HHS Public Access
Author manuscript
Am J Ind Med. Author manuscript; available in PMC 2019 October 01.

Published in final edited form as:
Am J Ind Med. 2018 October ; 61(10): 849–860. doi:10.1002/ajim.22902.

Knee pain in nursing home workers after implementation of a safe resident handling program

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Abstract

Purpose: Approximately 25–30% of nursing personnel experience knee pain (KP). We sought to identify physical and psychosocial work exposures, and personal factors related to prevalent, incident, and persistent KP 5–8 years after safe resident handing program (SRHP) implementation in nursing homes.

Methods: Health and exposure information was obtained from worker surveys 5–6 years (“F5”) and 7–8 years (“F6”) post-SRHP implementation. Prevalent KP correlates were examined at F5; persistent and incident KP predictors were analyzed at F6, utilizing robust Poisson multivariable regression.

Results: F5 KP prevalence (19.7%) was associated with combined physical exposures, and with either high job strain or low social support, in separate models. Two-year persistent KP was

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AUTHORS’ CONTRIBUTIONS
JEG analyzed the data, participated in data interpretation, and drafted the manuscript. AK assisted with study site selection and data collection, performed initial analyses of knee pain in this cohort, and participated in the data interpretation and drafting of the manuscript. LP designed the study and the survey instrument, oversaw data collection, and participated in data interpretation and drafting of the manuscript. RJG assisted with instrument development, supervised data entry and quality control, and provided critical statistical consulting support. All authors critically read and approved the final manuscript.

Institution at which the work was performed: University of Massachusetts Lowell.

ETHICS APPROVAL AND INFORMED CONSENT
This study was performed at the University of Massachusetts Lowell. This study was approved by the Institutional Review Board of the University of Massachusetts Lowell (approvals 06–1403 and 12–056). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all individual participants included in the study.

DISCLOSURE (AUTHORS)
The authors declare no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD
Paul Landsbergis declares that he has no conflict of interest in the review and publication decision regarding this article.

similarly associated with these psychosocial exposures. Being overweight was associated with KP in all analyses.

Conclusions: The SRHP program did not eliminate knee physical loading, which should be reduced to prevent nursing home worker KP. Workplace psychosocial exposures (high job strain, low social support) also appeared germane.

Keywords

healthcare workers; job strain; lower extremity; moving and lifting patients; workload

1 | INTRODUCTION

Occupationally-related musculoskeletal disorders (MSDs) of the knee are common, although under-studied. The U.S. Bureau of Labor Statistics reported an incidence rate of 3.1 injuries per 10 000 full-time workers in 2015 and a median of 19 days lost per injury.[1] Nursing personnel worldwide are notably affected by knee pain (KP); typical prevalence rates range from one-quarter to one-third.[2–5] Moreover, KP is a predictor of leaving the nursing profession.[6]

KP may be the consequence of a variety of knee disorders including osteoarthritis (OA), tendinitis, and chondromalacia. A diagnosis of knee OA (determined radiologically) is predicated on KP,[7] and KP may be a precursor to knee OA.[8,9] That is, there may be an overlap between the specific disorder of knee OA and non-specific KP.

Prior epidemiologic studies of prevalent KP and knee OA in both occupational and population cohorts have examined physical work and to a lesser extent psychosocial work exposures. Occupational kneeling/squatting and lifting/carrying have been highlighted as etiologically relevant with varying degrees of evidence in literature reviews.[10–14] Several studies have specifically examined prevalent knee disorders in nursing personnel. Physical exposures associated with KP in nurses include patient transfer tasks, especially manipulating the patient in bed[15]; often moving/lifting heavy loads[16]; and high perceived physical exertion.[17] Static standing and high-velocity motions or slips and trips in response to emergency “save-the-patient” situations may also put stress on the knee joint.[18–20]

The longitudinal “ProCare” study of nursing home employee health commenced upon the implementation of a safe resident handling program (SRHP) in a large long-term care corporation. Elements of this multi-component program included purchase of sufficient mechanical lifts for the residents in each facility, training, and protocols for lift use.[21] The overall study objective was to evaluate the effectiveness of the program in terms of physical exposure reduction, reduced musculoskeletal symptoms and injury rates, and return on investment.

Physical exposures and resident handling activities similar to those noted above were observed in this cohort even after the SRHP was implemented.[21–23] These included resident handling and mobilization activities such as manual and mechanically-assisted transfer of residents, lateral repositioning of residents without the use of transfer devices, ambulation assistance, and transporting residents. Additional exposures resulted from direct care tasks not addressed by the SRHP, such as dressing, bathing, and toileting residents, along with housekeeping tasks such as cart pushing and transport of dirty linens. These load the extremities as well as the back; for example, nearly two-thirds of the squatting, kneeling, and lunging postures previously observed were during resident handling, dressing, bathing, and housekeeping tasks.[24] Thus the SRHP reduced the biomechanical load on the back,[21] but did not eliminate all tasks with high physical workload.

The psychosocial work exposures of high job demands, low job control, shift work, and low schedule control have been frequently reported in nursing personnel working in long-term care.[25–27] In the ProCare study, low co-worker and supervisor support, low perceived respect from superiors at work and low decision authority were notable and affected general well-being, especially for nursing aides.[28]

Musculoskeletal disorder risk may be affected by psychosocial stressors, either directly or as effect modifies of physical load.[29] But there has been scant investigation of that question with regard to the lower extremity to date, and epidemiologic studies of psychosocial risk factors in relation to knee disorders have shown mixed results. Absenteeism due to KP in nursing personnel was associated with high job demands and low co-worker support,[16] and KP in taxi drivers was associated with "job stress."[30] However, several other studies have been failed to find associations.[5,15] Both confounding and effect modification of psychosocial stressors by physical workload may complicate interpretation of associations.

Compared with knee disorder prevalence, the prospective literature on knee disorder incidence and persistence is sparser. Again, both personal and work-related physical and psychosocial risk factors have been reported. For example, onset of KP was associated with lifting/carrying heavy loads in one hand as well as with psychological distress.[31] In a cohort of men employed by a national power utility, long-term occupational exposure to squatting was associated with incident knee pain.[32] Carrying/handling heavy loads and kneeling were associated with persistent knee pain in a large working population,[33,34] and knee pain persistence of forestry workers was related to both job dissatisfaction and trunk twisting.[35]

Two studies have examined the effects of patient handling interventions on knee disorders in health care settings. Knee "comfort" among hospital workers was significantly improved at 6 months following the introduction of mechanical patient lifts and training.[36] On the other hand, the Ohio Bureau of Workers' Compensation saw no reduction in the knee injury claim rate in nursing homes following training, consulting, or lift and other equipment purchases.[37]

The goal of this study was to identify work-related and personal factors associated with KP among nursing home employees both cross-sectionally and prospectively. The analyses focused on prevalence, cumulative incidence, and persistence of knee pain in survey data over a 2-year period, several years after the SRHP had been fully implemented.

2 | MATERIALS AND METHODS

2.1 | Study cohort and survey instrument

The ProCare study of nursing home employee health began in 2006. One survey was conducted 5–6 years after the SRHP was implemented ("F5"), in 24 facilities from one nursing home corporation located on the U.S. East coast (2012–2013). The survey was repeated 2 years later, at 7–8 years ("F6") post-SRHP (2014–2015). One facility surveyed at F5 had closed prior to F6.

Questionnaires were self-administered. Items included physical and psychosocial work exposures, recent medical history (prior knee injury, chronic disease), health behaviors such as smoking status (current/former/never) and frequency of intense aerobic exercise, demographic characteristics (age, race, gender, height, weight, marital status, years of education), work-family imbalance, holding a second job, frequency of assault by residents in the prior 3 months, years of seniority, and job title. This study was approved by the Institutional Review Board of the University of Massachusetts Lowell. Written informed consent was obtained from all individual participants included in the study.

