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The Effects of Resident and Nursing Home Characteristics on Activities of Daily Living

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Background. Existing studies on the relationships between impairments and activities of daily living (ADLs) in nursing home residents have serious limitations. This study examines the relationships among admission impairments, including pain, depression, incontinence, balance, and falls, and follow-up ADLs, as well as the effect of the nursing home on follow-up ADLs of extended-stay nursing home residents.

Methods. This longitudinal cohort study consisted of 4,942 extended-stay residents who were admitted into 377 Minnesota nursing homes during 2004. General linear mixed models were used for all analyses, with 14 resident-level and 8 facility-level control variables.

Results. Incontinence and balance function at admission were significantly associated with increases in ADL dependence at follow-up. Individual nursing homes had independent effects on all three ADL models. Similar findings were found after facility-level control variables were added.

Conclusions. Incontinence predicts subsequent ADL functional levels. The relationship between balance dysfunction and subsequent ADL dependence could be causal. Future studies of the causal relationships between impairments and ADL should examine the effectiveness of impairment interventions on ADL as well as these relationships in different subgroups of nursing home residents.

Key Words: Nursing homes—Activities of daily living—Impairments—Incontinence—Falls.

PAIN, depression, bowel and bladder incontinence, balance dysfunction, and falls are prevalent among nursing home residents, but their impact on activity of daily living (ADL) dependence is not well established (1–9). To date, studies that have examined the relationships between these impairments and ADL dependencies have serious limitations (10–20), because (i) most studies were conducted in community-dwelling populations, (ii) few specifically examined which factors predict individual ADL dependence (21), (iii) some failed to include important confounding variables that may simultaneously affect the predictor and outcome variables (eg, balance function and pain) (16, 18, 19), and (iv) none have accounted for the clustering of residents within a facility or have included a random nursing home effect to determine whether living in a particular facility will affect residents' ADL dependence. Failure to account for this correlated data structure may have produced inefficient coefficient estimates in previous studies; that is, it is more likely to commit a Type II error where the false null hypothesis was not rejected.

This study addresses these limitations by examining which resident-level impairments at admission—pain, depression, bowel and bladder incontinence, balance dysfunction, and falls—predict 6-month follow-up ADL dependence and whether there is an independent nursing home effect on these individual ADLs at 6-month follow-up.

Methods

Study Design and Data Sources

Data for this longitudinal cohort study of extended-stay nursing home residents in Minnesota were assembled from resident-level variables derived from the 2004 Minimum Data Set (MDS), nursing home characteristics from 2004 Minnesota state administrative data systems, and staffing levels from the 2004 Minnesota Department of Human Services Annual Facility Survey. The Institutional Review Board at the University of Minnesota approved this study.

Study Sample

Inclusion criteria required that the resident was aged 65 years or older at admission; admitted to a Minnesota nursing home in 2004; administered a MDS admission assessment and

*This study was conducted at Division of Health Policy and Management, University of Minnesota in Twin Cities.

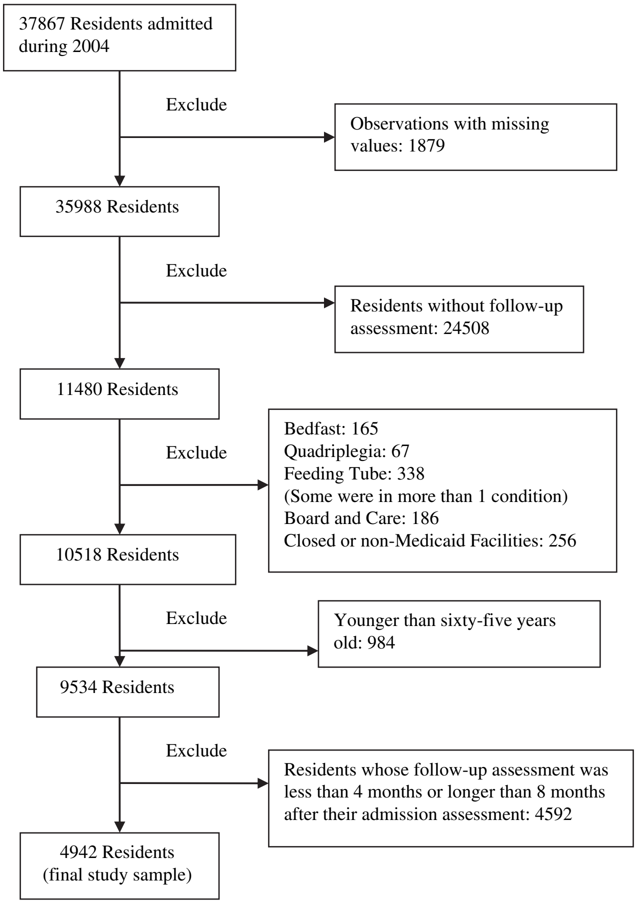

Figure 1. Participant selection flow diagram.

