhealed skin ulcer (n=5,525, 20%) and the lowest proportion of HHC episodes for patients who had an ED visit/hospitalization (n=3,977, 14%).

Associations Between Symptom Clusters and ED Visits/Hospitalizations

We conducted bivariate pairwise analyses to identify sociodemographic (age, patient sex, race [Asian/Pacific Islander, Black, multi-racial, Native American, White], ethnicity [Hispanic], living arrangements, caregiver assistance with ADLs), clinical (cardiovascular disease, diabetes, depression, kidney disease, stroke, history of two or more falls, taking five or more medications, decline in mental or behavioral status, presence of an unhealed skin ulcer, urinary tract infection within the past 14 days), and symptom cluster (*Cluster 1* [anxiety], *Cluster 2* [broadly symptomatic], *Cluster 3* [dizziness and anxiety], *Cluster 4* [constipation, anxiety, and dizziness], and *Cluster 5* [no symptoms]) variables significantly associated with ED visits/hospitalizations. All variables were significantly associated with ED visits/hospitalizations ($p < .05$) except living arrangements ($p = .142$). The 24 significant variables were included in the backward stepwise logistic regression.

The final results of the backward stepwise logistic regression are provided in **Table 5.3**. Overall, the final model included 15 variables associated with ED visit/hospitalization risk. The variance inflation factor was less than five for all retained variables, indicating that multicollinearity was not present in the final model (see **Appendix F**). Four symptom clusters were retained in the model, including *Cluster 1* (anxiety), *Cluster 2* (broadly symptomatic), *Cluster 3* (dizziness and anxiety), and *Cluster 4* (constipation, anxiety, and dizziness). *Cluster 5* (no symptoms) was not significantly associated with ED visit/hospitalization risk.

All four symptom clusters retained in the final model had higher ED visit/hospitalization odds. After adjusting for sociodemographic and clinical factors, HHC episodes for patients in *Cluster 2* (broadly symptomatic) were twice as likely to have ED visits/hospitalizations (OR=2.00, 95% CI [1.80 – 2.22], $p < .001$). HHC episodes for patients in *Cluster 3* (dizziness and anxiety) were 55% more likely (OR=1.55, 95% CI [1.39 – 1.75], $p < .001$), *Cluster 4*

(constipation, anxiety, and dizziness) were 47% more likely (OR=1.48, 95% CI [1.28 – 1.70], $p < .001$), and *Cluster 1* (anxiety) were 38% more likely (OR=1.38, 95% CI: [1.28 – 1.49], $p < .001$) to have ED visits/hospitalizations.

In terms of sociodemographic characteristics, compared to males, HHC episodes for females were 11% less likely (OR=0.89, 95% CI [0.83 – 0.94], $p < .001$) to have ED visits/hospitalizations. HHC episodes for Black and Hispanic patients were 31% (OR=1.31, 95% CI: [1.21 – 1.41], $p < .001$) and 37% (OR=1.37, 95% CI [1.27 – 1.49], $p < .001$) more likely; and HHC episodes for Asian/Pacific Islander patients were 20% (OR=0.80, 95% CI [0.70-0.90], $p < .001$) less likely to have ED visits/hospitalizations.

Regarding clinical characteristics, HHC episodes for patients with an unhealed skin ulcer were more than twice as likely (OR=2.04, 95% CI [1.92 – 2.18], $p < .001$) and HHC episodes for patients with a urinary tract infection within 14 days prior to HHC admission were 30% more likely (OR=1.30, 95% CI [1.19 – 1.42], $p < .001$) to have ED visits/hospitalizations compared to HHC episodes for patients without these clinical characteristics.

5.4 Discussion

This study highlights new evidence regarding factors, including symptom clusters, associated with ED visits/hospitalizations among older adults with UI in the HHC setting. Results revealed that HHC episodes for patients with four specific symptom clusters had higher odds of ED visits/hospitalizations, underscoring the need for multidimensional interventions tailored to specific subgroups. We also observed disparities in ED visits/hospitalizations, with increased risk for HHC episodes for male, Black, and Hispanic patients. Additionally, HHC episodes for patients with an unhealed skin ulcer and patients with a urinary tract infection within 14 days prior to HHC admission exhibited elevated risk. Developing interventions to

effectively identify and address these factors among older adults with UI offers an opportunity to mitigate continually high hospitalization rates in HHC.

Overall, we found that approximately 16% of HHC episodes resulted in ED visits/hospitalizations. This finding is similar to prior studies in the HHC setting in which this rate was approximately 15% (Song, Ojo et al., 2022; Topaz et al., 2021). In terms of symptom clusters, all four symptomatic clusters (i.e., *Cluster 1* [anxiety], *Cluster 2* [broadly symptomatic], *Cluster 3* [dizziness and anxiety], and *Cluster 4* [constipation, anxiety, and dizziness]) had higher odds of ED visits/hospitalizations. This finding is consistent with prior research suggesting that patients with greater symptom burdens have a higher risk of ED visits/hospitalizations (Patel et al., 2019; Topaz et al., 2021). For example, among 7,609 community-dwelling older adults aged 65 years and older, older adults with three symptoms were two times more likely to be hospitalized than older adults with no symptoms (Patel et al., 2019). This is expected, as clinicians may document more symptom information for patients with more severe health conditions whose clinical trajectories lead to ED visits/hospitalizations.

Further investigation is needed to identify underlying reasons for ED/hospital admissions to inform targeted interventions to reduce these persistently high rates. Specifically, given that UI would not be listed as a reason for admission, it would be valuable to identify the admitting diagnosis and retrospectively examine clinical factors leading up to the admission. These analyses may identify UI as an initial trigger or contributing factor to the detrimental cascade, providing evidence for the need to address UI at different timepoints in clinical pathways. This can foster the implementation of early interventions, targeting the root cause of the deteriorating trend before complications and negative outcomes ensue.

Cluster 2 (broadly symptomatic) had the highest odds of ED visits/hospitalizations. *Cluster 2* (broadly symptomatic) represents eight symptoms across psychologic, neurologic, cardiovascular, gastrointestinal, and genitourinary domains. Our results suggest that the dynamic interplay between symptoms may significantly contribute to adverse outcomes. Although associations between symptom burden based on the number of symptoms and hospitalizations have been shown in prior work (Patel et al., 2019; Topaz et al., 2021), little is known about these relationships based on symptom severity or interactions. How symptoms affect each other is likely a multifaceted phenomenon, driven by physiologic, psychologic, environmental, and biobehavioral factors. Further, social determinants of health and cultural characteristics may affect symptom expression and management (Norton et al., 2017). Prior research suggests that shared underlying physiologic mechanisms may account for symptom expressions, such as alterations in the autonomic nervous system (Ben-Dror et al., 2012; Choi et al., 2005), hypothalamic-pituitary-adrenal axis, and inflammatory responses (Kim et al., 2012; Nemeroff, 2004; Pecina et al., 2017; Smith et al., 2016). Emerging evidence suggests that inflammatory responses are linked to bladder dysfunction, as well as other conditions, including chronic stress disorders (Chess-Williams et al., 2021), heart failure (Liu et al., 2014), and type 2 diabetes (Guest et al., 2008). Further investigation is needed to examine potential shared underlying physiologic mechanisms to understand relationships between conditions and design treatment plans at a foundational level.

Following *Cluster 2* (broadly symptomatic), *Cluster 3* (dizziness and anxiety), had the next highest ED visit/hospitalization odds. Reasons for this may include associations between dizziness and falls among older adults with UI (Dokuzlar et al., 2020). A recent systematic review and meta-analysis of 38 studies, including 230,129 participants, found that UI was

significantly associated with falls among adults aged 65 years and older (OR=1.59, 95% CI [1.31–1.93]) (Moon et al., 2021). The link between UI and falls may be attributed to urinary urgency, nocturia, and mobility impairment (Moon et al., 2021; Teo et al., 2006). Falls among older adults can lead to significant disability, health complications, and preventable hospitalizations (Moon et al., 2021; Song et al., 2023). For these reasons, fall prevention interventions may be needed specifically for older adults with UI in the HHC setting. Although some HHC fall risk assessments contain items soliciting patients' UI status (Flemming & Ramsay, 2012), fall prevention interventions specific to patients with UI are lacking. Further, although fall prevention tools have been effective in hospital settings (Christiansen et al., 2020; Dykes et al., 2020; Dykes et al., 2010), the HHC setting poses additional risks specific to patients' home designs that need to be considered. For example, stairs, rugs, household clutter, and pets are some characteristics that may impact fall risk in the HHC setting. Additionally, fall prevention interventions may be different for HHC patients who live alone versus with others. EHR systems can prompt fall prevention interventions when clinicians record a patient's UI status on the HHC admission form, tailoring strategies based on the patient's unique needs. This may reduce the incidence of falls in the HHC setting, preventing several negative outcomes, including ED visits, hospitalizations, and mortality.

We also observed racial and ethnic disparities in ED visits/hospitalizations, with HHC episodes for Black and Hispanic patients having higher odds of ED visits/hospitalizations compared to other racial groups in our sample. These findings align with prior research demonstrating higher acute care utilization rates among racial and ethnic minoritized groups (Chase et al., 2020; Fortinsky et al., 2014; Jencks et al., 2009; Remler et al., 2011). For example, in a study of 22,368 HHC patients, Black and Hispanic patients were more likely (55%) to be

hospitalized compared to White patients (25%) (Chase et al., 2020). Patient race has been associated with several negative clinical outcomes in the literature (Anger et al., 2007; Gupta et al., 2016; Mossey, 2011; Siddiqui et al., 2016; Wilson & Sule, 2023), including delayed diagnoses (Wilson & Sule, 2023) and inadequate symptom management (Mossey, 2011). Reasons for this may include conscious or unconscious biases among clinicians (Barcelona et al., 2023; Beach et al., 2021; Himmelstein et al., 2022; Sun et al., 2022) or symptom underreporting by patients due to past experiences of discrimination (Bazargan et al., 2021). Additionally, prior work has shown that patient-level clinical factors among racially and ethnically minoritized groups (e.g., chronic conditions, symptoms, and medications) significantly influence the relationship between race or ethnicity and ED visits/hospitalizations (Fortinsky et al., 2014). These findings underscore the need for interventions addressing systemic healthcare disparities to improve the quality of care for diverse populations. Interventions may include clinician education at the early stages, designed to cultivate awareness of potential biases and facilitate recurring self-assessments of beliefs, values, and impacts on clinical care. Accounting for preexisting biases related to UI is essential, especially considering the cultural variations in UI-perception and associated stigma (Huang et al., 2007; Mendes et al., 2017; Wang et al., 2015). Future research should address these aspects comprehensively, by developing and testing interventions that work toward dismantling racial and ethnic biases in HHC.

Our findings indicate that HHC episodes for Asian/Pacific Islander patients exhibited lower rates of ED visits/hospitalizations compared to HHC episodes for other racial or ethnic groups. This contrasts with previous research in the HHC setting, which found higher odds of ED visits/hospitalizations among Asian patients (Chase et al., 2020). Notably, our study specifically focused on older adults with UI, while other studies (Chase et al., 2020) examined a

more general population. This discrepancy may be explained by reduced healthcare-seeking behavior among Asian adults with UI (Li et al., 2024; Wang et al., 2015). Reasons for this may be cultural stigma pertaining to UI, related to social rejection and shame (Wang et al., 2015). Further, symptom perception influenced by cultural norms and attitudes may also affect care-seeking. In a study of 351 Chinese women, 53.2% had UI, but only 25% sought care (Li et al., 2024). Among women who did not seek care, the most frequent reason was that they perceived UI as not severe enough to warrant treatment (Li et al., 2024). Although HHC episodes for Asian/Pacific Islander patients in our study had lower ED visit/hospitalization rates, it is essential to recognize that UI poses long-term risks that could escalate without proper intervention, potentially leading to more severe outcomes over time. Therefore, future research should explore cultural nuances to develop culturally sensitive interventions to promote early detection and treatment of UI among Asian populations. Longitudinal studies investigating the long-term consequences of untreated UI in diverse racial and ethnic groups are warranted to inform tailored interventions and mitigate potential adverse outcomes among diverse populations.

Similarly, we found that HHC episodes for older adult females were less likely to have ED visits/hospitalizations than males. This is consistent with other studies examining differences in hospitalization rates by patient sex (Cameron et al., 2010; Gruneir et al., 2013; Song et al., 2006). This finding may be explained by a higher prevalence of chronic conditions, greater functional and cognitive impairment, and more clinical instability among male patients in HHC compared to female patients (Gruneir et al., 2013). Another potential contributing factor is caregivers of male patients may experience more caregiver distress than caregivers of female patients (Grunier et al., 2013). As the structure of HHC includes intermittent nursing visits, caregiver support is integral to health maintenance (Rodrigo-Baños et al., 2021). UI has been

associated with increased caregiver burden in the literature (Akpınar et al., 2023; Tamanini et al., 2011), which can lead to caregiver distress, burnout, and negative outcomes. For example, increased caregiver burden has been associated with increased healthcare utilization, including ED visits or hospitalizations (Elango et al., 2021). Therefore, future research should examine the complexity of caregiver support among male HHC patients with UI to determine the specific mechanisms underlying the observed sex-based differences in hospitalization rates. Investigating potential interventions to alleviate caregiver distress and enhance support for caregivers of male patients with UI could be beneficial. HHC nurses should prioritize assessing and addressing caregiver needs, particularly in caring for male patients with UI, to reduce ED visits or hospitalizations and optimize outcomes.

In terms of clinical factors, an unhealed skin ulcer was a significant risk factor for ED visits/hospitalizations in our sample. This may be expected, as it is consistent with findings in prior research examining risk factors for hospitalization in the HHC setting (Song et al., 2023; Topaz et al., 2021). However, our study, which specifically focused on older adults with UI, revealed a higher estimated risk of ED visits/hospitalizations (OR=2.04, 95% CI [1.92 – 2.18]) in comparison to other studies that included a more general sample (OR=1.90, 95% CI [1.81-2.00]) (Topaz et al., 2021). Reasons for this may include a heightened likelihood of skin ulcers progressing to a more severe stage among patients with UI (Kayser et al., 2021). Prior studies have indicated that skin contact with urine has the potential to result in skin breakdown in a timeframe as brief as 15 minutes (Phipps et al., 2017). In addition to increased risk for complications, including skin infection, sepsis, and mortality, hospitalized patients with UI also experience longer stays and higher hospital-incurred costs (Kayser et al., 2021). These adverse outcomes make skin care a priority among older adults with UI. In the HHC setting, nurses are

pivotal in implementing proactive skin care measures. This includes regular assessment and monitoring of skin integrity and promptly addressing any signs of skin breakdown.

Additionally, nurses should educate patients and caregivers about skin care strategies, nutrition, and adequate hydration to promote skin integrity. Even if the primary reason for the nursing visit is not skin-related, it would likely be beneficial to implement routine skin assessments for older adults with UI. Further, older adults with UI may require more frequent HHC visits, depending on their degree of self-efficacy with care, availability of caregiver support, or risk for skin breakdown. Nurse-led continence care interventions may be useful in HHC settings, especially given that nursing is the primary discipline providing clinical care. Although prior research has shown that nurse-led continence care interventions have been effective in other clinical settings, such as primary care (Choi et al., 2015), little is known about the impact of these interventions in the HHC setting. Such interventions include initial assessments conducted by nurses with specialized education in urology or continence care, pelvic floor muscle treatments, dietary guidance, and bladder training (Choi et al., 2015). Although this may entail additional time and expenditures at the HHC level, adopting a proactive approach can reduce the likelihood of adverse health consequences for patients and ultimately decrease acute care utilization and associated costs.

We identified being diagnosed and treated for a urinary tract infection within 14 days prior to HHC admission as a significant factor associated with an increased risk of ED visits/hospitalizations. This may be surprising, as clinicians may consider a treated urinary tract infection as resolved and no longer posing any additional risks. However, among community-dwelling older adults, having a history of a urinary tract infection increases the risk for a subsequent infection (Hu et al., 2004; Jackson et al., 2004). For example, in a case-control study

of 899 women aged 55-75 years with urinary tract infections and 911 in the control group, those with a prior urinary tract infection were over four times more likely to develop another infection compared to those without a previous diagnosis (Hu et al., 2004). Additionally, although the standard urine culture is used to diagnose urinary tract infections in clinical practice, prior research has shown that the standard urine culture does not detect all bacteria that may be causing urinary tract infections (Hilt et al., 2014; Price et al., 2018).

Existing evidence indicates that expanded quantitative urine culture (EQUC) protocols can detect bacteria in urine specimens deemed negative by the standard urine culture (Brubaker & Wolfe, 2016; Hilt et al., 2014). EQUC protocols use 100 times more urine plated on different media with twice the incubation time compared to the standard urine culture (Price et al., 2018). Therefore, EQUC protocols can detect a wide range of bacteria at lower thresholds, offering opportunities to identify urinary tract infections accurately (Deen et al., 2023). Although EQUC protocols have not been used routinely in clinical practice due to insufficient data, emerging evidence suggests clinical utility regarding treatment response and symptom resolution (Deen et al., 2023). Additionally, studies using EQUC protocols suggest that the composition of the urinary microbiome may contribute to UI (Price et al., 2020; Thomas-White et al., 2017). For example, in a study of 309 women aged 22-90, more bacteria were detected in urine samples from women with urgency UI than women without this condition (Price et al., 2020). In addition to a useful mechanism for detecting urinary tract infections, EQUC protocols may effectively inform targeted UI treatments based on urinary microbiome characteristics. As further research examines the diagnostic and treatment benefits of EQUC protocols, clinical utility among older adults with UI in the HHC setting should be investigated, given the prevalence of UI and associated risk for negative outcomes among this population.

Results of this study provide preliminary evidence for developing and implementing risk prediction models for older adults with UI in the HHC setting. These models can include features identified in this study (i.e., symptoms, sociodemographic, and clinical characteristics) and other relevant risk factors for negative outcomes. In addition to ED visits/hospitalizations, outcomes of interest may include falls, infections, caregiver burden, and healthcare costs. Implementing these models in HHC EHR systems could aid in identifying at-risk patients and alerting clinicians, facilitating preventive interventions before negative outcomes occur. This is especially important for older adults with UI, as the potential for adverse outcomes might not be immediately evident. Although evidence supports the efficacy of EHR-based predictive models in improving clinical outcomes within hospital settings (Gerry et al., 2020), their effectiveness in HHC remains relatively unexplored. Further research is needed to develop risk prediction models specific to older adults with UI and test the impact on negative outcomes in the HHC setting.

5.5 Limitations

This study has some limitations. We examined symptom clusters generated from a limited set of symptoms based on expert clinician-driven Delphi survey rounds, literature review, and NLP extraction from free-text clinical notes. Although this was appropriate to investigate a set of symptoms that may be common among older adults with UI, including additional symptoms may yield different results. Additionally, the symptom clusters did not account for symptom severity or changes over time. This can be addressed in future longitudinal analyses examining symptom trajectories and future outcomes.

We selected variables based on a theoretical framework (Lenz et al., 1997) and literature focusing on comorbidities (Murtaugh et al., 2009; Scharp et al., 2023) and non-biologic factors that impact UI management (Norton et al., 2017); however, we may not have captured all risk

factors for hospitalization among older adults with UI. We examined ED visits/hospitalizations as a composite binary outcome. Although this was appropriate for this study, delineating these outcomes in future studies could generate clinical implications, risk stratification, and understanding of patients' healthcare needs at a more granular level. We analyzed data from 2015-2017, which may not represent the current state of documentation. However, this allowed us to mitigate the risk of confounding factors related to the COVID-19 pandemic and provide a basis for future studies utilizing more recent data. Finally, this study focused on older adults receiving HHC services from one HHC agency in New York. Therefore, findings may not be generalizable to other clinical settings, geographic locations, or younger individuals.

5.6 Conclusion

In this study, we identified factors associated with ED visits/hospitalizations among older adults with UI in the HHC setting. Our findings demonstrate a variety of sociodemographic and clinical risk factors, highlighting symptom clusters associated with increased risk. Different symptom combinations revealed distinct impacts on the odds of ED visits/hospitalizations, supporting the need for multidimensional interventions tailored to patients' unique needs. Overall, this study underscores the complexity of factors contributing to ED visits/hospitalizations among older adults with UI in the HHC setting and emphasizes the need for tailored assessments and interventions addressing symptom clusters, healthcare disparities, and clinical risk factors. Future research should focus on developing interventions with culturally sensitive approaches to improve outcomes for this vulnerable population.

