Aggregate Health Burden and the Risk of Hospitalization in Older Persons Post Hip Replacement Surgery

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Background. We sought to understand the association between aggregate health burden—chronic conditions, functionally limiting health problems and mental well-being—and the likelihood of hospitalization among older persons post hip replacement surgery.

Methods. Eight hundred and twenty-eight Medicare recipients from three U.S. states completed a questionnaire 3 years postsurgery. Using administrative data (Medicare Provider Analysis and Review), participants were prospectively followed for 12 months postquestionnaire to capture hospitalizations. Using logistic regression, demographic, socioeconomic, and behavioral characteristics and medical comorbidities were considered as predictors. Subsequently, musculoskeletal (MSK) functional and geriatric problems were added as predictors, then mental well-being and activity limitations. Path analysis was employed to elucidate interrelationships between these predictors, investigating whether mediated effects through mental well-being and activity limitations were operational.

Results. Mean age was 76 years (range: 67–96); 63% were women; 23% had ≥1 hospitalization(s). When medical comorbidity, MSK limitations, and geriatric problems were considered, each was independently associated with hospitalization (odds ratios: 1.3, 1.1, 1.2, respectively). When mental well-being and activity limitations were added, these variables were predictive of hospitalization (odds ratios: 1.2, 1.1, respectively), while MSK limitations and geriatric problems were no longer predictive. Path analysis results suggested that the influence of medical comorbidity and MSK and geriatric problems were mediated through mental well-being and activity limitations.

Conclusions. Several health domains predict hospitalization, beyond and including medical comorbidity. Efforts aimed at delaying/minimizing hospitalizations in this population should consider an array of domains for potentially targeted intervention. These findings can serve as a baseline against which future research can assess the impact of changes to the health care system.

Key Words: Hospitalization—Older persons—Health burden—Hip replacement.

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The rapidly growing population of persons greater than 65 years of age (now 12% of the total U.S. population) (1) is projected to increase by 2050 to 20% of the total U.S. population (2). Accompanying this increase will be greater resource demands and expenditures for health care services for this segment of the population, necessitating prioritization and cost-effective allocation of health care resources. Older individuals living in the community are at risk for a variety of adverse outcomes, including hospitalization, nursing home placement, functional decline, and mortality. In United States, inpatient and outpatient hospitalizations are among the most expensive services used by older persons and provided under Medicare (3). Identifying risk factors for hospitalization among older persons can aid the critical process of prioritization and resource allocation, contributing to the effective development of planning, design, and evaluation policies.

The risk factors found to be statistically significant in any given study can vary depending on the outcome examined and the range of factors considered (4). Medical morbidities have long been recognized as significant predictors of hospitalization (4–6), particularly for individuals with multiple medical morbidities (ie, medical comorbidity). However, for older persons, the risk of hospitalization can be influenced by more than medical morbidities alone. Poor psychosocial status, musculoskeletal (MSK) functional problems, activity limitations, and/or geriatric problems likely also contribute significantly...
to the likelihood of hospitalization; however, findings have been mixed (4,7). We posit that this variability may be a function of the analytical modeling approaches adopted.

The primary objective of this study was to assess the effect of aggregate health burden—a construct comprised of MSK functional status, activity limitations, mental well-being, and geriatric functional problems, in addition to medical comorbidity—on the likelihood of hospitalization. Using path analyses, we elucidate the interrelationships among these determinants of hospitalization.

Methods

Study Sample

Subjects were members of a cohort of Medicare beneficiaries aged ≥65 years who underwent elective primary total hip replacement (THR) in 1995/1996 (diagnoses, 89% osteoarthritis). Recruitment details have been published (8). Briefly, a stratified random sample of beneficiaries who underwent THR in Ohio, Pennsylvania, or Colorado hospital was selected. Hospitals were divided into THR-volume strata. Within each stratum, hospitals were randomly selected, sampling with the probability of being selected proportional to hospital size. Within each hospital, patients were randomly selected who underwent elective primary THR. In all, 1,939 patients were chosen from a cohort of 7,092 beneficiaries. Thirty-two died prior to contact and addresses were incorrect for 20. Of the remaining subjects, 519 never responded, 338 refused participation, and 1,030 agreed to participate. Of these, 958 returned their questionnaire. Respondents were younger than nonrespondents and more likely to be white and report higher income (9).