2.2 | Outcome and variable construction

The study outcome, knee pain (KP), was defined as pain in the knee during the last 3 months (as indicated on a pain diagram), with at least mild severity during the prior week. Chronic disease was defined as a history of diagnosis or treatment for any of: high cholesterol, diabetes, and hypertension. Body mass index (BMI) was computed from questionnaire height and weight responses in the standard way, and obesity defined as BMI ≥ 30.[38] Frequency of intense aerobic exercise was ascertained through the question, "How many times a week on average do you exercise to work up a sweat (at least 20 min per session, e.g., fast walking, jogging, bicycling, swimming, rowing, etc.)?"

The psychosocial work exposures of decision latitude (range: 2–8), psychological job demands (range: 2–8), and social support (sum of co-worker support and supervisor support; range: 4–16) were assessed through a short version of the Job Content Questionnaire (JCQ).[39] Job strain (high demands and low control) was defined as the combination of low decision latitude (≤5) and high psychological job demands (>5).

Occupational physical exposures were assessed through self-reported items (rapid continuous physical activity, heavy lifting, kneeling/squatting, whole body awkward posture, head and arm awkward posture), each answered using a four-point Likert scale (strongly disagree, disagree, agree, strongly agree). A composite score for physical workload (range: 5–20) was constructed as the mean of the five ratings. Frequency of resident lift device usage, work-family imbalance, schedule control, and physical assault were defined as previously described.[40,41]

2.3 | Data analysis

Prevalent KP was assessed cross-sectionally in the entire F5 data set. Incident and persistent KP were assessed at F6 among respondents to both surveys. Inclusion for persistence of KP at F6 was restricted to those with KP at F5, and cumulative incidence at F6 was estimated among those with no KP at F5. Single predictor and multivariable robust Poisson regression models were constructed to determine the association of KP with occupational and other factors. Robust Poisson regression modeling was used, as most of our multivariable log-binomial models did not converge.[42]

The modeling approach focused on estimating associations with KP and on identifying potential confounders, beginning with testing the prior hypothesis that physical exposures and psychosocial exposures at work were associated with KP. Survey data on independent variables from F5, including work exposures, demographic characteristics, and health behaviors, were utilized in both the cross-sectional (prevalence) and longitudinal (cumulative incidence, persistence) analyses (see Table 1).

The covariate inclusion criterion was $P < 0.05$. Confounding was defined as a change of 20% or more in the computed risk estimate of the primary physical or psychosocial exposure in the model. Two-way effect modification between these exposure variables and other covariates was also assessed, with a P-value of <0.05 required for retention. To determine the most appropriate model fit, the quasi-likelihood information criterion (QIC) was used. Smoothing utilizing SAS PROC LOESS was used to visualize the estimated risk of KP and BMI, stratified by job strain. SAS 9.4 (SAS Institute Inc., Cary, NC) was used for all statistical analyses.

3 | RESULTS

A total of $n = 4526$ workers were eligible at F5. The response rate to the F5 survey was 58% ($n = 2642$) (Figure 1), and at F6 it was 67% of eligible workers ($n = 1237$). The majority of study respondents (e.g., 55.3% at F5) consisted of clinical staff, mainly nurses and nursing aides. Most of the other respondents were rehabilitation professionals, food service workers, and housekeepers.

Survey respondents had a mean age of 41.6 (SD = 13.1) years, with an average seniority of 10.1 (SD = 9.5) years (Table 1). Eighty-two percent were female, and 61% were college-educated. The majority (54.1%) was white, and 28.5% were African American. Almost one-third had been diagnosed with a chronic disease, and 66.8% had a BMI greater than “normal” (≥25). Thirty-two percent of respondents were classified as obese. Approximately one-fourth engaged in intense exercise three or more times per week, and 65% had never smoked. The distributions of gender, age, and race were almost identical to those of the total workforce in 2012 (unpublished data provided by the company).

Among the F5 survey participants, $n = 520$ (19.7%) reported KP and were therefore eligible for analysis of KP persistence. Of these, 253 (48.6%) were lost to follow-up, including 17 who were in the facility that closed. A total of 2122 cohort members had no KP at F5 and thus were eligible for analysis of incident KP at F6. Just over one-half of these ($n = 1152$, or 54.3%) were lost to follow-up, including 98 who were in the closed facility.

3.1 | Prevalent knee pain

KP was more prevalent in nursing personnel than in other workers (22.1% vs 16.7%, P = 0.0005, chi-square test). In univariate modeling, knee pain at F5 was associated with both physical and psychosocial work exposures, including the composite physical exposure score (prevalence rate ratio (PRR) = 1.03 [1.00–1.05]), psychological job demands (PRR = 1.09 [1.02–1.17]) and job strain (PRR = 1.30 [1.10–1.54]) (Table 1). Social support was negatively associated with KP. Other positive associations were found for knee injury during the prior 12 months, history of chronic disease, BMI (continuous) and particularly obesity, female gender and increasing age. Neither frequency of lift device used, schedule control, smoking, nor intense leisure-time exercise was associated with KP.

Two multivariable robust Poisson regression models of KP prevalence were constructed. The first model showed a positive association with the composite physical exposure score (PRR = 1.03 [95%CI: 1.01–1.06]), and a protective effect of social support (PRR = 0.97 [0.94–1.01]) (Table 2, Model A). These were adjusted for serious knee injury in the prior 12 months, obesity, gender, and age. The second model was the same as the first, except that job strain was substituted for social support (Table 2, Model B). In this model, job strain had a positive association with KP (PRR = 1.29 [1.07–1.55]). It was not possible to fit a model with the three workplace exposures of composite physical exposure score, job strain, and social support. A model with psychological job demands instead of job strain or social support, constructed with identical covariates to the previously mentioned models, yielded a marginally significant prevalence ratio of 1.07 (95%CI: 0.99–1.16) for the work exposure (not shown in Table 2) (composite physical exposure score and psychological job demands: Pearson's r = 0.25 (P < 0.0001). None of these models showed evidence of confounding or interaction with exposure of prior knee injury, obesity, gender, age, chronic disease, intensive physical exercise frequency, or number of assaults in the last month.

3.2 | Incident knee pain

The health behaviors and work exposures of those who were lost to follow-up at F6 were substantially similar to those who were surveyed at that time period. The only exceptions were that cohort members lost to follow-up were more likely to have a college or post-graduate education, slightly more likely to be white, and about 2 years less senior with the company.

The 2-year cumulative incidence of KP was 14.5% (141/970) (Table 3). In multivariable modeling, new KP at F6 was associated with F5 psychological job demands and number of hours worked (Table 4). BMI and prior knee injury also predicted new KP. There was no confounding or effect modification of psychological demands by prior knee injury, BMI, gender, age, chronic disease, intensive physical exercise frequency, or number of assaults in the last month.

3.3 | Persistent knee pain

Knee pain persisting from F5 to F6 was experienced by n = 135 (50.6%) of those with the condition at F5 who were followed up (Table 3). Two multivariable robust Poisson regression models were constructed (Table 5). Each model showed a small positive effect of both BMI and age. In Model A, decreased social support at work predicted persistent KP 2 years later. For this model, there was no confounding or effect modification with social support by prior knee injury, gender, BMI, age, chronic disease, intensive physical exercise frequency, or number of assaults in the last month.

In Model B, job strain (PRR = 4.87 [1.42–16.74]) was separately associated with continued KP. The same covariates were tested, and job strain also appeared to modify the effect of BMI. With no job strain, BMI (from a threshold of approximately 30), increased the risk of persistent KP (Figure 2). However, in the presence of job strain, BMI did not influence the estimated risk of persistence.