Table 5.1*Sociodemographic and Clinical Characteristics for Home Healthcare Episodes for Older Adults**with Urinary Incontinence (n=39,179)*

Characteristic	n (%)
Age (mean, SD)	84 (9)
Sex	
Female	29,041 (74%)
Male	10,138 (26%)
Race	
White	24,044 (61%)
Black	6,870 (18%)
Asian/Pacific Islander	2,739 (7%)
Multi-racial	104 (0.3%)
Native American	71 (0.2%)
Ethnicity	
Hispanic	5,351 (14%)
Living Arrangements	
Patient lives with others	23,969 (61%)
Patient lives alone	15,210 (39%)
Comorbidities	
Diabetes	12,345 (32%)
Cardiovascular disease	6,671 (17%)
Depression	3,340 (8.5%)
Stroke	4,376 (11%)
Kidney disease	1,101 (2.8%)
Risk for hospitalization	
Taking five or more medications	31,912 (81%)
History of falls (two or more)	10,506 (27%)
Decline in mental/ behavioral status	8,379 (21%)
Unhealed skin ulcer	7,240 (18%)
UTI in the past 14 days	3,523 (9%)
ED visit/hospitalization	6,162 (16%)

Note. SD, standard deviation; UTI, urinary tract infection; ED, emergency department

Table 5.2*Sociodemographic and Clinical Characteristics by Symptom Cluster for Home Healthcare Episodes for Older Adults with Urinary**Incontinence (n=39,179)*

Characteristic	Cluster 1: Anxiety (n=5,423)	Cluster 2: Broadly symptomatic (n=2,268)	Cluster 3: Dizziness and anxiety (n=2,044)	Cluster 4: Constipation, anxiety, and dizziness (n=1,448)	Cluster 5: No symptoms (n=27,996)
Age (mean, SD)	83 (9)	84 (9)	84 (8)	84 (9)	84 (9)
Sex (n, %)					
Female	4,279 (79%)	1,637 (72%)	1,531 (75%)	1,119 (77%)	20,474 (73%)
Male	1,144 (21%)	631 (28%)	513 (25%)	329 (23%)	7,522 (27%)
Race (n, %)					
White	3,794 (70%)	1,408 (62%)	1,186 (58%)	954 (66%)	16,702 (60%)
Black	697 (13%)	405 (18%)	302 (15%)	193 (13%)	5,272 (19%)
Asian/Pacific Islander	249 (5%)	132 (6%)	192 (9%)	97 (7%)	2,069 (7%)
Multi-racial	15 (0.3%)	3 (0.1%)	7 (0.3%)	5 (0.3%)	74 (0.3%)
Native American	8 (0.1%)	4 (0.1%)	4 (0.2%)	4 (0.3%)	51 (0.2%)
Ethnicity (n, %)					
Hispanic	660 (12%)	316 (14%)	353 (17%)	195 (13%)	3,827 (14%)
Living Arrangements (n, %)					
Patient lives with others	3,184 (59%)	1,331 (59%)	1,111 (54%)	901 (62%)	17,444 (62%)
Patient lives alone	2,239 (41%)	937 (41%)	933 (46%)	547 (38%)	10,552 (38%)

Comorbidities (n, %)					
Diabetes	1,586 (29%)	724 (32%)	684 (33%)	388 (27%)	8,962 (31%)
Cardiovascular disease	861 (16%)	569 (25%)	423 (21%)	203 (14%)	4,615 (17%)
Depression	684 (13%)	194 (9%)	195 (10%)	179 (12%)	2,088 (8%)
Stroke	585 (11%)	272 (12%)	234 (11%)	147 (10%)	3,138 (11%)
Kidney disease	128 (2%)	60 (3%)	66 (3%)	26 (2%)	821 (3%)
Risk for hospitalization (n, %)					
Taking five or more medications	4,410 (81%)	1,880 (83%)	1,727 (84%)	1,234 (85%)	22,660 (81%)
History of falls (two or more)	1,687 (31%)	729 (32%)	670 (33%)	407 (28%)	7,018 (25%)
Decline in mental/behavioral status	1,407 (26%)	485 (21%)	366 (18%)	295 (20%)	5,816 (21%)
Unhealed skin ulcer	977 (18%)	310 (14%)	204 (10%)	224 (15%)	5,525 (20%)
UTI in the past 14 days	510 (9%)	285 (13%)	176 (9%)	133 (9%)	2,419 (9%)
ED visit/hospitalization (n, %)	971 (18%)	553 (24%)	395 (19%)	266 (18%)	3,977 (14%)

Note. SD, standard deviation; UTI, urinary tract infection; ED, emergency department

Table 5.3

Results of Backward Stepwise Logistic Regression to Select a Subset of Variables Significantly Associated with Risk of Emergency Department Visits or Hospitalizations Among Home Healthcare Episodes for Older Adults with Urinary Incontinence (n=39,179)

Variable	OR	95% CI	p-value
Symptom cluster			
1: Anxiety	1.38	1.28 – 1.49	< .001
2: Broadly symptomatic	2.00	1.80 – 2.22	< .001
3: Dizziness and anxiety	1.55	1.38 – 1.75	< .001
4: Constipation, anxiety, and dizziness	1.48	1.28 – 1.70	< .001
Sex (female)	0.89	0.83 – 0.94	< .001
Race			
Asian/Pacific Islander	0.80	0.70 – 0.90	< .001
Black	1.31	1.21 – 1.41	< .001
Ethnicity			
Hispanic	1.38	1.27 – 1.49	< .001
Comorbidities			
Cardiovascular disease	1.33	1.24 – 1.43	< .001
Diabetes	1.32	1.24 – 1.40	< .001
Kidney disease	1.88	1.62 – 2.16	< .001
Risk for hospitalization			
Taking five or more medications	1.26	1.16 – 1.36	< .001
Decline in mental or behavioral status	1.12	1.05 – 1.20	< .001
UTI within the past 14 days	1.30	1.19 – 1.42	< .001
Unhealed skin ulcer	2.04	1.92 – 2.18	< .001

Note. Variables with p-values <.05 were retained in the final model.

UTI, urinary tract infection

Full output of the backward stepwise logistic regression is presented in **Appendix J**.

Chapter 6: Conclusion

This chapter summarizes the results of the studies included in this dissertation and discusses the contributions to science, strengths and limitations, and implications for clinical practice, policy, and future research.

The overall purpose of this dissertation was to leverage natural language processing (NLP) in the home healthcare (HHC) setting to understand symptom clusters and risk for acute care utilization among older adults with urinary incontinence (UI). Studies included in this dissertation used electronic health record (EHR) data collected between January 1, 2015, and December 31, 2017, from a large HHC agency in New York. EHR data provided information on sociodemographic, clinical characteristics, and emergency department (ED) visits/hospitalizations from a structured data form (i.e., Outcome and Assessment Information Set (OASIS)) and symptom information from unstructured free-text clinical notes. Guided by the Theory of Unpleasant Symptoms (Lenz et al., 1997), the studies in this dissertation aimed to: 1) identify comorbidities of older adults with UI, 2) develop and test an NLP algorithm to extract symptoms from free-text clinical notes and examine differences by race or ethnicity, 3) identify symptom clusters for older adults with UI and investigate differences in sociodemographic and clinical correlates, and 4) examine factors associated with ED visits/hospitalizations among older adults with UI, including the impact of symptom clusters.

6.1 Discussion of Results

Chapter 2: This scoping review was conducted to identify comorbidities of community-dwelling older adults with UI to broadly characterize this population and provide a basis for future symptom-based research (Scharp et al., 2023). We identified 10 studies that found significant associations between comorbidities and UI across neurologic, cardiovascular, psychological, respiratory, endocrine, genitourinary, and musculoskeletal systems. Most studies examined comorbidities as antecedents to UI; however, existing evidence suggests that relationships may be bidirectional (Brady et al., 2022; Huang et al., 2017). Results suggest that

comorbidities and UI are interrelated, supporting a need for holistic care rather than individualized disease-specific approaches.

Chapter 3: UI is often under-identified and undertreated in the HHC setting (Albertson, 2018; McCann et al., 2022), leaving patients at risk for potentially serious complications. Most older adult HHC patients with UI have multiple chronic conditions (Murtaugh et al., 2009), requiring comprehensive symptom evaluations. We sought to use NLP to uncover symptom information in free-text clinical notes and analyze differences by race or ethnicity to inform holistic, equitable care.

Based on a literature review (Murtaugh et al., 2009; Scharp et al., 2023) and expert clinician-driven Delphi survey rounds, the following symptoms of older adults with UI were identified: anxiety, dizziness, constipation, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, and vision impairment/blurred vision. The NLP algorithm achieved excellent performance (average precision=0.92) in extracting these symptoms from free-text clinical notes. Overall, 29% (11,183/39,179) of HHC episodes had relevant symptom information. Anxiety (n=6,964, 17.8%), dizziness (n=2,627, 6.7%), and constipation (n=1,628, 4.2%) were the most frequently documented symptoms. Urinary hesitancy/retention (n=164, 0.42%), urinary frequency/urgency (n=185, 0.47%), and vision impairment/blurred vision (n=358, 0.91%) were the least frequently documented symptoms. Compared to White patients, HHC episodes for Asian/Pacific Islander patients were 26% less likely (OR=0.74, 95% CI [0.67 – 0.80], $p < .001$), Black patients were 31% less likely (OR=0.69, 95% CI [0.64 – 0.73], $p < .001$), and Hispanic patients were 9% less likely (OR=0.91, 95% CI [0.85 – 0.97], $p < .01$) to have any symptoms documented.

Chapter 4: Knowledge of symptom clusters for older adults with UI in HHC can enhance clinicians' understanding of the presentation of UI and related symptoms. Symptom clusters can help build clinical phenotypes (i.e., groups of characteristics deviating from normal physiology or behavior (Robinson, 2012)) to guide assessment and treatment strategies tailored to each subgroup. We sought to identify symptom clusters by performing agglomerative hierarchical clustering on NLP-extracted symptom variables (i.e., anxiety, dizziness, constipation, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, and vision impairment/blurred vision) and analyze differences by sociodemographic and clinical correlates. We identified five distinct symptom clusters: *Cluster 1* (anxiety), *Cluster 2* (broadly symptomatic), *Cluster 3* (dizziness and anxiety), *Cluster 4* (constipation, anxiety, and dizziness) and *Cluster 5* (no symptoms). *Cluster 1* (anxiety) had a significantly higher proportion of HHC episodes for females (79%) and patients with depression (13%) and a lower proportion of HHC episodes for patients from racially or ethnically minoritized groups (i.e., Asian/Pacific Islander, Black, Hispanic, multi-racial, and Native American) (30%) compared to *Cluster 5* (no symptoms) (73%, 7%, 40%, respectively). *Cluster 2* (broadly symptomatic) had a significantly higher proportion of HHC episodes for patients with cardiovascular disease (25%) compared to *Cluster 5* (no symptoms) (16%). *Cluster 3* (dizziness and anxiety) had a significantly higher proportion of HHC episodes for patients who lived alone (46%) and had a history of falls (33%) compared to *Cluster 5* (no symptoms) (38% and 25%, respectively). *Cluster 4* (constipation, anxiety, and dizziness) had a significantly higher proportion of HHC episodes for patients taking five or more medications (85%) compared to *Cluster 5* (no symptoms) (81%) (all $p < .001$).

Chapter 5: Persistently elevated hospitalization rates in the HHC setting require attention to less explored potential risk factors. Understanding what may contribute to ED

visits/hospitalizations among older adults with UI in the HHC setting remains limited, particularly the impact of symptom clusters. We aimed to identify factors associated with ED visits/hospitalizations among older adults with UI in HHC to inform comprehensive interventions aiming to prevent potentially avoidable hospitalizations. After adjusting for sociodemographic and clinical factors, we identified four symptom clusters with increased ED visits/hospitalizations odds. Specifically, *Cluster 1* (anxiety) (OR=1.38, 95% CI: [1.28 – 1.49], $p < .001$), *Cluster 2* (broadly symptomatic) (OR=2.00, 95% CI [1.80 – 2.22], $p < .001$), *Cluster 3* (dizziness and anxiety) (OR=1.55, 95% CI [1.39 – 1.75], $p < .001$), and *Cluster 4* (constipation, anxiety, and dizziness) (OR =1.48, 95% CI [1.28 – 1.70], $p < .001$) were significantly more likely to have ED visits/hospitalizations. We observed disparities in ED visits/hospitalizations, with HHC episodes for Black (OR=1.31, 95% CI: [1.21 – 1.41], $p < .001$) and Hispanic (OR=1.37, 95% CI [1.27 – 1.49], $p < .001$) patients significantly more likely; and HHC episodes for Asian/Pacific Islander patients significantly less likely (OR=0.80, 95% CI [0.70-0.90], $p < .001$) to have ED visits/hospitalizations. Additionally, compared to males, HHC episodes for females were 11% less likely (OR=0.89, 95% CI [0.83 – 0.94], $p < .001$) to have ED visits/hospitalizations. Regarding clinical factors, HHC episodes for patients with an unhealed skin ulcer (OR=2.04, 95% CI [1.92 – 2.18], $p < .001$) and patients with a urinary tract infection within 14 days prior to HHC admission (OR=1.30, 95% CI [1.19 – 1.42], $p < .001$) were significantly more likely to have ED visits/hospitalizations compared to HHC episodes for patients without these clinical characteristics.

6.2 Contributions to Science

UI can contribute to declining clinical pathways, resulting in ED visits, hospitalizations, and mortality (John et al., 2016). Although UI has been associated with several complications in

the literature that can lead to these outcomes (Kayser et al., 2019; Moon et al., 2021; Moore et al., 2008), UI remains underdressed in the HHC setting (Albertson et al., 2018). The undertreatment of UI is amplified by disparities in care, which may be fueled by racial and ethnic biases in healthcare (Bazargan et al., 2021). Most older adults with UI have multiple comorbidities (Murtaugh et al., 2009), making their clinical presentations increasingly complex. However, little is known about the range and frequency of symptoms among older adults with UI in HHC and whether certain co-occurring symptoms are associated with negative outcomes. This knowledge gap impedes comprehensive assessment and treatment strategies. This dissertation generated new evidence on clinical phenotypes of older adults with UI in HHC and associations between risk factors and ED visits/hospitalizations among this population.

Investigating clinical phenotypes of older adults with UI in HHC is timely and warranted, given persistently elevated hospitalization rates in the HHC setting (Medicare Payment Advisory Commission, 2023; Siclovan et al., 2021). Employing NLP allowed us to leverage an untapped source of symptom information (i.e., free-text clinical notes) to build clinical phenotypes underscored by data-driven characterization. First, we broadly characterized older adults with UI by identifying relevant comorbidities, offering valuable insight into the interrelation of disease processes and highlighting potential symptoms that may co-occur. We used this evidence to identify symptoms among older adults with UI, incorporating the perspectives of expert clinicians through Delphi survey rounds. Results of this process demonstrate that older adults with UI may have symptoms across several physiological systems, emphasizing the need for holistic care approaches. Based on this evidence, we developed a well-performing NLP algorithm, a novel application in this context. Our findings illuminate what symptoms clinicians

may assess and document, offering opportunities for improved comprehensive assessment strategies.

Examining symptoms by race or ethnicity is needed given higher rates of acute care utilization and other negative clinical outcomes among racially and ethnically minoritized groups (Chase et al., 2020; Fortinsky et al., 2014; Jencks et al., 2009; Remler et al., 2011). However, little is known about disparities in care among older adults with UI in the HHC setting. Our findings illuminate how race or ethnicity may impact this population's symptom assessment and acute care utilization. For example, we found that HHC episodes for Asian/Pacific Islander, Black, and Hispanic patients were less likely to have any symptoms documented compared to White patients, and HHC episodes for Black and Hispanic patients were more likely to have ED visits/hospitalizations. Our findings highlight the need to examine potential biases at the clinician-level to inform enhanced clinician education in the care of diverse older adults with UI in the HHC setting.

The five distinct symptom clusters we identified offer a preliminary roadmap for navigating symptom assessment among complex older adults with UI in HHC. Bidirectional relationships may exist between symptoms and UI, suggesting the need to prioritize UI assessment and care among patients experiencing certain symptoms. Patients with similar symptoms shared some sociodemographic and clinical characteristics, deepening the understanding of clinical phenotypes. These findings highlight the potential for interventions that address patients' physiologic, psychosocial, and environmental needs to improve health outcomes for older adults with UI.

Further, patients with multidimensional symptoms, especially anxiety, dizziness, and constipation, may be at increased risk for ED visits/hospitalizations. Patients with skin ulcers and

recent urinary tract infections may also be at high risk. Patients with these conditions or symptoms may require closer monitoring through enhanced nursing support and advanced technologies. Given that nursing constitutes the primary discipline providing clinical care in the HHC setting, nurses have a pivotal role in symptom assessment and treatment. Our findings contribute to understanding specific facets of clinical presentations of older adults with UI that demand heightened vigilance and proactive interventions. HHC nurses are well-positioned to address the comprehensive needs of older adults with UI, given their propensity to provide holistic care driven by the goal of achieving better outcomes for diverse populations.

6.3 Strengths and Limitations

This dissertation has several strengths. Studies included in this dissertation employed rigorous methodology to ensure the robustness of our findings and reduce the potential for bias. We performed several quality checks to support the strength of our findings, including a quality appraisal of the studies included in the scoping review, a performance evaluation of the NLP algorithm, and tests for multicollinearity. The Theory of Unpleasant Symptoms (Lenz et al., 1997) informed this work, fostering a comprehensive examination of a broad range of factors contributing to a thorough understanding of symptom experiences among older adults with UI in HHC. The quantitative analyses used data from a sizeable sample from the largest HHC agency in New York, which may provide generalizable findings to older adults with UI in other HHC settings. We developed a well-performing NLP algorithm informed by expert clinician-driven Delphi survey rounds, highlighting the efficiency of applying NLP to free-text HHC clinical notes underscored by clinical insight in this context. Nearly 40% of the samples analyzed in the quantitative studies represented racially or ethnically minoritized groups, promoting opportunities to conduct analyses among diverse samples. Our findings provide preliminary

evidence of clinical phenotypes and risk for ED visits/hospitalizations among older adults with UI, addressing an understudied phenomenon in the HHC setting.

There are also some limitations. The quantitative studies were secondary analyses limited to available data. We examined data from 2015-2017, which may not accurately reflect the current state of documentation. However, this timeframe enabled us to reduce the potential impact of confounding factors associated with the COVID-19 pandemic and establish a foundation for future studies leveraging more recent data. We investigated symptoms derived from expert clinician-driven Delphi survey rounds and a literature review, informed by the Theory of Unpleasant Symptoms (Lenz et al., 1997), facilitating the consideration of physiologic, psychological, and situational factors affecting the symptom experience. Although this was appropriate for these studies examining clinical documentation, including other symptoms may generate different results. Additionally, some relevant symptom information may have been missed, as we analyzed free-text clinical notes documented by clinicians, and patients may report symptoms that are not documented. We used binary symptom data (i.e., present or absent) and did not account for symptom severity, number of times a symptom was documented, or changes over time. UI status was assessed at the time of HHC admission; therefore, we did not include patients who developed UI during their time in HHC. Further, available data did not include information about UI subtype (e.g., stress, urgency, or mixed UI). Patients with incident UI or different UI subtypes may have different underlying biological mechanisms influencing UI and experience changes in functional status and risk for complications, which may impact outcomes. These studies provide a basis for longitudinal analyses examining symptom trajectories specific to UI subtype, the development and progression of UI over time, and associations with underlying comorbid conditions and future outcomes. Finally, these studies included older adults

from one HHC agency in New York; therefore, results may not be generalizable to other clinical settings or younger patients. However, these studies provide foundational information on a diverse sample of older adults in HHC and lay the groundwork for other, more geographically diverse studies.

6.4 Implications for Clinical Practice

Findings from this dissertation have implications for clinical practice in HHC settings caring for older adults with UI. We identified comorbidities and symptoms among older adults with UI across several physiological systems, highlighting the need for holistic clinical care. Clinical practice is founded on disease-specific care guidelines, typically focusing on each condition as a separate entity (Salisbury et al., 2018; Valentijn et al., 2013). Older adults often have multiple specialists addressing individual health conditions, which can result in disjointed care, excessive healthcare costs, and treatments that may inadvertently worsen other conditions. Additionally, clinicians may focus on a single condition they perceive as the most significant, potentially neglecting the broader spectrum of patients' health needs. Understanding relationships between UI and comorbidities can help clinicians systematically assess multiple co-occurring symptoms.

The most frequently documented symptoms for older adults with UI were anxiety, dizziness, and constipation. Patients with these symptoms may require screening for UI, even if the reason for the visit is not urinary-focused. Among the least commonly documented symptoms were urinary hesitancy/retention and urinary frequency/urgency. Urinary symptoms have been associated with patient underreporting in the literature (Filipetto et al., 2014; Jung et al., 2015; Li et al., 2024; Mendes et al., 2017; Silay et al., 2016), though existing evidence suggests patients may be receptive to clinician-initiated screening (Hagglund & Wadensten,

2007). Clinicians must elicit symptoms from patients, ensuring the comprehensive collection of relevant data and preventing the oversight of pertinent information. The Theory of Unpleasant Symptoms (Lenz et al., 1997) promotes a comprehensive approach to assessing and treating symptom experiences tailored to patients' unique needs. Nurses, with their holistic care approach and commitment to addressing patients' needs comprehensively, are ideally positioned to lead initiatives to change how older adults with UI are assessed and treated. Our findings provide a basis for this much-needed change to reduce ED visits/hospitalizations and negative health outcomes among older adults with UI in HHC.

