MOBILITY disability is common in older persons and is associated with adverse health consequences (1–6). Persons aged 65 years and older represent the fastest growing segment of the population and will double in number within the next 25 years (7). Given our rapidly aging population, identifying risk factors that predict mobility disability in elderly persons, which may be amenable to intervention, is an important public health concern. Cross-sectional studies have demonstrated an association between musculoskeletal pain and mobility disability with most (8–12) but not all (13) utilizing self-reported rather than performance-based mobility disability as the outcome. Limited data from longitudinal studies are available, with those that exist either examining the relationship between the presence of musculoskeletal pain and incidence (14,15) or progression (16) of self-reported mobility disability. As self-reported mobility disability is prone to the effects of recall bias and other factors (17), the use of a performance-based assessment of mobility disability complements self-report.

To test the hypothesis that musculoskeletal pain is associated with the development of severe mobility disability, we used data from more than 750 community-dwelling older clergy without dementia who were participating in the Rush Religious Orders Study (18), a longitudinal epidemiological study of aging. Participants underwent assessment of musculoskeletal pain in the year before baseline and annual clinical exams, which assessed mobility disability. Severe performance-based mobility disability was defined as a gait speed of less than or equal to 0.4 m/s
(19–21) and self-reported mobility disability was based on the Rosow–Breslau scale (22). We examined whether musculoskeletal pain in the year before baseline was associated with incident mobility disability.

**METHODS**

**Participants**

All participants were older Catholic nuns, priests, and brothers who agreed to annual clinical evaluations and autopsy at time of death. They come from about 40 sites across the United States. The study was approved by the Institutional Review Board of Rush University Medical Center. Each person underwent a uniform structured clinical evaluation, which included medical history, neurological examination, and cognitive testing (see later). Annual follow-up evaluations were identical in all essential details to the baseline examination. The study began in 1994, and follow-up for this study was available through July 2008. Inclusion criteria for these analyses involved an evaluation of musculoskeletal pain in the year before baseline and at least one follow-up clinical evaluation of mobility disability. 

Exclusion criteria involved baseline diagnosis of dementia, stroke, or Parkinson’s disease or severe performance-based mobility disability. We excluded 72 participants who met baseline criteria for dementia, 68 participants with stroke, and 36 participants with Parkinson’s disease. We then excluded 73 participants who had baseline severe performance-based mobility disability and 22 participants who had no evaluation of musculoskeletal pain in the year before baseline. Of the remaining participants, 23 died before the first follow-up evaluation, 13 had completed their baseline evaluation but were not yet eligible for their first follow-up evaluation, and 7 were eligible for follow-up, but follow-up had not yet been accomplished. The remaining 759 participants are included in these analyses.

**Clinical Diagnoses**

Clinical diagnoses were made using a multistep process, as previously described (18). Participants were administered a battery of 21 cognitive function tests, which were reviewed by a neuropsychologist (23). Participants were then evaluated by an experienced clinician who diagnosed dementia, stroke, Parkinson’s disease, and other common neurological conditions affecting cognitive or physical function. 

Criteria for dementia followed the joint working group of the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association (24). Diagnosis of stroke was made as outlined for the Trial of ORG 10172 in Acute Stroke Treatment (25). The diagnosis of Parkinson’s disease was made according to the clinical criteria recommended by the Core Assessment Program for Intracerebral Transplantation (26).

**Musculoskeletal Pain**

Musculoskeletal pain was assessed at baseline by asking the participant if they had experienced pain or aching in any of their joints on most days for at least 1 month during the prior year. Pain in the year before baseline was used in analyses to maintain the temporal relation between pain and the first occurrence of mobility disability. Moreover, the veracity of pain reporting was preserved as persons with dementia at baseline were excluded. Individuals who reported musculoskeletal pain were then asked if they had pain or aching in their back or neck, in their hands, in their hips, in their knees, or in their feet. We created a variable for the baseline presence or absence of any musculoskeletal pain. As the distribution of the number of musculoskeletal areas affected with pain was skewed, we defined three groups: a reference group that reported no pain, a group that reported pain in one or two areas, and a group that reported pain in three or more areas.

