How consistently does sleep quality improve at retirement? Prospective analyses with group-based trajectory models

Paraskevi Peristera¹ | Anna Nyberg¹,² | Linda L. Magnusson Hanson¹ | Hugo Westerlund¹,³ | Loretta G. Platts¹

¹Department of Psychology, Stress Research Institute, Stockholm University, Stockholm, Sweden
²Department of Public Health and Caring Sciences, Uppsala University, Uppsala, Sweden
³Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden

Summary
Growing evidence indicates that retiring from paid work is associated, at least in the short-term, with dramatic reductions in sleep difficulties and more restorative sleep. However, much is still not known, in particular how universal these improvements are, how long they last, and whether they relate to the work environment. A methodological challenge concerns how to model time when studying abrupt changes such as retirement. Using data from Swedish Longitudinal Occupational Survey of Health (n = 2,148), we studied difficulties falling asleep, difficulties maintaining sleep, premature awakening, restless sleep, a composite scale of these items, and non-restorative sleep. We compared polynomial and B-spline functions to model time in group-based trajectory modelling. We estimated variations in the individual development of sleep difficulties around retirement, relating these to the pre-retirement work environment. Reductions in sleep difficulties at retirement were sudden for all outcomes and were sustained for up to 11 years for non-restorative sleep, premature awakening, and restless sleep. Average patterns masked distinct patterns of change: groups of retirees experiencing greatest pre-retirement sleep difficulties benefitted most from retiring. Higher job demands, lower work time control, lower job control, and working full-time were work factors that accounted membership in these groups. Compared to polynomials, B-spline models more appropriately estimated time around retirement, providing trajectories that were closer to the observed shapes. The study highlights the need to exercise care in modelling time over a sudden transition because using polynomials can generate artefactual uplifts or omit abrupt changes entirely, findings that would have fallacious implications.

KEYWORDS
latent curve analysis, psychosocial working characteristics, retirement, sleep problems
1 | INTRODUCTION

People often look forward to retirement as a time when they can sleep undisturbed, no longer worried by work or having to set an alarm. Indeed, the developing picture from longitudinal studies is that retirement is associated, at least in the short-term, with both dramatic reductions in sleep difficulties and more restorative sleep (Marquié et al., 2012; Myllyntausta et al., 2018, 2019; Straat et al., 2020; Vahtera et al., 2009). Despite the substantial sizes of these retirement-related changes, much is still not known: how universal these improvements are, how long they last, and to what degree they relate to specific aspects of the work environment that people have retired from.

1.1 | Average trends in sleep difficulties at retirement

Longitudinal studies provide consistent evidence that sleep becomes less disturbed and more restorative after retirement (Marquié et al., 2012; Myllyntausta et al., 2018, 2019; Straat et al., 2020; Vahtera et al., 2009). To our knowledge, evidence is still very limited when it comes to how retirement affects specific types of sleep difficulties (e.g. difficulties falling asleep, difficulties maintaining sleep, premature awakening, non-restorative sleep) and comes from very few countries (Marquié et al., 2012; Myllyntausta et al., 2018, 2019).

An important question concerns how long the effects of retirement last. Existing evidence suggests that changes in sleep disturbance and non-restorative sleep take place quickly, within 3 months of retirement (Myllyntausta et al., 2019), and may be sustained over subsequent years (Myllyntausta et al., 2018, 2019; Vahtera et al., 2009). Vahtera et al. (2009) found that sleep disturbance gradually increased over the 7-year post-retirement follow-up period without attaining pre-retirement levels. More evidence is needed, using longer study periods after retirement, to observe how long-lasting any reductions in sleep difficulties at retirement are and whether individuals return to their pre-retirement levels.

1.2 | Individual differences in the development of sleep difficulties at retirement

Previous work on changes in sleep difficulties at retirement has used a variable-oriented approach, examining average changes over time. However, the average development may mask substantial variation between unobserved subgroups. Such variation can be modelled with person-oriented approaches, such as group-based trajectory models, that, by clustering similar individual trajectories, provide insights into typical patterns of development at retirement (Bergman & Trost, 2006; Nagin, 2005; Nagin & Odgers, 2010). While no prior studies have examined whether there are individual variations in sleep difficulties at retirement, distinct trajectories at retirement have been observed for other health outcomes, including sleep duration (Ahlin et al., 2018; Halonen et al., 2017; Myllyntausta et al., 2020; Nyberg et al., 2019; Peristera et al., 2020).

Group-based trajectory models use a polynomial link function between time and outcome, which is often a serious shortcoming as it generates patterns unsupported by the data, such as uplifts at each end of the time axis (Francis et al., 2016) and cannot follow sharp turning points, such as the discontinuity in sleep disturbance over the retirement transition (Straat et al., 2020). B-spline group-based trajectory models have been proposed as a more flexible modelling approach in order to tackle the problems associated with polynomial link functions (Francis et al., 2016). B-spline models enable the time period to be divided up using knots, between which polynomial functions are calculated. Although they have rarely been used with health and retirement data, these models may offer more accurate representations of developmental processes and improved insights into population heterogeneity (Peristera et al., 2020).