a follow-up assessment in the same facility approximately 6 months after the admission assessment; and not comatose, bedridden, quadriplegic, or on a feeding tube at baseline.

Figure 1 illustrates the participant selection process, which excluded 24,508 residents without follow-up assessments. Compared with the remaining 11,480 residents, the excluded residents were somewhat younger (mean age 77.8 vs 80.2, $p < .001$) and considerably more likely to have been admitted from an acute care hospital (87.9% vs 61.7%, $p < .001$). The excluded group also had a much lower proportion of cognitively impaired residents (40.9% vs 67.0%, $p < .001$) and had fewer residents with bowel and bladder incontinence, although they were likely to have more frequent and intense pain. Because of a quarterly MDS assessment requirement and a mandatory evaluation whenever a resident had a significant change in status, 4,592 residents were excluded because their length of follow-up was shorter than 4 months or longer than 8 months. Their demographics showed no significant difference from the final sample (N= 4,942), except that the final sample had a higher percentage of cognitively impaired residents (72.9% vs 64.2%, $p < .001$) and a lower proportion of residents with pain (52.5% vs 63.4%, $p < .001$). The final analytical file contains 4,942 residents with a length of follow-up between 4 and 8 months in 377 Minnesota nursing homes.

Table 1. Characteristics of Minnesota Nursing Homes' Sample in 2004 (N = 377)

Characteristics	Number of Facilities	Percentage
Ownership		
Government	54	14.32
For profit	98	25.99
Nonprofit	225	59.68
Hospital affiliation		
Hospital based	65	17.24
Freestanding	312	82.76
Location		
Twin Cities area	116	30.77
Other metro area	51	13.53
Rural	210	55.70
Characteristics	Mean (*SD*)	Range
Total bed size	96.74 (57.36)	24–559
Number of participants per facility	13.11 (9.48)	1–88
Licensed staffing level (hours per resident day)	1.00 (0.23)	0.37–2.06
Unlicensed staffing level (hours per resident day)	2.22 (0.34)	0.43–3.83
Percentage of Medicare days	9.22% (4.71%)	0.63%–34.00%
Community discharge rates	38.38% (13.31%)	0%–71.47%
Total ADL change score	−0.48 (2.39)	−9 to 7

Note: ADL = activity of daily living.

Outcome Variables

An ordered loss among ADLs has been found in nursing home residents (22, 23):

1. Early-loss ADLs: dressing and personal hygiene.
2. Middle-loss ADLs: toileting, transfer, and locomotion.
3. Late-loss ADLs: bed mobility and eating.

We used personal hygiene, toileting, and eating as indicators of early, middle, and late ADL loss. In the MDS, each ADL task is scored from 0 (independent) to 4 (totally dependent). Each task was examined separately in regression models using the same predictor variables to assess whether different impairments may predict the ADLs that are lost in various stages.

Independent Variables

Pain was measured by the MDS Pain Scale, with a score ranging from 0 (no pain) to 3 (daily severe pain) (24). Depression was measured by the existence of a depression diagnosis in the MDS record. Bowel and bladder incontinence, each rated in MDS from 0 (continent) to 4 (incontinent), were entered separately as independent variables. Standing balance and sitting balance items in MDS were used to develop an overall balance scale, with a score ranging from 0 (good standing and sitting balance) to 5 (worst standing and sitting balance). Two MDS fall items, "fell in past 30 days" and "fell in past 31 to 180 days," were included as separate independent variables.

