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THE ROLE OF INTERVENING ILLNESSES AND INJURIES IN PROLONGING THE DISABLING PROCESS

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Abstract

Objective—To evaluate the relationship between intervening illnesses and injuries leading to hospitalization and restricted activity, respectively, and prolongation of disability in four essential activities of daily living among newly disabled older persons.

Design—Prospective cohort study.

Setting—Greater New Haven, Connecticut.

Participants—632 community-living persons, aged 70 years or older, who had at least one episode of disability from March 1998 to June 2013.

Measurements—Disability and exposure to intervening illnesses and injuries leading to hospitalization and restricted activity, respectively, were assessed every month. Prolongation of disability was operationalized in two complementary ways: as a dichotomous outcome, based on the persistence of any disability, and as a count of the number of disabled activities.

Results—During a median follow-up of 114 months, the 632 participants experienced 2,764 disability episodes. The mean exposure rates (95% confidence interval) for hospitalization and restricted activity were 80.7 (73.7–88.4) and 173.6 (162.5–185.5), respectively, per 1000 person-months. After adjustment for multiple disability risk factors, the likelihood of disability prolongation was increased 2.5-fold (odds ratio 2.54, 95% confidence interval 2.05 to 3.15) for hospitalization and 21% (1.21, 1.06 to 1.40) for restricted activity, while the mean number of disabilities increased by 35% (risk ratio 1.35, 1.30 to 1.39) and 7% (1.07, 1.05 to 1.09) in the setting of a hospitalization and restricted activity, respectively.

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Dr. Gill had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors meet the criteria for authorship stated in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals.

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Conclusions—Intervening illnesses and injuries leading to hospitalization and restricted activity, respectively, are strongly associated with prolongation of disability among newly disabled older persons. Efforts to prevent and more aggressively manage these intervening events have the potential to break the cycle of disability among older persons.

Keywords

aged; cohort studies; activities of daily living; disability evaluation

Introduction

Among older persons, the ability to perform daily activities, such as bathing, dressing and transferring, is essential for independent living. The onset of disability, defined as the need for personal assistance, in these essential activities marks a serious decline in functional health, conferring increased risk of institutionalization and death and leading to substantial financial costs and reductions in quality of life.^{1, 2}

As with other conditions affecting older persons, such as falls³ and delirium,⁴ disability is often considered a geriatric syndrome. A defining feature of geriatric syndromes is the independent contribution of predisposing factors that make one vulnerable, such as physical frailty and cognitive impairment, and intervening illnesses or injuries that act as precipitants, such as pneumonia and an injurious fall. Evidence supporting this model of disability has been shown for essential activities of daily living⁵ and long-term disability in community mobility.⁶

Unlike conditions that invariably progress, such as Alzheimer's Disease, disability is often a recurrent disorder, characterized by high rates of recovery.⁷ While the predisposing and precipitating factors for the onset of disability have been well characterized,^{5, 8} relatively little is known about the factors that may prolong (or perpetuate) disability after its initial onset, especially the role of intervening illnesses and injuries (hereafter referred to collectively as intervening events).

The objective of the current study was to evaluate the relationship between intervening events and the prolongation of disability in essential activities of daily living among newly disabled older persons, while accounting for established predisposing factors for disability. We used data from a unique longitudinal study that includes monthly assessments of intervening events and essential activities of daily living for more than 15 years in a cohort of community-living older persons.

METHODS

Study Population

Participants were members of the Precipitating Events Project, a longitudinal study of community-living persons, 70+ years, who were nondisabled in four essential activities of daily living—bathing, dressing, walking, and transferring.⁹ Exclusion criteria included significant cognitive impairment with no available proxy,¹⁰ inability to speak English, diagnosis of a terminal illness, and plans to move out of the area during the next 12 months.

The assembly of the cohort, which took place between March 1998 and October 1999, has been described in detail elsewhere.^{7, 9} In brief, potential participants were identified from a computerized list of 3,157 age-eligible members of a large health plan in greater New Haven, Connecticut. Based on our initial sample size calculations, persons were oversampled if they were physically frail, defined on the basis of slow gait speed.¹¹ Eligibility was determined during a screening telephone interview and was confirmed during an in-home assessment. Only 4.6% of the persons contacted refused screening, and 754 (75.2%) of the 1002 eligible members agreed to participate in the project. Persons who refused to participate did not differ significantly from those who were enrolled in terms of age or gender.