4 | DISCUSSION

In this longitudinal cohort of nursing home personnel, the prevalence of KP about 5 years following a safe resident handling program was 20% among all respondents, and 22% in nursing personnel. This is well within the range of 16–61 percent reported in other studies of nursing personnel.[2–5,43–46] Prevalent KP was associated with self-reported work exposures, after adjusting for other known risk factors. Separately, both a composite physical exposure score and psychosocial job strain were positively associated with KP, while social support at work appeared protective. Similarly, high job strain and low social support reported in the first survey predicted persistent KP 2 years later. Further, incident KP was associated with earlier psychological job demands and the number of hours worked per week. Given that psychological demands is one element of job strain, this represents qualitatively a high degree of concordance in the identified risk factors among three different analyses.

4.1 | Physical occupational exposures and knee pain

We observed an association between KP and the sum of self-reported physical exposures involving heavy lifting, kneeling and squatting, rapid continuous physical activity, and awkward postures. Combinations of physical exposures that increase biomechanical load on the knee have previously been shown to be associated with knee disorders. For example, KP in nurses was associated with self-reported patient transfer tasks[15]; such tasks often include a combination of heavy lifting, and awkward body and head/arm postures. Several other studies have found an increased risk of knee OA when occupational heavy lifting was combined with knee flexion or kneeling/squatting.[47–52]

Although epidemiologic evidence is ample, the pathomechanisms by which physical stressors may lead to knee disorders are still unclear. Repetitive loading of the knee may induce microinjuries of the cartilage, leading to collagen breakdown and OA.[48] An inflammatory cascade with accompanying pain may follow (see Section 4.3 below). During kneeling, contact forces between the tibia and femur increase, with concomitant decrease in contact area in the tibiofemoral joint, thus increasing the likelihood of degenerative changes, particularly in the meniscus.[53,54] Heijink et al,[55] and Englund[56] provide detailed descriptions of the role of biomechanics in knee OA.

4.2 | Psychosocial occupational exposures and knee pain

Previous studies of prevalent knee disorders offer mixed results with regard to occupational psychosocial exposures. In nursing personnel, neither job demands, job control, nor social support was associated with KP.[5] Job stress in taxi drivers was associated with KP, while job dissatisfaction was not,[30] although the latter is more logically characterized as an intermediate variable, or even an outcome of occupational stressors. In another study of nurses, prevalent KP was not associated with time pressure or work stress.[15]

In the current study, psychological job demands were associated with incident KP. Jones et al[31] found associations of 2-year incident KP with general psychological distress (from the General Health Questionnaire[57]), job monotony, and lack of job control. They defined a monotonous job as one that was “monotonous or repetitive greater than half of the time.” Therefore, it is unknown whether their finding reflects physically repetitive work, or work that is minimally mentally stimulating (or both).

Few other studies have examined psychosocial factors and KP persistence, specifically. Miranda et al.[35] found an association between job dissatisfaction and persistent KP. We found an association with job strain (for both prevalent and persistent KP), and certainly persons with job strain may experience job dissatisfaction. To our knowledge, ours is the first study that has examined the association between persistent KP and either job strain or social support.

Low social support was associated with both prevalent and persistent KP in the current study. We postulate that the most likely mechanism for this is either instrumental (tangible) or informational. If workers perceive low social support from coworkers and/or supervisors, they may attempt challenging physical tasks on their own rather than asking for help. For clinical staff this may mean they are performing manual transfers of residents on their own, resulting in excess physical loading, which over time may lead to knee (or other) MSDs. Alternatively, workers with low social support may not feel comfortable asking for or receiving advice from other workers about how to manage physically difficult tasks, excessive loads or high time pressure.

As is customary, our job demands variable was partially derived from a JCQ item, “my job requires working very hard,” which may be subject to differing interpretations. Depending on the nature of their jobs, workers may understand this question as referring to physical workload rather than—or in combination with—psychological demands. A study of university workers in multiple occupations reported on “collaborative interviews” that explored the interpretation of this item.[58] Workers who performed more physical tasks on the job (maintenance and trade workers, police officers) tended to interpret the item as representing physical aspects of their job, in contrast to administrative/middle management and research office staff who interpreted it to be a psychological demand question. A later focus group in firefighters similarly reported confusion as to whether it was intended to assess physical or psychological demands.[59] Karasek et al.[60] also noted possible ambiguity in interpretation of the “work very hard” question. We could not ask the nursing home workers in this study directly but they also might have been more likely to interpret this question as a physical demand, due to the physical nature of tasks they perform.

If it is not mediated through physical load, psychosocial job strain might influence musculoskeletal pain through other mechanisms. For example, muscles may tense up when an individual experiences stress without sufficient time to relax.[61] The concomitant localized decreased blood flow may affect MSD risk through a variety of mechanisms.[62] Alternatively, high job demands may influence mechanical load through changes in posture or acceleration.[29]

Separately, elevated cortisol may be elevated with increased job strain[63–68] and low social support,[67–69] although evidence is mixed. Cortisol inhibited the action of pro-inflammatory cytokine interleukin (IL)-1beta on glucose uptake in human articular cartilage in vitro, thus reducing chondrocyte metabolic activity.[70] This may inhibit cartilage repair, and thus may be germane to the pathomechanisms of knee OA.

4.3 | Obesity and knee pain

In the present study, workers with higher BMI scores had more prevalent, incident, and persistent KP. Obesity is a well-established risk factor for knee disorders and has been previously described in prevalent,[5,71–78] incident,[9,34,35] and persistent[33,79–81] knee morbidity.

There are several pathways whereby overweight/obesity may be related to persistent painful knee disorders, such as knee OA. First, excessive loading on the knee may affect joint biomechanical properties, including irreversible destruction of collagen in cartilage.[82] Mechanoreceptors on chondrocytes may be activated by joint overloading resulting in metalloproteinase production, which acts to degrade cartilage extracellular matrix (ECM).[83] Activated mechanoreceptors may also secrete IL-1, which acts as a pro-inflammatory.[83] Further, adipose tissue secretes inflammatory-influencing substances such as leptin, andiponectin, and resistin.[84] Serum inflammatory markers have been shown to be associated with knee cartilage loss[85,86] and with increased perception of pain.[83] A positive feedback loop may be at play whereby obese individuals with OA become less mobile, leading to further weight gain.[87]

Several studies have shown an interaction between occupational physical exposures and BMI for knee OA. In Coggon et al,[88] the interaction of occupational kneeling and squatting with obesity was approximately multiplicative. Similarly, in another population, a nearly multiplicative interaction was observed between each of lifting/ carrying and kneeling/ squatting exposures with BMI.[89]

However, we know of no study that reported an interaction between psychosocial job factors and BMI in association with KP. In the present study, it appears that when job strain is present, it overshadows the effect of BMI in its association with KP persistence. Again, job strain may be serving at least in part as a surrogate for physical exposure. The relative contribution of BMI and job strain to the persistence of KP (and perhaps other musculoskeletal pain) warrants further research.

4.4 | Study strengths and limitations

This study had a relatively large loss to follow-up between F5 and F6 (46.8%), resulting from an unknown mix of workers either leaving their jobs during that interval or choosing not to participate in the second survey. Included in this loss to follow-up, one of the nursing homes closed in the 2 years between study periods ($n = 115$); obviously it was impossible to follow up with these individuals, but they were a small proportion overall. The response rate in the later survey was higher than in the earlier one, so we infer that leaving the job was likely a predominant reason. Unfortunately, we could not track individuals by name in the company roster to confirm or refute this.