Table 2. Basic Characteristics of Minnesota Nursing Home Residents Sample (N = 4,942)

Characteristics	Mean (*SD*) or *n* (%)	Range
Age	84.3 (7.6)	65–106
Gender		
Male	1,517 (30.7%)	
Female	3,425 (69.3%)	
Race		
White	4,819 (97.5%)	
Non-White	123 (2.5%)	
Education		
No schooling	59 (1.2%)	
8th grade or less	1,244 (25.2%)	
9th–11th grade	456 (9.2%)	
High school	1,757 (35.6%)	
Technical or trade school	365 (7.4%)	
Some college	579 (11.7%)	
Bachelor's degree	350 (7.1%)	
Graduate degree	132 (2.7%)	
Admission sources		
Community (home, board and care facility, assistive living, and group home	1,501(30.4%)	
Nursing homes	668 (13.5%)	
Hospitals	2,711 (54.5%)	
Other	62 (1.3%)	
Length of follow-up* (days)	172.8 (15.4)	110–219
Cognition (MDS Cognition Scale)		
Intact to mild impairment	1,342 (27.2%)	
Mild to moderate impairment	1,790 (36.2%)	
Moderate to severe impairment	1,631 (33.0%)	
Severe to very severe impairment	179 (3.6%)	
Vision		
Adequate	3,382 (68.4%)	
Impaired	935 (18.9%)	
Moderately impaired	361 (7.3%)	
Highly impaired	196 (4.0%)	
Severely impaired	68 (1.4%)	
Number of comorbidities	1.4 (1.1)	0–7
Number of medications	9.4 (4.3)	0–32
Pain (MDS Pain Scale)		
No pain	2,346 (47.5%)	
Less than daily pain	1,321 (26.7%)	
Mild/moderate daily pain	1,080 (21.9%)	
Severe daily pain	195 (4.0%)	
Balance dysfunction score		
0	245 (5.0%)	
1	892 (18.1%)	
2	2,427 (49.1%)	
3	134 (2.7%)	
4	870 (17.6%)	
5	374 (7.6%)	
Depression	1,683 (34.1%)	

(Table *Continued*)

Table 2. Continued

Characteristics	Mean (*SD*) or *n* (%)	Range
Bowel incontinence		
Continent	3,293 (66.6%)	
Usually continent	427 (8.6%)	
Occasionally incontinent	342 (6.9%)	
Frequently incontinent	453 (9.2%)	
Incontinent	427 (8.6%)	
Bladder incontinence		
Continent	2,049 (41.5%)	
Usually continent	444 (9.0%)	
Occasionally incontinent	673 (13.6%)	
Frequently incontinent	1,189 (24.1%)	
Incontinent	587 (11.9%)	
Fall		
In past 30 d	2,005 (40.6%)	
In past 31–180 d	662 (13.4%)	
Restraint use		
Bedrail		
Not used at all	4,184 (84.7%)	
Used	758 (15.3%)	
Non-bedrail		
Not used at all	4,815 (97.4%)	
Used	127 (2.6%)	

Notes: MDS = Minimum Data Set.
*From admission assessment to follow-up assessment.

Resident-Level Control Variables

All three ADL models included 14 resident-level control variables: age, gender, ethnicity, education, vision, cognition, restraint use, number of comorbidities, being admitted from a hospital, Medicare-reimbursed admission to the nursing home, unstable resident conditions, number of medications taken, previous nursing home admission, and length of follow-up (to account for the differences among residents in the 4- to 8-month follow-up period).

Cognition was measured by MDS Cognition Scale, with a score of 0 to 10 (25–27). Because of low restraint use, the five types of restraints were grouped into two variables—bedrail restraint and non-bedrail restraint—and were entered separately as control variables. Both were scored from 0 (not used) to 2 (used daily).

A total comorbidity score was calculated by adding the number of chronic conditions a resident had among 10 chronic conditions: diabetes mellitus, arthritis, hip fracture, congestive heart failure, peripheral vascular disease, osteoporosis, pathological bone fracture, cerebrovascular accident, Parkinson's disease, and chronic obstructive pulmonary disease. The comorbidity scores ranged from 0 to 10.

