Patterns of sleep quality during and after postacute rehabilitation in older adults: a latent class analysis approach

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SUMMARY

Sleep quality is related to emotional, physical, psychological and cognitive functioning and functional independence in later life. After acute health events, older adults are likely to utilize postacute rehabilitation services to improve functioning and facilitate return to independent living. Patterns of how sleep changes with postacute rehabilitation, and predictors of such patterns, are unknown. The current investigation employed latent class analysis (LCA) methods to classify older adults (n = 233) into groups based on patterns of self-reported sleep quality pre-illness, during postacute rehabilitation and up to 1 year following postacute rehabilitation. Using LCA, older adults were grouped into (1) consistently good sleepers (46%), (2) good sleepers who transitioned into poor sleepers (34%), (3) consistently poor sleepers (14%) and (4) poor sleepers who transitioned into good sleepers (6%). In three planned analyses, pain was an independent predictor of membership in classes 1 or 2 (good pre-illness sleep quality) versus classes 3 or 4 (poor pre-illness sleep quality), and of membership in class 1 (consistently good sleep) versus class 2 (good sleep that transitioned to poor sleep). A lower Mini-Mental State Examination score was a predictor of membership in class 1 versus class 2. There were no statistically significant predictors of membership in class 3 versus class 4. Demographics, comorbidities and depressive symptoms were not significant predictors of class membership. These findings have implications for identification of older adults at risk for developing poor sleep associated with changes in health and postacute rehabilitation. The findings also suggest that pain symptoms should be targeted to improve sleep during postacute rehabilitation.

INTRODUCTION

Sleep complaints and sleep disorders are common in older adults (Foley et al., 1995; Martin and Ancoli-Israel, 2003), and while numerous studies have focused on changes that occur in sleep architecture and symptomatology with age, less is known about how sleep is altered in response to acute changes in health. Studies have described sleep during acute hospitalization (Drouot et al., 2008; Isaia et al., 2011), but there is limited research on longitudinal patterns of changes in sleep among older adults after acute health events.

In the United States, older adults often receive rehabilitation services after acute health events requiring hospitalization in in-patient postacute rehabilitation settings. During postacute rehabilitation older adults receive physical, occupational and other therapies aimed at improving functional status and facilitating the patient’s return to independent living. In our recent work we found that older adults in postacute rehabilitation settings suffer from extremely fragmented sleep and have short sleep duration at night (Alessi et al., 2008; Martin et al., 2011). The level of sleep disturbances seen was similar to what has been found in acute-care hospitals (Drouot et al., 2008; Isaia et al., 2011). We
also found that more daytime sleeping during postacute rehabilitation predicted less functional improvement during the rehabilitation stay and for up to 3 months after discharge, even after controlling for known predictors of rehabilitation outcomes (i.e. cognitive functioning, hours of rehabilitation therapy, acute care hospital transfer during rehabilitation and reason for rehabilitation admission). Additionally, worse self-reported sleep quality during rehabilitation was associated with increased mortality risk within 1 year, after adjusting for gender, hours of rehabilitation therapy, comorbidities and reason for rehabilitation admission (Martin et al., 2011). These findings suggest that disturbances in sleep might represent important independent risk factors for negative outcomes among older adults recovering from acute health events.

To follow-up on our previous work, we explored patterns of sleep quality among older adults before, during and after in-patient postacute rehabilitation. We selected latent class analysis (LCA) to investigate patterns of sleep quality over time. Recent investigations have employed LCA to examine sleep, including two cross-sectional studies of sleep in middle-aged adults (Foley et al., 2010) and one 20-year longitudinal study of insomnia symptoms (Green et al., 2012). To our knowledge, no study has employed LCA to examine patterns of change in sleep related to acute changes in health or to inpatient postacute rehabilitation. LCA could yield information useful in identifying older adults ‘at risk’ for chronic poor sleep, and this could be useful in identifying candidates for targeted sleep interventions during postacute rehabilitation.