High worker turnover in the long-term care sector is not unusual. The median annual turnover rate in 2013 for clinical staff in U.S. skilled nursing care facilities was 44%.[90] Annual turnover rates have been documented to range as high as 55–85% for nurses,[91,92] and in excess of 100% for nursing aides.[92–94]

A proportion of any turnover in the current cohort may have been due to work-related injuries or illnesses. Specifically, those with KP might have been more likely to leave work, especially those who were also experiencing more physical workload or psychosocial job strain. This healthy worker survivor effect, if the nursing home workers who remained employed were both healthier and less exposed than those who left work, could have resulted in an underestimation of KP at F6 as well as of its association with any exposures that also predicted leaving work.

Because survey data were self-reported, there is potential for recall bias in cross-sectional analyses of risk factors for KP prevalence. In particular, individuals with KP might have been more likely to over-recall any exposures that aggravated their symptoms. This would have resulted in under-estimation of the associations between exposure and KP. Additionally, since the prevalence analyses were cross-sectional in nature, there is temporal ambiguity associated with results from these analyses, meaning that we cannot demonstrate that the exposures preceded the development of KP.

Although log-binomial models estimate the prevalence rate ratio directly, we used robust Poisson regression modeling because of its better convergence properties.[42] These two model types give slightly different estimates.[95] Due to the small sample sizes available for prospective analysis, there was insufficient power for nested models. It is not clear how this would have influenced our results (see[41] for a further discussion). Smoothing regression exercises, such as that used here to investigate the interaction between BMI and job strain, are typically used for exploratory hypothesis development rather than investigation of causal relationships. These analyses can provide insight into potential causality, but one should be cautious to avoid over-interpretation.

It is unknown whether the KP reported by the nursing home workers is reflective of OA, tendinitis, bursitis, chondromalacia, or another disorder, as there were no clinical examinations or radiological scans. Since the mean age of the nursing home workers was 41.6 years, and the most common cause of chronic KP in persons aged 50 and above is OA,[10] it is quite possible that many in our sample had knee OA. However, the relationship between knee pain, radiological findings indicative of OA, and a confirmed OA diagnosis is not straightforward. A study of NHANES respondents[81] reported that only 15% of those with KP had radiologic changes signifying OA. On the other hand, in two longitudinal population-based studies, KP was a risk factor for progressive radiographic knee OA.[8,9] In the present material, we cannot determine to what extent KP is serving as either a surrogate for OA or as a precursor to OA.

It was not possible to determine whether all incident pain at follow-up was truly new. The questionnaire item asked about KP in the prior 3 months, so earlier episodic KP between F5 and F6 may not have been captured. Also, our questionnaire only asked participants to report knee injuries during the previous year. As prior knee injuries have been associated with incident KP in previous studies,[9,33] the lack of information on earlier (lifetime) knee injuries may have produced some unmeasured confounding by prior injury.

Few studies have examined determinants of KP following an intervention involving mechanical lifts and training. The current study adds to this literature. The surveys conducted were comprehensive, with questions covering many domains of health, health behaviors, and working conditions. This allowed for exploration of many personal and work-related factors for associations with KP. The large study population allowed for adjustment for many confounders and testing for effect modification in multivariable modeling.

5 | CONCLUSION

Most studies of MSDs in healthcare workers have focused on the low back; other body areas have been understudied.[96] The current prospective study adds to the understanding of factors associated with prevalent, incident, and persistent KP in this sector. Prevalent KP in nursing home workers 5 years after a SRHP intervention was associated with both self-reported physical exposures and psychosocial job strain, while social support reduced KP risk. Similarly, high job strain and low social support were related to persistent KP over 2 years. Incident KP during this 2-year period was associated with number of hours worked per week and with psychological job demands. BMI was a notable predictor for all three health outcomes. Workplace physical exposures to the knee still presented after implementation of a SRHP,[21,22] due to both resident handling and other tasks. Measures should be taken to reduce psychosocial strain in these jobs. Workplaces can be more health-promoting through showing respect for staff at all levels, fostering good supervision and supporting co-worker relationships, and involving workers in decision-making. In addition, nursing home workers should be assisted to lose weight to protect against KP, even after SRHP programs are instituted.

ACKNOWLEDGMENTS

The authors would like to thank Genesis HealthCare Corporation for permission and access to carry out data collection, especially Donna LaBombard, Deb Slack-Katz, and Mary Tess Crotty for liaising with individual nursing facilities. Many student research assistants assisted with questionnaire distribution, data scanning, and cleaning.

FUNDING

Grant Sponsor: U.S. National Institute for Occupational Safety and Health (NIOSH/CDC). Grant number: U19-OH008857.

Funding information

National Institute for Occupational Safety and Health, Grant number: U19-OH008857

REFERENCES

1. Nonfatal cases involving days away from work: selected characteristics. United States Department of Labor; 2015 https://www.bls.gov/data/#injuries. Accessed June 16, 2017.
2. Amin NA, Nordin R, Fatt QK, Noah RM, Oxley J. Relationship between psychosocial risk factors and work-related musculoskeletal disorders among public hospital nurses in Malaysia. Ann Occup Environ Med 2014;26:23. [PubMed: 25852937]
3. Harcombe H, McBride D, Derrett S, Gray A. Prevalence and impact of musculoskeletal disorders in New Zealand nurses, postal workers and office workers. Aust N Z J Public Health 2009;33:437–441. [PubMed: 19811479]
4. Kee D, Seo SR. Musculoskeletal disorders among nursing personnel in Korea. Int J Ind Ergon 2007;37:207–212.
5. Lagerstrom M, Wenemark M, Hagberg M, Hjelm EW. Occupational and individual factors related to musculoskeletal symptoms in five body regions among Swedish nursing personnel. Int Arch Occup Environ Health 1995;68:27–35. [PubMed: 8847110]
6. Fochsen G, Josephson M, Hagberg M, Toomingas A, Lagerstrom M. Predictors of leaving nursing care: a longitudinal study among Swedish nursing personnel. Occup Environ Med 2006;63:198–201. [PubMed: 16497862]
7. Altman R, Asch E, Bloch D, et al. Development of criteria for the classification and reporting of osteoarthritis. Classification of osteoarthritis of the knee. Diagnostic and Therapeutic Criteria Committee of the American Rheumatism Association. Arthritis Rheum 1986; 29:1039–1049. [PubMed: 3741515]
8. Hart DJ, Doyle DV, Spector TD. Incidence and risk factors for radiographic knee osteoarthritis in middle-aged women: the Chingford Study. Arthritis Rheum 1999;42:17–24. [PubMed: 9920009]
9. Muraki S, Akune T, Oka H, et al. Incidence and risk factors for radiographic knee osteoarthritis and knee pain in Japanese men and women: a longitudinal population-based cohort study. Arthritis Rheum 2012;64:1447–1456. [PubMed: 22135156]
10. Fransen M, Agaliotis M, Bridgett L, Mackey MG. Hip and knee pain: role of occupational factors. Best Pract Res Clin Rheumatol 2011;25:81–101. [PubMed: 21663852]
11. D’Souza JC, Franzblau A, Werner RA. Review of epidemiologic studies on occupational factors and lower extremity musculoskeletal and vascular disorders and symptoms. J Occup Rehabil 2005;15:129–165. [PubMed: 15844673]
12. Reid CR, Bush PM, Cummings NH, McMullin DL, Durrani SK. A review of occupational knee disorders. J Occup Rehabil 2010;20:489–501. [PubMed: 20490901]
13. Blagojevic M, Jinks C, Jeffery A, Jordan KP. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. Osteoarthritis Cartilage 2010;18:24–33. [PubMed: 19751691]
14. Ezzat AM, Li LC. Occupational physical loading tasks and knee osteoarthritis: a review of the evidence. Physiother Can 2014; 66:91–107. [PubMed: 24719516]
15. Warming S, Precht DH, Suadicani P, Ebbehoj NE. Musculoskeletal complaints among nurses related to patient handling tasks and psychosocial factors-based on logbook registrations. Appl Ergon 2009;40:569–576. [PubMed: 18789431]
16. Alexopoulos EC, Tanagra D, Detorakis I, et al. Knee and low back complaints in professional hospital nurses: occurrence, chronicity, care seeking and absenteeism. Work 2011;38:329–335. [PubMed: 21508522]
17. Choobineh A, Movahed M, Tabatabaie SH, Kumashiro M. Perceived demands and musculoskeletal disorders in operating room nurses of Shiraz city hospitals. Ind Health 2010;48:74–84. [PubMed: 20160411]

