Impact of Functional Change Before and During Hospitalization on Functional Recovery 1 Month Following Hospitalization

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Background. The functional changes that occur immediately before acute hospitalization and those that occur during hospitalization are pertinent to posthospitalization functional status in older adults. Our primary aim was to estimate the effects of membership in categories that take into account pre- and within-hospital functional changes on the likelihood of functional recovery (FR) 1 month after discharge.

Methods. The sample included 691 older (≥70) adults admitted to general-medical inpatient units in two hospitals in Israel. FR was defined as a restoration of functioning 1 month postdischarge to levels reported 2 weeks prior to admission. Patients were classified according to functional decline or stability during the prehospital stage and decline, stability, or improvement between admission and discharge in terms of ability to perform self-care or mobility activities. We performed multivariate logistic regressions to test the association between categories of functional change and FR.

Results. Patients who remained stable before and during hospitalization had the highest odds of maintaining their premorbid functional levels. Those who experienced functional improvement during hospitalization, despite previous functional loss, were 2.3–2.9 times more likely than persistent decliners to experience FR (p < .05 for all). Comparable patterns were found in the relationship between pre- and in-hospital functional trajectories and recovery, both in self-care and in mobility.

Conclusions. Differentiating between pre- and in-hospital functional changes is important for promoting short-term posthospitalization FR. In-hospital function-focused care that takes into account preadmission functional history may help improve posthospitalization FR.

Key Words: Physical function—Hospital related—Mobility—Functional recovery—Longitudinal.

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Acute illness and hospitalization have been described as crucial events leading to change in functioning (1). Studies showed that up to 30% of hospitalized older patients do not recover their premorbid functional status (FS) (2). This nonrecovery has been associated with increased risk of death and prolonged disability in both short- (1–3 months) and long-term (up to 3 years) follow-up periods (3).

Several studies examined risk factors for short-term functional recovery (FR) and found that older age, physical and cognitive frailty, severity of medical illness, prehospitalization FS, and functional dynamics are important (2,4,5). Of these, functional changes around acute illness and hospitalization are especially pertinent because they may be amenable to intervention. Changes in FS around acute hospitalization have shown a robust predictive validity with respect to many health-related outcomes (3,6,7). However, distinction between changes that occur immediately before hospitalization and those that occur during the hospitalization, and examination of their cumulative effects on subsequent FR, is notably lacking. This lack of a distinction is perplexing given that prehospital and subsequent in-hospital functional changes are inherently distinct processes; the former are likely to represent the effects of acute illness, and the latter may represent individual responses to received care. Thus, untangling functional changes across the illness continuum could uncover additional information, which in turn may help in planning patients’ tailored interventions. Hence, our primary aim was to estimate the effects of membership in categories that take into account pre- and within-hospital functional changes on the likelihood of FR 1 month after discharge. We hypothesized that differential relationships exist between the categories of change in functioning and posthospitalization FR.

Next, in most studies to date, functional change has been described as the difference between two or more time points in a global physical functional assessment. Although methodologically sound, this description might obscure important information about the interplay between
different dimensions of functioning such as self-care and mobility. Some studies showed differential effects of self-care and mobility functional deficits on mortality in community-dwelling older adults (eg, Bernard and colleagues (8)); however, similar studies of hospitalized older patients, to the best of our knowledge, are surprisingly absent. Therefore, to address this gap, our secondary aim was to examine differences between categories of change in self-care and mobility dimensions of functioning with regard to their impact on posthospitalization FR. Finally, given that multiple interdependent domains of functional capacity have been suggested (9), our third aim was to estimate the extent to which changes in self-care are related to recovery of mobility functioning and, conversely, the extent to which mobility changes are associated with self-care recovery, in a short posthospitalization follow-up period.