After identifying the latent classes we considered a set of variables that, based on previous research, might predict latent class membership. The set of predictors measured within this study were age, comorbidity burden, cognitive functioning, pain symptoms, depression and reason for rehabilitation admission (orthopaedic versus all other reasons). Previous studies show that each measure might be related to changes in sleep quality over time among older adults. Specifically, studies have shown that changes in health status can lead to changes in sleep quality (Foley et al., 2007; Roth et al., 2011; Schubert et al., 2002), and both poor physical health and pain symptoms have been shown to affect sleep in later life (Roth et al., 2011; Vitiello et al., 2002). While there is some controversy about whether self-reported sleep quality truly worsens with advancing age (Grandner et al., 2012), we elected to include age as a predictor because earlier studies have shown an association between advancing age and increasingly disturbed sleep (Kales et al., 1967). Studies also show that cognitive impairment is related to sleep disturbances, and we also included this as a potential predictor (Blackwell et al., 2008). Finally, in our own previous work, the reason for rehabilitation admission (orthopaedic versus all other), was associated significantly with sleep quality in the postacute care setting and we therefore included this predictor in our models (Alessi et al., 2008; Martin et al., 2010).

The objectives of the current investigation were to determine whether distinct patterns of self-reported sleep quality emerged among older adults identified during a postacute rehabilitation stay and followed for 1 year afterwards, and then to examine predictors of class membership. Based on the four distinct patterns that emerged from that analysis, we formed and tested three meaningful comparisons to determine whether or not clinical information gathered during postacute rehabilitation would predict class membership. We hypothesized specifically that age, comorbidity burden, cognitive functioning, pain symptoms, depression and reason for rehabilitation admission (orthopaedic versus all other) would be significant predictors of membership in classes with good self-reported pre-illness sleep quality versus poor self-reported pre-illness sleep quality. Among those with comparatively good self-reported pre-illness sleep quality, we hypothesized that these variables would predict membership in a class suggesting development of poor sleep quality during rehabilitation versus those who maintained good sleep. Lastly, we hypothesized that these variables would predict membership in a class suggesting chronically poor sleep quality versus membership in a class suggesting poor pre-illness sleep quality that improved following postacute rehabilitation.

**METHODS**

**Participants**

Within a prospective cohort study of older postacute rehabilitation patients, 245 individuals aged more than 65 years had their self-reported sleep quality assessed on six occasions with the Pittsburgh Sleep Quality Index (PSQI, described below). In total, 233 participants (95%) provided PSQI data at one or more time-points and constitute the sample for the current analyses. Overall, 87% of participants provided two or more PSQI scores, and 67% provided three or more PSQI scores. Demographic information for the sample analysed is shown in Table 1.

A detailed description of participants has been published previously (Alessi et al., 2008). All patients aged more than 65 years, admitted for rehabilitation services (i.e. for physical, occupational or kinesiotherapy; n = 996) at two postacute care sites (a freestanding, for-profit, community nursing home focused on short-term rehabilitation, and an inpatient rehabilitation unit within a Veterans Administration Medical Center) were approached for screening as soon as possible after admission. Those residing in nursing homes as long-stay residents prior to admission, those with severe medical illness (e.g. end of life care) or behavioural disturbance (e.g. dementia with severe agitation) and those unable to communicate verbally in English during screening were excluded. In total, 938 individuals (97% of those admitted) agreed to screening, of whom 737 (79%) met these eligibility criteria. Two hundred and forty-five individuals (33% of those eligible) were enrolled into the study and provided written informed consent.
Research methods were reviewed and approved by the Veterans Administration Greater Los Angeles Healthcare System Institutional Review Board.

Procedures

After enrolment, participants completed a baseline assessment, including a series of questionnaires administered in interview format (description of questionnaires provided below). The interview was divided into two segments: the first completed immediately after enrolment and the second completed 1 week later (or immediately prior to discharge if the length of stay was fewer than 7 days; n = 6). After discharge, a structured medical record review was completed by a trained research nurse to document medications taken in the rehabilitation facility, the length of acute hospital stay prior to rehabilitation admission, reason for rehabilitation admission (dichotomized into orthopaedic rehabilitation versus all others), length of rehabilitation stay and medical record information required for completion of the comorbidity measure (described below).