Data Collection

Comprehensive home-based assessments were completed at baseline and subsequently at 18-month intervals for 162 months (except for 126 months), while telephone interviews were completed monthly through June 2013. For participants who had significant cognitive impairment or were otherwise unavailable, a proxy was interviewed using a rigorous protocol, with demonstrated reliability and validity.¹⁰ Deaths were ascertained from local obituaries and/or an informant during a subsequent interview. 588 (77%) participants died after a median of 93 months, while 42 (5.6%) dropped out of the study after a median of 27 months. Data were otherwise available for 99.2% of the 79,446 monthly interviews.

Assessment of Predisposing Factors—During each of the comprehensive assessments, data were collected on several predisposing factors and other covariates, including demographic characteristics, physical frailty, cognitive status as assessed by the Mini-Mental State Examination (MMSE),¹² depressive symptoms as assessed by the Center for Epidemiologic Studies Depression (CES-D) Scale,¹³ and nine self-reported, physician-diagnosed chronic conditions: hypertension, myocardial infarction, congestive heart failure, stroke, diabetes mellitus, arthritis, hip fracture, chronic lung disease, and cancer. Data on these covariates were 100% complete at baseline and greater than 95% complete during the subsequent comprehensive assessments. Participants were considered to be cognitively impaired if they scored less than 24 on the MMSE,¹² and to have high depressive symptoms if they scored 20 or higher on the CES-D.¹³

Assessment of Intervening Events—The intervening events included illnesses and injuries leading to either hospitalization or restricted activity. During the monthly telephone interviews, participants were asked whether they had stayed at least overnight in a hospital since the last interview, i.e. during the past month. The accuracy of these reports was high, with Kappa=0.94.¹⁴

To ascertain less potent intervening events, participants were asked two questions related to restricted activity using a standardized protocol with high reliability, i.e. Kappa=0.90⁹: 1) “Since we last talked on (date of last interview), have you cut down on your usual activities due to an illness, injury or other problem?” and 2) “Since we last talked on (date of last interview), have you stayed in bed for at least half a day due to an illness, injury or other

problem?” Participants who answered “Yes” to one or both of these questions were considered to have restricted activity during a specific month.⁹

For each month during the follow-up period, exposure to the intervening events was categorized as hospitalization, restricted activity without hospitalization, referred to hereafter simply as restricted activity, or neither hospitalization nor restricted activity.

Assessment of Disability—Complete details regarding the assessment of disability, including formal tests of reliability and accuracy, are provided elsewhere.^{6, 7, 10} During the monthly telephone interviews, participants were assessed for disability using standard questions that were identical to those used during the screening telephone interview. For each of the four essential activities, we asked, “At the present time, do you need help from another person to (complete the task)?” Participants who needed help with any of the tasks were considered to be disabled. To address the small amount of missing data on disability, multiple imputation was used with 100 random draws per missing observation.¹⁵

Outcome and Analytic Sample—The primary outcome was prolongation of a disability episode. Participants who were disabled at Month t were at risk for prolongation of disability at Month $t+1$ if they were still alive and active in the study. The analytic sample included participants who had at least one episode of disability. Of the 754 participants, 50 (6.6%) had no disability during the follow-up period; 47 (6.2%) died without developing disability; and 25 (3.3%) died or dropped out of the study the month after developing their first episode of disability, which precluded prolongation. The analytic sample, therefore, included 632 participants, who could each potentially contribute more than one disability episode.

For each disability episode, prolongation, which was assessed each month, was operationalized in two complementary ways. For the first, the monthly outcome was dichotomized as prolonged (yes or no), based on the presence of any disability. For the second, the monthly outcome was evaluated as a count of the number of disabled activities. For the dichotomous and count outcomes, disability was considered prolonged until the participant had regained independence in all four activities, had died or had reached the end of the follow-up period.

Statistical Analysis

Baseline characteristics of participants who were included and excluded from the analytic sample were calculated as counts (percentages) for categorical variables and medians (interquartile ranges) for continuous variables. The chi-square test was used to evaluate differences in percentages, while the Wilcoxon rank sum test was used to evaluate differences in medians. Descriptive characteristics were calculated for the number and duration of the disability episodes and the number of months at risk for prolongation of disability. To quantify exposure to the two intervening events—hospitalization and restricted activity, we calculated the mean rate for each as the number of person-months exposed divided by all person-months observed. The corresponding confidence intervals were obtained using intercept-only Poisson models.