**Methods**

**Participants**

The study sample included 767 older (≥70) adults enrolled in the Hospitalization Process Effects on Functional Outcomes and Recovery (HoPE-FOR) study. Patients were admitted to one of eight general-medical inpatient units of two hospital centers in the northern part of Israel, between 2009 and 2011, for a nondisabling diagnosis. Design, recruitment, attrition, and data collection protocols are published elsewhere (10). Briefly, participants’ functional, cognitive, and medical statuses were assessed in a prospective manner at admission, discharge, and 1 month after discharge. Patients with moderate to severe cognitive impairment required the involvement of a surrogate (a family member who serves as the primary caregiver) during the consent process and subsequent interviews. Only participants with no missing data on functional assessments and those who were still alive at 1 month after discharge were included in this analysis. Thus, the analytic sample used here included 691 initially nondisabled older people with complete information on study outcomes. All participants provided written informed consent, and the study was approved by the hospital and Ministry of Health review boards.

**Measurements**

**Functional status.**—FS was assessed by self-report at four time points using the Modified Barthel Index (MBI), Shah and colleagues (11)). Upon admission to the hospital (24–48 hours), patients were asked retrospectively to report about their premorbid (2 weeks prior to admission) FS and to estimate their concurrent FS (admission FS). The next data collection occasions were at discharge (in person) and at 1 month after discharge (by telephone).

The MBI is a validated FS scale that estimates subjective ability to perform basic activities of daily living and includes 10 items. Of these, three items pertain to mobility function (chair–bed transfers, ambulation, and stair climbing) and seven items pertain to self-care capacity (eg, feeding, bathing; (9,12)). Each item is ranked on an ordinal five category scale indicating the amount of assistance required in functional independence in each task. Scoring for categories is level-of-assistance-specific, with great dependency graded as low as 1 point and inability to perform a task graded as 0. The total score for the 10 items ranges from 0 to 100, with lower scores indicating a lower level of function. Mobility and self-care subscale scores range from 0 to 40 and 0 to 60, respectively.

**Functional recovery.**—Study patients were classified as having recovered in terms of self-care, mobility, or total functioning 1 month after discharge if they were able to at least regain the same levels of functioning as those reported 2 weeks prior to hospital admission. Similarly, study patients were defined as nonrecovered if during the telephone interview they reported worse MBI scores than their respective preadmission scores.

**Categories of functional change.**—Patients were classified into one of six mutually exclusive categories of functional change depending on whether they declined or remained stable between preadmission and admission (prehospital phase) and whether they declined, remained stable, or improved between admission and discharge (in-hospital phase) in terms of their ability to perform activities of daily living. Category assignments were calculated separately for total, self-care, and mobility scores. Meaningful change in FS was defined as a 1-unit change in self-care or in total functional measure, and as a 2-unit change in mobility score. The units of change were selected based on the lowest score representing any, even minimal, change in functioning in the respective dimension. For example, for stair-climbing activity (mobility dimension) a 2-unit change represented the difference between an older adult’s ability to walk upstairs and downstairs with assistance and a complete inability to perform the activity. Similarly, for personal hygiene activity (self-care dimension) a 1-unit change indicated the difference between an older patient’s ability to conduct his or her own personal hygiene with substantial assistance and complete inability to attend to the activity.

To ease interpretation, we labeled each of the derived category of change groups such that the first word of a label represents prehospital change (eg, Decline, Stable) and the second word indicates in-hospital change (eg, Decline, Stable, Improvement). For example, the Decline-Decline group demonstrated a consistently downward trajectory in both prehospital and in-hospital phases, whereas the Decline-Improvement group experienced functional decline in the 2 weeks prior to hospital admission, and the...
reverse trend in the postadmission follow-up period. Other category groups were Stable-Stable, Stable-Improvement, Decline-Stable, and Stable-Decline.

Adjustment variables.—Cognitive status was assessed using the Short Portable Mental Status Questionnaire (13). The Short Portable Mental Status Questionnaire is a validated tool for assessing 10 items related to orientation, memory, and concentration. Total scores ranged from 0 to 10, with higher scores indicating higher cognitive status. Severity of acute illness was estimated using the Acute Physiology and Chronic Health Evaluation II scale (14). Comorbidities were assessed using Charlson’s comorbidity index (15), which weighs the number and severity of 20 health conditions. Data regarding severity of acute or chronic illness and length of stay were retrieved from the patients’ medical records. A measure of the occurrence of recurrent hospitalization within 30 days was calculated using combined self-reported and administrative data.