**Mobility Disability**

Performance-based mobility disability was assessed using a structured annual evaluation of the time it took participants to walk 8 feet (2.4 m) at their usual pace (27). A single 8-foot walk was performed, and time was measured with a stopwatch. Performance-based mobility disability was defined as a gait speed of \( \leq 0.4 \) m/s, a commonly used cutoff for severe disability, which has been associated with functional dependence in elderly participants (19–21). Self-reported mobility disability was determined using the Rosow–Breslau scale, which assesses three activities: walking up and down a flight of stairs; walking a half mile; and doing heavy housework like washing windows, walls, or floors (22). Participants were asked if they could perform each task without help from another person, and those who reported being unable to do one or more task were classified as being disabled.

**Other Baseline Covariates**

Age, sex, and years of education were determined based on participant self-report. Body mass index was calculated as weight in kilograms divided by height in square meters. Using a 10-item version of the Center for Epidemiological Studies-Depression scale (28), the number of depressive symptoms reported was determined, with higher scores representing more depressive symptoms. The presence of seven chronic medical conditions was determined by self-report (cancer, head injury, and thyroid disease), self-report and medication review (diabetes and hypertension), and self-report and clinician assessment (stroke), as previously described (29,30). Self-report of arthritis was not measured. The number of hours of physical activities engaged in the previous 2 weeks was determined by self-report (31). Non-steroidal antiinflammatory, opioid, and acetaminophen use was determined by inspection of each participant’s medications, as previously described (32).
Statistical Analysis
We compared the baseline characteristics of participants reporting musculoskeletal pain in the year before baseline with those not reporting musculoskeletal pain using \( t \) tests and chi-square tests.

We utilized the data from the cohort to answer the question of whether reporting musculoskeletal pain in the year before baseline was associated with first occurrence of mobility disability. Discrete-time Cox proportional hazard models (33), with terms to control for age, sex, and education, were used to estimate the odds ratio (OR) for the presence of musculoskeletal pain and the hazard for incident severe performance-based mobility disability. Participants were censored at the first follow-up examination where gait speed was \( \leq 0.4 \text{ m/s} \). This initial model was augmented three times, each time with an interaction term between the presence of musculoskeletal pain and age, sex, or education. Next, the following covariates were added individually into the model with the report of musculoskeletal pain in the year before baseline: self-reported mobility disability, gait speed, body mass index, depressive symptoms, physical activity, number of chronic medical conditions reported, and analgesic medication use. In order to examine if the number of painful regions exhibited a dose effect on incident mobility disability, we replaced the report of musculoskeletal pain in the year before baseline with the following variables in the same model: (a) one or two areas of reported pain compared with no musculoskeletal pain and (b) three or more areas of reported pain compared with no areas of reported pain. The relation of musculoskeletal regions with pain and incident mobility disability was examined by adding terms for each of the seven possible combinations of reporting pain in the lower extremity, upper extremity, and axial region as compared with no report of pain. We repeated similar models using the first occurrence of self-reported mobility disability on the Rosow–Breslau scale as the outcome.

All models were validated graphically and analytically. Analyzes were carried out in SAS, Version 9.2 (SAS Institute Inc., Cary, NC).

RESULTS
Descriptive Properties of Baseline Musculoskeletal Pain
There were 759 participants included in these analyzes. The mean age of the group was 73.9 years (SD = 6.6), 68.0% were women, and the average education was 18.2 years (SD = 3.4). Musculoskeletal pain in the year before baseline was absent in 477 (62.9%) participants, whereas 86 (11.3%) had pain in one area, 97 (12.8%) had pain in two areas, and 99 (13.0%) had pain in three or more areas (58 with three areas, 21 with four areas, and 20 with five areas). Participants who reported musculoskeletal pain were more likely to be female, more likely to self-report mobility disability, have a slower gait speed, have a greater body mass index, report more depressive symptoms, be more physically active, have more chronic medical conditions, and have greater analgesic medication use (Table 1). The duration of follow-up was the same for participants reporting musculoskeletal pain and those not reporting musculoskeletal pain.