18. Brinckmann P, Frobin W, Leivseth G. 2002 Musculoskeletal Biomechanics New York: Thieme.
19. Chapman AE. 2008 Biomechanical Analysis of Fundamental Human Movements Champaign, IL: Human Kinetics.
20. Smith SM, Cockburn RA, Hemmerich A, Li RM, Wyss UP. Tibiofemoral joint contact forces and knee kinematics during squatting. Gait Posture 2008;27:376–386. [PubMed: 17583512]
21. Kurowski A, Boyer J, Fulmer S, Gore R, Punnett L. Changes in ergonomic exposures of nursing assistants after the introduction of a safe resident handling program in nursing homes. Int J Ind Ergon 2012;42:525–532.
22. Kurowski A, Buchholz B, Punnett L, ProCare Research T. A physical workload index to evaluate a safe resident handling program for nursing home personnel. Hum Factors 2014;56:669–683. [PubMed: 25029893]
23. Kurowski A, Gore R, Buchholz B, Punnett L. Differences among nursing homes in outcomes of a safe resident handling program. J Healthc Risk Manag 2012;32:35–51. [PubMed: 22833329]
24. Kurowski A 2011 Ergonomic exposure assessment of nursing assistants in nursing homes following a safe resident handling intervention Lowell, MA: Department of Work Environment, University of Massachusetts Lowell.
25. Elovainio M, Heponiemi T, Kuusio H, et al. Job demands and job strain as risk factors for employee wellbeing in elderly care: an instrumental-variables analysis. Eur Public Health 2015;25:103–108.
26. Miranda H, Gore RJ, Boyer J, Nobrega S, Punnett L. Health behaviors and overweight in nursing home employees: contribution of workplace stressors and implications for worksite health promotion. Sci World J 2015;2015:915359.
27. Willemse BM, de Jonge J, Smit D, Depla MF, Pot AM. The moderating role of decision authority and coworker- and supervisor support on the impact of job demands in nursing homes: a cross-sectional study. Int J Nurs Stud 2012;49:822–833. [PubMed: 22410102]
28. Zhang Y, Punnett L, Gore R, Team C-NR. Relationships among employees' working conditions, mental health, and intention to leave in nursing homes. J Appl Gerontol 2014;33:6–23. [PubMed: 24652941]
29. Bongers PM, de Winter CR, Kompier MA, Hildebrandt VH. Psychosocial factors at work and musculoskeletal disease. Scand J Work Environ Health 1993;19:297–312. [PubMed: 8296178]
30. Chen JC, Dennerlein JT, Shih TS, et al. Knee pain and driving duration: a secondary analysis of the Taxi Drivers' Health Study. Am J Public Health 2004;94:575–581. [PubMed: 15054008]
31. Jones GT, Harkness EF, Nahit ES, McBeth J, Silman AJ, Macfarlane GJ. Predicting the onset of knee pain: results from a 2-year prospective study of new workers. Ann Rheum Dis 2007;66:400–406. [PubMed: 16935910]
32. Evanoff A, Sabbath EL, Carton M, et al. Does obesity modify the relationship between exposure to occupational factors and musculoskeletal pain in men? Results from the GAZEL cohort study. PLoS ONE 2014;9:e109633. [PubMed: 25330397]
33. Herquelot E, Bodin J, Petit A, et al. Long-term persistence of knee pain and occupational exposure in two large prospective cohorts of workers. BMC Musculoskelet Disord 2014;15:411. [PubMed: 25475051]
34. Herquelot E, Bodin J, Petit A, et al. Incidence of chronic and other knee pain in relation to occupational risk factors in a large working population. Ann Occup Hyg 2015;59:797–811. [PubMed: 25711951]
35. Miranda H, Viikari-Juntura E, Martikainen R, Riihimaki H. A prospective study on knee pain and its risk factors. Osteoarthritis Cartilage 2002;10:623–630. [PubMed: 12479384]
36. Li J, Wolf L, Evanoff B. Use of mechanical patient lifts decreased musculoskeletal symptoms and injuries among health care workers. Inj Prev 2004;10:212–216. [PubMed: 15314047]
37. Park RM, Bushnell PT, Bailer AJ, Collins JW, Stayner LT. Impact of publicly sponsored interventions on musculoskeletal injury claims in nursing homes. Am J Ind Med 2009;52:683–697. [PubMed: 19670260]
38. Centers for Disease Control and Prevention. About Adult BMI 2015; http://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html#Interpreted. Accessed December 9, 2015.

39. Landsbergis PA, Schnall PL, Pickering TG, Schwartz JE. Validity and reliability of a work history questionnaire derived from the Job Content Questionnaire. J Occup Environ Med 2002;44:1037–1047. [PubMed: 12448355]
40. Miranda H, Punnett L, Gore R, Boyer J. Violence at the workplace increases the risk of musculoskeletal pain among nursing home workers. Occup Environ Med 2011;68:52–57. [PubMed: 20876554]
41. Gold JE, Punnett L, Gore RJ, ProCare Research T. Predictors of low back pain in nursing home workers after implementation of a safe resident handling programme. Occup Environ Med 2016;74:389–395. [PubMed: 27919063]
42. Deddens JA, Petersen MR. Approaches for estimating prevalence ratios. Occup Environ Med 2008;65:481 501–486. [PubMed: 18562687]
43. O'Reilly SC, Muir KR, Doherty M. Occupation and knee pain: a community study. Osteoarthritis Cartilage 2000;8:78–81. [PubMed: 10772236]
44. Smith DR, Ohmura K, Yamagata Z, Minai J. Musculoskeletal disorders among female nurses in a rural Japanese hospital. Nurs Health Sci 2003;5:185–188. [PubMed: 12877719]
45. Tinubu BM, Mbada CE, Oyeyemi AL, Fabunmi AA. Work-related musculoskeletal disorders among nurses in Ibadan, South-west Nigeria: a cross-sectional survey. BMC Musculoskelet Disord 2010;11:12. [PubMed: 20089139]
46. Smith DR. A comparison of musculoskeletal disorders among female nursing-home nurses in Japan and Korea. Ergon Aust 2002;16:16–19.
47. Felson DT, Hannan MT, Naimark A, et al. Occupational physical demands, knee bending, and knee osteoarthritis: results from the Framingham Study. J Rheumatol 1991;18:1587–1592. [PubMed: 1765986]
48. Cooper C, McAlindon T, Coggon D, Egger P, Dieppe P. Occupational activity and osteoarthritis of the knee. Ann Rheum Dis 1994; 53:90–93. [PubMed: 8129467]
49. Amin S, Goggins J, Niu J, et al. Occupation-related squatting, kneeling, and heavy lifting and the knee joint: a magnetic resonance imaging-based study in men. J Rheumatol 2008;35:1645–1649. [PubMed: 18597397]
50. Teichtahl AJ, Wluka AE, Wang Y, et al. Occupational activity is associated with knee cartilage morphology in females. Maturitas 2010;66:72–76. [PubMed: 20153945]
51. Seidler A, Bolm-Audorff U, Abolmaali N, Elsner G. Knee osteoarthritis s-g. The role of cumulative physical work load in symptomatic knee osteoarthritis—a case-control study in Germany. J Occup Med Toxicol 2008;3:14. [PubMed: 18625053]
52. Kivimaki J, Riihimaki H, Hanninen K. Knee disorders in carpet and floor layers and painters. Scand J Work Environ Health 1992;18:310–316. [PubMed: 1439658]
53. Rytter S, Jensen LK, Bonde JP. Clinical knee findings in floor layers with focus on meniscal status. BMC Musculoskelet Disord 2008;9:144. [PubMed: 18945344]
54. Rytter S, Egund N, Jensen LK, Bonde JP. Occupational kneeling and radiographic tibiofemoral and patellofemoral osteoarthritis. J Occup Med Toxicol 2009;4:19. [PubMed: 19594940]
55. Heijink A, Gomoll AH, Madry H, et al. Biomechanical considerations in the pathogenesis of osteoarthritis of the knee. Knee Surg Sports Traumatol Arthrosc 2012;20:423–435. [PubMed: 22173730]
56. Englund M The role of biomechanics in the initiation and progression of OA of the knee. Best Pract Res Clin Rheumatol 2010;24:39–46. [PubMed: 20129198]
57. Goldberg DP. 1978 Manual of the General Health Questionnaire Windsor, England: NFER Publishing.
58. Choi B, Kurowski A, Bond M, et al. Occupation-differential construct validity of the Job Content Questionnaire (JCQ) psychological job demands scale with physical job demands items: a mixed methods research. Ergonomics 2012;55:425–439. [PubMed: 22423675]
59. Choi B, Ko S, Dobson M, et al. Short-term test-retest reliability of the Job Content Questionnaire and Effort-Reward Imbalance Questionnaire items and scales among professional firefighters. Ergonomics 2014;57:897–911. [PubMed: 24712524]