Our findings suggest that clinically relevant factors associated with ED visits/hospitalizations among older adults with UI in HHC may include skin breakdown, prior urinary tract infections, and dizziness-related falls. Although addressing these factors aligns with fundamental nursing care principles, there is a need for improvements in patient care in the HHC setting. For example, routine skin assessment for older adults with UI, pelvic floor muscle treatments, dietary guidance, and increased involvement of patients and caregivers in treatment plans can improve UI treatment and prevent UI-related complications. Expanded quantitative urine culture protocols may be useful to evaluate the urinary microbiome to detect urinary tract infections more effectively and inform UI treatment for older adults. Fall prevention interventions that account for UI and unique aspects of patients' homes can prevent fall-related ED visits/hospitalizations. UI-specific fall interventions may involve an interdisciplinary team including physical and occupational therapists, urologists, and nurses who collaborate to address UI and fall risk factors comprehensively. Leveraging collaborative nursing care in the HHC setting is essential to promote holistic care and achieve better health outcomes for older adults with UI.

Given the under-identification and undertreatment of UI in the HHC setting (Albertson et al., 2018), there is a critical need for clinical decision support systems integrated with the EHR to identify at-risk patients. These systems can leverage NLP algorithms to extract real-time symptom information from free-text clinical notes, alerting clinicians to UI, associated symptoms, and other risk factors for ED visits/hospitalizations. This may assist clinicians in prioritizing aspects requiring immediate interventions while concurrently strategizing for the subsequent treatment of other clinically relevant factors, ensuring that nothing is overlooked. Additionally, EHR-based clinical decision support systems can help prevent potentially serious or serious complications resulting in ED visits, hospitalizations, or mortality by identifying patients who may require closer monitoring or interventions.

6.5 Implications for Policy

This dissertation has implications for policy in the HHC setting related to caring for older adults with UI. Low symptom documentation frequencies in free-text clinical notes that we found indicate potential gaps in clinician assessment or prioritization of symptom documentation and treatment. It is essential to evaluate how HHC clinicians are educated to assess and document symptoms at each visit to inform policy changes at the initial stages of clinical education. Additionally, thorough continuing education requirements for re-licensure and certification are needed. Presently, HHC visits may have narrow scopes, limiting clinicians' ability to detect other pertinent clinical factors. For example, if the reason for the HHC visit is a wound dressing change, perhaps clinicians do not ask about symptoms affecting other physiological systems. However, given that our findings suggest that clusters of co-occurring symptoms increase the risk of ED visits/hospitalizations among older adults with UI, routinely assessing other symptoms may be of clinical utility. Although nursing education is underscored

by a holistic approach to care, barriers, including time constraints, clinician workload, and limited resources, may hinder clinicians' ability to assess all relevant factors during HHC visits. Knowledge generated from this dissertation suggests factors that may be important to focus on, providing a foundation for enhanced clinician education and refined models of care to elevate standards of care for older adults with UI.

The infrastructure and resource allocation within HHC may require attention to improve care and outcomes for older adults with UI. For example, older adults with UI may need more frequent nursing visits, depending on the degree of patient self-efficacy and the availability of caregiver support. Most older adults in our study samples had Medicare insurance, which imposes restrictions on the frequency and duration of nursing visits. Further, changes in nursing care models in the HHC setting should be considered, including involving a specialist continence nurse in caring for older adults with UI. Given that evidence suggests that these care models improve UI identification, enhance treatment, and reduce healthcare costs in other clinical settings (Holtzer-Goor et al., 2015; Williams et al., 2005), integrating a specialist continence nurse into HHC may be beneficial. Although more frequent and comprehensive visits could entail increased expenditures at the HHC level, these changes may reduce overall healthcare costs by preventing UI-related complications, ED visits, and hospitalizations.

In addition to nursing care, pelvic floor physical therapy is essential to treatment plans for patients with UI. Although evidence supports pelvic floor physical therapy as an effective treatment modality for UI (Alouini et al., 2022), it may be underutilized in the HHC setting. Physical therapy in HHC often focuses on strength, balance, and functional improvement (LeDoux et al., 2020). Effective pelvic floor physical therapy for UI often involves manual techniques to release muscle tension, manipulation of the pelvic floor and surrounding muscles,

exercises focused on awareness and relaxation, and bladder training (van Reijn-Baggen et al., 2022). The Theory of Unpleasant Symptoms (Lenz et al., 1997) can be used to inform physical therapy interventions that account for the mind-body connection and additional factors, including functional status and caregiver availability. Insurance coverage for pelvic floor physical therapy varies widely, and cost has been identified as among the leading barriers to care (Washington et al., 2011; Zoorob et al., 2017). The way physical therapy services are billed and reimbursed in the HHC setting should be investigated to determine potential amendments at the policy-level that may improve healthcare access and delivery.

Policy implications for EHR redesign in HHC should prioritize incentivizing the adoption of digital technologies to improve healthcare delivery, reduce costs, and enhance patient care. Although digital health solutions may promote improvements in care, there are several barriers to effective integration into healthcare systems, especially in settings with low digital maturity (Jacob et al., 2020). Digital maturity is comprised of social, organizational, and technological factors that facilitate the implementation of technologies into clinical practice (Jacob et al., 2020). Existing evidence suggests barriers to the adoption of digital technologies in HHC may include time or cost inefficiencies, lack of or varying levels of experience or technical skills among clinicians, and challenges regarding usability or workflow (Radhakrishnan et al., 2016; Taylor et al., 2016). Policymakers can foster the integration of digital technologies in HHC by offering funding, clinician education, and clear regulations and guidelines for safe and responsible use (Zhang et al., 2010).

Currently, structured data forms in HHC EHRs (e.g., OASIS) may exacerbate documentation burden (Moy et al., 2023) and restrict comprehensive assessments by clinicians. Despite clinicians predominantly documenting clinical characteristics and risk factors in free-text

clinical notes (Hobensack et al., 2022; Sockolow et al., 2014; Song, Hobensack et al., 2022), inefficiencies in referencing these notes may lead to overlooked details. Utilizing NLP algorithms to extract symptoms from free-text notes lays a foundation for real-time implementation. By integrating NLP algorithms with EHRs, clinicians can efficiently access extracted information such as symptoms, diagnoses, and treatments. Policy initiatives at local, state, and federal levels could encourage the implementation of NLP-driven solutions as part of broader efforts to enhance patient-centered care and support care coordination across healthcare settings. This could involve advocating for funding mechanisms to support the adoption of NLP technologies in HHC settings and promoting interoperability standards to ensure seamless data exchange between different care providers. Additionally, policy frameworks can focus on establishing guidelines for the responsible use of NLP technologies, ensuring data privacy and fostering collaboration between clinical stakeholders to promote the adoption of EHR redesign. Further, integrating clinical decision support systems leveraging NLP-processed patient-generated data can improve clinician decision-making. This may enhance nursing workforce capacity by augmenting clinical decision-making capabilities. These advancements have the potential to streamline workflows and enhance information retrieval, facilitating more effective identification and treatment strategies for older adults with UI.

6.6 Implications for Future Research

This dissertation highlights areas where future research is needed to improve assessment and outcomes for older adults with UI in HHC. Specifically, more work is needed to further characterize older adults with UI, understand dynamic relationships between health conditions, and investigate disparities in care. This can facilitate developing and testing interventions to improve identification, treatment, and outcomes for older adults with UI in the HHC setting.

Our NLP algorithm identified that most symptoms were infrequently documented in free-text clinical notes. Further research is needed to examine more recent datasets to determine current documentation trends in comparison to our results. Additionally, underlying reasons for infrequent symptom documentation need to be explored. These reasons are likely multifaceted, due to underreporting of symptoms by patients or limited assessment and documentation by clinicians. A comparison of symptom reporting among older adult HHC patients with UI and symptom documentation by HHC clinicians is warranted to understand potential barriers to care. This is especially important for patients with UI, as symptoms may not be disclosed unless clinicians explicitly inquire about them. Engaging patients and clinicians in the research process can enable a thorough understanding of patient-clinician interactions in HHC and facilitate the practical integration of improved symptom assessment techniques into clinical practice.

Findings from this dissertation indicate that older adults with UI can have symptoms across several physiological systems. Although we investigated a comprehensive set of symptoms, further symptom-based research is warranted to better understand the depth and breadth of symptoms that older adults with UI may experience in the HHC setting. This can be achieved using qualitative methods with relevant stakeholders, including patients, caregivers, and clinicians. Results can be triangulated to enhance the rigor of developing a core set of symptoms and promote the reliability of future symptom-based analyses. Identifying symptoms can improve the characterization of older adults with UI and ensure future research consistently includes important symptoms to relevant stakeholder groups. This set of symptoms can inform the development of NLP algorithms that can be applied to other data sources, including audio-recorded patient-clinician conversations and electronic patient-authored text. This can guide

data-driven characterization underscored by patient insight through participation in research, enhancing the understanding of symptom experiences of older adults with UI.

This dissertation lays the groundwork for future longitudinal analyses to examine symptom trajectories among older adults with UI and associations with underlying comorbid conditions and subsequent outcomes. Bidirectional and mediated relationships may exist between symptoms and comorbidities (Brady et al., 2022; Huang et al., 2017); however, these relationships remain poorly understood. Employing longitudinal analyses involving a core set of symptoms relevant to patients, caregivers, and clinicians can provide valuable insight into the progression of UI and related symptoms over time. Further, longitudinal studies can elucidate underlying shared mechanisms between symptoms and comorbid conditions, facilitating the development of targeted assessment and treatment strategies in the HHC setting. Existing longitudinal datasets that may be relevant to examine include the National Health and Aging Trends Study (NHATS) (National Health and Aging Trends Study, 2024) and the Health and Retirement Study (HRS) (The Regents of the University of Michigan, 2023), containing data on urinary symptoms and health-related variables among older adults. Longitudinal studies can help identify factors that can lead to adverse outcomes, promoting multidimensional interventions addressing complex patient needs. This can enable the evaluation of the effectiveness of interventions over time to optimize care and outcomes for older adults with UI in HHC.

Disparities in UI care based on race or ethnicity have been documented in other studies (Anger et al., 2007; Gupta et al., 2016; Siddiqui et al., 2016; Willis-Gray et al., 2015), and patient race has been associated with several negative health outcomes in the literature (Anger et al., 2007; Gupta et al., 2016; Mossey, 2011; Siddiqui et al., 2016; Wilson & Sule, 2023). Findings from this dissertation suggest that Black and Hispanic older adults are less likely to

have any symptoms documented in free-text clinical notes and more likely to have ED visits/hospitalizations compared to White older adults. Although existing evidence suggests that conscious or unconscious clinician biases based on race or ethnicity may affect the perception and documentation of patient characteristics in other clinical settings (Barcelona et al., 2023; Beach et al., 2021; Himmelstein et al., 2022; Sun et al., 2022), few studies have examined clinician biases in HHC (Topaz et al., 2023). Additionally, older adults with UI may encounter nuanced biases given the potential stigma and cultural differences in perception of UI. Given our findings, future research must examine these biases specific to older adults with UI in the HHC setting to identify intervention opportunities and determine what interventions may improve equitable care.

The findings of this dissertation highlight sociodemographic and clinical risk factors for ED visits/hospitalizations among older adults with UI in the HHC setting. This provides preliminary evidence for future research to develop and test risk prediction models for this population. Based on a literature review, theoretical framework, and Delphi survey, we identified variables reflecting potential risk factors for ED visits/hospitalizations. Future research should incorporate insights from HHC clinicians and patients and examine admitting diagnoses for older adults with UI to identify additional risk factors that may significantly contribute to the risk of ED visits/ hospitalizations. This can enhance the predictive ability of these models and inform targeted interventions to mitigate adverse outcomes for this vulnerable population.

6.7 Conclusion

Improving the assessment and treatment of older adults with UI is an urgent priority given persistently elevated hospitalization rates in the HHC setting. Older adults with UI may have multidimensional symptom clusters requiring comprehensive assessments and treatment

strategies. This is especially important among diverse groups of older adults receiving HHC, in which disparities in care may perpetuate negative outcomes. Nurses can identify nuanced symptoms and risk factors by employing a holistic approach to care and enact timely interventions to prevent UI-related complications. Future research should continue to examine symptoms and relationships between health conditions among older adults with UI to improve holistic assessment, equitable treatment, and prevent negative outcomes.

References

- Aikawa, K., Yamaguchi, O., Oguro, T., Ishibashi, K., Yanagida, T., Nomiya, M., Haga, N., Yoshiyasu, T., & Kobayashi, T. (2012). New classification for men with lower urinary tract symptoms: Cluster analysis using the International Prostate Symptom Score. *BJU International*, *110*(3), 408-412. <https://doi.org/10.1111/j.1464-410X.2011.10771.x>
- Akbar, A., Liu, K., Michos, E. D., Brubaker, L., Markossian, T., Bancks, M. P., & Kramer, H. (2021). Racial differences in urinary incontinence prevalence, overactive bladder and associated bother among men: The multi-ethnic study of atherosclerosis. *Journal of Urology*, *205*(2), 524-531. <https://doi.org/10.1097/JU.0000000000001353>
- Akpinar, N. B., Unal, N., & Akpinar, C. (2023). Urinary incontinence in older adults: Impact on caregiver burden. *Journal of Gerontological Nursing*, *49*(4), 39-46. <http://doi.org/10.3928/00989134-20230310-01>
- Albertson, M. (2018). Decreasing urinary incontinence in home healthcare. *Home Healthcare Now*, *36*(4), 232-237. <https://doi.org/10.1097/NHH.0000000000000670>
- Alouini, S., Memic, S., & Couillandre, A. (2022). Pelvic floor muscle training for urinary incontinence with or without biofeedback or electrostimulation in women: A systematic review. *International Journal of Environmental Research and Public Health*, *19*(5), 2789. <https://doi.org/10.3390/ijerph19052789>.
- Andrade, A. M., Silva, K. L., Seixas, C. T., & Braga, P. P. (2017). Nursing practice in home care: An integrative literature review. *Brazilian Nursing Journal*, *70*(1), 210-219. <https://doi.org/10.1590/0034-7167-2016-0214>

- Anger, J. T., Rodriguez, L. V., Wang, Q., Chen, E., Pashos, C. L., & Litwin, M. S. (2007). Racial disparities in the surgical management of stress incontinence among female Medicare beneficiaries. *Journal of Urology*, *177*(5), 1846-1850.
<https://doi.org/10.1016/j.juro.2007.01.035>
- Avery, K., Donovan, J., Peters, T. J., Shaw, C., Gotoh, M., & Abrams, P. (2004). ICIQ: A brief and robust measure for evaluating the symptoms and impact of urinary incontinence. *Neurourology and Urodynamics*, *23*(4), 322-330. <https://doi.org/10.1002/nau.20041>
- Baffy, N., Foxx-Orenstein, A. E., Harris, L. A., & Sterler, S. (2017). Intractable constipation in the elderly. *Current Treatment Options in Gastroenterology*, *15*(3), 363–381.
<https://doi.org/10.1007/s11938-017-0142-2>
- Barcelona, V., Scharp, D., Idnay, B. R., Moen, H., Goffman, D., Cato, K., & Topaz, M. (2023). A qualitative analysis of stigmatizing language in birth admission clinical notes. *Nursing Inquiry*, e12557. <https://doi.org/10.1111/nin.12557>
- Barsevick, A. M. (2007). The elusive concept of the symptom cluster. *Oncology Nursing Forum*, *34*(5), 971-980. <https://doi.org/10.1188/07.ONF.971-980>
- Bayliss, E. A., Edwards, A. E., Steiner, J. F., & Main, D. S. (2008). Processes of care desired by elderly patients with multimorbidities. *Family Practice*, *25*(4), 287-293.
<https://doi.org/10.1093/fampra/cmn040>
- Bazargan, M., Cobb, S., & Assari, S. (2021). Discrimination and medical mistrust in a racially and ethnically diverse sample of California adults. *Annals of Family Medicine*, *19*(1), 4-15. <https://doi.org/10.1370/afm.2632>
- Beach, M. C., Saha, S., Park, J., Taylor, J., Drew, P., Plank, E., Cooper, L. A., & Chee, B. (2021). Testimonial injustice: Linguistic bias in the medical records of Black patients and

women. *Journal of General Internal Medicine*, 36(6), 1708-1714.

<https://doi.org/10.1007/s11606-021-06682-z>

Bender, M. S., Janson, S. L., Franck, L. S., & Lee, K. A. (2017). Theory of Symptom Management. In M. J. Smith & P. R. Liehr (Eds.), (pp. 147-178). Springer Publishing Company. <https://doi.org/10.1891/9780826159922.0008>

Ben-Dror, I., Weissman, A., Leurer, M. K., Eldor-Itskovitz, J., & Lowenstein, L. (2012). Alterations of heart rate variability in women with overactive bladder syndrome. *International Urogynecology Journal*, 23(8), 1081-1086. <https://doi.org/10.1007/s00192-012-1738-7>

Bignell, V. & Getliffe, K. (2001). Clinical guidelines for the promotion of continence in primary care: Community nurses' knowledge, practice and perceptions of their role. *Primary Health Care Research & Development*, 2(3), 173-186. <https://doi.org/10.1191/146342301678227879>

Bogner, H. R., O'Donnell, A. J., de Vries, H. F., Northington, G. M., & Joo, J. H. (2011). The temporal relationship between anxiety disorders and urinary incontinence among community-dwelling adults. *Journal of Anxiety Disorders*, 25(2), 203-208. <https://doi.org/10.1016/j.janxdis.2010.09.003>

Brady, S. S., Bavendam, T. G., Bradway, C. K., Conroy, B., Dowling-Castronovo, A., Epperson, C. N., Hijaz, A. K., Hsi, R. S., Huss, K., Kim, M., Lazar, J., Lee, R. K., Liu, C. K., Loizou, C. N., Miran, S., Mody, L., Norton, J. M., Reynolds, W. S., Sutcliffe, S., . . . Hokanson, J. A. (2022). Noncancerous genitourinary conditions as a public health priority: Conceptualizing the hidden burden. *Urology*, 166, 39-49. <https://doi.org/10.1016/j.urology.2021.08.040>

- Bramer, W. M., Giustini, D., de Jonge, G. B., Holland, L., & Bekhuis, T. (2016). De-duplication of database search results for systematic reviews in EndNote. *Journal of the Medical Library Association, 104*(3), 240-243. <https://doi.org/10.3163/1536-5050.104.3.014>
- Branch, L. G., Walker, L. A., Wetle, T. T., DuBeau, C. E., & Resnick, N. M. (1994). Urinary incontinence knowledge among community-dwelling people 65 years of age and older. *Journal of the American Geriatrics Society, 42*(12), 1257-1262. <https://doi.org/10.1111/j.1532-5415.1994.tb06507.x>
- Bresee, C., Dubina, E. D., Khan, A. A., Sevilla, C., Grant, D., Eilber, K. S., & Anger, J. T. (2014). Prevalence and correlates of urinary incontinence among older community-dwelling women. *Female Pelvic Medicine and Reconstructive Surgery, 20*(6), 328-333. <https://doi.org/10.1097/SPV.0000000000000093>
- Brown, J. S., Seeley, D. G., Fong, J., Black, D. M., Ensrud, K. E., & Grady, D. (1996). Urinary incontinence in older women: who is at risk? Study of Osteoporotic Fractures Research Group. *Obstetrics & Gynecology, 87*(5 Pt 1), 715-721. [https://doi.org/10.1016/0029-7844\(96\)00013-0](https://doi.org/10.1016/0029-7844(96)00013-0)
- Brown, J. S., Vittinghoff, E., Wyman, J. F., Stone, K. L., Nevitt, M. C., Ensrud, K. E., & Grady, D. (2000). Urinary incontinence: Does it increase risk for falls and fractures? Study of Osteoporotic Fractures Research Group. *Journal of the American Geriatrics Society, 48*(7), 721-725. <https://doi.org/10.1111/j.1532-5415.2000.tb04744.x>
- Brubaker, L., & Wolfe, A. (2016). The urinary microbiota: A paradigm shift for bladder disorders? *Current Opinions in Obstetrics & Gynecology, 28*(5), 407-412. <https://doi.org/10.1097/GCO.0000000000000298>