Musculoskeletal Pain and Incident Severe Performance-Based Mobility Disability
Over a mean follow-up of 8.5 years (SD = 3.8, range = 1–14), 289 of 759 (38.1%) had at least one gait speed performance of less than or equal to 0.4 m/s. Approximately half \( (n = 149) \) subsequently walked faster than 0.4 m/s at a later evaluation. In a proportional hazards model, which was adjusted for age, sex, and education, musculoskeletal pain in the year before baseline was associated with a 47% greater hazard for incident performance-based mobility disability (odds ratio [OR] = 1.47, 95% confidence interval [CI] = 1.17–1.85). The incidence of severe performance-based mobility disability as a function of time in the study is shown in Figure 1 for participants with and without musculoskeletal pain in the year before baseline. Musculoskeletal pain was associated with severe mobility disability after (1) adding interaction terms between pain and demographic variables and (2) adjusting for self-report mobility disability, gait speed, body mass index, depressive symptoms, chronic medical conditions, physical activity, and use of analgesic medications in separate models (Table 2). Furthermore, there was a dose–response association between the number of painful areas and hazard for incident mobility disability. As graphically shown in Figure 2, compared with a typical participant (an 80-year-old woman with 18 years of
education) reporting no musculoskeletal pain in the year before baseline, a typical participant reporting one or two musculoskeletal areas with pain had a 30% greater hazard for incident severe mobility disability (OR = 1.30, 95% CI = 1.00–1.70). A typical participant reporting three or more areas with pain had an 80% greater hazard for incident severe mobility disability (OR = 1.78, 95% CI = 1.31–2.47). Individuals reporting pain in the lower extremity, axial region, or combinations including the two regions had a greater hazard for severe mobility disability than participants reporting no musculoskeletal pain in the year before baseline (Table 3).

Table 2. OR for Musculoskeletal Pain in the Year Before Baseline
With Hazard of Mobility Disabilities

<table>
<thead>
<tr>
<th>Model Terms in Addition to</th>
<th>Performance-Based Disability (n = 759)</th>
<th>Self-Reported Disability (n = 486)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, Sex, Education, and Musculoskeletal Pain*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1.47 (1.17–1.85)</td>
<td>1.38 (1.10–1.73)</td>
</tr>
<tr>
<td>Self-reported mobility disability</td>
<td>1.39 (1.09–1.78)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Gait speed</td>
<td>1.35 (1.06–1.71)</td>
<td>1.36 (1.06–1.74)</td>
</tr>
<tr>
<td>Depressive symptoms</td>
<td>1.39 (1.09–1.77)</td>
<td>1.33 (1.04–1.69)</td>
</tr>
<tr>
<td>Body mass index</td>
<td>1.44 (1.13–1.83)</td>
<td>1.33 (1.04–1.70)</td>
</tr>
<tr>
<td>Physical activity</td>
<td>1.50 (1.18–1.90)</td>
<td>1.39 (1.09–1.78)</td>
</tr>
<tr>
<td>Chronic medical conditions</td>
<td>1.47 (1.16–1.87)</td>
<td>1.38 (1.08–1.76)</td>
</tr>
<tr>
<td>Analgesic medication use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsteroidal antiinflammatory</td>
<td>1.41 (1.11–1.81)</td>
<td>1.37 (1.07–1.75)</td>
</tr>
<tr>
<td>Opioids</td>
<td>1.47 (1.14–1.88)</td>
<td>1.33 (1.04–1.71)</td>
</tr>
<tr>
<td>Acetaminophen</td>
<td>1.45 (1.14–1.85)</td>
<td>1.37 (1.07–1.75)</td>
</tr>
</tbody>
</table>

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

*Entries are ORs (95% CI) for musculoskeletal pain in year before baseline from discrete-time proportional hazards models with adjustment for baseline age, sex, and years of education and additional covariate.

**Performance-based severe mobility disability defined as a gait speed less than or equal to 0.4 m/s.

**Self-reported disability by Rosow–Breslau scale.

Musculoskeletal Pain and Incident Self-Report Mobility Disability

As mobility disability also can be determined by self-report, we examined whether the relation between musculoskeletal pain in the year before baseline and mobility disability varied based on the outcome measurement method. At baseline, 486 of the 759 (64.0%) participants did not have self-report mobility disability, as defined by the Rosow–Breslau scale. During follow-up, 332 of 486 (68.3%) developed incident self-reported mobility disability. After adjusting for age, sex, and education, the hazard for the first self-reported mobility disability was higher (OR = 1.38, 95% CI = 1.10–1.73) among participants who reported musculoskeletal pain in the year before baseline (Figure 3). The results were unchanged with adjustments for other covariates (Table 2). Compared with reporting no musculoskeletal areas with pain in the year before baseline, the report of one or two musculoskeletal areas with pain was associated with a 30% greater hazard for incident mobility disability (OR = 1.30, 95% CI = 1.02–1.67), and the report of three or more musculoskeletal areas with pain was associated with a 60% greater hazard for incident disability (OR = 1.62, 95% CI = 1.09–2.40).

