Novel Electronic Health Record Strategies to Identify Frailty Among Hospitalized Older Adults with Multiple Chronic Conditions

Julia V. Loewenthal, MD[1,2], *Natalie C. Ernecoff, PhD, MPH*[3], *and Anuj K. Dalal, MD*[2,4]

[1]Division of Aging, Brigham and Women's Hospital, Boston, MA, USA; [2]Harvard Medical School, Boston, MA, USA; [3]RAND, Pittsburgh, PA, USA; [4]Division of General Internal Medicine, Brigham and Women's Hospital, Boston, MA, USA

ABSTRACT

A growing number of aging adults are living with multiple chronic conditions (MCC). Older adults living with MCC are predisposed to developing frailty, a state of decreased physiologic reserve that increases risk for geriatric syndromes and associated morbidity and mortality. The electronic frailty index (eFI) is computed passively using structured EHR data and can aid in prospective screening. Unfortunately, certain diagnoses, such as functional status assessments in unstructured documentation, are less likely captured by eFI, potentially underestimating the degree of frailty. Here, we discuss current gaps for using eFI to identify frail older adults living with MCC, and artificial intelligence (AI) approaches to enhance eFI accuracy. Accurate and routine frailty assessment can aid the generalist providing care to older adults living with MCC across multiple care settings to optimize physiologic reserve for these vulnerable patients.

J Gen Intern Med 40(6):1275–9
DOI: 10.1007/s11606-024-09227-2

THE POPULATION OF OLDER ADULTS LIVING WITH MULTIPLE CHRONIC CONDITIONS IS GROWING

A growing number of aging adults are living with multiple chronic conditions (MCC), defined as the co-occurrence of two or more chronic physical or mental health conditions. The prevalence of people living with MCC is estimated to be 55–98% in adults age 65 and older.[1] Older persons living with MCC often receive fragmented healthcare services across multiple care settings and institutions, and have worse outcomes. In addition, adults living with MCC account for a disproportionate share of healthcare utilization, including 70% of hospitalizations and 71% of all healthcare spending.[2] Transforming care for patients living with MCC is a high-level priority for both patients and payors. As US hospitals increasingly care for a growing population of older adults living with MCC, it is imperative that health systems develop strategies to prospectively identify high-risk patients to improve patient-centered care and prevent adverse health outcomes.

Prior Presentations *None.*

Received June 28, 2024
Accepted November 19, 2024
Published online December 4, 2024

OLDER ADULTS LIVING WITH MCC ARE AT INCREASED RISK FOR DEVELOPING FRAILTY AND POOR HEALTH OUTCOMES

Frailty can be defined as a state of decreased physiologic reserve that develops as biological deficits accumulate with age and assessed on a spectrum from fit to severely frail.[3] Frailty often coexists with chronic diseases, with odds for frailty increasing in proportion to the number of conditions.[4–6] Older adults with frailty are at higher risk for poor health outcomes including increased healthcare utilization, disability, long-term institutionalization, and mortality.[7] In addition, frail older adults are at risk of developing geriatric syndromes, or clinical conditions common among older adults that do not fit into discrete organ-based disease categories (e.g., delirium, dementia, falls), which can, in turn, worsen frailty (Fig. 1).[8] Geriatric syndromes are highly prevalent (Table 1), tend to co-occur, and are often under-recognized. Studies have suggested that hospital clinicians do not document geriatric syndromes in 33 to 95% of cases.[9–11] Even when recognized, they are not reliably communicated using structured documentation tools such as the EHR's problem list.