At the time of recruitment, participants who were health maintenance organization (HMO) members were excluded from the study. Within the year following questionnaire completion, 13.6% of the sample were HMO members. As there is no incentive for an HMO to report hospitalizations in instances where the organization is provided capitated prospective payment per enrollee, irrespective of level of subsequent service use, the analytic sample was limited to individuals who remained HMO nonmembers (n = 828). A sample derivation figure is included (Supplementary Figure 1).

Data Sources

Inpatient hospitalization data were captured through Medicare Provider Analysis and Review files, which contain claims data for inpatient services provided to beneficiaries. Patient-reported data were obtained via questionnaire 3 years following surgery.

Primary outcome.—Hospitalization (yes/no) within the 12 months following questionnaire completion.

Study Measures

Study measures captured by the self-report questionnaire were as follows: age (years), sex, race (as only 3% of the sample reported a race other than “white,” race was categorized as nonwhite and white), household income—low (<$20,000) versus middle-high ($20,000) (21% of the sample did not report income; a “missing” category was retained), education—high school or lesser and some college or higher, urban/rural—based on county codes, living alone—yes/no, drinking—yes/no to ≥2 alcoholic drinks per day, smoking—yes/no current smoker, and obesity—based on self-reported height and weight, body mass index was calculated (kg/m²); body mass index ≥30 was classified as obese.

For regression analyses, reference groups were as follows: male, white, middle-high income, some college or higher, urban, live with other(s), less than two drinks per day, nonsmoker, and body mass index less than 30.

Medical comorbidity.—Participants identified chronic diseases in the last 10 years (stroke; cancer; heart attack; congestive heart failure; high blood pressure; diabetes; kidney disease; asthma, bronchitis, emphysema, or other lung disease; ulcer or stomach disease; anemia or other blood disease; rheumatoid arthritis). An unweighted summative index was used (10).

Musculoskeletal functional limitations.—Participants reported whether activities were limited by problems in six anatomic regions: hands, wrists, arms, or shoulders; neck; back; hips; knees; and ankles or feet (11). Responses were summed; scores ranged 0–6.

Geriatric problems (12).—Memory problems or confusion, vision problems, hearing problems, falling down, difficulty controlling bowel or bladder, and poor balance were recorded. Positive responses were summed; scores ranged from 0–6.

Activity limitations (13).—Concerning problems with work or daily activities as a result of physical health, participants were asked about limitations in accomplishing activities and the extent of limitations, indicated as follows: 1—limited a lot to 3—not limited at all. Responses were summed and standardized to a 0–10 scale; higher scores represented greater limitation.

Mental well-being.—It was assessed with the Mental Health Inventory (14), comprised of five items. Responses were summed and standardized to a 0–10 scale; higher scores represented worse status.

Analyses

Bivariate analyses examined associations between study measures and hospitalization status.

Logistic regression analysis was undertaken that initially included demographic, socioeconomic, and lifestyle factors and medical comorbidity count as predictors of hospitalization (model 1). Subsequently, MSK functional and geriatric problems were included (model 2). Finally, mental well-being and activity limitation status were included, as
we hypothesized that these broad domains would encompass much of the variance explained by medical comorbidity, mental health, and MSK and geriatric problems (model 3). Additionally, seeking to develop a more parsimonious model (model 4), three model-building techniques were considered: backward elimination, forward selection, and stepwise selection (entry and/or exit $\alpha = 0.15$). In sensitivity analyses, individual medical comorbidities and geriatric problems, rather than summative indices, were considered.

Finally, associations among the predictors and with hospitalization were examined by path analysis (model 5). The aim was to assess whether mediated effects were operational. The hypothesized path model (Figure 1) was conceptually based on findings from the literature (7,15–19). Analyses were conducted with Mplus 6.11 (20). Full information maximum likelihood was used to handle missing data. This produces unbiased, consistent, and efficient parameter estimates under a missing-at-random assumption (21).