Facility-Level Control Variables

Eight facility-level control variables were included in the second-phase analyses: facility profit status (profit, nonprofit,

Table 3. ADL Scores of Minnesota Nursing Home Residents at Admission and Follow-up Assessment ($N = 4{,}942$)

	Number (%)	
	Baseline	Follow-up
Total ADL score		
Totally independent	286 (5.8)	480 (9.7)
Totally dependent	82 (1.7)	128 (2.6)
Personal hygiene		
Independent	581 (11.8)	767 (15.5)
Supervision	502 (10.2)	361 (7.3)
Limited assistance	973 (19.7)	796 (16.1)
Extensive assistance	2,312 (46.8)	2,287 (46.3)
Total dependence	574 (11.6)	731 (14.8)
Chi-square test*	Chi-square test statistic = 85.4 ($p < .001$)	
Toilet use		
Independent	766 (15.5)	1,075 (21.8)
Supervision	306 (6.2)	204 (4.1)
Limited assistance	844 (17.1)	695 (14.1)
Extensive assistance	2,462 (49.8)	2,297 (46.5)
Total dependence	564 (11.4)	671 (13.6)
Chi-square test*	Chi-square test statistic = 101.7 ($p < .001$)	
Eating		
Independent	3,021 (61.1)	2,864 (58.0)
Supervision	1,033 (20.9)	956 (19.3)
Limited assistance	348 (7.0)	413 (8.4)
Extensive assistance	375 (7.6)	463 (9.4)
Total dependence	165 (3.3)	246 (5.0)
Chi-square test*	Chi-square test statistic = 37.9 ($p < .001$)	

Notes: ADL = activity of daily living.
*Chi-square tests, two-tailed tests.

or public), location (Twin Cities metro, other metro, rural), facility size (total number of beds), hospital affiliation, licensed staffing levels (registered nurses and licensed practical nurses), unlicensed staffing levels (certified nursing assistants and medicine assistants), percentage of Medicare days, and nursing home community discharge rates. Percentage of Medicare days was calculated by dividing the number of Medicare-paid resident days per year by the number of resident days per year paid by all payment sources. Staffing levels were calculated by dividing the number of staffing hours per day by the total number of residents per day. The community discharge rate of each facility was calculated by dividing the number of residents who were discharged into community settings within the first 4 months by the number from the original cohort admitted into that facility ($n = 37{,}867$).

Statistical Analysis

All statistical analyses were conducted using SAS, Version 9.1 (SAS Institute, Inc., Cary, NC). The significance levels were set at .05. We used general linear mixed models (GLMMs) to conduct multivariate analyses and included a random nursing home effect to take into account the cluster-correlated data structure in the sample and produce more efficient fixed-effect estimates. Nursing home random effects also represented the combination of any unmeasured facility-level control variables that were not included in the model and allowed us to examine whether living in a particular nursing home affects a resident's follow-up ADL.

The nursing home random effect was tested using likelihood ratio test statistics, calculated by subtracting the negative log likelihood of the reduced model (without nursing home effects) from the negative log likelihood of the full model (with nursing home effects). The resulting test statistic, the negative likelihood ratio, followed a mixture of chi-square (0) and chi-square (1) distributions (28). In this study, the likelihood ratio test statistics were compared with the critical levels of a chi-square (1) distribution, thus providing conservative p value estimates. Model details for nursing home random effects are shown in Appendix 1. Two series of analyses were conducted: In Series 1, baseline ADL, 7 resident-level independent variables, and 14 resident-level control variables were used as predictors; in Series 2, eight additional facility-level control variables were added to the Series 1 models.

Results

Descriptive Statistics

The characteristics of the 377 nursing homes where the 4,942 participants resided are shown in Table 1, and Tables 2 and 3 show the demographics, impairment levels, and functional status of the study participants. The correlations among various predictor variables were generally low (tables not shown); thus, multicollinearity, a situation where there are high correlations between predictor variables, is not a concern in this study.

Effects of Impairments

Table 4 shows the GLMMs coefficients for the three ADL models. Bladder incontinence was associated with ADL declines in all three models, whereas bowel continence and balance dysfunction predicted worse toileting and personal hygiene. Pain, depression, and falls within the past month were not associated with any ADL decline. Follow-up hygiene dependence, an early-loss ADL, was predicted by bowel and bladder incontinence, balance dysfunction, and falls within 2–6 months. Toileting, a middle-loss ADL, was predicted by bowel and bladder incontinence and balance dysfunction. Eating, a late-loss ADL, was predicted only by bladder incontinence. These patterns were not changed by the addition of facility-level control variables into the models (Table 5). Cognition, admission from a hospital, and length of follow-up were significantly associated with all three ADL outcomes, but sociodemographic factors, including age, gender, race, and educational level, were not consistently associated with the outcomes. Few facility-level characteristics