STRATEGIES TO SCREEN OLDER ADULTS LIVING WITH MCC FOR FRAILTY AND EARLIER INTERVENTION

Because frailty denotes vulnerability in older adults with MCC and is associated with a high burden of other geriatric syndromes (e.g., falls, functional decline), prospective screening for frailty has potential for earlier intervention to increase physiologic reserve, mitigate stressors, and decrease morbidity.[12] In fact, in August 2024, the Centers for Medicare & Medicaid Services included a new Age-Friendly Hospital Measure as part of the Hospital Inpatient Quality Reporting (IQR) Program. Beginning in 2025, hospitals that participate in the IQR Program will be required to report whether they implement frailty screening and intervention,

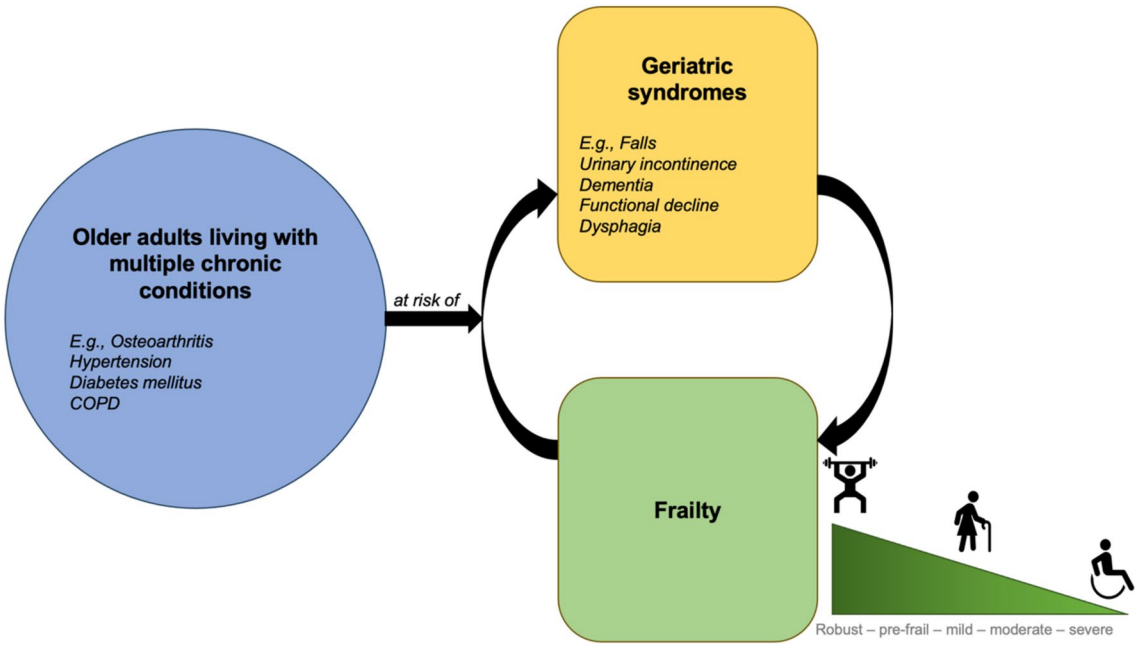

Figure 1 Older adults with multiple chronic conditions (MCC) are at risk for developing frailty, which increases risk for developing geriatric syndromes. Geriatric syndromes, in turn, can drive worsening frailty.

Table 1 Prevalence of Geriatric Syndromes for Older Adult Patients Exposed to Hospital Care by Age-Friendly Health System[33] "M" Domain (Mobility, Mentation, Medications, and What Matters)

Age-Friendly Health Systems "M" domain	Geriatric syndrome	Estimated prevalence		
		Admission	Discharge	3 months after discharge
Mobility	Functional impairment (ADLs/iADLs)	62.3–70.7%[34,35]	53.9%[35]	42.5%[34]
	Mobility impairment	54.6%[34]		52.7%[34]
	Fear of falling	40.6%[34]		
	Fall in 90 days prior to admission	39.2–42%[11,35]		
	Fall in hospital		6.4%[35]	
	Incontinence (bladder or bowel)	37–44%[34,35]	35.3–38.6%[11,35]	
	Frailty	27–87%[36–41]		
	Sarcopenia	23–24%[42]		
Mentation and Mood	Cognitive impairment (e.g., mild cognitive impairment or dementia)	20–34.3%[11,34,35,43]	32.6%[35]	
	Delirium	8.2–18.4%[11,35,43]	3.8%[35]	
	Depressive symptoms (including apathy)	57.5%[34]	29.9%[11]	
	Pain	37–40%[34]	22.3%[11]	
	Sleep disturbance (e.g., insomnia, OSA)	40–80%[44–46]		
	Hearing impairment			
Medications	Polypharmacy (≥5 medications)	84%[47]	95%[47]	
What Matters and Other	Malnutrition	37–40%[34]	32.8%[11]	
	Fatigue	77.2%[34]		48.1%[34]
	Dysphagia	22.8–82.4%[48–50]		
	Pressure injury	4.9%[35]	5.7–14.9%[11,35]	
	Social isolation			
	Loneliness	37%[51]		
	Caregiver stress			
	Elder abuse and/or self-neglect			