Follow-up assessments were conducted in person at the participant’s place of residence 3, 6, 9 and 12 months from the date of admission to the rehabilitation facility. When an in-person interview could not be completed (e.g. participant had moved away or preferred not to have a research assistant visit his/her home), the assessment was performed by telephone (33% of all follow-up interviews). Twelve months after admission, all participants were contacted by telephone and all interviews were completed by telephone. All data were collected by trained research personnel for research purposes only.

Sleep measures

The main measure of self-reported sleep quality was the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989). The PSQI is a 19-item questionnaire (score range: 0–21) that assesses overall sleep quality. On enrolment, participants were asked about their sleep for a 1-month period ‘before their recent illness’ (pre-illness PSQI). This was intended to describe sleep patterns before the events that precipitated hospitalization and the rehabilitation facility stay. The PSQI was repeated 1 week later, and participants were queried about their sleep during their postacute rehabilitation stay during the previous week (7-day PSQI). As described above, at 3-month intervals participants were again contacted and the PSQI was repeated (in person or by telephone) to assess sleep quality over the previous week.

Other measures

Basic demographic information (age, gender, ethnicity and reason for admission to the rehabilitation facility) was obtained for each participant from the transferring hospital discharge records and review of the rehabilitation facility medical records.

During the postacute care stay, general cognitive functioning was assessed with the Mini-Mental State Examination (MMSE), a 20-item measure where higher scores suggest better cognitive functioning (score range: 0–30) (Folstein et al., 1975). Individuals with MMSE<15 were excluded from the study because many of the study measures have not been validated in patients with severely impaired global cognition. Symptoms of depression during postacute rehabilitation were assessed with the 15-item version of the Geriatric Depression Scale (GDS-15; score range: 0–15)

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Table 1 Characteristics of the overall sample at baseline (n = 233), and of study participants in each of the four classes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total sample Mean (SD) or n (%)</th>
<th>Class 1 Mean (SD) or n (%)</th>
<th>Class 2 Mean (SD) or n (%)</th>
<th>Class 3 Mean (SD) or n (%)</th>
<th>Class 4 Mean (SD) or n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>233 (7.09)</td>
<td>107 (6.91)</td>
<td>80 (6.84)</td>
<td>80.46 (7.88)</td>
<td>79.19 (8.54)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>80.40 (7.09)</td>
<td>80.19 (41.12%)</td>
<td>80.86 (28.75%)</td>
<td>80.46 (28.75%)</td>
<td>81.25 (50.00%)</td>
</tr>
<tr>
<td>Gender (female)</td>
<td>233 (38.20%)</td>
<td>107 (37.77%)</td>
<td>80 (40.00%)</td>
<td>32 (37.50%)</td>
<td>14 (50.00%)</td>
</tr>
<tr>
<td>Ethnicity, non-Hispanic white</td>
<td>233 (78.97%)</td>
<td>107 (81.31%)</td>
<td>80 (75.00%)</td>
<td>32 (81.25%)</td>
<td>14 (78.57%)</td>
</tr>
<tr>
<td>Orthopaedic reason for admission to rehabilitation</td>
<td>233 (37.77%)</td>
<td>107 (34.58%)</td>
<td>80 (40.00%)</td>
<td>32 (37.50%)</td>
<td>14 (50.00%)</td>
</tr>
<tr>
<td>Days in hospital prior to rehabilitation</td>
<td>10.82 (16.02)</td>
<td>12.33 (21.86)</td>
<td>9.74 (7.62)</td>
<td>10.38 (10.70)</td>
<td>6.50 (3.57)</td>
</tr>
<tr>
<td>Days in rehabilitation facility</td>
<td>21.55 (14.59)</td>
<td>21.59 (17.67)</td>
<td>22.59 (12.43)</td>
<td>19.69 (9.57)</td>
<td>19.57 (8.90)</td>
</tr>
<tr>
<td>Number of medications received</td>
<td>16.00 (7.20)</td>
<td>15.05 (7.04)</td>
<td>17.50 (7.21)</td>
<td>16.09 (7.50)</td>
<td>14.43 (6.84)</td>
</tr>
<tr>
<td>Geriatric pain measure, pain intensity subscale score</td>
<td>46.54 (28.05)</td>
<td>37.41 (28.25)</td>
<td>51.16 (26.29)</td>
<td>56.81 (25.02)</td>
<td>65.73 (19.46)</td>
</tr>
<tr>
<td>Mini-Mental State Examination, total score</td>
<td>23.77 (5.66)</td>
<td>22.65 (6.41)</td>
<td>24.61 (4.88)</td>
<td>25.28 (4.45)</td>
<td>24.29 (4.89)</td>
</tr>
<tr>
<td>Cumulative Illness Rating</td>
<td>22.51 (5.90)</td>
<td>22.58 (6.57)</td>
<td>22.73 (5.41)</td>
<td>21.97 (5.68)</td>
<td>22.00 (3.59)</td>
</tr>
<tr>
<td>Scale–Geriatrics, total score</td>
<td></td>
<td>4.15 (3.29)</td>
<td>3.63 (3.19)</td>
<td>4.36 (3.09)</td>
<td>5.55 (3.40)</td>
</tr>
<tr>
<td>Geriatric Depression Scale–Short Form, total score</td>
<td>4.15 (3.29)</td>
<td>3.63 (3.19)</td>
<td>4.36 (3.09)</td>
<td>5.55 (3.40)</td>
<td>3.64 (4.07)</td>
</tr>
</tbody>
</table>