Statistical Analysis

The characteristics of the study participants according to FR status were described. Differences in demographic, medical, and functional measures between functionally recovered and nonrecovered participants were examined using a t test for continuous variables and a chi-square test for categorical variables. Multivariate logistic regression was used to estimate the log odds of being in a given functional category group (Stable-Stable, Stable-Improvement, Decline-Improvement, Decline-Stable, Stable-Decline) compared with the reference category (Decline-Decline). The reference category was selected as being clinically relevant to represent the physically vulnerable group. In the partially adjusted model, we controlled for age, gender, education, and length of hospital stay (results not shown). In the fully adjusted model, we also added indicators for cognitive status, Acute Physiology and Chronic Health Evaluation II scores, Charlson comorbidity, prehospital MBI scores, and rehospitalization within 30 days. Separate models were fitted for total functional scores, self-care, and mobility MBI subscales. To address the third aim, we used fully adjusted logistic regressions with self-care categories of change groups fitted in the model with mobility recovery outcome and, similarly, mobility categories of change groups fitted in the model with recovery in self-care outcome, replacing the original respective categories of functional change variables. All p values reported are for two-tailed tests. The statistical software STATA, version 11.2 (StataCorp, College Station, TX), was used for the statistical analysis.

RESULTS

Table 1 describes the characteristics of the study participants according to their FR status in terms of total MBI index. Overall, those who functionally recovered 1 month after discharge were younger, had more years of education, had a shorter length of stay, were more likely to be female, had lower severity of acute illness, had a lower comorbidity index, were less likely to be rehospitalized within 30 days, and had higher functional scores throughout the prehospital period and their in-hospital stay (p < .001 for all) than their nonrecovered counterparts. In addition, as Figure 1 illustrates, there were marked differences in membership in categories of functional change groups (p < .001), with a larger proportion of functionally recovered patients being in more favorable groups (ie, Decline-Improve, Stable-Stable, Stable-Improvement) than in less favorable groups (ie, Decline-Decline, Decline-Stable, Stable-Decline).

Table 2 summarizes the results of three fully adjusted multivariate logistic regression analyses predicting the likelihood of recovery of self-care, mobility, or total functioning as a result of membership in the categories of functional change groups. The results suggest that patients whose FS remained stable before and during hospitalization (Stable-Stable) had the highest odds of FR compared with the reference category (Decline-Decline). Adjusted odds ratios (AORs) were 6.0 (95% confidence interval [CI], 3.3–10.9); 9.8 (95% CI, 5.0–19.1); and 10.0 (95% CI, 4.2–24.0) in the total function, self-care, and mobility dimensions, respectively. Furthermore, older adults who experienced postadmission improvement in FS had relatively high odds of FR 1 month after hospitalization, with the strongest gain observed in the Stable-Improvement trajectory group: for total function scores (AOR = 3.6; 95% CI, 1.6–8.2), for self-care (AOR = 5.5; 95% CI, 2.3–13.6), and for mobility measures (AOR = 5.3; 95% CI, 1.8–15.5). Another important finding is that older patients who experienced functional improvement during hospitalization despite
functional loss in the prehospital phase were 2.3–3.0 times more likely to experience FR than those who experienced a persistent downward trajectory. Conversely, those who experienced any occasion of functional decline (prehospital or in-hospital) had risks of FR similar to those in the reference category, with the notable exception of the Stable-Decline group in the self-care category. Comparing the relative effects of membership in functional trajectories of change groups in self-care with mobility dimensions on FR, we also observed the largest differences in the Stable-Decline group, with AOR equal to 2.2 (95% CI, 1.0–4.5) for self-care indicators versus AOR equal to 1.4 (95% CI, 0.5–3.7) for mobility scores.