60. Karasek R, Brisson C, Kawakami N, Houtman I, Bongers P, Amick B. The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol 1998;3:322–355. [PubMed: 9805280]
61. Lundberg U Psychophysiology of work: stress, gender, endocrine response, and work-related upper extremity disorders. Am J Ind Med 2002;41:383–392. [PubMed: 12071491]
62. Visser B, van Dieen JH. Pathophysiology of upper extremity muscle disorders. J Electromyogr Kinesiol 2006;16:1–16. [PubMed: 16099676]
63. Steptoe A, Cropley M, Griffith J, Kirschbaum C. Job strain and anger expression predict early morning elevations in salivary cortisol. Psychosom Med 2000;62:286–292. [PubMed: 10772410]
64. Alderling M, Theorell T, de la Torre B, Lundberg I. The demand control model and circadian saliva cortisol variations in a Swedish population based sample (The PART study). BMC Public Health 2006;6:288. [PubMed: 17129377]
65. Maina G, Bovenzi M, Palmas A, Larese Filon F. Associations between two job stress models and measures of salivary cortisol. Int Arch Occup Environ Health 2009;82:1141–1150. [PubMed: 19554345]
66. Maina G, Palmas A, Bovenzi M, Filon FL. Salivary cortisol and psychosocial hazards at work. Am J Ind Med 2009;52:251–260. [PubMed: 19023870]
67. Rydstedt LW, Cropley M, Devereux JJ, Michalianou G. The relationship between long-Term job strain and morning and evening saliva cortisol secretion among white-Collar workers. J Occup Health Psychol 2008;13:105–113. [PubMed: 18393580]
68. Evolahti A, Hultcrantz M, Collins A. Women’s work stress and cortisol levels: a longitudinal study of the association between the psychosocial work environment and serum cortisol. J Psychosom Res 2006;61:645–652. [PubMed: 17084142]
69. Marchand A, Juster RP, Durand P, Lupien SJ. Work stress models and diurnal cortisol variations: the SALVEO study. J Occup Health Psychol 2016;21:182–193. [PubMed: 26322441]
70. Hernvann A, Jaffray P, Hilliquin P, Cazalet C, Menkes CJ, Ekindjian OG. Interleukin-1 beta-mediated glucose uptake by chondrocytes. Inhibition by cortisol. Osteoarthritis Cartilage 1996;4:139–142. [PubMed: 8806115]
71. Sobti A, Cooper C, Inskip H, Searle S, Coggon D. Occupational physical activity and long-term risk of musculoskeletal symptoms: a national survey of post office pensioners. Am J Ind Med 1997;32:76–83. [PubMed: 9131214]
72. Cooper C, McAlindon T, Snow S, et al. Mechanical and constitutional risk factors for symptomatic knee osteoarthritis: differences between medial tibiofemoral and patellofemoral disease. J Rheumatol 1994;21:307–313. [PubMed: 8182642]
73. Englund M, Guermazi A, Roemer FW, et al. Meniscal tear in knees without surgery and the development of radiographic osteoarthritis among middle-aged and elderly persons: the Multicenter Osteoarthritis Study. Arthritis Rheum 2009;60:831–839. [PubMed: 19248082]
74. Gelber AC, Hochberg MC, Mead LA, Wang NY, Wigley FM, Klag MJ. Joint injury in young adults and risk for subsequent knee and hip osteoarthritis. Ann Inter Med 2000;133:321–328.
75. Niu J, Zhang YQ, Torner J, et al. Is obesity a risk factor for progressive radiographic knee osteoarthritis?. Arthritis Rheum 2009;61:329–335. [PubMed: 19248122]
76. Sowers MF, Yosef M, Jamadar D, Jacobson J, Karvonen-Gutierrez C, Jaffe M. BMI vs. body composition and radiographically defined osteoarthritis of the knee in women: a 4-year follow-up study. Osteoarthritis Cartilage 2008;16:367–372. [PubMed: 17884608]
77. Yoshimura N, Kinoshita H, Hori N, et al. Risk factors for knee osteoarthritis in Japanese men: a case-control study. Mod Rheumatol 2006;16:24–29. [PubMed: 16622720]
78. Yoshimura N, Nishioka S, Kinoshita H, et al. Risk factors for knee osteoarthritis in Japanese women: heavy weight, previous joint injuries, and occupational activities. J Rheumatol 2004;31:157–162. [PubMed: 14705235]
79. Soni A, Kiran A, Hart DJ, et al. Prevalence of reported knee pain over twelve years in a community-based cohort. Arthritis Rheum 2012;64:1145–1152. [PubMed: 22180258]
80. Jin X, Ding C, Wang X, et al. Longitudinal associations between adiposity and change in knee pain: tasmanian older adult cohort study. Semin Arthritis Rheum 2016;45:564–569. [PubMed: 26596913]