SD, standard deviation.
(Sheikh and Yesavage, 1986). To assess illness severity and comorbidities at baseline, the Cumulative Illness Rating Scale for Geriatrics (CIRS-G) was completed by an experienced research registered nurse, using data collected from a structured medical record review and a brief physical examination by a study physician (Miller et al., 1992; Parmelee et al., 1995). Pain during postacute rehabilitation was measured with the pain intensity and frequency components of the Geriatric Pain Measure (GPM; score range: 0–29, higher scores indicate worse pain) (Ferrell et al., 2000).

Statistical analysis

We have reported previously that, other than an expected gender difference (43.0 versus 96.6% men at facilities A and B, respectively), there were few differences between study sites (Alessi et al., 2008); therefore, findings are presented for the combined sample. Two-sample t-tests were used to assess differences in the variables studied between participants included in the model (n = 233) and those excluded (n = 12). Those excluded due to missing PSQI data had significantly lower MMSE scores (t_{226} = −4.78, P < 0.001) than those who provided sleep data; however, there were no other statistical differences between groups. For all statistical tests, a P-value of <0.05 was considered statistically significant. Analyses were conducted using Stata version 12.1 (StataCorp LP; College Station, TX, USA).

To evaluate patterns of sleep quality over time, we developed a series of latent class analysis (LCA) models. An LCA model is akin to a factor analysis model in that both models seek to use observed variables to identify underlying latent variables. Where a factor analysis seeks to identify continuous underlying factors, LCA seeks to identify latent nominal categories (classes). In this study, LCA was used to identify different latent classes of sleep quality observed at six time-points: (1) pre-illness, assessed on admission to postacute rehabilitation; (2) during postacute rehabilitation, assessed 1 week after admission; (3) 3 months follow-up; (4) 6 months follow-up; (5) 9 months follow-up; and (6) 12 months follow-up. One key objective of such an analysis is to identify the correct number of latent classes in the model. This is achieved by fitting a model with two classes to the data and testing the null hypothesis that one class is sufficient to explain the data, compared to the alternative hypothesis that two (or more) classes are required. This process is then repeated iteratively with one additional class added with each iteration until the alternative hypothesis (i.e. that fewer classes do not explain the data more clearly) is no longer rejected. At that point, models are evaluated to determine which of the statistically significant models is the most parsimonious and theoretically congruent explanation of the data. In the current study, the best identified model was a four-class model (see Results), including: consistently good sleep quality (class 1), good sleep quality that transitioned to poor sleep during rehabilitation (class 2), consistently poor sleep quality (class 3) and poor sleep quality that transitioned to good sleep quality after rehabilitation (class 4). Overall, 67% of participants provided PSQI data at the 3-month follow-up or later, and there were no differences in missing follow-up observations across the four latent classes (χ² = 1.89; P = 0.609).