Table 3 presents the results of fully adjusted logistic regressions, in which cross-effects were fitted using self-care categories of change groups as independent variables in the model with mobility recovery outcome and, similarly, mobility categories of change groups in the model with self-care recovery outcome. Results indicate subtle differences in cross-effects, with AOR estimates being larger in the mobility recovery on self-care than in the self-care recovery on mobility models. Furthermore, an improvement during hospitalization in self-care functioning despite prehospital loss is associated with a statistically significant likelihood of mobility recovery (AOR = 2.4; 95% CI, 1.4–4.4) but an insignificant estimate of the effect of mobility dynamics on self-care recovery (AOR = 2.2; 95% CI, 0.8–5.9).

**DISCUSSION**

This study contributes to current knowledge on hospitalization and functional outcomes in two important ways. First, we distinguished within-hospitalization functional changes from the overall acute care functional continuum, showing that even after preadmission functional decline, within-hospital functional improvement, but not in-hospital stability in functioning, is significantly associated with recovery 1 month after discharge. Furthermore, we demonstrated that in-hospital stability in functioning needs to

Figure 1. Functional status-change categories among 691 older patients according to 1-mo posthospitalization total functional recovery. Categories denote prehospital and in-hospital decline (D-D; Decline-Decline); prehospital decline and in-hospital stability (D-S; Decline-Stable); prehospital and in-hospital improvement (D-I; Decline-Improvement); prehospital stability and in-hospital decline (S-D; Stable-Decline); prehospital and in-hospital stability (S-S; Stable-Stable); and prehospital stability and in-hospital improvement (S-I; Stable-Improvement).

**Table 3. Adjusted* Association of Functional Status-Change Categories in Self-care and 1-Mo Posthospitalization Functional Recovery in Mobility; Adjusted* Association of Functional Status-Change Categories in Mobility and 1-Mo Posthospitalization Functional Recovery in Self-care in 691 Hospitalized Older Patients**

<table>
<thead>
<tr>
<th>Functional Change Category</th>
<th>Odds of Functional Recovery in Mobility by Self-care Categories</th>
<th>Odds of Functional Recovery in Self-care by Mobility Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable-Stable</td>
<td>OR (95% CI) 8.1 (4.3–15.2) p value &lt;.001</td>
<td>OR (95% CI) 7.5 (3.1–18.3) p value &lt;.001</td>
</tr>
<tr>
<td>Stable-Improvement</td>
<td>2.9 (1.3–6.8) .012</td>
<td>2.3 (0.9–5.8) .068</td>
</tr>
<tr>
<td>Decline-Improvement</td>
<td>2.4 (1.4–4.4) .003</td>
<td>2.2 (0.8–5.9) .114</td>
</tr>
<tr>
<td>Decline-Stable</td>
<td>2.5 (0.9–6.6) .065</td>
<td>1.4 (0.4–4.2) .594</td>
</tr>
<tr>
<td>Stable-Decline</td>
<td>1.5 (0.7–3.0) .256</td>
<td>2.2 (0.8–5.9) .114</td>
</tr>
<tr>
<td>Decline-Decline</td>
<td>Reference</td>
<td>Reference</td>
</tr>
</tbody>
</table>

**Table 2. Adjusted* Association of Functional Status-Change Categories and 1-Mo Posthospitalization Functional Recovery in 691 Hospitalized Older Patients**

<table>
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<tr>
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<tbody>
<tr>
<td>Stable-Stable</td>
<td>6.0 (3.3–10.9) &lt;.001</td>
<td>9.8 (5.0–19.1) &lt;.001</td>
<td>10.0 (4.2–24.0) &lt;.001</td>
</tr>
<tr>
<td>Stable-Improvement</td>
<td>3.6 (1.6–8.2) .002</td>
<td>5.5 (2.3–13.6) &lt;.001</td>
<td>5.3 (1.8–15.5) .002</td>
</tr>
<tr>
<td>Decline-Improvement</td>
<td>2.3 (1.3–4.0)</td>
<td>3.0 (1.6–5.7) .001</td>
<td>2.8 (1.2–6.8) .020</td>
</tr>
<tr>
<td>Decline-Stable</td>
<td>1.4 (0.5–4.1) .517</td>
<td>2.0 (0.7–5.4) .185</td>
<td>1.8 (0.6–5.0) .295</td>
</tr>
<tr>
<td>Stable-Decline</td>
<td>1.3 (0.6–2.5) .534</td>
<td>2.2 (1.0–4.5) .036</td>
<td>1.4 (0.5–3.7) .470</td>
</tr>
<tr>
<td>Decline-Decline</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
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</table>

**Notes:** CI = confidence interval; OR = odds ratio.

*Adjusted for age, gender, cognition, length of stay, severity of illness, Charlson score, premorbid functional status, and rehospitalization within 30 d.