The two complementary outcomes were modeled according to their statistical distributions. A logistic regression model was used for the dichotomous outcome, while a negative binomial model was used for the count outcome. Generalized estimating equations, with an autoregressive covariance structure, were used to account for the serial correlation of the monthly repeated measures of each outcome within each participant. The primary independent variables included hospitalization and restricted activity, which were both time varying. For the dichotomous outcome, the associated odds ratios refer to the odds of remaining disabled at Month $t+1$, based on exposure to hospitalization and restricted activity during the preceding month (t). For the count outcome, the associated risk ratios refer to the relative increase in the mean disability count at Month $t+1$, based on exposure to hospitalization and restricted activity during the preceding month (t). The multivariable models also included three fixed covariates—sex, race/ethnicity, and years of education—and six time-varying covariates—age 85 years or older, living alone, number of chronic conditions, physical frailty, cognitive impairment, and depressive symptoms. These covariates represent important sociodemographic factors and relevant predisposing factors that have been linked to disability in prior studies.^{5, 16} Age was dichotomized to facilitate clinical interpretation. The time-varying covariates were updated using data from the subsequent comprehensive assessments. To further facilitate clinical interpretation, adjusted least-square means were calculated for the number of disabled activities in the month following exposure to hospitalization and restricted activity, respectively, and in the month following no exposure to these intervening events.

All analyses were performed using SAS V9.3 (SAS Institute, Cary, North Carolina).

RESULTS

As shown in Table 1, the baseline characteristics of participants who were included in the analytic sample did not differ significantly from those of participants who were excluded, although marginal differences were observed for sex and physical frailty. Among participants included in the analytic sample, the median age was 78 years; about two-thirds were female, 90% were non-Hispanic white, and 40% lived alone. Physical frailty was present in more than two out of five participants, while cognitive impairment and depressive symptoms were present in about one out of eight and one out of seven participants, respectively.

During a median follow-up of 114 months, the 632 participants experienced 2,764 disability episodes, with a median per participant (interquartile range (IQR)) of 4 (2–7). Nearly half of these episodes were preceded (within a month) by either a hospitalization (25.1%) or restricted activity (22.4%). The median (IQR) duration of the disability episodes was 2 (1–4) months, while the mean (standard deviation) duration was 6.3 (14.2) months. The median (IQR) number of months at risk for prolongation of disability was 15 (4–41) months. A relatively small minority of participants (11.4%) was at risk for only one month. The mean exposure rates (95% confidence interval) for the two intervening events—hospitalization and restricted activity—were 80.7 (73.7–88.4) and 173.6 (162.5–185.5), respectively, per 1000 person-months at risk for prolongation of disability.

In bivariate analysis, hospitalization was significantly associated with prolongation of disability, with an unadjusted odds ratio (95% confidence interval) of 2.15 (1.77–2.62) for the dichotomous outcome and an unadjusted risk ratio of 1.31 (1.27–1.36) for the count outcome. The corresponding results for restricted activity were 1.05 (0.93–1.19) and 1.02 (1.002–1.04), respectively. Table 2 shows the multivariable associations with prolongation of disability, as a dichotomous outcome and count outcome, respectively. Hospitalization and restricted activity were significantly associated with both outcomes. For the dichotomous outcome, the likelihood of disability prolongation was increased 2.5-fold for hospitalization and 21% for restricted activity. For the count outcome, the mean number of disabilities increased by 35% and 7% in the setting of a hospitalization and restricted activity, respectively. In absolute terms, the mean number of disabilities (95% confidence interval) in the month following hospitalization was 1.10 (1.06–1.13) as compared with 0.73 (0.72–0.75) in the month following no hospitalization. The corresponding values were 0.96 (0.93–0.99) and 0.87 (0.85–0.88) in the month following restricted activity and no restricted activity, respectively. As shown in Table 2, age, physical frailty, cognitive impairment and depressive symptoms were significantly associated with both outcomes; female sex was associated with the dichotomous outcome, but not the count outcome; and living alone and number of chronic conditions were associated with the count outcome but not the dichotomous outcome. The results did not change appreciably when the nine individual chronic conditions were substituted for the number of chronic conditions (results available upon request).