ADLs, activities of daily living; *iADLs*, instrumental activities of daily living; *OSA*, obstructive sleep apnea

in addition to four other geriatric domains.[13] Developing best practices to identify frailty in hospitalized patients, especially for the growing population of older adults living with MCC who are most vulnerable, is now a national priority.

While an in-person comprehensive geriatric assessment by a geriatrician is the gold standard for frailty assessment, it is resource intensive and may not be feasible in many health systems.[14,15] The electronic frailty index (eFI) was developed to be computed passively within the EHR based on the deficit accumulation model.[16] Typically, eFIs are computed using ambulatory and inpatient International Classification of Diseases (ICD-10) codes, certain measures (e.g., durable medical equipment [DME] codes), and other conditions (e.g., conditions from the EHR problem list) that are distributed across age-associated deficits related to function, cognition, vision, and hearing.[16]

Various institutions have developed and validated eFIs which have consistently demonstrated modest accuracy. The US Department of Veterans Affairs (VA) system developed a 31-item FI (VA-FI) that was validated in over three million veterans, with a 3-year area under the curve (AUC) of 0.70 for mortality and 0.71 for institutionalization.[17,18] The 36-item eFI developed and implemented in the English National Health Service (NHS) reported AUC of 0.70 to 0.75 for mortality, emergency hospitalization, and nursing home admission.[19] Atrium Health-Wake Forest Baptist eFI also incorporates functional assessments from Medicare Annual Wellness Visits and has an AUC of 0.72 to 0.75 for 1-year mortality, injurious falls, and hospitalization.[20] In short, eFIs can identify frail adults who may benefit from comprehensive geriatric assessment, changes to routine clinical care such as liberal glycemic targets,[21] and targeted resources to increase physiologic reserve via physical activity and other interventions.[22]

GAPS AND LIMITATIONS FOR USING EFI

While eFI holds promise for aiding clinicians in prospective screening, it has limitations. First, it relies strictly on structured data, such as ambulatory and inpatient ICD-10 codes associated with an encounter or conditions listed on the EHR problem list, which are often discrepant with one another.[23] Another limitation is suboptimal EHR interoperability across different health systems, which is primarily driven by health data privacy policy. For example, if a patient is hospitalized out of state and receives a new diagnosis, this may not be reliably added or imported to the problem list at their home institution. In addition, many important functional deficits are strikingly absent from ambulatory and inpatient problem lists.[24] These problems may not be documented for a variety of reasons: such problems represent undifferentiated clinical signs and symptoms (e.g., debility, fatigue); clinicians may not be trained to readily diagnose certain conditions (e.g., dementia); or clinicians feel these problems are another team member's responsibility (e.g., imbalance recognized by a physical therapist). While frequently not well captured as structured data, such functional deficits are typically pronounced during acute illness and hospitalization, associated with adverse outcomes, and are often well documented in physical therapy and case management notes.