- Buchman, N. M., Leurgans, S. E., Shah, R. J., VanderHorst, V., Wilson, R. S., Bachner, Y. G., Tanne, D., Schneider, J. A., Bennett, D. A., & Buchman, A. S. (2017). Urinary incontinence, incident Parkinsonism, and Parkinson's disease pathology in older adults. *The Journals of Gerontology, Series A, Biological Sciences and Medical Sciences*, 72(9), 1295-1301. <https://doi.org/10.1093/gerona/glw235>
- Burgio, K. L., Ives, D. G., Locher, J. L., Arena, V. C., & Kuller, L. H. (1994). Treatment seeking for urinary incontinence in older adults. *Journal of the American Geriatrics Society*, 42(2), 208-212. <https://doi.org/10.1111/j.1532-5415.1994.tb04954.x>
- Burti, J. S., Santos, A. M., Pereira, R. M., Zambon, J. P., & Marques, A. P. (2012). Prevalence and clinical characteristics of urinary incontinence in elderly individuals of a low income. *Archives of Gerontology and Geriatrics*, 54(2), e42-46. <https://doi.org/10.1016/j.archger.2011.04.004>
- Cameron, K. A., Song, J., Manheim, L. M., & Dunlop, D. D. (2010). Gender disparities in health and healthcare use among older adults. *Journal of women's health (2002)*, 19(9), 1643–1650. <https://doi.org/10.1089/jwh.2009.1701>
- Canto-Cerdan, M., Cacho-Martinez, P., & Garcia-Munoz, A. (2020). Delphi methodology for symptomatology associated with visual dysfunctions. *Scientific Reports*, 10(1), 19403. <https://doi.org/10.1038/s41598-020-76403-9>
- Centers for Medicare and Medicaid Services. (2017). *Outcome Assessment and Information Set OASIS-C2 guidance manual*. Retrieved from: <https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HomeHealthQualityInits/Downloads/2016-OASIS-User-Manuals-archive.pdf>

- Charmaz, K. (1991). *Good Days Bad Days: The Self in Chronic Illness and Time*. Rutgers University Press.
- Charrad, M., Ghazzali, N., Boiteau, V., Niknafs, A. (2014). NbClust: An R package for determining the relevant number of clusters in a data set. *Journal of Statistical Software*, 61(6), 1-36. <https://doi.org/10.18637/jss.v061.i06>
- Chase, J. D., Russell, D., Huang, L., Hanlon, A., O'Connor, M., & Bowles, K. H. (2020). Relationships between race/ethnicity and health care utilization among older post-acute home health care patients. *Journal of Applied Gerontology*, 39(2), 201-213. <https://doi.org/10.1177/0733464818758453>
- Chen, G. D. (2007). Pelvic floor dysfunction in aging women. *Taiwan Journal of Obstetrics and Gynecology*, 46(4), 374-378. [https://doi.org/10.1016/S1028-4559\(08\)60006-6](https://doi.org/10.1016/S1028-4559(08)60006-6)
- Chen, E. S., & Sarkar, I. N. (2014). Mining the electronic health record for disease knowledge. *Methods in Molecular Biology*, 1159, 269-286. https://doi.org/10.1007/978-1-4939-0709-0_15
- Chess-Williams, R., McDermott, C., Sellers, D. J., West, E. G., & Mills, K. A. (2021). Chronic psychological stress and lower urinary tract symptoms. *Lower Urinary Tract Symptoms*, 13(4), 414-424. <https://doi.org/10.1111/luts.12395>
- Choi, E. P., Chin, W. Y., Lam, C. L., Wan, E. Y., Chan, A. K., & Chan, K. H. (2015). Evaluation of the effectiveness of nurse-led continence care treatments for Chinese primary care patients with lower urinary tract symptoms. *PLoS One*, 10(6), e0129875. <https://doi.org/10.1371/journal.pone.0129875>

- Choi, J. B., Kim, Y. B., Kim, B. T., & Kim, Y. S. (2005). Analysis of heart rate variability in female patients with overactive bladder. *Urology*, *65*(6), 1109-1112.
<https://doi.org/10.1016/j.urology.2005.01.029>
- Christiansen, T. L., Lipsitz, S., Scanlan, M., Yu, S. P., Lindros, M. E., Leung, W. Y., Adelman, J., Bates, D. W., & Dykes, P. C. (2020). Patient activation related to fall prevention: A multisite study. *The Joint Commission Journal on Quality and Patient Safety*, *46*(3), 129-135. <https://doi.org/10.1016/j.jcjq.2019.11.010>
- Cleeland, C. S., Bennett, G. J., Dantzer, R., Dougherty, P. M., Dunn, A. J., Meyers, C. A., Miller, A. H., Payne, R., Reuben, J. M., Wang, X. S., & Lee, B. N. (2003). Are the symptoms of cancer and cancer treatment due to a shared biologic mechanism? A cytokine-immunologic model of cancer symptoms. *Cancer*, *97*(11), 2919-2925.
<https://doi.org/10.1002/cncr.11382>
- Corwin, E. J., Berg, J. A., Armstrong, T. S., DeVito Dabbs, A., Lee, K. A., Meek, P., & Redeker, N. (2014). Envisioning the future in symptom science. *Nursing Outlook*, *62*(5), 346-351.
<https://doi.org/10.1016/j.outlook.2014.06.006>
- Coyne, K. S., Wein, A., Nicholson, S., Kvasz, M., Chen, C. I., & Milsom, I. (2013). Comorbidities and personal burden of urgency urinary incontinence: A systematic review. *International Journal of Clinical Practice*, *67*(10), 1015-1033.
<https://doi.org/10.1111/ijcp.12164>
- Coyne, K. S., Wein, A. J., Tubaro, A., Sexton, C. C., Thompson, C. L., Kopp, Z. S., & Aiyer, L. P. (2009). The burden of lower urinary tract symptoms: evaluating the effect of LUTS on health-related quality of life, anxiety and depression: EpiLUTS. *BJU International*, *103*(3), 4-11. <https://doi.org/10.1111/j.1464-410X.2009.08371.x>

- Curran, E., Rosato, M., Ferry, F., & Leavey, G. (2020). Prevalence and factors associated with anxiety and depression in older adults: Gender differences in psychosocial indicators. *Journal of Affective Disorders*, 267, 114-122. <https://doi.org/10.1016/j.jad.2020.02.018>
- da Silva, J. B., de Abreu, R. M., Padilha, J. F., Borghi-Silva, A., Catai, A. M., & Driusso, P. (2022). Heart rate variability dynamics in women with urinary incontinence: a systematic review. *International Urogynecology Journal*, 33(5), 1145-1155. <https://doi.org/10.1007/s00192-021-05060-x>
- De Raedt, S., De Vos, A., & De Keyser, J. (2015). Autonomic dysfunction in acute ischemic stroke: an underexplored therapeutic area? *Journal of Neurology Science*, 348(1-2), 24-34. <https://doi.org/10.1016/j.jns.2014.12.007>
- De Vlieghe, K., Paquay, L., Vernieuwe, S., & Van Gansbeke, H. (2010). The experience of home nurses with an electronic nursing health record. *International Nursing Review*, 57(4), 508-513. <https://doi.org/10.1111/j.1466-7657.2010.00827.x>
- Dean, K. E., Long, A. C. J., Matthews, R. A., & Buckner, J. D. (2018). Willingness to seek treatment among Black students with anxiety or depression: The synergistic effect of sociocultural factors with symptom severity and intolerance of uncertainty. *Behavior Therapy*, 49(5), 691-701. <https://doi.org/10.1016/j.beth.2017.12.008>
- Dean, K. E., Long, A. C. J., Trinh, N. H., McClendon, J., & Buckner, J. D. (2022). Treatment seeking for anxiety and depression among Black adults: A multilevel and empirically informed psycho-sociocultural model. *Behavior Therapy*, 53(6), 1077-1091. <https://doi.org/10.1016/j.beth.2022.04.005>

- Deen, N. S., Ahmed, A., Tasnim, N. T., & Khan, N. (2023). Clinical relevance of expanded quantitative urine culture in health and disease. *Frontiers in Cellular Infection Microbiology, 13*, 1210161. <https://doi.org/10.3389/fcimb.2023.1210161>
- Diaz, D., Robinson, D., Bosch, R., Costantini, E., Cotterill, N., Espuna-Pons, M., Kocjancic, E., Lemos, N., Tarcan, T., & Yoshida, M. (2017). Initial assessment of urinary incontinence in adult male and female patients. In P. Abrams, L. Cardozo, A. Wagg, & A. Wein (Eds.), *Incontinence* (6th ed., pp. 497-540). International Continence Society.
- Dingwall, L., & McLafferty, E. (2006). Do nurses promote urinary continence in hospitalized older people?: An exploratory study. *Journal of Clinical Nursing, 15*(10), 1276-1286. <https://doi.org/10.1111/j.1365-2702.2006.01381.x>
- Divani, A. A., Majidi, S., Barrett, A. M., Noorbaloochi, S., & Luft, A. R. (2011). Consequences of stroke in community-dwelling elderly: The health and retirement study, 1998 to 2008. *Stroke, 42*(7), 1821-1825. <https://doi.org/10.1161/STROKEAHA.110.607630>
- Dodd, M. J., Miaskowski, C., & Lee, K. A. (2004). Occurrence of symptom clusters. *Journal of the National Cancer Institute* (32), 76-78. <https://doi.org/10.1093/jncimonographs/lgh008>
- Dokuzlar, O., Koc Okudur, S., Smith, L., Soysal, P., Yavuz, I., Aydin, A. E., & Isik, A. T. (2020). Assessment of factors that increase risk of falling in older women by four different clinical methods. *Aging Clinical and Experimental Research, 32*(3), 483-490. <https://doi.org/10.1007/s40520-019-01220-8>
- Dordunoo, D., Abernethy, P., Kayuni, J., McConkey, S., & Aviles, G. M. (2022). Dismantling "race" in health research. *Canadian Journal of Nursing Research, 54*(3), 239-245. <https://doi.org/10.1177/08445621221074849>

- Drake, M. J. (2018). Fundamentals of terminology in lower urinary tract function. *Neurourology and Urodynamics*, 37(S6), S13-S19. <https://doi.org/10.1002/nau.23768>
- Dugan, E., Roberts, C. P., Cohen, S. J., Preisser, J. S., Davis, C. C., Bland, D. R., & Albertson, E. (2001). Why older community-dwelling adults do not discuss urinary incontinence with their primary care physicians. *Journal of the American Geriatrics Society*, 49(4), 462-465. <https://doi.org/10.1046/j.1532-5415.2001.49094.x>
- Dumoulin, C., Korner-Bitensky, N., & Tannenbaum, C. (2005). Urinary incontinence after stroke: does rehabilitation make a difference? A systematic review of the effectiveness of behavioral therapy. *Top Stroke Rehabilitation*, 12(3), 66-76. <https://doi.org/10.1310/ENMX-RUV5-15WL-VNA2>
- Duralde, E. R., Walter, L. C., Van Den Eeden, S. K., Nakagawa, S., Subak, L. L., Brown, J. S., Thom, D. H., & Huang, A. J. (2016). Bridging the gap: Determinants of undiagnosed or untreated urinary incontinence in women. *American Journal of Obstetrics and Gynecology*, 214(2), 261-266, 269. <https://doi.org/10.1016/j.ajog.2015.08.072>
- Dykes, P. C., Burns, Z., Adelman, J., Benneyan, J., Bogaisky, M., Carter, E., Ergai, A., Lindros, M. E., Lipsitz, S. R., Scanlan, M., Shaykevich, S., & Bates, D. W. (2020). Evaluation of a patient-centered fall-prevention tool kit to reduce falls and injuries: A nonrandomized controlled trial. *JAMA Network Open*, 3(11), e2025889. <https://doi.org/10.1001/jamanetworkopen.2020.25889>
- Dykes, P. C., Carroll, D. L., Hurley, A., Lipsitz, S., Benoit, A., Chang, F., Meltzer, S., Tsurikova, R., Zuyov, L., & Middleton, B. (2010). Fall prevention in acute care hospitals: A randomized trial. *JAMA*, 304(17), 1912-1918. <https://doi.org/10.1001/jama.2010.1567>

- Ekundayo, O. J., Markland, A., Lefante, C., Sui, X., Goode, P. S., Allman, R. M., Ali, M., Wahle, C., Thornton, P. L., & Ahmed, A. (2009). Association of diuretic use and overactive bladder syndrome in older adults: a propensity score analysis. *Archives of Gerontology and Geriatrics, 49*(1), 64-68. <https://doi.org/10.1016/j.archger.2008.05.002>
- Elango, S., Whitmire, R., Kim, J., Berhane, Z., Davis, R., & Turchi, R. M. (2022). Family experience of caregiver burden and health care usage in a statewide medical home program. *Academic pediatrics, 22*(1), 116–124. <https://doi.org/10.1016/j.acap.2021.07.010>
- Elliott, S., Painter, J., & Hudson, S. (2009). Living alone and fall risk factors in community-dwelling middle age and older adults. *Journal of Community Health, 34*(4), 301–310. <https://doi.org/10.1007/s10900-009-9152-x>
- Elstad, E. A., Taubenberger, S. P., Botelho, E. M., & Tennstedt, S. L. (2010). Beyond incontinence: The stigma of other urinary symptoms. *Journal of Advanced Nursing, 66*(11), 2460-2470. <https://doi.org/10.1111/j.1365-2648.2010.05422.x>
- Epperson, C. N., Duffy, K. A., Johnson, R. L., Sammel, M. D., & Newman, D. K. (2020). Enduring impact of childhood adversity on lower urinary tract symptoms in adult women. *Neurourology and Urodynamics, 39*(5), 1472-1481. <https://doi.org/10.1002/nau.24375>
- Erdogan, T., Bahat, G., Kilic, C., Kucukdagli, P., Oren, M. M., Erdogan, O., & Karan, M. A. (2019). The relationship between sarcopenia and urinary incontinence. *European Geriatric Medicine, 10*(6), 923-929. <https://doi.org/10.1007/s41999-019-00232-x>
- Eshkoor, S. A., Hamid, T. A., Shahar, S., & Mun, C. Y. (2017). Factors related to urinary incontinence among the Malaysian elderly. *The Journal of Nutrition, Health & Aging, 21*(2), 220–226. <https://doi-org/10.1007/s12603-016-0779-x>

- Everitt, B. S., Landau, S., Leese, M., & Stahl, D. (2011). Hierarchical Clustering. In W. A. Shewhart & S. S. Wilks (Eds.), *Cluster Analysis* (5th ed., Chapter 4).
<https://doi.org/10.1002/9780470977811.ch4>
- Felde, G., Bjelland, I., & Hunskaar, S. (2012). Anxiety and depression associated with incontinence in middle-aged women: a large Norwegian cross-sectional study. *International Urogynecology Journal*, 23(3), 299-306. <https://doi.org/10.1007/s00192-011-1564-3>
- Felde, G., Ebbesen, M. H., & Hunskaar, S. (2017). Anxiety and depression associated with urinary incontinence. A 10-year follow-up study from the Norwegian HUNT study (EPINCONT). *Neurourology and Urodynamics*, 36(2), 322–328. <https://doi-org.ezproxy.cul.columbia.edu/10.1002/nau.22921>
- Fialkow, M. F., Melville, J. L., Lentz, G. M., Miller, E. A., Miller, J., & Fenner, D. E. (2003). The functional and psychosocial impact of fecal incontinence on women with urinary incontinence. *American Journal of Obstetrics and Gynecology*, 189(1), 127-129.
<https://doi.org/10.1067/mob.2003.548>
- Filipetto, F. A., Fulda, K. G., Holthusen, A. E., McKeithen, T. M., & McFadden, P. (2014). The patient perspective on overactive bladder: A mixed-methods needs assessment. *BMC Family Practice*, 15(96). <https://doi.org/10.1186/1471-2296-15-96>
- Flemming, P. J., & Ramsay, K. (2012). Falls risk assessment begins with hello: Lessons learned from the use of one home health agency's fall risk tool. *Home Healthcare Nurse*, 30(9), 516-523. <https://doi.org/10.1097/NHH.0b013e31826a3436>
- Forbush, T. B., Gundlapalli, A. V., Palmer, M. N., Shen, S., South, B. R., Divita, G., Carter, M., Redd, A., Butler, J. M., & Samore, M. (2013). "Sitting on pins and needles":

characterization of symptom descriptions in clinical notes. *AMIA Joint Summits on Translational Science proceedings. AMIA Joint Summits on Translational Science, 2013*, 67–71.

Fortinsky, R. H., Madigan, E. A., Sheehan, T. J., Tullai-McGuinness, S., & Kleppinger, A. (2014). Risk factors for hospitalization in a national sample of Medicare home health care patients. *Journal of Applied Gerontology*, *33*(4), 474-493.

<https://doi.org/10.1177/0733464812454007>

Frisch, N. C., & Rabinowitsch, D. (2019). What's in a definition? Holistic nursing, integrative health care, and integrative nursing: Report of an integrated literature review. *Journal of Holistic Nursing*, *37*(3), 260-272. <https://doi.org/10.1177/0898010119860685>

Gartside, S. E., Johnson, D. A., Leitch, M. M., Troakes, C., & Ingram, C. D. (2003). Early life adversity programs changes in central 5-HT neuronal function in adulthood. *European Journal of Neuroscience*, *17*(11), 2401-2408. <https://doi.org/10.1046/j.1460-9568.2003.02668.x>

Gerry, S., Bonnici, T., Birks, J., Kirtley, S., Virdee, P. S., Watkinson, P. J., & Collins, G. S. (2020). Early warning scores for detecting deterioration in adult hospital patients: systematic review and critical appraisal of methodology. *BMJ*, *369*, m1501.

<https://doi.org/10.1136/bmj.m1501>

Gerst, K., Ray, L. A., Samper-Ternent, R., Espino, D. V., & Markides, K. S. (2011). Self-reported urge urinary incontinence (UUI) among older Mexican-American men: Risk factors and psycho-social consequences. *Journal of Immigrant and Minority Health*, *13*(6), 1110-1115. <https://doi.org/10.1007/s10903-010-9383-z>

- Gordon, K., Steele Gray, C., Dainty, K. N., DeLacy, J., Ware, P., & Seto, E. (2020). Exploring an innovative care model and telemonitoring for the management of patients with complex chronic needs: Qualitative description study. *Journal of Medical Internet Research Nursing*, 3(1), e15691. <https://doi.org/10.2196/15691>
- Gorina, Y., Schappert, S., Bercovitz, A., Elgaddal, N., & Kramarow, E. (2014). Prevalence of incontinence among older Americans. *Vital Health Stat* 3(36), 1-33. <https://www.ncbi.nlm.nih.gov/pubmed/24964267>
- Grippo, A. J. (2009). Mechanisms underlying altered mood and cardiovascular dysfunction: the value of neurobiological and behavioral research with animal models. *Neuroscience and Biobehavioral Reviews*, 33(2), 171-180. <https://doi.org/10.1016/j.neubiorev.2008.07.004>
- Gruneir, A., Forrester, J., Camacho, X., Gill, S. S., & Bronskill, S. E.. (2013). Gender differences in home care clients and admission to long-term care in Ontario, Canada: A population-based retrospective cohort study. *BMC Geriatrics*, 13(48). <https://doi.org/10.1186/1471-2318-13-48>
- Guest, C. B., Park, M. J., Johnson, D. R., & Freund, G. G. (2008). The implication of proinflammatory cytokines in type 2 diabetes. *Frontiers in Bioscience : A Journal and Virtual Library*, 13, 5187–5194. <https://doi.org/10.2741/3074>
- Gupta, S., Ding, L., Granieri, M., Le, N. B., & Peterson, A. C. (2016). Utilization of surgical procedures and racial disparity in the treatment of urinary incontinence after prostatectomy. *Neurourology and Urodynamics*, 35(6), 733-737. <https://doi.org/10.1002/nau.22790>
- Gupta, P., Gaines, N., Sirls, L. T., & Peters, K. M. (2015). A multidisciplinary approach to the evaluation and management of interstitial cystitis/bladder pain syndrome: an ideal model

- of care. *Translational Andrology and Urology*, 4(6), 611-619.
<https://doi.org/10.3978/j.issn.2223-4683.2015.10.10>
- Hagglund, D., & Wadensten, B. (2007). Fear of humiliation inhibits women's care-seeking behaviour for long-term urinary incontinence. *Scandinavian Journal of Caring Sciences*, 21(3), 305-312. <https://doi.org/10.1111/j.1471-6712.2007.00481.x>
- Hall, S. A., Cinar, A., Link, C. L., Kopp, Z. S., Roehrborn, C. G., Kaplan, S. A., & Rosen, R. C. (2008). Do urological symptoms cluster among women? Results from the Boston Area Community Health Survey. *BJU International*, 101(10), 1257-1266.
<https://doi.org/10.1111/j.1464-410X.2008.07557.x>
- Hall, S. A., Link, C. L., Tennstedt, S. L., Mollon, P., Aiyer, L. P., Chapple, C. R., Wein, A. J., & Rosen, R. C. (2009). Urological symptom clusters and health-related quality-of-life: Results from the Boston Area Community Health Survey. *BJU International*, 103(11), 1502-1508. <https://doi.org/10.1111/j.1464-410X.2008.08334.x>
- Han, C., Rice, M. W., & Cai, D. (2016). Neuroinflammatory and autonomic mechanisms in diabetes and hypertension. *American Journal of Physiology-Endocrinology and Metabolism*, 311(1), E32-41. <https://doi.org/10.1152/ajpendo.00012.2016>
- Haylen, B. T., de Ridder, D., Freeman, R. M., Swift, S. E., Berghmans, B., Lee, J., Monga, A., Petri, E., Rizk, D. E., Sand, P. K., & Schaer, G. N. (2010). An International Urogynecological Association (IUGA)/International Continence Society (ICS) joint report on the terminology for female pelvic floor dysfunction. *International Urogynecology Journal*, 21(1), 5-26. <https://doi.org/10.1007/s00192-009-0976-9>