DISCUSSION

In this prospective study of community-living older persons, we found that intervening illnesses and injuries leading to hospitalization and restricted activity, respectively, are strongly associated with prolongation of disability among those who had become disabled in their essential activities of daily living. These associations were observed after adjustment for multiple predisposing factors, such as age, physical frailty, cognitive impairment, and depressive symptoms, that are established predictors of disability. The results from the current study, together with those from prior work,^{5, 6, 16} suggest that intervening illnesses and injuries play an important role not only in precipitating disability, but also in perpetuating the disabling process.

Our study is unique in that it included monthly assessments of disability. This allowed us to evaluate prolongation as both a dichotomous outcome, based on the presence or absence of disability for an additional month, and a count outcome, based on an increase in the mean number of disabled activities from one month to the next. The consistency of the multivariable results for these two complementary outcomes enhances the validity of the study. For both outcomes, we found that the magnitude of association for each intervening hospitalization, as denoted by the odds ratio and risk ratio, respectively, was comparable to that for physical frailty and cognitive impairment, two of the most potent predisposing factors for disability.^{5, 16} Because some participants likely had more than one hospitalization during an episode of disability,¹⁷ which lasted more than six months on average, the overall effect of hospitalization on prolongation of disability may be greater than that of these predisposing factors. In absolute terms, the mean number of disabled activities increased by

0.37 (on a 4-point scale) in the setting of a hospitalization, but only 0.09 in the setting of restricted activity.

Although the magnitude of association for restricted activity was less than that for hospitalization, the exposure rate for restricted activity was more than twice that for hospitalization, thereby enhancing the overall effect of these less potent intervening events on prolongation of disability. Prior research has shown that restricted activity and disability are distinct constructs, and one does not presuppose the other. In a cross-sectional study of community-living older persons, for example, restricted activity explained only 11.5% of the variance in functional limitations.¹⁸ In the current study, restricted activity was assessed “over the preceding month”, while disability was assessed “at the present time”, further distinguishing these two indicators of health.

Our results are important because several of the most common intervening events, such as pneumonia, injurious falls, and heart failure, are either preventable^{19–22} or amenable to aggressive in-hospital management^{4, 23–25} or restorative interventions after hospitalization.^{26–28} The heightened risk for untoward outcomes after hospital discharge has been termed post-hospital syndrome.²⁹ In the current study, one out of every four disability episodes was preceded by an acute hospitalization. Our results suggest that efforts to prevent hospital readmissions among newly disabled older persons, through improved care transitions and other innovative programs,^{29–31} may help to reduce the likelihood of disability being perpetuated. In addition, by establishing and quantifying the relationship between intervening hospitalizations and disability prolongation, the current study highlights the value of obtaining a functional history at the time of hospital admission. This information can be used to inform post discharge planning.

Because of the long duration of follow-up, which extended for more than 15 years, nearly seven out of every eight cohort members had at least one episode of disability, and most of these participants were included in the analytic sample. Because disability is a recurrent event, participants were allowed to contribute more than one disability episode to the analysis, thereby enhancing power. Although causality cannot be established by an observational study, the frequency of our assessments increases the likelihood that the intervening events at least preceded the prolongation of disability. The validity of our results is further strengthened by the nearly complete ascertainment of the intervening events and disability, by the high reliability and accuracy of these assessments, and by the low rate of attrition for reasons other than death.

Our results should be interpreted in the context of at least four potential limitations. First, information was not available on the duration of the intervening events. It is possible that the likelihood of prolongation increases as the duration of the intervening events increases. Second, although the current study was designed to evaluate the effect of these intervening events on prolongation of disability, it is likely that the relationship is bidirectional, such that disability increases the likelihood of hospitalization and restricted activity, respectively, leading in turn to a potential downward spiral. Additional research is needed to more completely elucidate these complex relationships. Third, for restricted activity, the results for the dichotomous outcome achieved statistical significance in the multivariable analysis,

but not the bivariate analysis, further highlighting the complex relationships between these events and prolongation of disability. Fourth, because our study participants were members of a single health plan in a small urban area in the US and were oversampled for physical frailty, our results may not be generalizable to older persons in other settings. However, the demographic characteristics of our cohort reflect those of older persons in New Haven County, Connecticut, which are similar to the characteristics of the US population as a whole, with the exception of race/ethnic group.³²

Intervening illnesses and injuries leading to hospitalization and restricted activity, respectively, are strongly associated with prolongation of disability among newly disabled older persons, independent of established risk factors for disability. Given the central role of these intervening events in precipitating and subsequently perpetuating the disabling process, aggressive efforts are warranted to prevent their occurrence and reduce their adverse consequences.