NOVEL STRATEGIES USING ARTIFICIAL INTELLIGENCE (AI) TO IMPROVE FRAILTY SCREENING

Many studies have suggested the value in analyzing unstructured data using natural language processing (NLP), a subset of AI that focuses on the interaction between humans and computers through language, to improve detection of geriatric syndromes that often occur, particularly in later stages of frailty.[25] Indeed, emerging research has underscored the potential for generating insights from unstructured clinical documentation to improve detection of vulnerable older adults. In one study, Chen et al. identified a range of geriatric syndromes in vulnerable older adults by applying novel NLP methods to unstructured free text in EHRs.[26] In another study, when unstructured EHR notes were examined using NLP, identification of geriatric syndromes increased substantially: falls were identified 3.2 times as often, malnutrition 18 times, and lack of social support 456 times.[25] In clinical practice, this may correspond to documentation of terms or phrases such as "muscle wasting" or "has been losing weight without trying" in free text portions of notes by a member of the care team but the relevant diagnosis, "protein-calorie malnutrition," is not captured. This typically happens for one of two reasons: the EHR's problem list was not updated, or the corresponding ICD-10 code was not added to the encounter because it was not identified during the billing and coding process.

While the experience using NLP for identifying relevant diagnoses to include in eFI calculation is encouraging, the requirement for large and well-labeled datasets has likely limited scalability for clinical practice. The rapid adoption of generative AI, a subset of AI that focuses on creating new content using large language models (LLMs), has much potential to improve the performance of eFI by overcoming these obstacles. Because LLMs are pre-trained on large amounts of text data to generate human-like language, they can significantly enhance the automation of the labeling process, which should decrease administrative burden considerably. Specifically, prompting and fine-tuning LLMs to extract clinically pertinent diagnoses (i.e., that map to the cumulative deficit model) from unstructured clinical documentation could facilitate more accurate eFI calculation and earlier intervention, potentially improving the quality and safety of care for frail older adults. For example, LLMs could identify functional deficits and social elements that are typically missing from encounter diagnoses or problem lists but

are often present in physical therapy, occupational therapy, nursing, case management, and other notes written by ancillary and consult services. In a future state when LLMs are integrated into the EHR, important assessments and observations from the interprofessional team can be incorporated automatically into the eFI to more efficiently and seamlessly characterize the degree of frailty in older adults living with MCC.

In summary, we believe that approaches from AI will improve the performance of eFI, potentially improving care for frail older adults. As clinicians, researchers, and hospitals adopt eFI screening for older adults living with MCC during hospitalization, they should understand current limitations, and collaborate with health system leadership to consider strategies for using AI to improve eFI accuracy. Innovative approaches that leverage generative AI should allow for more personalized, high-quality clinical care via the provision of the right resources to the right patients as underscored in the clinical case below. Doing so will address the burden of adverse health outcomes in this vulnerable population of patients, both during hospitalization and after discharge.[11,27–32]

CLINICAL CASE UTILIZING LLM-ENHANCED EFI SCREENING

A hospitalist admits a community-dwelling 85-year-old female with history of hypertension, hypothyroidism, depression, and chronic obstructive pulmonary disease for community-acquired pneumonia. During hospitalization, the eFI is reported as 0.17 (pre-frail) based on the presence of ICD-10 codes for hypertension, thyroid disease, lung disease, and mood disorder. By prompting EHR-embedded LLMs on nursing and physical therapy notes, additional codes are identified for arthritis, urinary incontinence, gait abnormality, and hearing impairment, increasing the eFI to 0.31 (moderately frail). The patient receives additional case management resources, identifying previously unmet needs including inpatient nutrition consultation, home physical therapy referral, durable medical equipment, and geriatrics clinic referral, with the goal of reducing future morbidity. In addition, the clinician is alerted to important geriatric assessments performed by the interprofessional team without additional documentation burden.