Table 4. GLMMs With Resident-Level Independent Variables and Control Variables*

	Hygiene	F Test	Toileting	F Test	Eating	F Test
Baseline	.501 (0.015)	**p < .001**	.520 (0.016)	**p < .001**	.422 (0.017)	**p < .001**
Pain = 0	.113 (0.075)	p = .222	.030 (0.080)	p = .544	.042 (0.076)	p = .792
Pain = 1	.053 (0.075)		−.018 (0.080)		.016 (0.076)	
Pain = 2	.075 (0.075)		−.016 (0.081)		.010 (0.076)	
Pain = 3	0		0		0	
Depression	.010 (0.030)	p = .742	−.002 (0.032)	p = .954	−.014 (0.031)	p = .649
Bowel incontinence = 0	−.112 (0.071)	**p = .026**	−.143 (0.076)	**p = .012**	−.202 (0.072)	p = .052
Bowel incontinence = 1	−.080 (0.081)		−.092 (0.087)		−.153 (0.082)	
Bowel incontinence = 2	−.002 (0.083)		−.063 (0.089)		−.108 (0.084)	
Bowel incontinence = 3	.045 (0.076)		.048 (0.081)		−.127 (0.077)	
Bowel incontinence = 4	0		0		0	
Bladder incontinence = 0	−.346 (0.062)	**p < .001**	−.431 (0.067)	**p < .001**	−.125 (0.063)	**p = .013**
Bladder incontinence = 1	−.319 (0.074)		−.277 (0.079)		−.116 (0.075)	
Bladder incontinence = 2	−.106 (0.068)		−.146 (0.073)		−.066 (0.069)	
Bladder incontinence = 3	−.076 (0.062)		−.090 (0.066)		.005 (0.062)	
Bladder incontinence = 4	0		0		0	
Balance score = 0	−.265 (0.086)	**p = .002**	−.399 (0.092)	**p < .001**	−.059 (0.086)	p = .220
Balance score = 1	−.236 (0.064)		−.379 (0.069)		−.046 (0.066)	
Balance score = 2	−.187 (0.058)		−.268 (0.062)		−.080 (0.059)	
Balance score = 3	−.195 (0.099)		−.237 (0.106)		−.030 (0.101)	
Balance score = 4	−.093 (0.060)		−.098 (0.065)		.024 (0.062)	
Balance score = 5	0		0		0	
Fall within 30 d	.021 (0.030)	p = .477	.016 (0.032)	p = .625	−.017 (0.030)	p = .574
Fall within 31–180 d	.097 (0.041)	**p = .018**	.061 (0.044)	p = .167	−.009 (0.041)	p = .825

Notes: All fixed effects were estimated with nursing home random intercept included in the models. Coefficients for resident-level control variables are not displayed. ADL = activity of daily living; GLMM = general linear mixed models.

*Data are GLMM coefficient and its standard error. The sign indicates the direction of the effect. A negative sign indicates an ADL decline.

†Values in bold denote significant findings.

were significantly associated with ADL dependence at follow-up, and none were associated consistently across the outcomes (tables not shown).

Individual Effect of Nursing Homes

Table 6 shows the results of individual nursing home effects. The large magnitude of the likelihood ratio test statistic (*T*) does not represent the size of individual nursing home effects but is associated with very small *p* values. The statistically significant likelihood ratio tests for all three ADL equations indicated that living in a particular nursing home predicted a resident's subsequent ADL dependence, independent of their impairments, even after controlling for specific facility characteristics.

Examination of Floor and Ceiling Effects

The proportion of residents who, at baseline, were completely independent (ceiling) or completely dependent (floor) in eating (64.4%), toileting (26.9%), or personal hygiene (23.4%) can lead to challenges with model interpretation (floor and ceiling effects). Analyses were repeated after excluding residents who were completely independent or dependent in toileting and personal hygiene at baseline. After removing these residents, significant individual nursing home effects remained in both models. The effect sizes of the relationships between impairments and follow-up ADL remained similar; however, bowel incontinence became a nonsignificant predictor of subsequent ADL dependence, possibly because of reduced sample sizes. An analysis was also conducted excluding only those at the floor but leaving those at the ceiling in the models, with results very similar to the original findings (tables not shown). The floor or ceiling analysis was not conducted on eating function because more than 60% of residents were totally dependent in eating and excluding these residents would have greatly reduced the statistical power of the analysis.