We then selected and tested three separate logistic regression models predicting membership in each of these four classes. Given the limited sample size and unequal distribution of participants across the four latent classes, we limited the total number of models tested to three. We chose this approach rather than testing all possible post-hoc comparisons as that would have increased the experiment-wide type I error rate, or would have reduced the likelihood of significant findings if a type I error rate adjustment was employed. All models included age, CIRS score, MMSE score, GPM score, GDS-15 score and reason for admission (orthopaedic versus all others) as predictors of class membership. Each of the three models tested is described below.

**Model 1**

For pre-illness sleep quality, the first model examined predictors of membership in classes indicating good pre-illness sleep quality (classes 1 and 2) as opposed to membership in classes indicating poor pre-illness sleep quality (classes 3 and 4).

**Model 2**

For change in good pre-illness sleep quality, the second model followed-up on that initial model by examining predictors of membership in class 1 (consistently good sleep quality) versus class 2 (good sleep quality → poor sleep quality).

**Model 3**

For change in poor pre-illness sleep quality, the third and final model also followed-up on model 1. We examined predictors of membership in class 3 (consistently poor sleep quality) versus class 4 (poor sleep quality → good sleep quality).

RESULTS

Results of the latent class analysis

Using the bootstrap likelihood ratio test (Nylund et al., 2007), the test of one class (versus two) was rejected (P < 0.0005), as was the test of three classes (versus two; P < 0.0005) and four classes (versus three; P < 0.0005). The test of five classes (versus four) was also significant (P = 0.020); however, the pattern of results for the five-class model was not as interpretable as the results for the four-class model, as it appeared that the five-class model split those with consistently poor sleep into two further classes. The four-
class model was also superior in terms of BIC (4724.04 and 4735.92 for the four- and five-class models, respectively, where smaller BIC values reflect better model fit). As a result, the four-class solution was adopted.

For reporting, we describe each of the four classes as: class 1, consistently good sleep quality (i.e. those who slept well before, during and after rehabilitation); class 2, good sleep quality → poor sleep quality (i.e. those who slept well prior to illness onset, but slept poorly during and after rehabilitation); class 3, consistently poor sleep quality (i.e. those who slept poorly before, during and after rehabilitation); and class 4, poor sleep quality → good sleep quality (i.e. those who slept poorly before and during rehabilitation, but slept better afterwards).

The largest proportion (46%) of participants fell into class 1 (consistently good sleep). Thirty-four per cent of participants fell into class 2 (good sleep → poor sleep), 14% of participants fell into class 3 (consistently poor sleep) and 6% of participants fell into class 4 (poor sleep → good sleep). Figure 1 shows the pattern of PSQI scores across the four classes showing separate lines for each class.

In terms of the classification quality of the four class LCA model, the entropy of the four class model was 0.73. Each participant was assigned to the class in which they had the highest probability of membership and the mean probability of correct class membership was >0.81, suggesting that members of each class were likely to be classified accurately (i.e. as the probability approaches 1, the probability of incorrect classification diminishes). The mean probability of classification into the correct class was 0.88 for class 1, 0.82 for class 2, 0.81 for class 3 and 0.83 for class 4.

Predictors of class membership

Based on the results of the LCA, participants were assigned to a class based on their modal probability of class membership and the class membership was treated as an observed variable. Logistic regression analysis was performed predicting class membership from age, CIRS score, MMSE score, GPM score, GDS score and reason for admission (orthopaedic versus non-orthopaedic).

Model 1

This logistic regression model predicted membership in classes 1 or 2 as opposed to membership in classes 3 or 4 from age, CIRS, MMSE, GPM, GDS and reason for admission ($\chi^2(6) = 18.70; P = 0.005$). The only significant independent predictor of class membership was GPM score [odds ratio (OR) = 0.94, P = 0.001]. More pain was associated with a lower likelihood of good pre-illness sleep quality (see Table 2).