Corresponding Author: *Julia V. Loewenthal, MD; , Division of Aging, Brigham and Women's Hospital, Boston, MA, USA (e-mail: jloewenthal@bwh.harvard.edu).*

Author Contribution: *J.V.L., N.C.E., and A.K.D. were responsible for manuscript concept and design, manuscript preparation, and critical review.*

Funding *J.V.L., N.C.E., and A.K.D. are supported by NIA R01 AG083035. J.V.L. is supported by HRSA GACA K01HP49053-01-01.*

Declarations:

Conflict of Interest: *None. The contents are those of the authors and do not necessarily represent the official views of, nor an endorsement, by HRSA, HHS, or the US Government.*

REFERENCES

1. **Marengoni A, Angleman S, Melis R, et al.** Aging with multimorbidity: a systematic review of the literature. Ageing Res Rev. 2011;10(4):430-439.
2. **Bierman AS, Wang J, O'Malley PG, Moss DK.** Transforming care for people with multiple chronic conditions: Agency for Healthcare Research and Quality's research agenda. Health Serv Res. 2021;56 Suppl 1(Suppl 1):973–979.
3. **Kim DH, Rockwood K.** Frailty in older adults. N Engl J Med. 2024;391(6):538-548.
4. **Rockwood K, Mitnitski A.** Frailty in relation to the accumulation of deficits. J Gerontol A Biol Sci Med Sci. 2007;62(7):722-727.
5. **Vetrano DL, Palmer K, Marengoni A, et al.** Frailty and multimorbidity: A systematic review and meta-analysis. J Gerontol A Biol Sci Med Sci. 2019;74(5):659-666.
6. **Hanlon P, Nicholl BI, Jani BD, Lee D, McQueenie R, Mair FS.** Frailty and pre-frailty in middle-aged and older adults and its association with multimorbidity and mortality: a prospective analysis of 493 737 UK Biobank participants. Lancet Public Health. 2018;3(7):e323-e332.
7. **Hoogendijk EO, Afilalo J, Ensrud KE, Kowal P, Onder G, Fried LP.** Frailty: implications for clinical practice and public health. Lancet. 2019;394(10206):1365-1375.
8. **Inouye SK, Studenski S, Tinetti ME, Kuchel GA.** Geriatric syndromes: clinical, research, and policy implications of a core geriatric concept. J Am Geriatr Soc. 2007;55(5):780-791.
9. **Dharmarajan K, Hsieh AF, Lin Z, et al.** Diagnoses and timing of 30-day readmissions after hospitalization for heart failure, acute myocardial infarction, or pneumonia. JAMA. 2013;309(4):355-363.
10. **Inouye SK, Foreman MD, Mion LC, Katz KH, Cooney LM Jr.** Nurses' recognition of delirium and its symptoms: comparison of nurse and researcher ratings. *Arch Intern Med.* 2001;161(20):2467-2473.
11. **Bell SP, Vasilevskis EE, Saraf AA, et al.** Geriatric syndromes in hospitalized older adults discharged to skilled nursing facilities. J Am Geriatr Soc. 2016;64(4):715-722.
12. **Dent E, Morley JE, Cruz-Jentoft AJ, et al.** Physical frailty: ICFSR international clinical practice guidelines for identification and management. J Nutr Health Aging. 2019;23(9):771-787.
13. New CMS Measure Will Publicly Report On Hospitals' Commitment And Capabilities To Provide Age-Friendly Care. The John A. Hartford Foundation. August 2, 2024. Accessed September 11, 2024. https://www.johnahartford.org/newsroom/view/new-cms-measure-will-publicly-report-on-hospitals-commitment-and-capabilities-to-provide-age-friendly-care.
14. **Callahan KE.** The future of frailty: Opportunity is knocking. J Am Geriatr Soc. 2022;70(1):78-80.
15. **Cooper L, Loewenthal J, Frain LN, et al.** From research to bedside: Incorporation of a CGA-based frailty index among multiple comanagement services. J Am Geriatr Soc. 2022;70(1):90-98.
16. **Orkaby AR, Callahan KE, Driver JA, Hudson K, Clegg AJ, Pajewski NM.** New horizons in frailty identification via electronic frailty indices: early implementation lessons from experiences in England and the United States. Age Ageing. 2024;53(2). https://doi.org/10.1093/ageing/afae025.
17. **Orkaby AR, Nussbaum L, Ho YL, et al.** The burden of frailty among U.s. veterans and its association with mortality, 2002-2012. J Gerontol A Biol Sci Med Sci. 2019;74(8):1257-1264.
18. Comparison of Claims Based Frailty Indices in US Veterans 65 and Older for Pre-Diction of Long-Term Institutionalization and Mortality.
19. **Clegg A, Bates C, Young J, et al.** Development and validation of an electronic frailty index using routine primary care electronic health record data. Age Ageing. 2016;45(3):353-360.
20. **Pajewski NM, Lenoir K, Wells BJ, Williamson JD, Callahan KE.** Frailty screening using the electronic health record within a Medicare Accountable Care Organization. J Gerontol A Biol Sci Med Sci. 2019;74(11):1771-1777.