- Heim, C., & Nemeroff, C. B. (2001). The role of childhood trauma in the neurobiology of mood and anxiety disorders: preclinical and clinical studies. *Biological Psychiatry*, *49*(12), 1023-1039. [https://doi.org/10.1016/s0006-3223\(01\)01157-x](https://doi.org/10.1016/s0006-3223(01)01157-x)
- Helms, J. E., Jernigan, M., & Mascher, J. (2005). The meaning of race in psychology and how to change it: a methodological perspective. *American Psychology*, *60*(1), 27-36. <https://doi.org/10.1037/0003-066X.60.1.27>
- Higgins, S., Dutta, S., & Kakar, R. S. (2023). Machine learning for lumbar and pelvis kinematics clustering. *Computer methods in biomechanics and biomedical engineering*, 1–14. Advance online publication. <https://doi.org/10.1080/10255842.2023.2241593>
- Hilt, E. E., McKinley, K., Pearce, M. M., Rosenfeld, A. B., Zilliox, M. J., Mueller, E. R., Brubaker, L., Gai, X., Wolfe, A. J., & Schreckenberger, P. C. (2014). Urine is not sterile: Use of enhanced urine culture techniques to detect resident bacterial flora in the adult female bladder. *Journal of Clinical Microbiology*, *52*(3), 871-876. <https://doi.org/10.1128/JCM.02876-13>
- Himmelstein, G., Bates, D., & Zhou, L. (2022). Examination of stigmatizing language in the electronic health record. *JAMA Network Open*, *5*(1), e2144967. <https://doi.org/10.1001/jamanetworkopen.2021.44967>
- Hobensack, M., Ojo, M., Barron, Y., Bowles, K. H., Cato, K., Chae, S., Kennedy, E., McDonald, M. V., Rossetti, S. C., Song, J., Sridharan, S., & Topaz, M. (2022). Documentation of hospitalization risk factors in electronic health records (EHRs): A qualitative study with home healthcare clinicians. *Journal of the American Medical Informatics Association*, *29*(5), 805-812. <https://doi.org/10.1093/jamia/ocac023>

- Holtzer-Goor, K. M., Gaultney, J. G., van Houten, P., Wagg, A. S., Huygens, S. A., Nielen, M. M., Albers-Heitner, C. P., Redekop, W. K., Rutten-van Molken, M. P., & Al, M. J. (2015). Cost-effectiveness of including a nurse specialist in the treatment of urinary incontinence in primary care in the Netherlands. *PLoS One*, *10*(10), e0138225. <https://doi.org/10.1371/journal.pone.0138225>
- Howell, H. B., Brawman-Mintzer, O., Monnier, J., & Yonkers, K. A. (2001). Generalized anxiety disorder in women. *Psychiatric Clinics of North America*, *24*(1), 165-178. [https://doi.org/10.1016/s0193-953x\(05\)70212-4](https://doi.org/10.1016/s0193-953x(05)70212-4)
- Hsiao, S. M., Su, T. C., Chen, C. H., Chang, T. C., & Lin, H. H. (2014). Autonomic dysfunction and arterial stiffness in female overactive bladder patients and antimuscarinics related effects. *Maturitas*, *79*(1), 65-69. <https://doi.org/10.1016/j.maturitas.2014.06.001>
- Hu, K. K., Boyko, E. J., Scholes, D., Normand, E., Chen, C. L., Grafton, J., & Fihn, S. D. (2004). Risk factors for urinary tract infections in postmenopausal women. *Archives of Internal Medicine*, *164*(9), 989-993. <https://doi.org/10.1001/archinte.164.9.989>
- Huang, A. J., Brown, J. S., Thom, D. H., Fink, H. A., Yaffe, K., & Study of Osteoporotic Fractures Research, G. (2007). Urinary incontinence in older community-dwelling women: The role of cognitive and physical function decline. *Obstetrics & Gynecology*, *109*(4), 909-916. <https://doi.org/10.1097/01.AOG.0000258277.01497.4b>
- Huang, C. L., Wu, M. P., Ho, C. H., & Wang, J. J. (2017). The bidirectional relationship between anxiety, depression, and lower urinary track symptoms: A nationwide population-based cohort study. *Journal of Psychosomatic Research*, *100*, 77-82. <https://doi.org/10.1016/j.jpsychores.2017.07.008>

- Hubeaux, K., Deffieux, X., Ismael, S. S., Raibaut, P., & Amarenco, G. (2007). Autonomic nervous system activity during bladder filling assessed by heart rate variability analysis in women with idiopathic overactive bladder syndrome or stress urinary incontinence. *Journal of Urology*, *178*(6), 2483-2487. <https://doi.org/10.1016/j.juro.2007.08.036>
- Hwang, R., Chuan, F., Peters, R., & Kuys, S. (2013). Frequency of urinary incontinence in people with chronic heart failure. *Heart & Lung*, *42*(1), 26-31. <https://doi.org/10.1016/j.hrtlng.2012.08.003>
- Im, H. W., Kim, M. D., Kim, J. C., & Choi, J. B. (2010). Autonomous nervous system activity in women with detrusor overactivity. *Korean Journal of Urology*, *51*(3), 183-186. <https://doi.org/10.4111/kju.2010.51.3.183>
- Irwin, D. E., Kopp, Z. S., Agatep, B., Milsom, I., & Abrams, P. (2011). Worldwide prevalence estimates of lower urinary tract symptoms, overactive bladder, urinary incontinence, and bladder outlet obstruction. *BJU International*, *108*(7), 1132-1138. <https://doi.org/10.1111/j.1464-410X.2010.09993.x>
- Jackson, S. L., Boyko, E. J., Scholes, D., Abraham, L., Gupta, K., & Fihn, S. D. (2004). Predictors of urinary tract infection after menopause: a prospective study. *American Journal of Medicine*, *117*(12), 903-911. <https://doi.org/10.1016/j.amjmed.2004.07.045>
- Jacob, C., Sanchez-Vazquez, A., & Ivory, C. (2020). Social, organizational, and technological factors impacting clinicians' adoption of mobile health tools: Systematic literature review. *JMIR mHealth and uHealth*, *8*(2), e15935. <https://doi.org/10.2196/15935>
- Jaul, E. (2010). Assessment and management of pressure ulcers in the elderly: current strategies. *Drugs and Aging*, *27*(4), 311-325. <https://doi.org/10.2165/11318340-000000000-00000>

- Jencks, S. F., Williams, M. V., & Coleman, E. A. (2009). Rehospitalizations among patients in the Medicare fee-for-service program. *New England Journal of Medicine*, *360*(14), 1418-1428. <https://doi.org/10.1056/NEJMsa0803563>
- John, G., Bardini, C., Combescure, C., & Dallenbach, P. (2016). Urinary incontinence as a predictor of death: A systematic review and meta-analysis. *PLoS One*, *11*(7), e0158992. <https://doi.org/10.1371/journal.pone.0158992>
- Johnson, A. K., & Grippo, A. J. (2006). Sadness and broken hearts: neurohumoral mechanisms and co-morbidity of ischemic heart disease and psychological depression. *Journal of Physiology and Pharmacology*, *57*(11), 5-29. <https://www.ncbi.nlm.nih.gov/pubmed/17244936>
- Jung, H. B., Kim, H. J., & Cho, S. T. (2015). A current perspective on geriatric lower urinary tract dysfunction. *Korean Journal of Urology*, *56*(4), 266-275. <https://doi.org/10.4111/kju.2015.56.4.266>
- Kayser, S. A., Koloms, K., Murray, A., Khawar, W., & Gray, M. (2021). Incontinence and incontinence-associated dermatitis in acute care: A retrospective analysis of total cost of care and patient outcomes from the Premier Healthcare Database. *Journal of Wound Ostomy and Continence Nursing*, *48*(6), 545-552. <https://doi.org/10.1097/WON.0000000000000818>
- Kayser, S. A., Phipps, L., VanGilder, C. A., & Lachenbruch, C. (2019). Examining prevalence and risk factors of incontinence-associated dermatitis using the International Pressure Ulcer Prevalence Survey. *Journal of Wound Ostomy and Continence Nursing*, *46*(4), 285-290. <https://doi.org/10.1097/WON.0000000000000548>

- Kim, J. H. (2019). Multicollinearity and misleading statistical results. *Korean Journal of Anesthesiology*, 72(6), 558-569. <https://doi.org/10.4097/kja.19087>
- Kim, J. C., Joo, K. J., Kim, J. T., Choi, J. B., Cho, D. S., & Won, Y. Y. (2010). Alteration of autonomic function in female urinary incontinence. *International Neurourology Journal*, 14(4), 232-237. <https://doi.org/10.5213/inj.2010.14.4.232>
- Kim, H. J., McGuire, D. B., Tulman, L., & Barsevick, A. M. (2005). Symptom clusters: Concept analysis and clinical implications for cancer nursing. *Cancer Nursing*, 28(4), 270-282. <https://doi.org/10.1097/00002820-200507000-00005>
- Koch, L. H. (2006). Help-seeking behaviors of women with urinary incontinence: an integrative literature review. *Journal of Midwifery and Womens Health*, 51(6), e39-44. <https://doi.org/10.1016/j.jmwh.2006.06.004>
- Koleck, T. A., Tatonetti, N. P., Bakken, S., Mitha, S., Henderson, M. M., George, M., Miaskowski, C., Smaldone, A., & Topaz, M. (2021). Identifying symptom information in clinical notes using natural language processing. *Nursing Research*, 70(3), 173-183. <https://doi.org/10.1097/NNR.0000000000000488>
- Koleck, T. A., Topaz, M., Tatonetti, N. P., George, M., Miaskowski, C., Smaldone, A., & Bakken, S. (2021). Characterizing shared and distinct symptom clusters in common chronic conditions through natural language processing of nursing notes. *Research in Nursing & Health*, 44(6), 906-919. <https://doi.org/10.1002/nur.22190>
- Kozomara-Hocke, M., Hermanns, T., & Poyet, C. (2016). Male urinary incontinence: A taboo issue. *Praxis*, 105(5), 269-277. <https://doi.org/10.1024/1661-8157/a002297>
- Kwekkeboom, K. L. (2016). Cancer symptom cluster management. *Seminars in Oncology Nursing*, 32(4), 373-382. <https://doi.org/10.1016/j.soncn.2016.08.004>

- Kwekkeboom, K. L., Abbott-Anderson, K., Cherwin, C., Roiland, R., Serlin, R. C., & Ward, S. E. (2012). Pilot randomized controlled trial of a patient-controlled cognitive-behavioral intervention for the pain, fatigue, and sleep disturbance symptom cluster in cancer. *Journal of Pain and Symptom Management, 44*(6), 810-822.
<https://doi.org/10.1016/j.jpainsymman.2011.12.281>
- Lardas, M., Grivas, N., Debray, T. P. A., Zattoni, F., Berridge, C., Cumberbatch, M., Van den Broeck, T., Briers, E., De Santis, M., Farolfi, A., Fossati, N., Gandaglia, G., Gillessen, S., O'Hanlon, S., Henry, A., Liew, M., Mason, M., Moris, L., Oprea-Lager, D., Ploussard, G., ...Mottet, N. (2022). Patient and tumour-related prognostic factors for urinary incontinence after radical prostatectomy for nonmetastatic prostate cancer: A systematic review and meta-analysis. *European Urology Focus, 8*(3), 674-689.
<https://doi.org/10.1016/j.euf.2021.04.020>
- Larsen, E. B., Fahnoe, C. L., Jensen, P. E., & Gregersen M. (2023). Absorbent incontinence pad use and the association with urinary tract infection and frailty: A retrospective cohort study. *International Journal of Nursing Studies Advances, 5*, 100131.
<http://doi.org/10.1016/j.ijnsa.2023.100131>
- LeDoux, C. V., Lindrooth, R. C., Seidler, K. J., Falvey, J. R., & Stevens-Lapsley, J. E. (2020). The impact of home health physical therapy on Medicare beneficiaries with a primary diagnosis of dementia. *Journal of the American Geriatrics Society, 68*(4), 867–871.
<https://doi.org/10.1111/jgs.16307>
- Lengacher, C. A., Reich, R. R., Paterson, C. L., Ramesar, S., Park, J. Y., Alinat, C., Johnson-Mallard, V., Moscoso, M., Budhrani-Shani, P., Miladinovic, B., Jacobsen, P. B., Cox, C. E., Goodman, M., & Kip, K. E. (2016). Examination of broad symptom improvement

- resulting from mindfulness-based stress reduction in breast cancer survivors: A randomized controlled trial. *Journal of Clinical Oncology*, 34(24), 2827-2834.
<https://doi.org/10.1200/JCO.2015.65.7874>
- Lengacher, C. A., Reich, R. R., Post-White, J., Moscoso, M., Shelton, M. M., Barta, M., Le, N., & Budhrani, P. (2012). Mindfulness based stress reduction in post-treatment breast cancer patients: an examination of symptoms and symptom clusters. *Journal of Behavioral Medicine*, 35(1), 86-94. <https://doi.org/10.1007/s10865-011-9346-4>
- Lenz, E. R., Pugh, L. C., Milligan, R. A., Gift, A., & Suppe, F. (1997). The middle-range theory of unpleasant symptoms: An update. *Advances in Nursing Science* 19(3), 14-17.
- Leung, F. W., & Schnelle, J. F. (2008). Urinary and fecal incontinence in nursing home residents. *Gastroenterology Clinics of North America*, 37(3), 697-707.
<https://doi.org/10.1016/j.gtc.2008.06.005>
- Li, M., Wang, H., Ko, W. K., & Kwong, S. K. (2024). Factors associated with health-seeking for urinary incontinence in Hong Kong Chinese women: a cross-sectional study. *International Urogynecology Journal*, 35(1), 95-101. <https://doi.org/10.1007/s00192-023-05656-5>
- Lifford, K. L., Curhan, G. C., Hu, F. B., Barbieri, R. L., & Grodstein, F. (2005). Type 2 diabetes mellitus and risk of developing urinary incontinence. *Journal of the American Geriatric Society*, 53(11), 1851-1857. <https://doi.org/10.1111/j.1532-5415.2005.53565.x>
- Liu, M., Chen, J., Huang, D., Ke, J., & Wu, W. (2014). A meta-analysis of proinflammatory cytokines in chronic heart failure. *Heart Asia*, 6(1), 130-136.
<https://doi.org/10.1136/heartasia-2013-010484>

- Lu, L., Shen, H., Tan, L., Huang, Q., Chen, Q., Liang, M., He, L., & Zhou, Y. (2023). Prevalence and factors associated with anxiety and depression among community-dwelling older adults in Hunan, China: a cross-sectional study. *BMC Psychiatry*, *23*(1), 107. <https://doi.org/10.1186/s12888-023-04583-5>
- Ma, C., Shang, J., Miner, S., Lennox, L., & Squires, A. (2018). The Prevalence, Reasons, and risk factors for hospital readmissions among Home health care patients: A systematic review. *Home Health Care Management & Practice*, *30*(2), 83-92. <https://doi.org/10.1177/1084822317741622>
- Matthews, C. A., Whitehead, W. E., Townsend, M. K., & Grodstein, F. (2013). Risk factors for urinary, fecal, or dual incontinence in the Nurses' Health Study. *Obstetrics & Gynecology*, *122*(3), 539-545. <https://doi.org/10.1097/AOG.0b013e31829efbff>
- Maywald, M., Pogarell, O., Levai, S., Paolini, M., Tschentscher, N., Rauchmann, B. S., Krause, D., Stöcklein, S., Goerigk, S., Röhl, L., Ertl-Wagner, B., Papazov, B., Keeser, D., Karch, S., & Chrobok, A. (2023). Neurofunctional differences and similarities between persistent postural-perceptual dizziness and anxiety disorder. *NeuroImage. Clinical*, *37*, 103330. <https://doi.org/10.1016/j.nicl.2023>.
- McCann, M., Kelly, A. M., Eustace-Cook, J., Howlin, C., & Daly, L. (2022). Community nurses' attitudes, knowledge and educational needs in relation to urinary continence, continence assessment and management: A systematic review. *Journal of Clinical Nursing*, *31*(7-8), 1041-1060. <https://doi.org/10.1111/jocn.15969>
- McLean, C. P., & Anderson, E. R. (2009). Brave men and timid women? A review of the gender differences in fear and anxiety. *Clinical Psychology Review*, *29*(6), 496-505. <https://doi.org/10.1016/j.cpr.2009.05.003>

- McLean, C. P., Asnaani, A., Litz, B. T., & Hofmann, S. G. (2011). Gender differences in anxiety disorders: prevalence, course of illness, comorbidity and burden of illness. *Journal of Psychiatric Research*, 45(8), 1027-1035. <https://doi.org/10.1016/j.jpsychires.2011.03.006>
- McPherson, S., Reese, C., & Wendler, M. C. (2018). Methodology update: Delphi studies. *Nursing Research*, 67(5), 404-410. <https://doi.org/10.1097/NNR.0000000000000297>
- Medicare Payment Advisory Commission. (2023). *Report to the Congress: Medicare payment policy. Home health care services* (pp. 237-252). Retrieved from: <https://www.medpac.gov/document/march-2023-report-to-the-congress-medicare-payment-policy/>
- Mehta, N. & Pandit, A. (2018). Concurrence of big data analytics and healthcare: A systematic review. *International Journal of Medical Informatics*, 114, 57-65. <https://doi.org/10.1016/j.ijmedinf.2018.03.013>
- Mendes, A., Hoga, L., Goncalves, B., Silva, P., & Pereira, P. (2017). Adult women's experiences of urinary incontinence: a systematic review of qualitative evidence. *JBIS Database Systematic Reviews and Implementation Reports*, 15(5), 1350-1408. <https://doi.org/10.11124/JBISRIR-2017-003389>
- Miaskowski, C. (2016). Future directions in symptom cluster research. *Seminars in Oncology Nursing*, 32(4), 405-415. <https://doi.org/10.1016/j.soncn.2016.08.006>
- Miaskowski, C., Barsevick, A., Berger, A., Casagrande, R., Grady, P. A., Jacobsen, P., Kutner, J., Patrick, D., Zimmerman, L., Xiao, C., Matocha, M., & Marden, S. (2017). Advancing symptom science through symptom cluster research: Expert panel proceedings and recommendations. *Journal of the National Cancer Institute*, 109(4). <https://doi.org/10.1093/jnci/djw253>

- Miaskowski, C., Dodd, M., & Lee, K. (2004). Symptom clusters: the new frontier in symptom management research. *Journal of the National Cancer Institute*, (32), 17-21.
<https://doi.org/10.1093/jncimonographs/lgh023>
- Middleton, A., Downer, B., Haas, A., Knox, S., & Ottenbacher, K. J. (2019). Functional status is associated with 30-day potentially preventable readmissions following home health care. *Medical Care*, 57(2), 145-151. <https://doi.org/10.1097/MLR.0000000000001047>
- Miller, M. L., Reed, B. N., & Malik, R. D. (2022). Association of lower urinary tract symptoms and diuretic adherence. *Lower Urinary Tract Symptoms*, 14(5), 366-372.
<https://doi.org/10.1111/luts.12452>
- Milsom, I., Kaplan, S. A., Coyne, K. S., Sexton, C. C., & Kopp, Z. S. (2012). Effect of bothersome overactive bladder symptoms on health-related quality of life, anxiety, depression, and treatment seeking in the United States: results from EpiLUTS. *Urology*, 80(1), 90-96. <https://doi.org/10.1016/j.urology.2012.04.004>
- Milsom, I., & Gyhagen, M. (2019). The prevalence of urinary incontinence. *Climacteric*, 22(3), 217-222. <https://doi.org/10.1080/13697137.2018.1543263>
- Moola, S., Munn, Z., Tufanaru, C., Aromataris, E., Sears, K., Sfetcu, R., Currie, M., Qureshi, R., Mattis, P., Lisy, K., & Mu, P.F. (2020). Systematic reviews of etiology and risk. In E. Aromataris & Z. Munn (Eds.), *JBIM Manual for Evidence Synthesis*. JBI.
<https://doi.org/10.46658/JBIMES-20-08>
- Moon, S., Chung, H. S., Kim, Y. J., Kim, S. J., Kwon, O., Lee, Y. G., Yu, J. M., & Cho, S. T. (2021). The impact of urinary incontinence on falls: A systematic review and meta-analysis. *PLoS One*, 16(5), e0251711. <https://doi.org/10.1371/journal.pone.0251711>