Model 2

The second model predicted membership in class 1 versus class 2 from the same set of predictors ($\chi^2(6) = 18.88; P = 0.004$). GPM score was a significant independent predictor of class membership (OR = 0.96, P = 0.006). Less pain was associated with a higher likelihood of maintaining good sleep (see Table 2). In addition, MMSE score was associated significantly with class membership (OR = 0.94, P = 0.042). Better cognitive functioning was associated with a lower likelihood of maintaining good sleep.

Model 3

The third and final logistic regression model predicted membership in class 3 versus membership in class 4 from the same set of predictors ($\chi^2(6) = 5.16; P = 0.524$). None of these variables were significant predictors of class membership.

DISCUSSION

The results of these analyses revealed four distinct patterns of sleep quality before, during and for 1 year following postacute rehabilitation in older adults: (1) consistently good sleepers, (2) good sleepers who developed poor sleep, (3) chronic poor sleepers and (4) poor sleepers whose sleep improved. Almost half the patients were consistently good sleepers, but approximately one-third became poor sleepers following postacute rehabilitation, and few had poor sleep that improved during or after postacute rehabilitation.

In the models tested, the most important predictor of membership in groups with poor pre-illness sleep quality was the presence of pain symptoms during postacute rehabilitation, such that individuals who reported more pain symptoms during postacute rehabilitation were more likely to experience sleep disturbance before admission and, if they slept well before admission, to develop poor sleep after discharge. While individuals in poorer health are likely to experience more pain, comorbidity score was not a significant predictor of class membership in model 1. In addition, poor sleep has

![Figure 1. Mean Pittsburgh Sleep Quality Index (PSQI) scores by latent class analysis group at each time-point (pre-illness, during postacute rehabilitation and 3, 6, 9 and 12 months follow-up).](image)
studies showing an increased prevalence of poor sleep in health is often cited as a primary explanatory variable in need of additional investigation. Although poor physical sleep and pain, especially in an at-risk population, are in et al. adults which might partially explain this relationship (Onen 2001). Potential bidirectional relationships between sleep and pain, especially in an at-risk population, are in need of additional investigation. Although poor physical health is often cited as a primary explanatory variable in studies showing an increased prevalence of poor sleep in later life (Roth et al., 2011; Vitiello et al., 2002), a ‘gold standard’ assessment of comorbidity burden, quantified with a medical record review and physical examination, was not predictive of membership in classes with poor pre-illness sleep quality. Generally poor health might be a less important predictor of chronically poor sleep than pain symptoms specifically during illness recovery.

Depressive symptoms were also not a significant predictor of class membership indicating good versus poor pre-illness sleep quality. This non-significant association is surprising, given the literature suggesting strong associations between depression and sleep disturbance in later life (Buysse, 2004). In postacute rehabilitation, chronic sleep disturbance and the development of sleep disturbance might be independent of depression. Also, as both sleep disturbance and depression are associated with pain sensitivity (Chiu et al., 2012), these variables might interact and exacerbate one another. We found that cognition was associated with changes in sleep; however, the direction of the relationship was the opposite of what we expected. Better cognitive functioning during postacute rehabilitation was associated with a lower likelihood of maintaining good sleep in model 2. This might be due to poorer recall of sleep disturbance and among those with lower cognitive functioning. Our findings should therefore be replicated with objective measures, repeated over time, to determine whether or not this was simply an effect of the measurement method (i.e. self-reported sleep quality) used in this study.

LCA provided useful information for understanding the patterns of sleep quality before, during and after postacute rehabilitation. The classes identified provided a useful framework for testing potential predictors, and the classes that emerged demonstrated how sleep quality changed or was stable over time. Classifying older patients’ sleep quality into common groups allowed for examination of predictors of class membership. This methodology has potential for broadening our understanding of the changes in sleep that occur with age, in response to acute and chronic health events, and potential avenues for identification and intervention to prevent negative changes in sleep.