21. American Diabetes Association Professional Practice Committee. 13. Older adults: Standards of Medical Care in diabetes-2022. Diabetes Care. 2022;45(Suppl 1):S195-S207.
22. **Dent E, Martin FC, Bergman H, Woo J, Romero-Ortuno R, Walston JD.** Management of frailty: opportunities, challenges, and future directions. Lancet. 2019;394(10206):1376-1386.
23. **Voss RW, Schmidt TD, Weiskopf N, et al.** Comparing ascertainment of chronic condition status with problem lists versus encounter diagnoses from electronic health records. J Am Med Inform Assoc. 2022;29(5):770-778.
24. **Tomita N, Kojima T, Ishiki A, et al.** Could problem lists summarize comprehensive geriatric assessments? A nationwide cross-sectional survey on geriatricians' attitudes towards problem lists. Geriatr Gerontol Int. 2019;19(2):159-164.
25. **Kharrazi H, Anzaldi LJ, Hernandez L, et al.** The value of unstructured electronic health record data in geriatric syndrome case identification. J Am Geriatr Soc. 2018;66(8):1499-1507.
26. **Chen T, Dredze M, Weiner JP, Kharrazi H.** Identifying vulnerable older adult populations by contextualizing geriatric syndrome information in clinical notes of electronic health records. J Am Med Inform Assoc. 2019;26(8-9):787-795.
27. **Mor V, Intrator O, Feng Z, Grabowski DC.** The revolving door of rehospitalization from skilled nursing facilities. Health Aff (Millwood). 2010;29(1):57-64.
28. **Kind AJH, Smith MA.** Documentation of Mandated Discharge Summary Components in Transitions from Acute to Subacute Care. In: Henriksen K, Battles JB, Keyes MA, Grady ML, eds. Advances in Patient Safety: New Directions and Alternative Approaches (Vol. 2: Culture and Redesign). Agency for Healthcare Research and Quality (US); 2008.
29. **Mueller SK, Fiskio J, Schnipper J.** Interhospital transfer: Transfer processes and patient outcomes. J Hosp Med. 2019;14(8):486-491.
30. **Mueller S, Zheng J, Orav EJ, Schnipper JL.** Inter-hospital transfer and patient outcomes: a retrospective cohort study. BMJ Qual Saf. 2019;28(11):e1.
31. **Ahn S, Hussein M, Mahmood A, Smith ML.** Emergency department and inpatient utilization among U.S. older adults with multiple chronic conditions: a post-reform update. BMC Health Serv Res. 2020;20(1):77.
32. **Hanlon P, Nicholl BI, Jani BD, et al.** Examining patterns of multimorbidity, polypharmacy and risk of adverse drug reactions in chronic obstructive pulmonary disease: a cross-sectional UK Biobank study. BMJ Open. 2018;8(1):e018404.
33. **Fulmer T, Mate KS, Berman A.** The Age-Friendly Health System Imperative. J Am Geriatr Soc. 2018;66(1):22-24.
34. **van Seben R, Reichardt LA, Aarden JJ, et al.** The Course of Geriatric Syndromes in Acutely Hospitalized Older Adults: The Hospital-ADL Study. J Am Med Dir Assoc. 2019;20(2):152-158.e2.
35. **Lakhan P, Jones M, Wilson A, Courtney M, Hirdes J, Gray LC.** A prospective cohort study of geriatric syndromes among older medical patients admitted to acute care hospitals. *J Am Geriatr Soc.* 2011;59(11):2001-2008.