A second sensitivity analysis was undertaken whereby the path analysis was restricted to hospitalizations for nonelective admissions only (model 6). In this instance, hospitalization discharge diagnosis codes were independently reviewed by two physicians to establish whether the admission was elective versus nonelective; definitions and code designations are provided (Supplementary Table 1). Interrater agreement was assessed with Cohen’s kappa coefficient. A kappa of 0.747 was observed with a maximum achievable of 0.848 (88.1% of maximum); consensus was then achieved on all diagnoses for which there was disagreement.

**RESULTS**

One hundred ninety individuals (23%) had ≥1 hospitalization during the 12 month follow-up: 131 had only 1 hospitalization, 43 had 2 hospitalizations, and 16 had ≥3 hospitalizations. Of the 190, 129 only underwent nonelective hospitalization, 35 only underwent elective hospitalization, and 26 underwent both. Eight hundred nine of the 828 participants were alive at the end of follow-up. Of the 19 non-survivors, 17 were hospitalized at least once prior to death; 1 survived 11.9 of the 12 months. The two nonsurviving nonhospitalized participants were classified as “not hospitalized.” All 828 participants were retained for study analyses.

Sample characteristics are summarized in Table 1. Significantly worse (higher) scores were observed for medical comorbidity, MSK functional problems, activity limitations, geriatric problems, and mental well-being in the hospitalized subjects compared with the nonhospitalized. Hospitalized individuals were slightly older, and a greater proportion were obese.

Results from the sequentially built logistic models (models 1–3) are presented in Table 2. Across models, increasing age predicted a greater likelihood of hospitalization. Being obese also predicted a greater likelihood, although the statistical significance was lost with the addition of mental well-being and activity limitations to the model (model 3). An increasing number of medical comorbidities increased the likelihood of hospitalization, although the magnitude of effect was attenuated with the addition of MSK functional and geriatric problems (model 2), and further still with the addition of mental well-being and activity limitations (model 3). MSK limitations and geriatric problems initially predicted a greater likelihood of hospitalization. These effects were no longer significant, however, with the addition of mental well-being and activity limitations to the model (model 3). Sex, race, income, education, rural/urban living, drinking, and smoking did not predict hospitalization.

The use of three selection criteria to develop a more parsimonious model resulted in identical findings. These results are presented in Table 2 (model 4). Of the 15 variables considered, only increasing age, number of medical comorbidities, worse mental well-being, and greater activity limitation
were retained in the models, each predicting a greater likelihood of a hospitalization.

From sensitivity analyses where individual medical comorbidities and geriatric problems were considered, cardiovascular disease, diabetes, kidney disease, and falls achieved statistical significance (Supplementary Table 2). The magnitude of effect for the medical conditions diminished with the addition of MSK functional and geriatric problems to the model. The addition of mental well-being scores was associated with higher medical comorbidity count and greater MSK functional limitation and geriatric problems. Worse activity limitation scores were significantly associated with increasing age, female sex, lower education, obesity, higher medical comorbidity count, and greater MSK functional limitations and geriatric problems. Worse mental well-being scores were associated with higher medical comorbidity count and greater MSK functional limitations and geriatric problems.