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Table 1

Baseline Characteristics of Participants Included and Excluded from Analytic Sample

	Included	Excluded	P Value ^a
Characteristic	N=632	N=122	
Age, y			
Median (IQR)	78 (74–82)	77 (74–82)	.241
85 or older, n (%)	82 (13.0)	20 (16.4)	.312
Female, n (%)	417 (66.0)	70 (57.4)	.069
Non-Hispanic white, n (%)	568 (89.9)	114 (93.4)	.219
Lives alone, n (%)	251 (39.7)	47 (38.5)	.806
Education, median (IQR), y	12 (10–14)	12 (11–14)	.137
Chronic conditions, median (IQR)	2 (1–3)	2 (1–2)	.346
Physical frailty ^b , n (%)	279 (44.2)	43 (35.3)	.069
Mental status			
MMSE score, median (IQR)	27 (25–29)	27 (26–29)	.081
Cognitive impairment ^c , n (%)	77 (12.2)	9 (7.4)	.126
Psychological status			
CES-D score, median (IQR)	8 (3–15)	7 (2–13)	.180
Depressive symptoms ^d , n (%)	88 (13.9)	12 (9.8)	.223

Abbreviations: IQR, interquartile range; MMSE, Mini-Mental State Examination; CES-D score, Center for Epidemiologic Studies Depression Scale.

^aThe Wilcoxon rank sum test was used to evaluate differences in medians, while the chi-square test was used to evaluate differences in percentages.

^bDefined on the basis of slow gait speed, as described in the Methods.

^cDefined as an MMSE score of less than 24.

^dDefined as a CES-D score of 20 or higher.

Table 2Factors Associated in Multivariable Analysis with Prolongation of Disability, N=632^a

Factor	Dichotomous Outcome		Disability Count	
	Odds Ratio (95% CI)	P Value	Risk Ratio (95% CI)	P Value
Age 85 years or older	2.01 (1.61 – 2.52)	<.001	1.20 (1.11 – 1.29)	<.001
Female sex	1.35 (1.04 – 1.76)	.027	1.04 (0.95 – 1.13)	.423
Non-Hispanic white	0.83 (0.59 – 1.19)	.314	0.96 (0.85 – 1.10)	.579
Lives alone	0.79 (0.61 – 1.02)	.074	0.84 (0.79 – 0.90)	<.001
Years of education	1.03 (0.99 – 1.08)	.136	1.01 (1.00 – 1.02)	.157
Number of chronic conditions	1.03 (0.94 – 1.13)	.511	1.03 (1.00 – 1.06)	.020
Physical frailty ^b	2.85 (2.21 – 3.67)	<.001	1.43 (1.31 – 1.56)	<.001
Cognitive impairment ^c	2.54 (1.99 – 3.23)	<.001	1.37 (1.29 – 1.46)	<.001
Depressive symptoms ^d	1.44 (1.15 – 1.81)	.001	1.11 (1.05 – 1.17)	<.001
New intervening events ^e				
Hospitalization	2.54 (2.05 – 3.15)	<.001	1.35 (1.30 – 1.39)	<.001
Restricted activity	1.21 (1.06 – 1.40)	.006	1.07 (1.05 – 1.09)	<.001

Abbreviation: CI: confidence interval.

^aThe 632 participants contributed 17,398 person-months of follow-up. Results are per each one-unit increase for the continuous factors (years of education and number of chronic conditions).^bDefined on the basis of slow gait speed, as described in the Methods^cDefined as a score of less than 24 on the Folstein Mini-Mental State Examination.^dDefined as a score of 20 or higher on the Center for Epidemiologic Studies Depression Scale.^eThe exposure period was the month prior to the assessment of prolongation. The comparison group included participants without an acute hospital admission or restricted activity.