36. **Chong E, Ho E, Baldevarona-Llego J, Chan M, Wu L, Tay L.** Frailty and risk of adverse outcomes in hospitalized older adults: A comparison of different frailty measures. J Am Med Dir Assoc. 2017;18(7):638.e7-638.e11.
37. **Dorner TE, Luger E, Tschinderle J, et al.** Association between nutritional status (MNA®-SF) and frailty (SHARE-FI) in acute hospitalised elderly patients. J Nutr Health Aging. 2014;18(3):264-269.
38. **Hammami S, Zarrouk A, Piron C, Almas I, Sakly N, Latteur V.** Prevalence and factors associated with frailty in hospitalized older patients. BMC Geriatr. 2020;20(1):144.
39. **Hao Q, Zhou L, Dong B, Yang M, Dong B, Weil Y.** The role of frailty in predicting mortality and readmission in older adults in acute care wards: a prospective study. Sci Rep. 2019;9(1):1207.
40. **Joosten E, Demuynck M, Detroyer E, Milisen K.** Prevalence of frailty and its ability to predict in hospital delirium, falls, and 6-month mortality in hospitalized older patients. BMC Geriatr. 2014;14:1.
41. **Hewitt J, Moug SJ, Middleton M, et al.** Prevalence of frailty and its association with mortality in general surgery. Am J Surg. 2015;209(2):254-259.
42 **Papadopoulou SK, Tsintavis P, Potsaki P, Papandreou D.** Differences in the prevalence of sarcopenia in community-dwelling, nursing home and hospitalized individuals. A systematic review and meta-analysis. J Nutr Health Aging. 2020;24(1):83-90.
43. **Reynish EL, Hapca SM, De Souza N, Cvoro V, Donnan PT, Guthrie B.** Epidemiology and outcomes of people with dementia, delirium, and unspecified cognitive impairment in the general hospital: prospective cohort study of 10,014 admissions. BMC Med. 2017;15(1). https://doi.org/10.1186/s12916-017-0899-0.
44. **Kumar S, McElligott D, Goyal A, Baugh M, Ionita RN.** Risk of obstructive sleep apnea (OSA) in hospitalized patients. Chest. 2010;138(4):779A.
45. **Kokras N, Kouzoupis AV, Paparrigopoulos T, et al.** Predicting insomnia in medical wards: the effect of anxiety, depression and admission diagnosis. Gen Hosp Psychiatry. 2011;33(1):78-81.
46. **Isaia G, Corsinovi L, Bo M, et al.** Insomnia among hospitalized elderly patients: prevalence, clinical characteristics and risk factors. Arch Gerontol Geriatr. 2011;52(2):133-137.
47. **Unlu O, Levitan EB, Reshetnyak E, et al.** Polypharmacy in older adults hospitalized for heart failure. Circ Heart Fail. 2020;13(11):e006977.
48. **Nagano A, Onaka M, Maeda K, et al.** Prevalence and characteristics of the course of dysphagia in hospitalized older adults. Nutrients. 2023;15(20):4371.
49. **Mateos-Nozal J, Montero-Errasquín B, Sánchez García E, Romero Rodríguez E, Cruz-Jentoft AJ.** High prevalence of oropharyngeal dysphagia in acutely hospitalized patients aged 80 years and older. J Am Med Dir Assoc. 2020;21(12):2008-2011.
50. **Doan TN, Ho WC, Wang LH, Chang FC, Nhu NT, Chou LW.** Prevalence and methods for assessment of oropharyngeal dysphagia in older adults: A systematic review and meta-analysis. J Clin Med. 2022;11(9):2605.
51. **Just SA, Seethaler M, Sarpeah R, Waßmuth N, Bermpohl F, Brandl EJ.** Loneliness in elderly inpatients. Psychiatr Q. 2022;93(4):1017-1030.