81. Hannan MT, Felson DT, Pincus T. Analysis of the discordance between radiographic changes and knee pain in osteoarthritis of the knee. J Rheumatol 2000;27:1513–1517. [PubMed: 10852280]
82. Musumeci G The effect of mechanical loading on articular cartilage. J Funct Morphol Kinesiol 2016;1:154–161.
83. McVinnie DS. Obesity and pain. B J Pain 2013;7:163–170.
84. Sowers MR, Karvonen-Gutierrez CA. The evolving role of obesity in knee osteoarthritis. Curr Opin Rheumatol 2010;22:533–537. [PubMed: 20485173]
85. Stannus O, Jones G, Cicuttini F, et al. Circulating levels of IL-6 and TNF-alpha are associated with knee radiographic osteoarthritis and knee cartilage loss in older adults. Osteoarthritis Cartilage 2010;18:1441–1447. [PubMed: 20816981]
86. Stannus OP, Jones G, Blizzard L, Cicuttini FM, Ding C. Associations between serum levels of inflammatory markers and change in knee pain over 5 years in older adults: a prospective cohort study. Ann Rheum Dis 2013;72:535–540. [PubMed: 22580582]
87. Richmond SA, Fukuchi RK, Ezzat A, Schneider K, Schneider G, Emery CA. Are joint injury, sport activity, physical activity, obesity, or occupational activities predictors for osteoarthritis? A systematic review. J Orthop Sports Phys Ther 2013;43:515–B519. [PubMed: 23756344]
88. Coggon D, Croft P, Kellingray S, Barrett D, McLaren M, Cooper C. Occupational physical activities and osteoarthritis of the knee. Arthritis Rheum 2000;43:1443–1449. [PubMed: 10902744]
89. Vrezas I, Elsner G, Bolm-Audorff U, Abolmaali N, Seidler A. Case-control study of knee osteoarthritis and lifestyle factors considering their interaction with physical workload. Int Arch Occup Environ Health 2010;83:291–300. [PubMed: 19921240]
90. American Health Care Association. 2014 Quality Report Washington, D.C 2014.
91. Halbur BT, Fears N. Nursing personnel turnover rates turned over: potential positive effects on resident outcomes in nursing homes. Gerontologist 1986;26:70–76. [PubMed: 3699484]
92. Castle NG, Engberg J. Staff turnover and quality of care in nursing homes. Med Care 2005;43:616–626. [PubMed: 15908857]
93. Cohen-Mansfield J Turnover among nursing home staff. A review. Nurs Manage 1997;28:59–62. 64. [PubMed: 9287799]
94. United States General Accounting Office. Nursing Workforce: Recruitment and Retention of Nurses and Nurse Aides is a Growing Concern Washington, D.C 2001.
95. Petersen MR, Deddens JA. A comparison of two methods for estimating prevalence ratios. BMC Med Res Methodol 2008;8:9. [PubMed: 18307814]
96. Davis KG, Kotowski SE. Prevalence of musculoskeletal disorders for nurses in hospitals, long-Term care facilities, and home health care: a comprehensive review. Hum Factors 2015;57:754–792. [PubMed: 25899249]

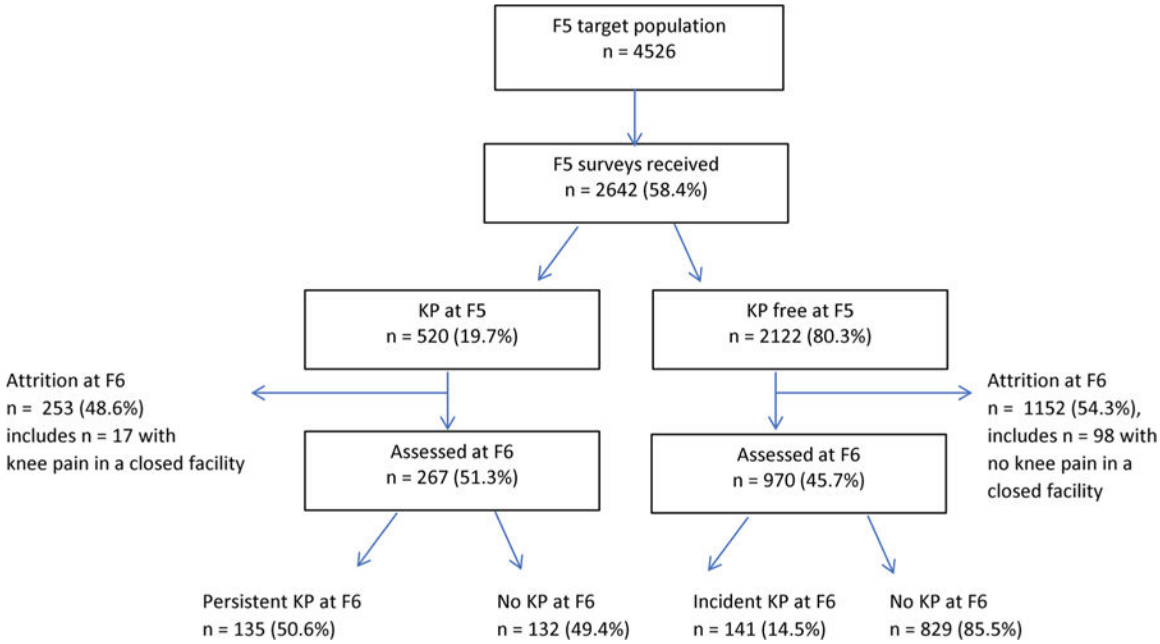

FIGURE 1.

Flow chart showing participation in nursing home workers longitudinal cohort, 2012–2015. KP: knee pain [Color figure can be viewed at wileyonlinelibrary.com]

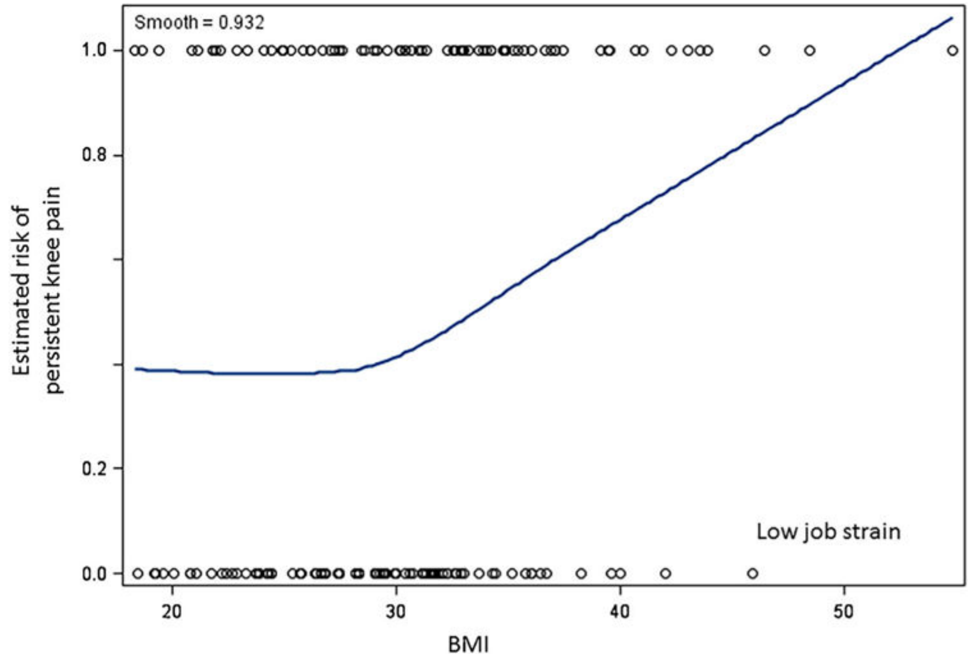

FIGURE 2.

Estimated risk of persistent knee pain due to BMI at low job strain [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1

Demographic characteristics, medical history, health behaviors, job exposures, and exposures external to job, nursing home workers, overall and stratified by knee pain status, and univariate robust poisson regression models of knee pain prevalence, 2012–2013 (F5: 5–6 years after SRHP implementation).