A greater comorbidity count was associated with lower income and obesity. Greater MSK functional limitation was associated with female sex, lower income, and obesity. Finally, more geriatric problems were associated with increasing age.
## Table 3. Path Analyses (models 5 and 6)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Model 5</th>
<th></th>
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<th>Model 6</th>
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<tbody>
<tr>
<td></td>
<td>Betas and 95% Confidence Intervals</td>
<td></td>
<td></td>
<td>Betas and 95% Confidence Intervals</td>
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<tr>
<td></td>
<td>Comorbidity Count</td>
<td>MSK Functional Limitations</td>
<td>Geriatric Problems</td>
<td>Mental Well-being</td>
<td>Activity Limitations</td>
<td>Final Outcome</td>
</tr>
<tr>
<td>Age</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.48</td>
<td>1.01</td>
<td>1.04</td>
</tr>
<tr>
<td>Female</td>
<td>−0.02, 0.01</td>
<td>−0.02, 0.02</td>
<td>−0.01, 0.03</td>
<td>0.15</td>
<td>0.74</td>
<td>0.49, 1.12</td>
</tr>
<tr>
<td>Race: nonwhite</td>
<td>0.05</td>
<td>0.55</td>
<td>0.04</td>
<td>−0.17, 0.18</td>
<td>0.01</td>
<td>−0.04, 0.36</td>
</tr>
<tr>
<td>Low income</td>
<td>0.25</td>
<td>0.34</td>
<td>0.17</td>
<td>−0.21</td>
<td>0.74</td>
<td>0.19, 2.59</td>
</tr>
<tr>
<td>Education: ≤high school</td>
<td>0.02</td>
<td>0.45</td>
<td>0.08</td>
<td>0.06, 0.71</td>
<td>0.01</td>
<td>0.56, 0.89</td>
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<tr>
<td>Rural</td>
<td>−0.05</td>
<td>−0.22</td>
<td>−0.14</td>
<td>−0.26, 0.10</td>
<td>−0.19, 0.78</td>
<td>0.29</td>
</tr>
<tr>
<td>Living alone</td>
<td>−0.08</td>
<td>0.03</td>
<td>0.15</td>
<td>0.00</td>
<td>0.09, 0.39</td>
<td>0.48</td>
</tr>
<tr>
<td>2≥ drinks per day</td>
<td>−0.20</td>
<td>0.04</td>
<td>−0.18, 0.18</td>
<td>−0.24, 0.25</td>
<td>−0.19, 0.78</td>
<td>0.02</td>
</tr>
<tr>
<td>Current smoker</td>
<td>0.01</td>
<td>−0.41</td>
<td>−0.17, 0.17</td>
<td>0.04</td>
<td>0.38</td>
<td>0.36</td>
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<tr>
<td>Obese</td>
<td>0.36</td>
<td>0.33</td>
<td>0.14</td>
<td>−0.43, 0.36</td>
<td>0.09, 0.41</td>
<td>0.15, 0.57</td>
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<tr>
<td>Comorbidity count</td>
<td>0.17, 0.54</td>
<td>0.06, 0.60</td>
<td>−0.15, 0.22</td>
<td>0.14</td>
<td>0.36, 1.39</td>
<td>0.39</td>
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<tr>
<td>MSK functional limitation</td>
<td>0.20</td>
<td>0.39</td>
<td>0.09, 0.30</td>
<td>0.32</td>
<td>0.19, 1.24</td>
<td>0.09</td>
</tr>
<tr>
<td>Geriatric problems</td>
<td>0.02</td>
<td>0.86</td>
<td>0.01</td>
<td>0.12</td>
<td>0.20</td>
<td>0.22</td>
</tr>
<tr>
<td>Mental well-being</td>
<td>0.30</td>
<td>0.36</td>
<td>0.04</td>
<td>0.15</td>
<td>0.10</td>
<td>0.30</td>
</tr>
<tr>
<td>Activity limitations</td>
<td>0.14</td>
<td>1.14</td>
<td>0.09</td>
<td>0.15</td>
<td>0.10</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Notes: *Bolded values indicate p < .05. MSK = musculoskeletal. †From sensitivity analysis examining nonelective hospitalization vs no hospitalization.
Limiting the analyses to nonelective admissions had no substantive effect on the results for the mediating dependent variables (data not shown). Similarly, findings were consistent for nonelective hospitalizations (Table 3, model 6), with the exception that obesity predicted a nonelective hospitalization.

**Discussion**

Several studies have identified potentially salient factors that affect health and overall quality of life, and subsequently the likelihood of hospitalization (6,16,17,22,23). Findings have been mixed, however. A review by Miller and Weissert (4,24) identified a plethora of variables for which the reported associations with hospitalization have varied from positive to negative to null across several studies. They concluded that the complexity of the analytical approach adopted should be consistent with the complexity of the proposed conceptual model under investigation. Our study embodies these authors’ suggestions: we found that traditional regression approaches would lead to the conclusion that the majority of variables under consideration were not associated with the likelihood of hospitalization because the effects of these variables were mediated by other factors. By using a path analytic modeling approach, we could specify the model to reflect our conceptually hypothesized mediated pathways, providing a fuller picture of the contributions of a range of domains. These findings are an important contribution to our understanding of the likely ways in which varied personal characteristics, health behaviors, and health states are related to hospitalization post hip replacement surgery.