Discussion

In this cohort of more than 750 community-dwelling older persons followed for up to 14 years, participants reporting musculoskeletal pain in the year before baseline had a greater hazard for first occurrence of mobility disability. Findings were similar using either performance-based or self-report assessments of mobility disability. Furthermore,
we observed a dose response such that participants reporting more areas with pain had a higher risk of developing mobility disability.

Finding that musculoskeletal pain is associated with the subsequent development of severe mobility disability may have important public health implications for the rapidly aging population. Mobility disability is common in older persons and has adverse health consequences. In a population-based study of persons aged 55–85 years in The Netherlands, the prevalence of performance-based mobility disability defined as a gait speed less than or equal to 0.4 m/s was reported to be 5.4% (21). During the screening phase of a community-based study of older women with disabilities, almost 50% self-reported mobility difficulties with 35% reporting walking difficulties and 23% reporting difficulties climbing 10 steps (1). Mobility disability is associated with an increased likelihood for further dependence in activities of daily living (2,3) and increased mortality (4–6).

Cross-sectional studies have shown that older persons reporting musculoskeletal pain are more likely to report concomitant mobility disability based on performance-based (13) and self-report (8–12) measures of mobility disability. The association of musculoskeletal pain in the year before baseline to self-report mobility disability in this study is consistent with several prior cross-sectional observations. The few longitudinal studies examining the relationship between musculoskeletal pain with incident mobility disability have either examined the association between the presence of musculoskeletal pain and worsening disability in participants with disability at study baseline or have utilized self-report of mobility disability (14–16). Some (15,16) but not all prior studies (14) have shown a relationship between musculoskeletal pain and increased mobility disability. The current study extends knowledge about the consequences of musculoskeletal pain in older persons in three ways and supports the association between musculoskeletal pain and subsequent development of severe mobility disability.

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Table 3. ORs for Musculoskeletal Pain Regions and Hazard of Performance-Based Mobility Disability

<table>
<thead>
<tr>
<th>Regions With Musculoskeletal Pain*</th>
<th>Performance-Based Disability†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Extremity</td>
<td>Upper Extremity</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
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<tr>
<td>No</td>
<td>Yes</td>
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<td>No</td>
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<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Notes: CI = confidence interval; OR = odds ratio.
*Entries are ORs (95% CI) for each combination of regions reported to have musculoskeletal pain in the year before baseline from a discrete-time proportional hazards model with adjustment for baseline age, sex, and years of education. Each combination is compared with no report of pain in the year before study baseline.
†Performance-based severe mobility disability defined as a gait speed less than or equal to 0.4 m/s.
pain and incident mobility disability. First, the current study examined the effect of musculoskeletal pain in the year before baseline and the first episode of mobility disability in community-dwelling older men and women without baseline mobility disability. Second, the current study examined the relationship of musculoskeletal pain to the development of severe mobility disability based on performance-based mobility disability as well as self-reported mobility disability. Third, the current study shows that higher numbers of areas reported with musculoskeletal pain and pain including the lower extremity and axial regions are associated with a greater hazard for incident severe mobility disability.

The results from the current study have important translational implications because they raise the possibility that treatments, which decrease musculoskeletal pain, may decrease the development of disability in older persons. However, factors linking musculoskeletal pain with mobility disability are not clear. Further investigation is needed to explore the biologic pathways linking musculoskeletal pain and development of mobility disability.

This study has several limitations. As a select cohort composed of nuns, priests, and brothers of the Catholic faith, whose level of education and other life experiences differs from the general population, further research on more diverse community-dwelling cohorts of older persons is needed. Also, pain is a multidimensional construct (8). Although the number of areas with musculoskeletal pain reported in the year before baseline and hazard for incident disability was examined in this study, further studies are needed to examine the contributions of other characteristics of pain, including chronicity, frequency, and severity. We did not have self-report, physical exam, radiological, or pathology findings of arthritis to try to objectively delineate the etiology of the pain. However, osteoarthritis research has documented that musculoskeletal pain rather than radiological findings is more tightly associated with report of disability (34). Other limitations include focusing on report of pain in the year before baseline, which may not be representative of pain during the course of the entire study; assessing mobility disability on an annual basis rather than more frequently; and addressing initial incidence of severe mobility disability, an outcome that recovers with time in some older persons (35). Confidence in the findings of this study is enhanced by several factors. The study used a standardized annual evaluation of mobility disability in a large cohort with up to 14 years of follow-up. Also, the study was able to account for the effects of several covariates that may affect the relationship of musculoskeletal pain and mobility disability.

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