		Knee pain at F5			
	Total	Yes	No	Prevalence rate ratio	95% confidence interval
Total, *n*	2642				
Demographic characteristics					
Age [mean (SD)]	41.6 (13.1)	43.4 (13.5)	41.2 (13.2)	1.01 *	1.00–1.02
Gender [*n* (%)]					
Male	460 (18.0)	56 (11.1)	404 (19.7)	1.0	
Female	2103 (82.1)	451 (89.0)	1652 (80.4)	1.76 *	1.36–2.28
Race [*n* (%)]					
White	1429 (54.1)	308 (59.2)	1121 (52.8)	1.0	
Black	753 (28.5)	133 (25.6)	620 (29.2)	0.80	0.64–1.00
Other/unk	460 (17.4)	79 (15.2)	381 (18.0)	0.82 *	0.68–0.98
BMI [mean (SD)]	28.3 (6.3)	29.9 (6.8)	27.9 (6.1)	1.04 *	1.03–1.05
BMI category [*n* (%)]					
Normal/Underweight/Overweight	1727 (67.7)	279 (55.6)	1448 (70.6)	1.0	
Obese/Extreme Obese	825 (32.3)	223 (44.4)	602 (29.4)	1.67 *	1.43–1.95
Marital status [*n* (%)]					
Married	1303 (50.4)	244 (47.5)	1059 (51.2)	1.0	
Divorced	403 (15.6)	90 (17.5)	313 (15.1)	1.19	0.96–1.48
Widowed	66 (2.6)	12 (2.3)	54 (2.6)	0.97	0.57–1.64
Single	812 (31.4)	168 (32.7)	644 (31.1)	1.10	0.93–1.32
Education					
Post-graduate	215 (8.4)	29 (5.7)	186 (9.1)	1.0	
Some college or college Graduate	1329 (52.5)	297 (58.4)	1032 (50.7)	1.66 *	1.16–2.36
High school or less	1002 (39.4)	183 (36.0)	819 (40.2)	1.35	0.94–1.95
Medical history					
Prev. knee inj in last 12 mo [*n* (%)]	88 (3.3)	62 (11.9)	26 (1.2)	3.93 *	3.35–4.60

	Total	Knee pain at F5		Prevalence rate ratio	95% confidence interval
		Yes	No		
Chronic disease [*n* (%)]	818 (31.5)	199 (38.5)	619 (29.8)	1.36 *	1.16–1.59
Health behaviors					
Smoking status [*n* (%)]					
Never	1684 (64.6)	315 (61.3)	1369 (65.4)	1.0	
Former	493 (18.9)	108 (21.0)	385 (18.4)	1.17	0.96–1.42
Current	429 (16.5)	91 (17.7)	338 (16.4)	1.13	0.92–1.40
Intense physical exercise frequency [*n* (%)]					
None	481 (18.3)	116 (22.4)	365 (17.3)	1.0	
<1 time/wk	594 (22.7)	129 (24.9)	465 (22.1)	0.90	0.72–1.12
1–2 times/wk	624 (23.8)	130 (25.1)	494 (23.5)	0.86	0.69–1.08
3 times/wk	472 (18.0)	71 (13.7)	401 (19.1)	0.62 *	0.48–0.81
> 3 times/wk	452 (17.2)	72 (13.9)	380 (18.1)	0.66 *	0.51–0.86
Job exposures					
Seniority (yrs) [mean (SD)]	10.1 (9.5)	11.7 (10.5)	9.7 (9.2)	1.00 *	1.00–1.00
Nursing personnel [*n* (%)]	1462 (55.3)	323 (22.1)	197 (16.7)	1.32 *	1.13–1.55
Composite physical exposure [mean (SD)]	11.7 (3.6)	12.0 (3.7)	11.6 (3.6)	1.03 *	1.00–1.05
Psychological job demands [mean (SD)]	5.7 (1.1)	5.8 (1.1)	5.6 (1.1)	1.09 *	1.02–1.17
Decision latitude [mean (SD)]	5.5 (1.3)	5.4 (1.4)	5.5 (1.3)	0.95	0.90–1.01
Job strain [*n* (%)]	590 (23.7)	143 (28.7)	447 (22.4)	1.30 *	1.10–1.54
Social support [mean (SD)]	11.4 (2.3)	11.2 (2.3)	11.5 (2.3)	0.95 *	0.92–0.98
Physical assault in last 3 months [*n* (%)]					
None	1843 (70.7)	331 (64.5)	1512 (72.2)	1.0	
1–2 times	426 (16.3)	93 (18.1)	333 (15.9)	1.47 *	1.20–1.80
3 or more times	338 (13.0)	89 (17.4)	249 (12.0)	1.22	0.99–1.49
Schedule control [mean (SD)]	5.2 (1.4)	5.2 (1.4)	5.2 (1.4)	1.01	0.96–1.07
Frequency of lift usage [*n* (%)]					
Never/rarely	414 (22.1)	71 (18.6)	349 (23.0)	1.0	
Sometimes/often/always	1460 (77.9)	311 (81.4)	1149 (77.0)	1.24	0.98–1.57

	Total	Knee pain at F5		Prevalence rate ratio	95% confidence interval
		Yes	No		
Other					
Other paid job [*n* (%)]	435 (16.9)	68 (13.4)	367 (17.8)	1.32 *	1.04–1.66
Work-family imbalance [mean (SD)]	2.4 (0.7)	2.5 (0.7)	2.3 (0.6)	1.36 *	1.21–1.53

* $P \leq 0.05$

TABLE 2

Multivariable robust Poisson regression models of knee pain prevalence, nursing home workers, 2012–2013 (F5), $n = 2642$; prevalence rate ratio (95% confidence interval)

	MODEL A		MODEL B	
Covariate	**Prevalence rate ratio**	**95% confidence interval**	**Prevalence rate ratio**	**95% confidence interval**
Demographic characteristics				
Age	1.01	1.00–1.02	1.01	1.01–1.02
Gender				
Male	1.0		1.0	
Female	1.68	1.29–2.19	1.60	1.24–2.08
BMI	1.03	1.02–1.04	1.03	1.02–1.04
Medical history				
Serious knee injury in last 12 months	3.32	2.73–4.03	3.39	2.78–4.03
Job exposures				
Composite physical exposure	1.03	1.01–1.06	1.04	1.01–1.06
Social support	0.97	0.94–1.01		
Job strain			1.29	1.07–1.56

No confounding or interaction of exposure effects by prior knee pain, BMI, gender, age, chronic disease, physical exercise, assault.

TABLE 3

Prevalence, persistence, and cumulative incidence of knee pain, nursing home workers, 2012–2015

	Prevalence		Cumulative Incidence		Persistence	
Survey period	**Total eligible, *n***	***n* (%)**	**Total eligible, *n***	***n* (%)**	**Total eligible, *n***	***n* (%)**
F5	2642	520 (19.7)	-	-	-	-
F6	1237[a]	276 (22.3)	970	141 (14.5)	267	135 (50.6)

[a]This includes those surveyed at F5 and F6.

TABLE 4

Multivariable robust Poisson regression models of 2-year incident knee pain, nursing home workers, 2012–2013 (F5) to 2014–2015 (F6), n = 970; prevalence rate ratio (95% confidence interval)

Covariate at F5	Prevalence rate ratio	95% confidence interval
Demographic characteristics		
BMI	1.03	1.01–1.05
Medical history		
Serious knee injury in last 12 months	4.32	2.31–8.09
Job exposures		
Psychological job demands	1.12	0.98–1.29
Hours worked in prior 2 weeks	1.01	1.00–1.02

No confounding or effect modification by prior knee pain, BMI, gender, age, chronic disease, physical exercise, assault.

TABLE 5

Multivariable robust Poisson regression models of knee pain two-year persistence, nursing home workers, 2012–2013 (F5) to 2014–2015 (F6), $n = 267$; prevalence rate ratio (95% confidence interval)

	MODEL A		MODEL B	
Covariate	**Prevalence rate ratio**	**95% confidence interval**	**Prevalence rate ratio**	**95% confidence interval**
Demographic characteristics				
BMI	1.02	1.00–1.04	1.01	0.99–1.03
Age	1.01	1.00–1.02	1.01	1.00–1.02
Job exposures				
Social support	0.93	0.88–0.97		
Job strain			4.87	1.42–16.74
Job strain *BMI			0.96	0.92–1.00*

No confounding by prior knee pain, BMI, gender, age, chronic disease, physical exercise, assault.

* $P = 0.04$