- Moore, E. E., Jackson, S. L., Boyko, E. J., Scholes, D., & Fihn, S. D. (2008). Urinary incontinence and urinary tract infection: temporal relationships in postmenopausal women. *Obstetrics and Gynecology*, *111*(2), 317-323.
<https://doi.org/10.1097/AOG.0b013e318160d64a>
- Mossey, J. M. (2011). Defining racial and ethnic disparities in pain management. *Clinical Orthopedics and Related Research*, *469*(7), 1859-1870. <https://doi.org/10.1007/s11999-011-1770-9>
- Moussa, M., Papatsoris, A., Chakra, M. A., Fares, Y., & Dellis, A. (2020). Lower urinary tract dysfunction in common neurological diseases. *Turkish Journal of Urology*, *46*(1), S70-S78. <https://doi.org/10.5152/tud.2020.20092>
- Moy, A. J., Hobensack, M., Marshall, K., Vawdrey, D. K., Kim, E. Y., Cato, K. D., & Rossetti, S. C. (2023). Understanding the perceived role of electronic health records and workflow fragmentation on clinician documentation burden in emergency departments. *Journal of the American Medical Informatics Association*, *30*(5):797-808.
<https://doi.org/10.1093/jamia/ocad038>
- Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology*, *18*(1), 143. <https://doi.org/10.1186/s12874-018-0611-x>
- Murtaugh, C., Peng, T., Totten, A., Costello, B., Moore, S., & Aykan, H. (2009). Complexity in geriatric home healthcare. *Journal of Healthcare Quality*, *31*(2), 34-43.
<https://doi.org/10.1111/j.1945-1474.2009.00017.x>

- Murukesu, R. R., Singh, D. K. A., & Shahar, S. (2019). Urinary incontinence among urban and rural community dwelling older women: Prevalence, risk factors and quality of life. *BMC Public Health*, *19*(4), 529. <https://doi.org/10.1186/s12889-019-6870-6>
- National Health and Aging Trends Study (NHATS). (2024). NHATS for Researchers. Retrieved from <https://nhats.org/researcher/nhats>
- National Library of Medicine (2023). SNOMED CT United States Edition. Retrieved from: https://www.nlm.nih.gov/healthit/snomedct/us_edition.html
- Nemeroff, C. B. (2004). Early-life adversity, CRF dysregulation, and vulnerability to mood and anxiety disorders. *Psychopharmacology Bulletin*, *38*(1), 14-20.
- Newman, D. K. (2014). In men and women with COPD the presence of urinary incontinence is associated with poorer quality of life. *Evidence Based Nursing*, *17*(1), 22-23. <https://doi.org/10.1136/eb-2013-101290>
- Nguyen, H., Brown, O., Bretschneider, C. E., Mueller, M., Geynisman-Tan, J., Lewicky-Gaupp, C., Kenton, K., & Collins, S. (2023). Use of a computerized decisional analysis tool in patients With urgency urinary incontinence. *Urogynecology*, *29*(9), 757-762. <https://doi.org/10.1097/SPV.0000000000001342>
- Norton, J. M., Dodson, J. L., Newman, D. K., Rogers, R. G., Fairman, A. D., Coons, H. L., Star, R. A., & Bavendam, T. G. (2017). Nonbiologic factors that impact management in women with urinary incontinence: review of the literature and findings from a National Institute of Diabetes and Digestive and Kidney Diseases workshop. *International Urogynecology Journal*, *28*(9), 1295-1307. <https://doi.org/10.1007/s00192-017-3400-x>
- Norton, J. M., Dowling-Castronovo, A., Conroy, B., Hijaz, A., Kim, M., Loizou, C., Meyer, D. E., & Constantine, M. L. (2022). The Inflection Point Model: A model to explore the

- hidden burdens of non-cancerous genitourinary conditions. *Urology*, *166*, 56-65.
<https://doi.org/10.1016/j.urology.2021.07.030>
- Ochodnický, P., Uvelius, B., Andersson, K. E., & Michel, M. C. (2013). Autonomic nervous control of the urinary bladder. *Acta Physiologica*, *207*(1), 16-33.
<https://doi.org/10.1111/apha.12010>
- Offermans, M. P., Du Moulin, M. F., Hamers, J. P., Dassen, T., & Halfens, R. J. (2009). Prevalence of urinary incontinence and associated risk factors in nursing home residents: a systematic review. *Neurourology and Urodynamics*, *28*(4), 288-294.
<https://doi.org/10.1002/nau.20668>
- Ostaszkiwicz, J., O'Connell, B., & Millar, L. (2008). Incontinence: Managed or mismanaged in hospital settings? *International Journal of Nursing Practice*, *14*(6), 495-502.
<https://doi.org/10.1111/j.1440-172X.2008.00725.x>
- Padilha B. M., Seidel E. J., Mazo G. Z., Marques J. L. B., & de Godoy Marques C. M. (2017). Assessment of cardiac autonomic modulation in the bladder filling process of women with urinary incontinence: the perspective of physiotherapy. *Fisioter Pesqui*, *24*(4), 363–370. <https://doi.org/10.1590/1809-2950/16196024042017>
- Palmer, M. H., Hardin, S. R., Behrend, C., Collins, S. K., Madigan, C. K., & Carlson, J. R. (2009). Urinary incontinence and overactive bladder in patients with heart failure. *Journal of Urology*, *182*(1), 196-202. <https://doi.org/10.1016/j.juro.2009.02.115>
- Park, J., & Son Hong, G. R. (2016). Association of functional ability and benign prostatic hyperplasia with urinary incontinence in older Korean men. *International Neurourology Journal*, *20*(2), 137-142. <https://doi.org/10.5213/inj.1630432.216>

- Patel, K. V., Guralnik, J. M., Phelan, E. A., Gell, N. M., Wallace, R. B., Sullivan, M. D., & Turk, D. C. (2019). Symptom burden among community-dwelling older adults in the United States. *Journal of the American Geriatrics Society*, *67*(2), 223-231.
<https://doi.org/10.1111/jgs.15673>
- Pecina, M., Sikora, M., Avery, E. T., Heffernan, J., Pecina, S., Mickey, B. J., & Zubieta, J. K. (2017). Striatal dopamine D2/3 receptor-mediated neurotransmission in major depression: Implications for anhedonia, anxiety and treatment response. *European Neuropsychopharmacology*, *27*(10), 977-986.
<https://doi.org/10.1016/j.euroneuro.2017.08.427>
- Peng, C. Y., Manz, B. D., & Keck, J. (2001). Modeling categorical variables by logistic regression. *American Journal of Health Behaviors*, *25*(3), 278-284.
<https://doi.org/10.5993/ajhb.25.3.15>
- Phipps L, Gray M, Call E. Single exposure to clinically relevant levels of moisture contained by an incontinence pad compromises skin health. Paper presented at: NPUAP; March, 2017; New Orleans.
- Pietak, P. A., & Rechberger, T. (2022). Overactive bladder as a dysfunction of the autonomic nervous system - A narrative review. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, *271*, 102-107. <https://doi.org/10.1016/j.ejogrb.2022.01.022>
- Price, T. K., Hilt, E. E., Dune, T. J., Mueller, E. R., Wolfe, A. J., & Brubaker, L. (2018). Urine trouble: should we think differently about UTI? *International Urogynecology Journal*, *29*(2), 205-210. <https://doi.org/10.1007/s00192-017-3528-8>
- Price, T. K., Lin, H., Gao, X., Thomas-White, K. J., Hilt, E. E., Mueller, E. R., Wolfe, A. J., Dong, Q., & Brubaker, L. (2020). Bladder bacterial diversity differs in continent and

- incontinent women: a cross-sectional study. *American Journal of Obstetrics & Gynecology*, 223(5), 729 e721-729 e710. <https://doi.org/10.1016/j.ajog.2020.04.033>
- Quaghebeur, J., Petros, P., Wyndaele, J. J., & De Wachter, S. (2021). Pelvic-floor function, dysfunction, and treatment. *European Journal of Obstetrics, Gynecology, and Reproductive Biology*, 265, 143-149. <https://doi.org/10.1016/j.ejogrb.2021.08.026>
- R Core Team (2021). *A language and environment for statistical computing*. R Foundation for Statistical Computing. Retrieved from <https://www.R-project.org/>
- Radhakrishnan, K., Xie, B., Berkley, A., & Kim, M (2016). Barriers and facilitators for sustainability of tele-homecare programs: A systematic review. *Health Services Research*, 51(1),48–75. <http://doi.org/10.1111/1475-6773.12327>.
- Ramage, A. G. (2006). The role of central 5-hydroxytryptamine (5-HT, serotonin) receptors in the control of micturition. *British Journal of Pharmacology*, 147(2), S120-131. <https://doi.org/10.1038/sj.bjp.0706504>
- Real, R., & Vargas, J. M. (1996). The probabilistic basis of Jaccard's index of similarity. *Systematic Biology*, 45(3), 380–385. <https://doi.org/10.1093/sysbio/45.3.380>
- Reis, A. M., Brito, L. G. O., Lunardi, A. L. B., Pinto, E. S. M. P., & Juliato, C. R. T. (2021). Depression, anxiety, and stress in women with urinary incontinence with or without myofascial dysfunction in the pelvic floor muscles: A cross-sectional study. *Neurourology and Urodynamics*, 40(1), 334-339. <https://doi.org/10.1002/nau.24563>
- Remler, D. K., Teresi, J. A., Weinstock, R. S., Ramirez, M., Eimicke, J. P., Silver, S., & Shea, S. (2011). Health care utilization and self-care behaviors of Medicare beneficiaries with diabetes: comparison of national and ethnically diverse underserved populations. *Population Health Management*, 14(1), 11-20. <https://doi.org/10.1089/pop.2010.0003>

- Robinson, P. N. (2012). Deep phenotyping for precision medicine. *Human Mutation*, 33(5), 777-780. <https://doi.org/10.1002/humu.22080>
- Rodrigo-Baños, V., Moral-Pairada, M. D., & González-de Paz, L. (2021). A comprehensive assessment of informal caregivers of patients in a primary healthcare home-care program. *International Journal of Environmental Research and Public Health*, 18(21), 11588. <https://doi.org/10.3390/ijerph182111588>
- Rodrigues, A. J., Leao, P., Carvalho, M., Almeida, O. F., & Sousa, N. (2011). Potential programming of dopaminergic circuits by early life stress. *Psychopharmacology*, 214(1), 107-120. <https://doi.org/10.1007/s00213-010-2085-3>
- Roy, H. A., Nettleton, J., Blain, C., Dalton, C., Farhan, B., Fernandes, A., Georgopoulos, P., Klepsch, S., Lavelle, J., Martinelli, E., Panicker, J. N., Radoja, I., Rapidi, C. A., Pereira, E. S. R., Tudor, K., Wagg, A. S., & Drake, M. J. (2020). Assessment of patients with lower urinary tract symptoms where an undiagnosed neurological disease is suspected: A report from an International Continence Society consensus working group. *Neurourology and Urodynamics*, 39(8), 2535-2543. <https://doi.org/10.1002/nau.24469>
- Rubin, E. B., Buehler, A. E., & Halpern, S. D. (2016). States worse than death among hospitalized patients with serious illnesses. *JAMA Internal Medicine*, 176(10), 1557–1559. <http://doi.org/10.1001/jamainternmed.2016.4362>
- Salisbury, C., Man, M. S., Bower, P., Guthrie, B., Chaplin, K., Gaunt, D. M., Brookes, S., Fitzpatrick, B., Gardner, C., Hollinghurst, S., Lee, V., McLeod, J., Mann, C., Moffat, K. R., & Mercer, S. W. (2018). Management of multimorbidity using a patient-centred care model: a pragmatic cluster-randomised trial of the 3D approach. *Lancet*, 392(10141), 41-50. [https://doi.org/10.1016/S0140-6736\(18\)31308-4](https://doi.org/10.1016/S0140-6736(18)31308-4)

- Scharp, D., Harkins, S. E., & Topaz, M. (2023). Comorbidities of community-dwelling older adults with urinary incontinence: A scoping review. *Geriatric Nursing*, 53, 280-294. <https://doi.org/10.1016/j.gerinurse.2023.08.005>
- Scharp, D., Hobensack, M., Davoudi, A., & Topaz, M. (2024). Natural language processing applied to clinical documentation in post-acute care settings: A scoping review. *Journal of the American Medical Directors Association*, 25(1), 69–83. <https://doi.org/10.1016/j.jamda.2023.09.006>
- Seki, S., Igawa, Y., Kaidoh, K., Ishizuka, O., Nishizawa, O., & Andersson, K. E. (2001). Role of dopamine D1 and D2 receptors in the micturition reflex in conscious rats. *Neurourology and Urodynamics*, 20(1), 105-113. [https://doi.org/10.1002/1520-6777\(2001\)20:1](https://doi.org/10.1002/1520-6777(2001)20:1)
- Shahzad, M., Upshur, R., Donnelly, P., Bharmal, A., Wei, X., Feng, P., & Brown, A. D. (2019). A population-based approach to integrated healthcare delivery: a scoping review of clinical care and public health collaboration. *BMC Public Health*, 19(708). <https://doi.org/10.1186/s12889-019-7002-z>
- Siclovan, D. M., Bang, J. T., Yakusheva, O., Hamilton, M., Bobay, K. L., Costa, L. L., Hughes, R. G., Miles, J., Bahr, S. J., & Weiss, M. E. (2021). Effectiveness of home health care in reducing return to hospital: Evidence from a multi-hospital study in the US. *International Journal of Nursing Studies*, 119, 103946. <https://doi.org/10.1016/j.ijnurstu.2021.103946>
- Siddiqui, N. Y., Ammarell, N., Wu, J. M., Sandoval, J. S., & Bosworth, H. B. (2016). Urinary incontinence and health-seeking behavior among White, Black, and Latina women. *Female Pelvic Medicine and Reconstructive Surgery*, 22(5), 340-345. <https://doi.org/10.1097/SPV.0000000000000286>

- Silay, K., Akinci, S., Ulas, A., Yalcin, A., Silay, Y. S., Akinci, M. B., Dilek, I., & Yalcin, B. (2016). Occult urinary incontinence in elderly women and its association with geriatric condition. *European Review for Medical and Pharmacological Sciences*, 20(3), 447-451.
- Smith, A. L., Hantsoo, L., Malykhina, A. P., File, D. W., Valentino, R., Wein, A. J., Sammel, M. D., & Epperson, C. N. (2016). Basal and stress-activated hypothalamic pituitary adrenal axis function in postmenopausal women with overactive bladder. *International Urogynecology Journal*, 27(9), 1383-1391. <https://doi.org/10.1007/s00192-016-2988-6>
- Smith, A. L., Wang, P. C., Anger, J. T., Mangione, C. M., Trejo, L., Rodriguez, L. V., & Sarkisian, C. A. (2010). Correlates of urinary incontinence in community-dwelling older Latinos. *Journal of the American Geriatrics Society*, 58(6), 1170-1176. <https://doi.org/10.1111/j.1532-5415.2010.02814.x>
- Sockolow, P. S., Bowles, K. H., Topaz, M., Koru, G., Helleso, R., O'Connor, M., & Bass, E. J. . (2021). The time is now: Informatics research opportunities in home health care. . *Applied Clinical Informatics*, 12(1), 100-106. <https://doi.org/https://doi.org/10.1055/S-0040-1722222/ID/JR200182IE-68>
- Sohn, K., Lee, C. K., Shin, J., & Lee, J. (2018). Association between female urinary incontinence and geriatric health problems: Results from Korean Longitudinal Study of Ageing (2006). *Korean Journal of Family Medicine*, 39(1), 10-14. <https://doi.org/10.4082/kjfm.2018.39.1.10>
- Song, J., Chae, S., Bowles, K. H., McDonald, M. V., Barron, Y., Cato, K., Rossetti, S. C., Hobensack, M., Sridharan, S., Evans, L., Davoudi, A., & Topaz, M. (2023). The identification of clusters of risk factors and their association with hospitalizations or

- emergency department visits in home health care. *Journal of Advanced Nursing*, 79(2), 593-604. <https://doi.org/10.1111/jan.15498>
- Song, J., Chang, R. W., Manheim, L. M., & Dunlop, D. D. (2006). Gender differences across race/ethnicity in use of health care among Medicare-aged Americans. *Journal of women's health (2002)*, 15(10), 1205–1213. <https://doi.org/10.1089/jwh.2006.15.1205>
- Song, J., Hobensack, M., Bowles, K. H., McDonald, M. V., Cato, K., Rossetti, S. C., Chae, S., Kennedy, E., Barron, Y., Sridharan, S., & Topaz, M. (2022). Clinical notes: An untapped opportunity for improving risk prediction for hospitalization and emergency department visit during home health care. *Journal of Biomedical Informatics*, 128, 104039. <https://doi.org/10.1016/j.jbi.2022.104039>
- Song, J., Ojo, M., Bowles, K. H., McDonald, M. V., Cato, K., Rossetti, S. C., Adams, V., Chae, S., Hobensack, M., Kennedy, E., Tark, A., Kang, M. J., Woo, K., Barron, Y., Sridharan, S., & Topaz, M. (2022). Detecting language associated with home healthcare patients' risk for hospitalization and emergency department visit. *Nursing Research*, 71(4), 285-294. <https://doi.org/10.1097/NNR.0000000000000586>
- Sprod, L. K., Fernandez, I. D., Janelins, M. C., Peppone, L. J., Atkins, J. N., Giguere, J., Block, R., & Mustian, K. M. (2015). Effects of yoga on cancer-related fatigue and global side-effect burden in older cancer survivors. *Journal of Geriatric Oncology*, 6(1), 8-14. <https://doi.org/10.1016/j.jgo.2014.09.184>
- Starfield, B., Lemke, K. W., Bernhardt, T., Foldes, S. S., Forrest, C. B., & Weiner, J. P. (2003). Comorbidity: implications for the importance of primary care in 'case' management. *Annals of Family Medicine*, 1(1), 8-14. <https://doi.org/10.1370/afm.1>

- Stenzelius, K., Mattiasson, A., Hallberg, I. R., & Westergren, A. (2004). Symptoms of urinary and faecal incontinence among men and women 75+ in relations to health complaints and quality of life. *Neurourology and Urodynamics*, 23(3), 211-222.
<https://doi.org/10.1002/nau.20030>
- Sun, M., Oliwa, T., Peek, M. E., & Tung, E. L. (2022). Negative patient descriptors: Documenting racial bias in the electronic health record. *Health Affairs*, 41(2), 203-211.
<https://doi.org/10.1377/hlthaff.2021.01423>
- Syakur, M., Khotimah, B., Rochman, E., & Satoto, B. D. (2018). Integration k-means clustering method and elbow method for identification of the best customer profile cluster. *IOP Conference Series: Materials Science and Engineering*, 336(1), 012017. <https://doi.org/10.1088/1757-899X/336/1/012017>
- Tamanini, J. T., Santos, J. L., Lebrão, M. L., Duarte, Y. A., & Laurenti, R. (2011). Association between urinary incontinence in elderly patients and caregiver burden in the city of Sao Paulo/Brazil: Health, Wellbeing, and Ageing Study. *Neurourology and urodynamics*, 30(7), 1281–1285. <https://doi.org/10.1002/nau.21040>
- Tannenbaum, C., Gray, M., Hoffstetter, S., & Cardozo, L. (2013). Comorbidities associated with bladder dysfunction. *International Journal of Clinical Practice*, 67(2), 105-113.
<https://doi.org/10.1111/ijcp.12085>
- Taylor, A., Wade, V., Morris, G., Pech, J., Rechter, S., Kidd, M., & Carati, C (2016). Technology support to a telehealth in the home service: qualitative observations. *Journal of Telemedicine and Telecare.*, 22(5),296–303.
<http://doi.org/10.1177/1357633X15601523>

- Teo, J. S., Briffa, N. K., Devine, A., Dhaliwal, S. S., & Prince, R. L. (2006). Do sleep problems or urinary incontinence predict falls in elderly women? *Australian Journal of Physiotherapy*, 52(1), 19-24. [https://doi.org/10.1016/s0004-9514\(06\)70058-7](https://doi.org/10.1016/s0004-9514(06)70058-7)
- The Regents of the University of Michigan. (2023). The Health and Retirement Study. Retrieved from <http://hrs.isr.umich.edu/>
- Thibodeau, J. T., & Drazner, M. H. (2018). The Role of the Clinical Examination in Patients With Heart Failure. *Journal of the American College of Cardiology: Heart Failure*, 6(7), 543-551. <https://doi.org/10.1016/j.jchf.2018.04.005>
- Thom, D. H., Haan, M. N., & Van Den Eeden, S. K. (1997). Medically recognized urinary incontinence and risks of hospitalization, nursing home admission and mortality. *Age and Ageing*, 26(5), 367-374. <https://doi.org/10.1093/ageing/26.5.367>
- Thom, D. H., van den Eeden, S. K., Ragins, A. I., Wassel-Fyr, C., Vittinghof, E., Subak, L. L., & Brown, J. S. (2006). Differences in prevalence of urinary incontinence by race/ethnicity. *Journal of Urology*, 175(1), 259-264. [https://doi.org/10.1016/S0022-5347\(05\)00039-X](https://doi.org/10.1016/S0022-5347(05)00039-X)
- Thomas-White, K. J., Kliethermes, S., Rickey, L., Lukacz, E. S., Richter, H. E., Moalli, P., Zimmern, P., Norton, P., Kusek, J. W., Wolfe, A. J., & Brubaker, L. (2017). Evaluation of the urinary microbiota of women with uncomplicated stress urinary incontinence. *American Journal of Obstetrics & Gynecology*, 216(1), 55 e51-55 e16. <https://doi.org/10.1016/j.ajog.2016.07.049>
- Topaz, M., Adams, V., Wilson, P., Woo, K., & Ryvicker, M. (2020). Free-Text Documentation of Dementia Symptoms in Home Healthcare: A Natural Language Processing Study. *Gerontol Geriatr Med*, 6, 2333721420959861. <https://doi.org/10.1177/2333721420959861>