Discussion

This study found that bowel and bladder incontinence, along with balance dysfunction, were significant predictors of ADL decline at follow-up. Early-loss ADL was predicted by more impairments than was late-loss ADL. Contrary to previous studies, this study found that pain and depression were not associated with ADL decline at follow-up (13,20, 29–31). However, the relationships between incontinence and toileting function can be correlational, not causal. Our analyses showed that at baseline, residents who had more problems with incontinence had worse toileting function at follow-up. Still, many continent residents required extensive assistance with toileting, possibly for toilet transfer, commode set up, or catheter. In contrast to incontinence, balance dysfunction may directly impede a resident's ability to complete personal hygiene and toileting independently and, thus, could be causally related to ADL decline at follow-up. To establish causal relationships between impairments and ADL in nursing home populations, future

Table 5. GLMMs With Resident-Level Independent Variables, Control Variables, and Facility Factors*

	Hygiene	*F* Test	Toileting	*F* Test	Eating	*F* Test
Baseline	.500 (0.015)	***p* < .001**	.518 (0.016)	***p* < .001**	.419 (0.017)	***p* < .001**
Pain = 0	.115 (0.075)	*p* = .226	.030 (0.080)	*p* = .555	.047 (0.076)	*P* = .806
Pain = 1	.057 (0.075)		−.016 (0.080)		.024 (0.076)	
Pain = 2	.079 (0.075)		−.016 (0.081)		.015 (0.076)	
Pain = 3	0		0		0	
Depression	.008 (0.030)	*p* = .779	−.002 (0.032)	*p* = .947	−.012 (0.031)	*p* = .697
Bowel incontinence = 0	−.112 (0.071)	***p* = .031**	−.141 (0.077)	***p* = .014**	−.196 (0.073)	*p* = .058
Bowel incontinence = 1	−.079 (0.081)		−.094 (0.087)		−.149 (0.082)	
Bowel incontinence = 2	−.004 (0.083)		−.061 (0.089)		−.096 (0.084)	
Bowel incontinence = 3	.041 (0.076)		.049 (0.082)		−.121 (0.077)	
Bowel incontinence = 4	0		0		0	
Bladder incontinence = 0	−.347 (0.062)	***p* < .001**	−.430 (0.067)	***p* < .001**	−.124 (0.063)	***p* = .015**
Bladder incontinence = 1	−.318 (0.074)		−.271 (0.079)		−.116 (0.075)	
Bladder incontinence = 2	−.104 (0.068)		−.143 (0.073)		−.068 (0.069)	
Bladder incontinence = 3	−.074 (0.062)		−.084 (0.066)		.004 (0.062)	
Bladder incontinence = 4	0		0		0	
Balance score = 0	−.263 (0.086)	***p* = .002**	−.403 (0.092)	***p* < .001**	−.059 (0.086)	*p* = .230
Balance score = 1	−.237 (0.064)		−.380 (0.069)		−.046 (0.066)	
Balance score = 2	−.188 (0.058)		−.269 (0.062)		−.077 (0.059)	
Balance score = 3	−.194 (0.099)		−.235 (0.106)		−.030 (0.101)	
Balance score = 4	−.092 (0.060)		−.097 (0.065)		.027 (0.062)	
Balance score = 5	0		0		0	
Fall within 30 d	.019 (0.030)	*p* = .524	.012 (0.032)	*p* = .698	−.018 (0.030)	*p* = .551
Fall within 31–180 d	.094 (0.041)	***p* = .021**	.061 (0.044)	*p* = .168	−.008 (0.041)	*p* = .846

Notes: All fixed effects were estimated with nursing home random intercept included in the models. Coefficients for resident- and facility-level control variables are not displayed. ADL = activity of daily living; GLMM = general linear mixed models.

*Data are GLMM coefficient and its standard error. The sign indicates the direction of the effect. A negative sign indicates an ADL decline.

†Values in bold denote significant findings.

studies should examine the effectiveness of impairment interventions on ADL and assess whether these relationships are observed in different nursing home populations, such as residents with different levels of cognitive function.

In addition to impairment effects, significant individual nursing home effects were found for all three ADL measures. Most specific nursing home characteristics examined in this study did not significantly predict ADL decline at follow-up. Moreover, individual nursing home effects were still statistically significant after controlling for these facility-level factors. These results suggest that other important nursing home characteristics need to be identified and incorporated into assessments of quality and outcomes.

This study has limitations in its generalizability. The findings cannot be generalized to residents who were admitted for rehabilitation and who had a length of follow-up shorter than 4 months or longer than 8 months; to non-White nursing home populations because less than 3% of the sample is non-White; or beyond Minnesota. Future study should use a national sample of nursing home residents to assess whether our findings can be replicated, which would greatly improve the generalizability of these results.