Consistent with other studies, medical comorbidity significantly predicted hospitalization in our THR cohort. Additionally, and independently, poorer mental well-being and greater activity limitation were predictive of hospitalization. In the absence of the mental well-being and activity limitation limitations in our models, MSK limitations and geriatric problems significantly predicted hospitalization. In a sample of nondisabled Medicare beneficiaries, Penninx and his colleagues reported that individuals with poorer lower extremity performance were at increased risk of hospitalization, particularly among those with concomitant geriatric conditions (25).

An exclusive focus, therefore, on medical comorbidity is likely to limit the efficiency and effectiveness of any health policy or resource allocation strategy aimed at managing costs and improving health outcomes among older individuals in this population. From a clinical perspective, our finding that each of the health domains considered was associated with the likelihood of hospitalization supports a holistic approach to evaluating health among older persons, in which discrete medical problems are considered along with more integrated functional domains such as mental well-being, activity limitations, and MSK and geriatric problems. Such an approach can help identify diverse areas for potential targeted interventions in an effort to improve overall patient health, and subsequently prevent or delay hospitalizations.

The variable analytic approaches and diverse range of variables considered in previous studies make a direct comparison of earlier results with our findings challenging. Nevertheless, consistent with some earlier works, older age, lower educational attainment, lower household income, and obesity increased the likelihood of a hospitalization (4,6,16,17,22,23,26).

Our study sample consisted principally of patients with a tracer condition, hip osteoarthritis, which is associated with osteoarthritis in other sites, functional limitation, and medical comorbidities (27,28). However, the population was deemed healthy enough to undergo surgery 3 years prior to the survey, and the health domains questions in the questionnaire elicited responses unattributed to osteoarthritis or the operated joint, reflecting general health states and problems. Thus, this is a suitable population for research on utilization and outcomes in older persons with chronic disease.

The study sample was comprised of Medicare beneficiaries who underwent a surgical procedure in 1995/1996. It is important to consider that since then changes may have taken place within the health care system that may have affected the outcome of interest and the interrelationship of risk factors. For example, there have been efforts to improve home care services and reduce hospitalizations or rehospitalizations, and moves toward pay for performance models to improve quality and outcomes of care (29–32). To our knowledge, however, mediated effects between health domains through to hospitalization have not previously been examined as done here. Therefore, this study likely represents a baseline against which new research might investigate whether there have been general changes (improvements) in hospitalization of hip replacement cohorts, net of changes (improvements) in risk factors, or changes specific to cohort subgroups receiving given types of postacute or enhanced (geriatric) primary care, for example.

The association between prior hospital use and subsequent hospitalizations has been mixed in the literature, with some reporting a positive relationship between the two, others reporting no association (4). Our cohort was comprised wholly of prior users. Still, our overall findings are generally consistent with the synthesis of the literature presented by Miller and Weissert (4), from the view of individual predictor effects and the effects from within a conceptual model of service use. In women who were initially disabled but independent in activities of daily living, Boyd and his colleagues reported that hospitalization increased the risk of long-term dependence in the activities of daily living (33). Wolinsky and his colleagues reported an increased risk of hospitalization for acute myocardial infarction among individuals with prior hospitalization, and reported an independent increased risk among those with a baseline report of arthritis, among other conditions (34).

It is unclear if data from 12 months in 3 states can be generalized to the entire United States. However, as noted earlier, we do identify several consistencies between our
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domain-specific findings and previous work that vari-
ably focused on specific health domain effects on hos-
italization, across different population samples. Finally,
the moderately low response rate might have introduced
selection bias, as responders may have been more health
conscious and therefore less likely to experience a
hospitalization.

The robustness of our findings was supported by a sen-
sitivity analysis that examined hospitalizations for non-
elective admissions only. The results, and ultimately the
cclusions drawn, remained unchanged. The only except-
ion was for the influence of being obese, which for non
elective admissions was found to have both indirect and
direct influences.

We have shown that a number of health domains, beyond
and including medical comorbidity, predict hospitalization
among older persons post hip replacement surgery. Efforts
aimed at improving health and delaying or minimizing hos-
italizations within this population should consider a broad
array of health domains for potentially targeted interven-
tion. Finally, our findings support analytical approaches
that allow the complexity of the relationships under the study
to be specified as conceptually envisioned.

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manuscript.

Conflict of Interest
The authors have no conflicts of interest/financial interests to disclose.

Supplementary Material
Supplementary material can be found at: http://biomedgerontology.
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