This study has several limitations. First, not all measures were repeated at all time-points, which prohibited examination of covariation across time among variables of interest. For example, we could not test if change in cognitive functioning was associated with changes in sleep because some follow-up interviews were completed by telephone and the full MMSE was not administered. Also, we did not have pre-illness measures of some predictors, including depression, which might have affected the associations (or lack of associations) seen. Secondly, few individuals were identified as members of group 4 (poor sleep quality that improved). Third limitation regards the nature of our sleep assessment. All sleep information was self-report in nature, and studies show that this does not overlap fully with objective monitoring of sleep. However, as self-reported sleep quality could precipitate treatment-seeking, we believe that this has value in and of itself. Lastly, our pre-illness sleep quality assessment was retrospective, collected during postacute rehabilitation, potentially introducing recall bias. In the absence of a method to identify older adults who will later require postacute rehabilitation, retrospective recall was necessary. Future studies could target individuals who are likely to experience postacute rehabilitation, such as those awaiting elective orthopaedic procedures; however, such an approach was beyond the scope of the current project.

Improved sleep in individuals with pain symptoms during postacute rehabilitation might reduce the likelihood of chronic poor sleep after discharge, and as recent studies show that

| Table 2 Predictors of class membership, based on models 1 and 2, for select scores on the Geriatric Pain Measure (GPM) |
|----------------------------------------|----------------------------------------|
| Geriatric Pain Measure: total score   | Model 1*: probability of having good pre-illness sleep quality (‘yes’) versus poor pre-illness sleep quality (‘no’)  |
|                                       | Model 2*: probability of having consistently good sleep quality (‘yes’) versus good sleep quality that transitions to poor sleep quality (‘no’)  |
| 5                                     | 0.920                                  | 0.700  |
| 15                                    | 0.862                                  | 0.665  |
| 25                                    | 0.775                                  | 0.503  |
| 35                                    | 0.654                                  | 0.402  |

*Adjusting for age, Cumulative Illness Rating Scale score, Mini-Mental State Examination.
†Adjusting for reason for admission and GDS.
‡Yes: class 1 and 2.
§No: classes 3 and 4.
¶Yes: class 1.
**No: class 2.

been associated with reduced pain thresholds in healthy adults which might partially explain this relationship (Onen et al., 2001). Potential bidirectional relationships between sleep and pain, especially in an at-risk population, are in need of additional investigation. Although poor physical health is often cited as a primary explanatory variable in studies showing an increased prevalence of poor sleep in later life (Roth et al., 2011; Vitiello et al., 2002), a ‘gold standard’ assessment of comorbidity burden, quantified with a medical record review and physical examination, was not predictive of membership in classes with poor pre-illness sleep quality. Generally poor health might be a less important predictor of chronically poor sleep than pain symptoms specifically during illness recovery.

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LCA provided useful information for understanding the patterns of sleep quality before, during and after postacute rehabilitation. The classes identified provided a useful framework for testing potential predictors, and the classes that emerged demonstrated how sleep quality changed or was stable over time. Classifying older patients’ sleep quality into common groups allowed for examination of predictors of class membership. This methodology has potential for broadening our understanding of the changes in sleep that occur with age, in response to acute and chronic health events, and potential avenues for identification and intervention to prevent negative changes in sleep.

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Improved sleep in individuals with pain symptoms during postacute rehabilitation might reduce the likelihood of chronic poor sleep after discharge, and as recent studies show that
pain and sleep disturbance can be effectively treated simultaneously in outpatient settings (Pigeon et al., 2012), adaptation of these interventions for postacute care patients should be explored. Early screening for pain and sleep disturbances in older postacute rehabilitation patients should be implemented and available evidence-based treatments should be offered when screening is positive. This could prevent the development or sustainment of poor sleep quality among older adults and, in turn, this could improve outcomes of postacute rehabilitation and quality of life among older patients.

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AUTHOR CONTRIBUTIONS
All authors contributed to the writing of this manuscript. JLM was responsible for the study design, oversight and analysis plan. DMD and CHF contributed to the writing of the manuscript and interpretation of the findings. JLM conducted the statistical analyses and wrote the data analysis section of the paper. SJ and MM assisted with data analysis and writing of the methods section of the manuscript. CAA was responsible for the original design and contributed to the writing of the manuscript.

CONFLICTS OF INTEREST
No conflicts of interest declared.

REFERENCES


