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COMMENTARY

Predicting and improving hospital outcomes for older adults

Though older adults comprise less than 13% of the US population, they are disproportionately likely to be hospitalized (>40% of hospitalizations) and incur nearly half of all the hospital costs (Healthcare Cost and Utilization Project Facts and Figures, 2008; US Census Bureau, 2008; US Centers for Disease Control and Prevention, 2010). Notably, a recent study of older adults in Italy determined that individuals who were characterized as pre-frail based on the Functional Geriatric Evaluation (FGE) scale accounted for around 30% of the study participants, yet generated close to half of the cumulative hospital costs (Liotta *et al.*, 2019). Frailty on this scale has a multidimensional definition encompassing not only physical condition as traditionally emphasized (Fried *et al.*, 2001), but also mental health, functional status, as well as socioeconomic resources (community support, housing, social relationships, and financial situation). Therefore, identifying and promoting factors to mitigate the decline toward frailty would undoubtedly have a positive impact on healthcare costs and quality of life in older adults. A recent review of the literature confirmed that medical and psychiatric comorbidity was linked to longer hospital stays, higher medical costs, and more readmissions in all adults (Jansen *et al.*, 2018). Depression, in particular, increased the length of stay by 4–5 days. In older adults, dementia is a prominent risk factor for delirium, which is associated with worse clinical and functional outcomes (Gual *et al.*, 2018). In light of these findings, few studies have examined in systematic fashion how premorbid functioning in geriatric patients and other indices of frailty including neuropsychiatric symptoms affected hospitalization and patient outcomes.

In their naturalistic study, Haupt *et al.* (2020) perform a retrospective analysis of the outcomes for all inpatients admitted to the geriatrics department of a hospital in Germany during a 6-month period (for a total of 280 patients). One-third of the patients assessed were admitted secondary to neuropsychiatric disorders, and 20% of all patients had both physical and mental illness. Patients with mental illness were categorized as having depression, dementia, or delirium. Overall, mentally ill patients had a greater number of comorbidities than those without mental illness, and that number was associated with depression severity, but not with general cognitive functioning (Mini-Mental State Examination or MMSE). Using four functional scales (Barthel Index, Timed Up and Go Test, Gait and Balance Test of Tinetti, and De Morton Mobility Index) administered at admission and discharge, the authors reported that all patient groups improved over the course of their hospital stay, with group differences in the degree of improvement in all but the Timed Up and Go Test. As might be expected, patients with dementia had the least improvement, leading to the lowest functional scores overall. In contrast, the delirium group was the most impaired on admission but also showed the greatest improvement, which was most clearly reflected on the Barthel Index. Mentally healthy and depressed patients followed mostly parallel courses, indicating that depression alone is not necessarily an obstacle to inpatient functional improvement. Most of the cohorts did not have diagnoses of depression prior to hospitalization, therefore the onset of depression and the role of physical symptoms in causality are unknown. While the 100% improvement rate in delirium by the time of discharge was somewhat expected given the unlikelihood of discharging a patient with active symptoms, the 20% of patients with dementia who improved was more surprising given that most patients in the group had dementia secondary to a progressive neurodegenerative disorder or vascular process. Of note, the behavioral and psychological symptoms of dementia appeared to respond positively to the treatment of somatic symptoms rather than explicit cognitive treatment. Another unexpected finding was the lack of common physical comorbidities such as heart disease affecting treatment outcome.

With its emphasis on the interplay between mental and physical symptoms, this study underscored the importance of the mind–body connection, even in the hospital setting. Analogous to how treating physical comorbidities improved mental health, the authors speculated that the antidepressant therapy (prescribed prior to hospitalization) may have facilitated physical treatment in that subgroup. The authors further acknowledged the benefit of an "empathetic and supportive setting" in promoting patient improvement, and the need for "integrated medical treatment" in the care of geriatric patients, who often come to the hospital with multiple

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comorbidities and already on several medications. In this regard, an older interventional study on a smaller scale showed that an individualized graduated exercise program, progressive encouragement of functional independence, and cognitive stimulation sessions led to improved functional outcomes in geriatric inpatients as measured by the Barthel Index (Mudge *et al.*, 2008). The study participants were patients admitted for at least 3 days during a 10-week period. The intervention included early review (within 48 h of admission) by a physiotherapist, twice-daily exercises with a diary and daily review to track progress, information for family and caregivers to encourage patients with mobility, intensive education on the risks of deconditioning, recognizing, and incentivizing care team members (e.g. a "mobility challenge" competition among nurses), and afternoon group sessions (3–4 times per week) run by psychology staff which comprised socialization, orientation, and memory activities, as well as approaches to managing the psychological aspects of hospitalization with a focus on anxiety and depression. Prioritizing such interventions in older hospitalized patients may be challenging depending on the setting and available resources, but may decrease the burden on the healthcare system in the long run.

Another important application of this type of study data would be on a larger scale in the context of machine learning (ML). Extending the methodology of the Haupt *et al.* study to broad-based standardization of functional testing at admission and discharge, and obtaining additional data would create a novel dataset that would enable deeper analyses of the myriad of factors that impact outcomes of hospitalizations in older adults. One could envision a scenario where an admitted patient's diagnoses, medications, symptoms, and functional scores would be entered into the ML model, which would then output optimal treatment strategies to improve functional outcome while shortening the length of stay and reducing the chance of readmission. The practical considerations for such an approach would likely include the use of supervised ML with labeled training data to start with, until unsupervised or deep learning methods can be considered (Graham *et al.*, 2019). With any of these methods, the collection of high-quality longitudinal and standardizable data will be essential, with the breadth of data obtained helping to further attune the models for individually tailor care. Other non-standard types of data could include wearable sensors that assess behavioral and sleep patterns during hospitalization in order to detect and reduce the risk of delirium at the earliest stages, the use of smartphones for ecological momentary assessment of mood states, and microbiome data to reflect dietary intake and activity. Healthcare systems with a unified electronic health record and ability to implement large-scale changes would be better equipped to collect such data at first, though aggregation of multiple datasets across diverse care settings will become increasingly important and foster transdisciplinary and international collaborations.

While ML is poised to become a useful tool in hospital-based care, we must not forget the human aspect of medicine and its role in promoting healing, as epitomized by the multidisciplinary interventions that have shown success on a smaller scale. As the pioneer of medical education Sir William Osler (1849–1919) once said, "The good physician treats the disease, the great physician treats the patient who has the disease." Understanding how the individual patient's lifestyle and personality impact their health and well-being is important, yet difficult. ML may be a novel tool to better understand the whole patient and support clinical decision-making, but will never replace human clinicians. Studies such as that of Haupt *et al.* can help determine what types of data are most relevant in improving hospital outcomes for older patients, and how to use that information to bring us one step closer toward truly integrated and personalized geriatric inpatient care.

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Description of authors' roles

DHA conceptualized the paper, conducted the literature review, and wrote the first draft. EEL co-conceptualized the paper and edited the draft.

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