The quality of MDS and its appropriateness for research use remain controversial, so this presents an additional limitation (32–34). The study also did not consider amount of rehabilitation as a control variable, and rehabilitation services that residents received during their stay in the facility may have affected their ADL decline at follow-up. However, we were uncertain whether MDS accurately reported the amount of rehabilitation residents received, so we did not control for this variable. Finally, because our participants were admitted throughout 2004, the staffing-level data obtained from the 2004 annual survey may not correspond exactly to the period between admission and follow-up for every participant.

GLMM assumes the dependent variables (ADLs) as continuous variables. Our analyses indicated that the residuals of all models were, in general, normally distributed,

Table 6. Tests for Nursing Home Random Effect (N = 4,942)

	Series 1	Series 2
Personal hygiene		
Reduced model	13,819.2	13,870.1
Full model	13,758.0	13,814.0
Likelihood ratio	T^* = 61.2	T* = 56.1
	p value < .001	p value < .001
Toileting		
Reduced model	14,455.9	14,518.3
Full model	14,437.3	14,499.3
Likelihood ratio	T^* = 18.6	T* = 19.0
	p value < .001	p value < .001
Eating		
Reduced model	13,896.9	13,951.8
Full model	13,884.5	13,940.4
Likelihood ratio	T^* = 12.4	T* = 11.4
	p value < .001	p value < .005

Notes: Full model: with nursing home random effect. Reduced model: without nursing home random effect.

*T = (negative log likelihood of reduced model) − (negative log likelihood of full model).

so they supported this underlying assumption of GLMMs. The alternative would be to use multinominal logistic regression with five-level dependent variables, but the interpretation of results would be cumbersome.

This study has several strengths. First, it examined the relationships between multiple important resident-level impairments and ADL decline at follow-up. It also controlled for many confounders that may simultaneously affect baseline impairments and ADL decline at follow-up. Finally, it is the first study of this type to incorporate a random nursing home effect to account for clustering of residents within facilities, which allowed us to determine whether unmeasured nursing home characteristics unique to each facility predict ADL decline at follow-up.

According to this study, incontinence and balance dysfunction significantly predict ADL declines at follow-up, so nursing homes can use continence and balance measures to identify residents who are at risk of ADL deterioration and implement rigorous rehabilitation protocols to improve, maintain, or at least delay the deterioration of ADL. However, a case-mix payment system, like the current nursing home prospective payment system, in which residents with higher ADL dependence are paid at higher rates, provides disincentives for nursing homes to treat residents' ADL dysfunctions aggressively. A payment system that adjusts for the severity of ADL limitations but simultaneously rewards facilities for improving, maintaining, or delaying the deterioration of residents' ADLs would create more desired incentives.

Although specific nursing home characteristics had very limited direct effects on ADL decline at follow-up, there was a significant nursing home effect after these facility-level factors were controlled for. The presence of such variations in nursing home effects provides support for an outcome-based nursing home payment system that may encourage nursing homes to improve their quality of care.

APPENDIX I

Statistical Model

Full model:

$$Y_{ij} = \alpha_0 + \alpha_1 \mathbf{X}_{ij1} + \alpha_2 \mathbf{X}_{ij2} + \beta_i + \delta_{ij},$$

Reduced model:

$$Y_{ij} = \alpha_0 + \alpha_1 \mathbf{X}_{ij1} + \alpha_2 \mathbf{X}_{ij2} + \delta_{ij},$$

where i = nursing homes; j = residents within each nursing home; Yij = follow-up ADLs of resident j in nursing home i; $\mathbf{X}ij_1$= the vector of resident-level covariates, $\mathbf{X}ij_2$ = the vector of facility-level covariates; βi = nursing home–specific random intercept for nursing home i; δij = random error term for resident j in nursing home i; $\beta_i \sim N(0, \sigma^2_{\mathrm{NH}})$ and $\delta_{ij} \sim N(0, \sigma^2_e)$.

We test the following hypotheses: $H_0 : \sigma^2_{\mathrm{NH}} = 0$ versus H_a:O_{NH}>O.

If $\sigma^2_{\mathrm{NH}} = 0$, then βi ~ N(0,0) = 0, then the random intercept model becomes a simple regression model.

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