- Topaz, M., Koleck, T. A., Onorato, N., Smaldone, A., & Bakken, S. (2021). Nursing documentation of symptoms is associated with higher risk of emergency department visits and hospitalizations in homecare patients. *Nursing Outlook*, 69(3), 435-446. <https://doi.org/10.1016/j.outlook.2020.12.007>
- Topaz, M., Murga, L., Bar-Bachar, O., McDonald, M., & Bowles, K. (2019). NimbleMiner: An open-source nursing-sensitive natural language processing system based on word embedding. *Computers, Informatics, Nursing*, 37(11), 583-590. <https://doi.org/10.1097/CIN.0000000000000557>
- Topaz, M., Song, J., Davoudi, A., McDonald, M., Taylor, J., Sittig, S., & Bowles, K. (2023). Home health care clinicians' use of judgment language for Black and Hispanic patients: Natural language processing study. *JMIR Nursing*, 6, e42552. <https://doi.org/10.2196/42552>
- Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., Lewin, S., ... & Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine*, 169(7), 467-473. <https://doi.org/10.7326/M18-0850>
- Tripodiadis, F., Karayannis, G., Giamouzis, G., Skoularigis, J., Louridas, G., & Butler, J. (2009). The sympathetic nervous system in heart failure physiology, pathophysiology, and clinical implications. *Journal of the American College of Cardiology*, 54(19), 1747-1762. <https://doi.org/10.1016/j.jacc.2009.05.015>

- Troko, J., Bach, F., & Tooze-Hobson, P. (2016). Predicting urinary incontinence in women in later life: A systematic review. *Maturitas*, *94*, 110-116.
<https://doi.org/10.1016/j.maturitas.2016.09.006>
- Turner, R. J., & Lloyd, D. A. (2003). Cumulative adversity and drug dependence in young adults: racial/ethnic contrasts. *Addiction*, *98*(3), 305-315. <https://doi.org/10.1046/j.1360-0443.2003.00312.x>
- Valderas, J. M., Starfield, B., Sibbald, B., Salisbury, C., & Roland, M. (2009). Defining comorbidity: Implications for understanding health and health services. *Annals of Family Medicine*, *7*(4), 357-363. <https://doi.org/10.1370/afm.983>
- Valentijn, P. P., Schepman, S. M., Opheij, W., & Bruijnzeels, M. A. (2013). Understanding integrated care: a comprehensive conceptual framework based on the integrative functions of primary care. *International Journal of Integrated Care*, *13*, e010.
<https://doi.org/10.5334/ijic.886>
- van Reijn-Baggen, D. A., Han-Geurts, I. J. M., Voorham-van der Zalm, P. J., Pelger, R. C. M., Hagens-van Miert, C. H. A. C., & Laan, E. T. M. (2022). Pelvic floor physical therapy for pelvic floor hypertonicity: A systematic review of treatment efficacy. *Sexual Medicine Reviews*, *10*(2), 209–230. <https://doi.org/10.1016/j.sxmr.2021.03.0>
- Wagg, A., Gibson, W., Ostaszewicz, J., Johnson, T., 3rd, Markland, A., Palmer, M. H., Kuchel, G., Szonyi, G., & Kirschner-Hermanns, R. (2015). Urinary incontinence in frail elderly persons: Report from the 5th International Consultation on Incontinence. *Neurourology and Urodynamics*, *34*(5), 398-406. <https://doi.org/10.1002/nau.22602>

- Wang, C., Li, J., Wan, X., Wang, X., Kane, R. L., & Wang, K. (2015). Effects of stigma on Chinese women's attitudes towards seeking treatment for urinary incontinence. *Journal of Clinical Nursing*, 24(7-8), 1112-1121. <https://doi.org/10.1111/jocn.12729>
- Wang, L., Zhou, C., Zhu, D., Wang, X., Fang, L., Zhong, J., Mao, Q., Sun, L., Gong, X., Xia, J., Lian, B., & Xie, P. (2016). Serotonin-1A receptor alterations in depression: A meta-analysis of molecular imaging studies. *BMC Psychiatry*, 16(1), 319. <https://doi.org/10.1186/s12888-016-1025-0>
- Washington, B. B., Raker, C. A., & Sung, V. W. (2011). Barriers to pelvic floor physical therapy utilization for treatment of female urinary incontinence. *American Journal of Obstetrics and Gynecology*, 205(2), 152.e1-152.e9. <https://doi.org/10.1016/j.ajog.2011.03.029>
- Whipple, M. O., Hamel, A. V., & Talley, K. M. C. (2018). Fear of falling among community-dwelling older adults: A scoping review to identify effective evidence-based interventions. *Geriatric Nursing*, 39(2), 170-177. <https://doi.org/10.1016/j.gerinurse.2017.08.005>
- Williams, K. S., Assassa, R. P., Smith, N. K., Jagger, C., Perry, S., Shaw, C., Dallosso, H., McGrother, C., Clarke, M., Brittain, K. R., Castleden, C. M., & Mayne, C. (2000). Development, implementation and evaluation of a new nurse-led continence service: A pilot study. *Journal of Clinical Nursing*, 9(4), 566-573. <https://doi.org/10.1046/j.1365-2702.2000.00386.x>
- Williams, K. S., Assassa, R. P., Cooper, N. J., Turner, D. A., Shaw, C., Abrams, K. R., Mayne, C., Jagger, C., Matthews, R., Clarke, M., McGrother, C. W., & Leicestershire MRC Incontinence Study Team (2005). Clinical and cost-effectiveness of a new nurse-led

- continence service: a randomised controlled trial. *The British Journal of General Practice: The journal of the Royal College of General Practitioners*, 55(518), 696–703.
- Willis-Gray, M. G., Sandoval, J. S., Maynor, J., Bosworth, H. B., & Siddiqui, N. Y. (2015). Barriers to urinary incontinence care seeking in White, Black, and Latina women. *Female Pelvic Medicine and Reconstructive Surgery*, 21(2), 83-86.
<https://doi.org/10.1097/SPV.0000000000000100>
- Wilson, J., & Sule, A. A. (2023). Disparity in early detection of breast cancer. In *StatPearls*. StatPearls Publishing.
- Wilson, Y., White, A., Jefferson, A., & Danis, M. (2019). Intersectionality in clinical medicine: The need for a conceptual framework. *American Journal of Bioethics*, 19(2), 8-19.
<https://doi.org/10.1080/15265161.2018.1557275>
- Woo, K., Adams, V., Wilson, P., Fu, L. H., Cato, K., Rossetti, S. C., McDonald, M., Shang, J., & Topaz, M. (2021). Identifying urinary tract infection-related information in home care nursing notes. *Journal of the American Medical Directors Association*, 22(5), 1015-1021 e1012. <https://doi.org/10.1016/j.jamda.2020.12.010>
- Woo, S. E., Jebb, A. T., Tay, L., & Parrigon, S. (2018). Putting the “person” in the center: Review and synthesis of person-centered approaches and methods in organizational science. *Organizational Research Methods*, 21(4), 814-815.
<https://doi.org/10.1177/1094428117752467>
- Woo, K., Song, J., Adams, V., Block, L. J., Currie, L. M., Shang, J., & Topaz, M. (2022). Exploring prevalence of wound infections and related patient characteristics in homecare using natural language processing. *International Wound Journal*, 19(1), 211–221.
<https://doi.org/10.1111/iwj.13623>

World Health Organization. (2019). International Classification for Nursing Practice (ICNP).

Retrieved from: <https://www.who.int/standards/classifications/other-classifications/international-classification-for-nursing-practice>

World Health Organization. (2022). International Statistical Classification of Diseases and Related Health Problems (ICD). Retrieved from:

<https://www.who.int/standards/classifications/classification-of-diseases>

World Health Organization. (2023). Ageing. Retrieved from https://www.who.int/health-topics/ageing#tab=tab_1

Yim, W. W., Yetisgen, M., Harris, W. P., & Kwan, S. W. (2016). Natural language processing in oncology: A review. *JAMA Oncology*, 2(6), 797-804.

<https://doi.org/10.1001/jamaoncol.2016.0213>

Zesiewicz, T. A., Baker, M. J., Wahba, M., & Hauser, R. A. (2003). Autonomic Nervous System Dysfunction in Parkinson's Disease. *Current Treatment Options in Neurology*, 5(2), 149-160. <https://doi.org/10.1007/s11940-003-0005-0>

Zhang, H., Cocosila, M., & Archer, N (2010). Factors of adoption of mobile information technology by homecare nurses: a technology acceptance model 2 approach. *Computers, Informatics, Nursing*, 28(1), 49–56. <http://doi.org/10.1097/NCN.0b013e3181c0474a>.

Zoorob, D., Higgins, M., Swan, K., Cummings, J., Dominguez, S., & Carey, E. (2017). Barriers to pelvic floor physical therapy regarding treatment of high-tone pelvic floor

dysfunction. *Female Pelvic Medicine & Reconstructive Surgery*, 23(6), 444–448.

<https://doi.org/10.1097/SPV.0000000000000401>

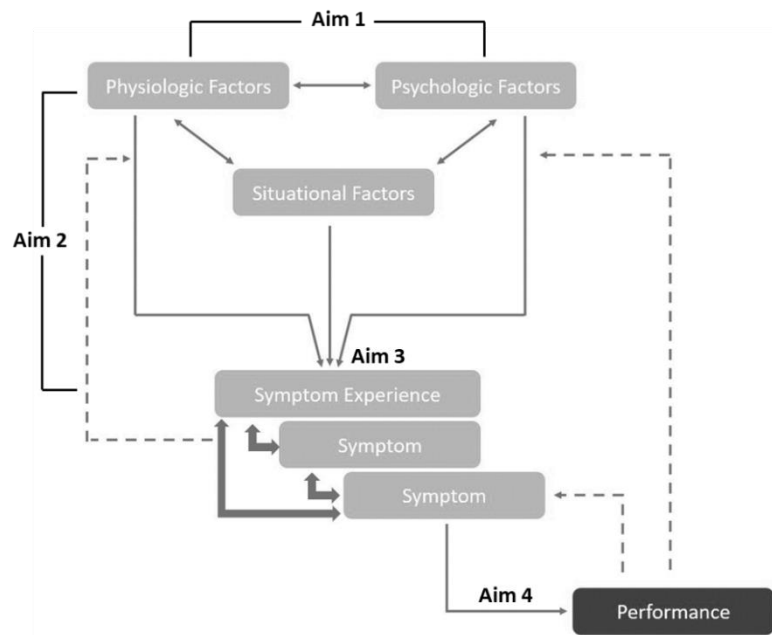
Appendix A

The Theory of Unpleasant Symptoms

The Theory of Unpleasant Symptoms provides the conceptual framework which informed this dissertation (Lenz et al., 1997). This appendix contains a revised depiction of this framework and maps each study aim to the theoretical constructs (**Figure 1**). In *Aim 1*, we addressed physiologic and psychologic factors (i.e., comorbidities) of older adults with urinary incontinence (UI) antecedent to symptom experience. In *Aim 2*, we focused on physiologic, psychologic, and situational factors antecedent to symptom experience and started to characterize symptom experience by identifying and extracting a set of symptoms. In *Aim 3*, we further characterized symptom experience by identifying symptom clusters. Lastly, in *Aim 4*, we focused on associations between these antecedents, symptom experience, and performance outcomes, operationalized as emergency department visits or hospitalizations.

Figure 1

Study Aims Mapped to the Theory of Unpleasant Symptoms (revised) (Lenz et al., 1997)



Appendix B

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping

Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	13
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	14-17
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	18
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	18
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	18-20
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	20

Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	20, 39-40
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	21
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	21
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	21
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	21-22
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	22
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	22-23, 61
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	23-24, 41-46
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	24-26. 47-58
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	26, 59-60
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	26-28

DISCUSSION

Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to review questions and objectives, and consider relevance to key groups.	29-36
Limitations	20	Discuss the limitations of the scoping review process.	36-37
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	37-38

FUNDING

Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.
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Note. JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med.* 2018;169:467–473. doi: 10.7326/M18-0850.

Appendix C

This appendix contains study variables mapped to the Theory of Unpleasant Symptoms' (Lenz et al., 1997) model dimensions. In **Table 1**, study variables, operational definitions, and measurement are specified.

Table 1*Study Variables Mapped to the Theoretical Model Dimensions, Operational Definitions, and Measurement*

Theoretical model dimension	Dimension definition	Variable	Operational definition	Measurement	Level of measurement
Physiologic factors	Normally functioning organ systems or pathologic processes that affect an individual's health status.	Comorbid conditions: Cardiovascular disease Diabetes Kidney disease Stroke	Presence of a comorbid diagnosis related to organ systems identified as common conditions among older adult HHC patients (Murtaugh et al., 2009; Scharp et al., 2023) at the time of HHC admission.	OASIS item M1028	Categorical, binary
		Urinary tract infection within the past 14 days	Diagnosed with and treated for a urinary tract infection within 14 days prior to HHC admission.	OASIS item M1600	Categorical, binary
		Unhealed skin ulcer	Presence of an unhealed skin ulcer stage two or higher at the time of admission to HHC.	OASIS item M1360	Categorical, binary

Psychologic factors	An individual's mental state or mood, reaction to illness, or degree of knowledge or uncertainty about symptoms.	Comorbid diagnoses: Depression	Presence of a comorbid diagnosis related to mental state identified as common conditions among older adult HHC patients (Murtaugh et al., 2009; Scharp et al., 2023) at the time of HHC admission.	OASIS item M1028	Categorical; binary
		Decline in mental or behavioral status	Change or deterioration in cognitive or emotional functioning since the last assessment was performed prior to HHC admission.	OASIS item M1360	Categorical, binary
Situational factors	Attributes of the physical and social environment that affect an individual's experience and prevalence of symptoms.	Age	Age in years at the time of admission to HHC.	OASIS item M0066	Continuous; ratio
		Sex	Patient sex documented by the clinician at the time of admission to HHC.	OASIS item M0069	Categorical; binary
		Race or ethnicity	Race or ethnicity documented by the clinician at the time of admission to HHC with the following response options: American Indian or Alaskan Native	OASIS item M0140	Categorical; multi-level (Aims 2 and 4), binary (Aim 3)

(i.e., Native American), Asian, Black, Hispanic, Native Hawaiian or Pacific Islander (i.e., Pacific Islander), or White. The Asian/Pacific Islander category combined patients reported as either Asian or Native Hawaiian or Pacific Islander. The multi-racial category included patients with more than one race or ethnicity selected.

Living arrangements	Living status documented by the clinician at the time of admission to HHC: alone or not alone (i.e., with others, congregate).	OASIS item M1100	Categorical; binary
Caregiver assistance with ADLs	Whether a patient had caregiver(s) likely to provide assistance with ADLs, caregiver(s) not likely to provide assistance with ADLs (i.e., may require assistance but have caregivers who are not	OASIS item M2100	Categorical, multi-level

	willing or able to provide assistance), or no assistance needed at the time of admission to HHC.		
Functional status	The sum of nine binary fields (i.e., 0 indicates no issue, 1 indicates moderate/significant issue) including OASIS items that described the patient's ability to perform the following ADLs at the time of admission to HHC: grooming, dressing lower body, dressing upper body, bathing, toilet transferring, toilet hygiene, transferring, ambulating, and eating.	OASIS items M1800, M1810, M1820, M1830, M1840, M1845, M1850, M1860, and M1870	Continuous, ratio
Taking five or more medications	Medication regimen including five or more prescribed or over-the-counter medications at the time of HHC admission.	OASIS item M1033	Categorical, binary

Symptom experience	Indicators of change in normal physiology or behavior as perceived by an individual which pose threats to health and risks for adverse outcomes.	History of falls (two or more)	Having a history of two or more falls (injurious or non-injurious) at any time prior to HHC admission.	OASIS item M1033	Categorical, binary
		Urinary incontinence	The involuntary leakage of urine; UI status documented by the clinician at the time of admission to HHC.	OASIS item M1610	Categorical; binary
		Anxiety	At least one occurrence of documentation by a clinician of anxiety or an anxiety-related term within the NLP algorithm vocabulary in the clinical notes at any time during the HHC episode.	Clinical notes; NLP	Categorical, binary
		Constipation	At least one occurrence of documentation by a clinician of constipation or a constipation-related term within the NLP algorithm vocabulary in the clinical notes at any time during the HHC episode.	Clinical notes; NLP	Categorical, binary

Dizziness	At least one occurrence of documentation by a clinician of dizziness or a dizziness-related term within the NLP algorithm vocabulary in the clinical notes at any time during the HHC episode.	Clinical notes; NLP	Categorical, binary
Syncope	At least one occurrence of documentation by a clinician of syncope or a syncope-related term within the NLP algorithm vocabulary in the clinical notes at any time during the HHC episode.	Clinical notes; NLP	Categorical, binary
Tachycardia	At least one occurrence of documentation by a clinician of tachycardia or a tachycardia-related term within the NLP algorithm vocabulary in the clinical notes at any time during the HHC episode.	Clinical notes; NLP	Categorical, binary

Urinary frequency/urgency	At least one occurrence of documentation by a clinician of urinary frequency/urgency or a urinary frequency/urgency-related term within the NLP algorithm vocabulary in the clinical notes at any time during the HHC episode.	Clinical notes; NLP	Categorical, binary
Urinary hesitancy/retention	At least one occurrence of documentation by a clinician of urinary hesitancy/retention or a urinary hesitancy/retention-related term within the NLP algorithm vocabulary in the clinical notes at any time during the HHC episode.	Clinical notes; NLP	Categorical, binary
Vision impairment/blurred vision	At least one occurrence of documentation by a clinician of vision impairment/blurred vision or a vision impairment/blurred vision-related term within the NLP	Clinical notes; NLP	Categorical, binary

			algorithm vocabulary in the clinical notes at any time during the HHC episode.		
Performance	The outcome or effect of the symptom experience, including physical role performance indicators experienced by patients and assessed by clinicians to inform decision-making about transferring to a higher level of care.	Acute care utilization (i.e., ED visit/hospitalization)	Receipt of emergent care or transfer to an inpatient facility during a HHC episode.	OASIS items M2300 and M0100	Categorical, binary

Note. Theoretical model dimensions derived from the Theory of Unpleasant Symptoms (Lenz et al., 1997).

HHC, home healthcare; OASIS, Outcome Assessment and Information Set; ADLs, activities of daily living; UI; urinary incontinence,

NLP; natural language processing

Appendix D

This appendix comprises the full results of the expert clinician-driven Delphi survey rounds conducted to identify symptoms among older adults with urinary incontinence (UI) (*Chapter 3: Applying Natural Language Processing to Understand Symptoms Among Older Adult Home Healthcare Patients with Urinary Incontinence*). Below is a summary of the comorbidity selection process based on literature review (**Table 1**) and symptom selection process based on clinical nursing expertise (**Tables 2-6**).