*Adjusted for age, gender, cognition, length of stay, severity of illness, Charlson score, premorbid functional status, and rehospitalization within 30 d.
be interpreted cautiously, as stability following prehospital decline is largely deleterious, whereas consistent stability from 2 weeks before hospitalization until discharge is the most beneficial in models adjusted for preadmission FS.

Second, this study is the first to examine how partitioning of total functioning into two dimensions, self-care and mobility, is associated with respective pre- to posthospitalization FR. Our results show that comparable patterns exist in the relationship between pre- and in-hospital functional trajectories and recovery in terms of both self-care and mobility. Interestingly, we also show that in-hospital improvement in self-care functioning is associated with recovery in mobility, whereas in-hospital improvement in mobility functioning is not associated with recovery in self-care.

Few studies have specifically examined the relationship between pre- and within-hospital functional dynamics and posthospitalization outcomes. A study that examined functional trajectories and nursing home admissions within 30 days after discharge showed that in-hospital functional improvement that follows prehospital decline was not significantly associated with subsequent institutionalization (6). Similarly, Sleiman and colleagues (7) showed that in-hospital FR to baseline following severe prehospital functional loss was not significantly associated with 3-month posthospitalization mortality. However, these null findings should be interpreted in light of the type of reference group used. Both studies used the most resilient trajectory as the comparison category. Examination of the descriptive data reported in both articles (6,7) shows that the in-hospital improvement group had lower rates of nursing home admission and mortality compared with persistently declining trajectories. Thus, these findings are consistent with ours and highlight the importance of in-hospital improvement in relation to posthospitalization outcomes.

Our finding that within-hospital stability needs to be viewed in the context of the preadmission trajectory is important for the identification of at-risk groups. Not differentiating between those who are functionally stable before acute hospitalization and throughout their hospital stay, and those who decline in the prehospital phase may result in under- or overestimation of the risks in one of the groups. This emphasis on the importance of preadmission functional change has also been noted by Rozzini and colleagues (16), who showed that preadmission to admission change in function was independently associated with 6-month mortality.

In addition to untangling functional changes that occur immediately before hospitalization from those that occur during the hospitalization, the aims of this study were to examine how partitioning of total functioning into two dimensions, self-care and mobility, is associated with respective pre- to posthospitalization FR, and also to estimate cross-effects among these functional domains. Our results demonstrate that comparable patterns exist in the relationship between pre- and in-hospital functional changes and recovery in terms of both self-care and mobility. We also show subtle differences in cross-effects, with a significant impact of self-care categories of change on mobility recovery. Pending further investigation, one cautious interpretation is that the self-care and mobility dimensions are closely interrelated, and that domain-specific interventions may have diffuse salutary effects on other domains of functioning. Our findings thus have potential implications for shaping in-hospital practices by highlighting functional-focused care through domain-specific–targeted interventions (17).

Several study limitations are noteworthy. First, our findings should be interpreted carefully, as causality cannot be determined. Nonetheless, the prospective design and the comprehensive assessment of a wide range of risk factors contribute to our ability to suggest the directionality of the reported relationships. Second, our findings are based on self-reports rather than on performance-based functional assessments. Although objective performance-based measurement has greater validity (18), a four-time-point assessment of functioning precludes such an elaborative evaluation. Finally, although our data lacked indicators of postacute use of rehabilitative services, these services in Israel are not widely available for older patients discharged from general-medical inpatient units with a nondisabling primary diagnosis.

In conclusion, our findings add to the understanding of how pre- and in-hospital functional changes are related to posthospitalization recovery and have potential implications for shaping in-hospital practices through function-oriented modalities.

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