Table 1*Summary of Process to Develop a List of Comorbidities Among Older Adult Home Healthcare**Patients with Urinary Incontinence Based on Literature Review*

Comorbidities of community-dwelling older adults with UI per scoping review (Scharp et al., 2023)	Most prevalent comorbidities among older adult HHC patients (Murtaugh et al., 2009)	Comorbidities retained to develop symptom list
Stroke	Hypertension	Stroke
Cerebrovascular disease	Diabetes mellitus	Heart failure
Parkinson's	Arthritis	Heart disease
Heart failure	Heart failure	Hypertension
Heart disease	COPD	Diabetes mellitus
Hypertension	Heart disease	Depression
Diabetes mellitus	Cardiac dysrhythmia	COPD
Anxiety	Stroke	Benign prostatic obstruction
Depression	Dementia	
COPD	Neurological diseases other than Alzheimer's and other cerebral degeneration	
Benign prostatic obstruction (genitourinary disease)	Alzheimer's	
Arthritis	Cancer	
Sarcopenia	Depression	
	Peripheral vascular disease	
	Chronic hepatic renal disease	
	Skin ulcer	
	AIDS/HIV	
	Genitourinary disease	

Note. UI, urinary incontinence; COPD, chronic obstructive pulmonary disease; AIDS/HIV, acquired immunodeficiency syndrome/human immunodeficiency virus

Table 2*Initial Symptom List for Delphi Survey Round One Based on Team Clinical Nursing Expertise*

Comorbidity	Symptom list round one
Arthritis	Back pain Fatigue Joint pain Joint stiffness
Benign prostatic obstruction	Nocturia Urinary frequency Urinary hesitancy Urinary retention Urinary urgency
COPD	Chest tightness Cough Dyspnea Dyspnea on exertion Shortness of breath Wheezing
Diabetes mellitus	Fatigue Numbness/tingling Polydipsia Polyphagia Urinary frequency Vision impairment/ blurred vision
Depression	Anxiety Constipation Insomnia Impaired cognition Fatigue Loss of interest Poor appetite Sadness
Heart disease	Chest pain Dizziness

	Fatigue Swelling Syncope Tachycardia
Heart failure	Cough Dyspnea on exertion Fatigue Orthopnea Shortness of breath Swelling Tachycardia Wheezing
Hypertension	Dizziness Epistaxis Headache Shortness of breath Nausea
Stroke	Dysarthria Dysphagia Hemiparesis Impaired cognition Insomnia Joint pain Muscle pain Paralysis Weakness

Table 3

Expert Clinician-Driven Delphi Survey Round One Results

Symptom	Nurse 1 response	Nurse 2 response	Nurse 3 response	Nurse 4 response	Nurse 5 response	Total “yes” responses
Anxiety	Yes	No	No	Yes	Yes	3
Back pain	No	No	No	No	No	0
Chest pain	Yes	No	No	No	No	1

Chest tightness	Yes	No	No	No	No	1
Constipation	Yes	Yes	Yes	Yes	Yes	5
Cough	Yes	No	No	No	No	1
Dizziness	Yes	Yes	Yes	Yes	Yes	5
Dysarthria	Yes	Yes	No	No	No	2
Dysphagia	Yes	Yes	No	No	Yes	3
Dyspnea	Yes	No	No	Yes	No	2
Dyspnea on exertion	Yes	No	No	Yes	No	2
Epistaxis	No	No	No	No	No	0
Fatigue	No	Yes	No	Yes	Yes	3
Headache	No	No	Yes	Yes	Yes	3
Hemiparesis	No	No	No	No	No	0
Impaired cognition	No	No	No	No	Yes	1
Insomnia	No	No	No	No	Yes	1
Joint pain	Yes	No	No	No	No	1
Joint stiffness	Yes	No	No	No	No	1
Loss of interest	No	No	No	Yes	No	1
Muscle pain	Yes	No	No	No	No	1
Nausea	No	No	No	No	No	0
Nocturia	Yes	No	Yes	Yes	No	3
Numbness/tingling	Yes	Yes	No	Yes	No	3

Orthopnea	Yes	No	No	Yes	No	2
Paralysis	No	No	No	Yes	No	1
Polydipsia	Yes	No	Yes	Yes	No	3
Polyphagia	No	No	Yes	No	No	1
Poor appetite	Yes	Yes	No	Yes	No	3
Sadness	No	No	No	Yes	No	1
Shortness of breath	Yes	No	No	Yes	Yes	3
Swelling	No	No	Yes	No	No	1
Syncope	Yes	No	Yes	Yes	Yes	4
Tachycardia	Yes	Yes	Yes	Yes	Yes	5
Urinary frequency	Yes	No	Yes	Yes	Yes	4
Urinary hesitancy	Yes	Yes	Yes	No	No	3
Urinary retention	Yes	Yes	Yes	Yes	Yes	5
Urinary urgency	Yes	No	Yes	Yes	No	3
Vision impairment/ blurred vision	Yes	Yes	Yes	Yes	Yes	5
Weakness	Yes	Yes	Yes	Yes	Yes	5
Wheezing	Yes	No	No	No	No	1

Note. Symptoms with three or more “yes” responses were retained

Table 4*Expert Clinician-Driven Delphi Survey Round Two Results*

Symptom	Nurse 1 response	Nurse 2 response	Nurse 3 response	Nurse 4 response	Nurse 5 response	Mean
Anxiety	3	2	3	2	4	2.8
Constipation	4	5	5	2	5	4.2
Dizziness	5	5	2	5	5	4.4
Dysphagia	4	5	3	2	4	3.6
Fatigue	3	3	2	4	5	3.4
Headache	2	3	2	3	2	2.4
Nocturia	4	3	2	4	1	2.8
Numbness/tingling	1	4	3	4	2	2.8
Polydipsia	2	2	2	3	1	2
Poor appetite	3	2	2	1	2	2
Shortness of breath	4	4	1	3	2	2.8
Syncope	5	3	5	4	5	4.4
Tachycardia	5	3	5	3	5	4.2
Urinary frequency	4	3	4	3	5	3.8
Urinary hesitancy	5	4	5	3	2	3.8
Urinary retention	5	5	5	4	5	4.8
Urinary urgency	5	4	4	3	3	3.8
Vision impairment/blurred vision	4	5	2	4	4	3.8
Weakness	3	4	3	4	4	3.6

Note. Symptoms with a mean of 3 or higher were retained

Table 5*Expert Clinician-Driven Delphi Survey Round Three Results*

Symptom	Nurse 1 response	Nurse 2 response	Nurse 3 response	Nurse 4 response	Nurse 5 response	Median
Constipation	Strongly agree	Strongly agree	Strongly agree	Agree	Strongly agree	5
Dizziness	Strongly agree	Strongly agree	Agree	Strongly agree	Strongly agree	5
Dysphagia	Neither	Disagree	Neither	Neither	Agree	3
Fatigue	Agree	Agree	Agree	Agree	Strongly agree	4
Syncope	Strongly agree	Agree	Strongly agree	Strongly agree	Strongly agree	5
Tachycardia	Strongly agree	Neither	Strongly agree	Strongly agree	Strongly agree	5
Urinary frequency	Strongly agree	Strongly agree	Agree	Agree	Strongly agree	5
Urinary hesitancy	Strongly agree	Agree	Strongly agree	Agree	Neither	5
Urinary retention	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	5
Urinary urgency	Strongly agree	Agree	Agree	Agree	Agree	5
Vision impairment/blurred vision	Strongly agree	Strongly agree	Agree	Strongly agree	Agree	5
Weakness	Agree	Neither	Agree	Strongly agree	Agree	4

Note. Symptoms with the median in the level of strongly agree (i.e., 5) and all scores between neither agree nor disagree and strongly agree were retained.

Table 6*Summary of Symptom Selection Process in Expert Clinician-Driven Delphi Survey Rounds*

Symptom list for Delphi survey round two (n=19)	Symptom list for Delphi survey round three (n=12)	Final symptom list to develop preliminary vocabulary for NLP algorithm (n=8)
Anxiety	Constipation	Anxiety
Constipation	Dizziness	Constipation
Dizziness	Dysphagia	Dizziness
Dysphagia	Fatigue	Syncope
Fatigue	Syncope	Tachycardia
Headache	Tachycardia	Urinary frequency/urgency
Nocturia	Urinary frequency	Urinary hesitancy/retention
Numbness/tingling	Urinary hesitancy	Vision impairment/blurred vision
Polydipsia	Urinary retention	
Poor appetite	Urinary urgency	
Shortness of breath	Vision impairment/blurred vision	
Syncope	Weakness	
Tachycardia		
Urinary frequency		
Urinary hesitancy		
Urinary retention		
Urinary urgency		
Vision impairment/blurred vision		
Weakness		

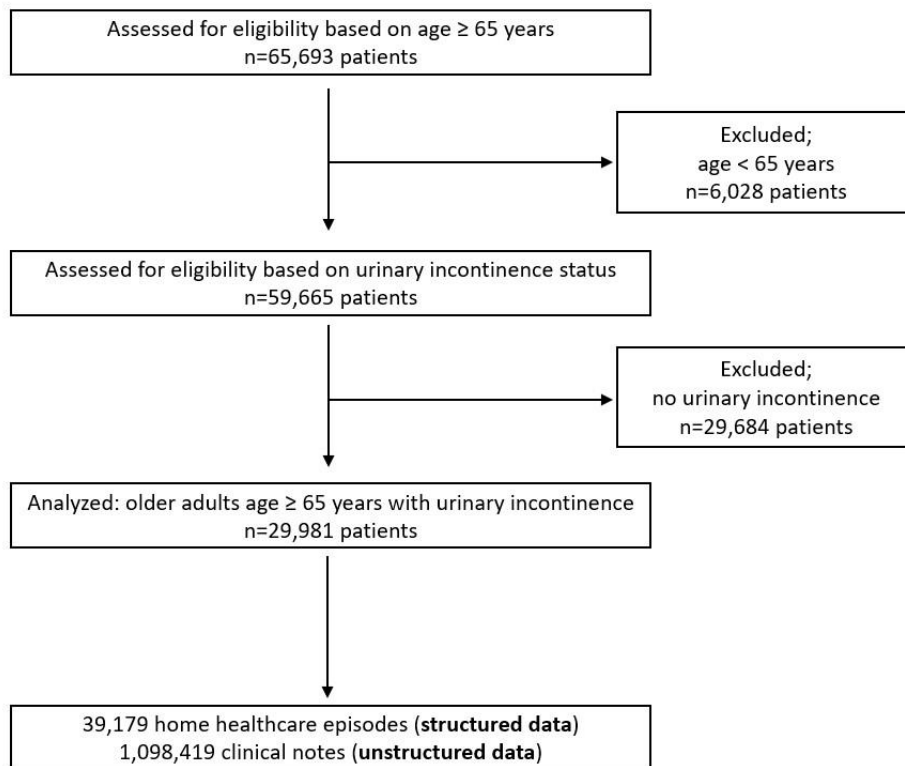
Note. NLP, natural language processing

Appendix E

This appendix contains a depiction of the sample selection process (**Figure 1**) for the studies conducted in *Chapter 3: Applying Natural Language Processing to Understand Symptoms Among Older Adult Home Healthcare Patients with Urinary Incontinence*, *Chapter 4: Characterizing Symptom Clusters for Older Adults with Urinary Incontinence in Home Healthcare*, and *Chapter 5: Risk Factors for Emergency Department Visits or Hospitalizations Among Older Adults with Urinary Incontinence in Home Healthcare*. Based on the inclusion and exclusion criteria, the final sample included 39,179 home healthcare episodes containing 1,098,419 free-text clinical notes for 29,981 distinct patients.

Figure 1

Sample Selection Process



Appendix F

Multicollinearity was evaluated for confounders in *Chapter 3* and *Chapter 5* by calculating variance inflation factors (VIFs). VIFs are used to determine the degree of correlation between confounders in multivariable regression models (Kim, 2019). Highly correlated confounders may produce inflated regression coefficients and misleading statistical results (Kim, 2019). In *Chapter 3: Applying Natural Language Processing to Understand Symptoms Among Older Adult Home Healthcare Patients with Urinary Incontinence*, VIFs for all confounders were less than five, indicating that multicollinearity was not present (Kim, 2019) (**Table 1**). In *Chapter 5: Risk Factors for Emergency Department Visits or Hospitalizations Among Older Adults with Urinary Incontinence in Home Healthcare*, VIFs for all confounders were less than five, indicating that multicollinearity was not present (Kim, 2019) (**Table 2**).

Table 1*Variance Inflation Factors for Confounders in Multivariable Regression Model Evaluating**Associations Between Race or Ethnicity and Symptom Documentation (Chapter 3)*

Variable	VIF
Race	1.086
Age	1.076
Sex	1.034
Caregiver assistance with ADLs	1.035
Living arrangements	1.051
Depression	1.010
Diabetes	1.054
Stroke	1.018
Cardiovascular disease	1.009
Kidney disease	1.011

Note. VIF, variance inflation factor; ADLs, activities of daily living**Table 2***Variance Inflation Factors for Confounders in Multivariable Regression Model Evaluating**Associations Between Symptom Clusters and Emergency Department Visits or Hospitalizations**(Chapter 5)*

Variable	VIF
Cluster 1	1.056
Cluster 2	1.040
Cluster 3	1.034
Cluster 4	1.023
Asian/Pacific Islander	1.047
Black	1.129
Hispanic	1.122
Sex	1.024
Taking five or more medications	1.027
Decline in mental/behavioral status	1.009
Unhealed skin ulcer	1.032
UTI past 14 days	1.006
Diabetes	1.079
Cardiovascular disease	1.029
Kidney disease	1.017

Note. VIF, variance inflation factor; UTI, urinary tract infection

Appendix G

This appendix includes the full output of the Chi-square tests used to examine group differences between documented symptoms in free-text clinical notes from home healthcare (HHC) episodes for older adults with urinary incontinence and race or ethnicity (*Chapter 3: Applying Natural Language Processing to Understand Symptoms Among Older Adult Home Healthcare Patients with Urinary Incontinence*). Below are the bivariate comparisons showing significant differences of proportions compared with HHC episodes for White patients as the reference group (**Table 1**).

Table 1*Output of Bivariate Comparisons of Symptom Presence in Clinical Notes by Race or Ethnicity (n=39,004)*

Symptom	Race or Ethnicity	χ^2	df	p-value
Anxiety	Asian/Pacific Islander	112.16	1	< .001
	Black	215.97		< .001
	Hispanic	43.91		< .001
	White	-		-
Constipation	Asian/Pacific Islander	0.98038	1	.322
	Black	18.916		< .001
	Hispanic	1.505		.220
	White	-		-
Dizziness	Asian/Pacific Islander	831.76	1	< .001
	Black	2016.3		< .001
	Hispanic	1365.3		< .001
	White	-		-
Syncope	Asian/Pacific Islander	3.8819	1	.050
	Black	0.73431		.392
	Hispanic	0.19325		.660
	White	-		-
Tachycardia	Asian/Pacific Islander	0.008348	1	.927
	Black	0.18807		.665
	Hispanic	0.32591		.568
	White	-		-

Urinary frequency/urgency	Asian/Pacific Islander	4.3145	1	< .05
	Black	14.924		< .001
	Hispanic	1.6627		.197
	White	-		-
Urinary hesitancy/retention	Asian/Pacific Islander	0.075502	1	.784
	Black	5.084		< .05
	Hispanic	1.2673e-25		.990
	White	-		-
Vision impairment/blurred vision	Asian/Pacific Islander	2.2079	1	.137
	Black	11.65		< .001
	Hispanic	0.39111		.531
	White	-		-

Source. Author's calculations based on VNS Health electronic health record data, January 1, 2015 – December 31, 2017.

Note. df, degrees of freedom

Appendix H

This appendix contains the full output of the logistic regression models used to analyze associations between race or ethnicity and documentation of any symptoms (i.e., anxiety, constipation, dizziness, syncope, tachycardia, urinary frequency/urgency, urinary hesitancy/retention, vision impairment/blurred vision) in free-text clinical notes from home healthcare episodes for older adults with urinary incontinence (*Chapter 3: Applying Natural Language Processing to Understand Symptoms Among Older Adult Home Healthcare Patients with Urinary Incontinence*). Below are the unadjusted and adjusted odds ratios for race or ethnicity and any symptoms (**Table 1**). Model two is adjusted for age, patient sex, caregiver assistance with activities of daily living, living arrangements, cardiovascular disease, depression, diabetes, kidney disease, and stroke.

Table 1*Output of Logistic Regression Models Examining Symptom Documentation by Race or Ethnicity**(n=39,004)*

	Estimate	SE	z-value	p-value	OR	95% CI
Model 1: unadjusted						
Asian/Pacific Islander	-0.306	0.047	-6.558	< .001	0.74	0.67 – 0.81
Black	-0.372	0.032	-11.705	< .001	0.69	0.65 – 0.73
Hispanic	-0.099	0.033	-2.962	.003	0.91	0.85 – 0.97
Model 2: adjusted						
Asian/Pacific Islander	-0.289	0.047	-6.127	< .001	0.75	0.69 – 0.83
Black	-0.411	0.033	-12.427	< .001	0.66	0.62 – 0.71
Hispanic	-0.132	0.034	-3.848	.001	0.88	0.82 – 0.94

Source. Author's calculations based on VNS Health electronic health record data, January 1,

2015 – December 31, 2017.

Note. Model 2 is adjusted for age, patient sex, caregiver assistance, living arrangements, cardiovascular disease, depression, diabetes, kidney disease, and stroke.

SE, standard error; OR, odds ratio; CI, confidence interval

Appendix I

This appendix contains the full output of the Chi-square tests used to examine differences between sociodemographic and clinical characteristics across five distinct symptom clusters (*Chapter 4: Characterizing Symptom Clusters for Older Adults with Urinary Incontinence in Home Healthcare*). Below are the bivariate comparisons showing significant differences of proportions compared with *Cluster 5* (no symptoms) as the reference group (**Table 1**).

Table 1*Output of Bivariate Comparisons of Sociodemographic and Clinical Characteristics by Symptom**Cluster (n=39,179)*

Characteristic	Cluster	χ^2	df	p-value
Sex (female)	1	78.456	1	< .001
	2	0.92701	1	.336
	3	2.9485	1	.086
	4	11.884	1	< .001
	5	-	-	-
Race (Other)	1	191.55	1	< .001
	2	3.3889	1	.066
	3	3.02	1	.082
	4	20.596	1	< .001
	5	-	-	-
Living status (alone)	1	24.676	1	< .001
	2	11.521	1	< .001
	3	50.67	1	< .001
	4	.001	1	.972
	5	-	-	-
Cardiovascular disease	1	9.3014	1	< .01
	2	155.11	1	< .001
	3	44.7	1	< .001
	4	1.2195	1	.270
	5	-	-	-
Diabetes	1	15.975	1	< .001
	2	0.0042799	1	.948
	3	1.7736	1	.183
	4	1.7736	1	.184
	5	-	-	-
Depression	1	158	1	< .001
	2	3.4548	1	.063
	3	11.46	1	< .001
	4	40.284	1	< .001
	5	-	-	-
Kidney disease	1	5.1883	1	< .05

	2	0.51474	1	.473
	3	0.48477	1	.486
	4	5.9708	1	< .05
	5	-	-	-
Stroke	1	0.77425	1	.379
	2	1.2119	1	.271
	3	0.08652	1	.769
	4	1.4476	1	.229
	5	-	-	-
Taking five or more medications	1	0.39608	1	.529
	2	5.0728	1	< .05
	3	15.468	1	< .001
	4	16.196	1	< .001
	5	-	-	-
History of falls (two or more)	1	83.137	1	< .001
	2	54.755	1	< .001
	3	59.06	1	< .001
	4	6.5822	1	< .05
	5	-	-	-
Decline in mental/behavioral status	1	71.364	1	< .001
	2	0.58612	1	.444
	3	9.4189	1	< .01
	4	0.11207	1	.738
	5	-	-	-

Source. Author's calculations based on VNS Health electronic health record data, January 1, 2015 – December 31, 2017.

Note. Cluster 1 is characterized by anxiety. Cluster 2 is characterized as broadly symptomatic. Cluster 3 is characterized by dizziness and anxiety. Cluster 4 is characterized by constipation, anxiety, and dizziness. Cluster 5 is characterized by no symptoms. 'Other' race category includes home healthcare episodes for Asian/Pacific Islander, Black, multi-racial, and Native American patients.

df, degrees of freedom

Appendix J

This appendix comprises the full output of the backward stepwise logistic regression used to analyze associations between sociodemographic characteristics, clinical factors, and symptoms clusters and emergency department (ED) visits or hospitalizations (*Chapter 5: Risk Factors for Emergency Department Visits or Hospitalizations Among Older Adults with Urinary Incontinence in Home Healthcare*). Below are the adjusted odds ratios of the sociodemographic, clinical, and symptom cluster variables and ED visits/hospitalizations (**Table 1**).

Table 1*Output of Stepwise Logistic Regression to Select a Subset of Variables Significantly Associated with Risk of Emergency Department**Visits or Hospitalizations Among Home Healthcare Episodes for Older Adults with Urinary Incontinence (n=39,179)*

Variable	Estimate	SE	z-value	p-value	OR	95% CI
Symptom cluster						
1: Anxiety	0.323	0.040	8.049	< .001	1.38	1.28 – 1.49
2: Broadly symptomatic	0.693	0.053	13.138	< .001	2.00	1.80 – 2.22
3: Dizziness and anxiety	0.440	0.060	7.388	< .001	1.55	1.38 – 1.75
4: Constipation, anxiety, and dizziness	0.389	0.071	5.482	< .001	1.48	1.28 – 1.70
Sex (female)	-0.120	0.032	-3.748	< .001	0.89	0.83 – 0.94
Race						
Asian/Pacific Islander	-0.227	0.063	-3.599	< .001	0.80	0.70 – 0.90
Black	0.267	0.038	7.103	< .001	1.31	1.21 – 1.41
Ethnicity						
Hispanic	0.318	0.041	7.794	< .001	1.37	1.27 – 1.49
Comorbidities						
Cardiovascular disease	0.284	0.036	7.826	< .001	1.33	1.24 – 1.43
Diabetes	0.276	0.030	9.104	< .001	1.32	1.24 – 1.40
Kidney disease	0.627	0.072	8.672	< .001	1.87	1.62 – 2.16
Risk for hospitalization						
Taking five or more medications	0.229	0.039	5.813	< .001	1.26	1.16 – 1.36
Decline in mental or behavioral status	0.115	0.034	3.403	< .001	1.12	1.05 – 1.20
UTI within the past 14 days	0.261	0.046	5.662	< .001	1.30	1.19 – 1.42
Unhealed skin ulcer	0.715	0.033	21.698	< .001	2.04	1.92 – 2.18

Source. Author's calculations based on VNS Health electronic health record data, January 1, 2015 – December 31, 2017.

Note. SE, standard error; OR, odds ratio; CI, confidence interval; UTI, urinary tract infection