1.3 | The role of work timing and stress in retirement-related reductions in sleep difficulties

Previous evidence regarding the role of the need to sleep at fixed times and the removal of work-related stressors after retirement is inconsistent. Lower pre-retirement levels of control of working hours and retiring from a full-time job have been associated with larger reductions in sleep difficulties at retirement (Marquié et al., 2012; Straat et al., 2020). Studies have observed associations between lack of work time control (WTC) and sleep disturbances (Salo et al., 2014) but not between WTC and retirement-related reductions in non-restorative sleep (Myllyntausta et al., 2019). Poorer psychosocial working conditions (e.g. high job demands, job strain) have been associated with greater reductions in sleep difficulties after retirement (Åkerstedt et al., 2015; Van Laethem et al., 2013; Myllyntausta et al., 2018; Straat et al., 2020; Vahtera et al., 2009) although one recent, well-conducted study failed to find systematic associations between changes in sleep difficulties after retirement and pre-retirement work stress (Myllyntausta et al., 2019).

The present study aimed to identify trajectories of sleep difficulties around retirement, using repeated measurements from a large, population-based Swedish cohort. Findings are presented for a composite index of sleep disturbances, each type of sleep disturbance (difficulties falling asleep, difficulties maintaining sleep, premature (final) awakening, disturbed/restless sleep) and non-restorative sleep. We tested whether any reductions in sleep difficulties taking place at retirement were confined to certain measures or occurred across the board. The use of 11-year periods both preceding and following retirement permitted observation of how long any improvements at retirement last and whether individuals returned to their pre-retirement levels of sleep difficulties. We performed group-based trajectory modelling to investigate whether any improvements at retirement occurred generally or were confined to specific groups of individuals. We compared the qualities of the
B-spline and polynomial group-based trajectories to ascertain the suitability of the two approaches for modelling abrupt retirement transitions. Inclusion of covariates related to the pre-retirement work environment permitted investigation of whether reduced need to sleep at fixed times (measured by participation in full-time/part-time work and degree of control over working hours) as well as removal of work-related stressors (measured by job demands, control and strain) were associated with trajectories in sleep difficulties at retirement.

2 | METHODS

2.1 | Study population

Data were derived from the Swedish Longitudinal Occupational Survey of Health (SLOSH) (Magnusson Hanson et al., 2018), an approximately nationally representative sample of gainfully employed individuals aged 16–64 years. SLOSH began in 2006 as a follow-up of participants in the Swedish Work Environment Surveys (SWES 2003–2011) and is a postal survey conducted every 2 years. Respondents completed one of two questionnaires: one for people in paid work for ≥30% of full-time and another for people working <30% or who have left the labour force (Kistendal et al., 2007; Magnusson Hanson et al., 2008). SLOSH was approved by the Regional Research Ethics Board in Stockholm and informed consent was obtained from all participants.

The study sample is based on SLOSH participants who responded to at least one questionnaire during 2006–2018 (n = 29,676). A retirement transition took place for 3,382 participants, defined as: completing the questionnaire for those in paid work and, in the following wave, both completing the questionnaire for those who worked <30% of full-time and reporting being retired. Participants who subsequently reported reverse transitions from retirement to paid work (126 people) were excluded, leaving 3,256 eligible participants. Only participants providing four or more measurements (not necessarily consecutive) were included in the analysis, as required for the B-spline group-trajectory models. These exclusions generated a sample of 2,148 individuals that was used to estimate the trajectories of sleep difficulties. In regression analyses, 1,817 participants were included after excluding individuals with missing covariates.

2.2 | Ascertainment of retirement and centring of time axis

Participants were classified as retired if they described their current situation as, on a full-time basis, old-age retirement or receiving another sort of pension (e.g. occupational pension) or receiving disability pension (early retirement on health grounds). The time axis was centred on the timing of the retirement transition for each individual. The first wave at which a participant reported being retired was assigned +1. As there is a 2-year gap between waves, the retirement transition took place between years −1 and +1. Time was measured in the number of years before and after retirement, ranging from 11 years before until 11 years after retirement. The pre-retirement period is −11 to −1 years and the post-retirement period is between +1 and +11 years.

2.3 | Variables

The validated Karolinska Sleep Questionnaire was used to measure sleep difficulties (Åkerstedt et al., 2002; Magnusson Hanson et al., 2011; Nordin et al., 2013). Participants indicated how often they experienced symptoms of disturbed and non-restorative sleep on a Likert scale with the categories: 0, “never”; 1, “rarely”; 2, “sometimes, a few times a month”; 3, “often, 1 to 2 times a week”; 4, “mostly, 3–4 times a week”; and 5, “always, five times a week or more”. Specific symptoms of sleep disturbance were: difficulties falling asleep, repeated awakenings with difficulties falling asleep again (hereafter “difficulties maintaining sleep”), premature final awakening (hereafter “premature awakening”) and disturbed or restless sleep (hereafter “restless sleep”). Sleep disturbance was obtained by the mean score of these four items (Nordin et al., 2013). Non-restorative sleep measures the degree to which people do not feel well rested upon awakening.

We investigated working conditions that could affect the association between retirement and sleep difficulties, following previous research (Salo et al., 2014; Tucker et al., 2016). Working hours was a binary variable where people reported working part-time (0) or full-time (1). We calculated WTC as the mean of six items measuring how much individuals could influence their working time in relation to: working day length, start and end times, work breaks, which days to work, scheduling vacation/other leave, and carrying out errands while at work (Straat et al., 2020; Tucker et al., 2016). All items were measured on a Likert-type response scale from 1 (“very little”) to 5 (“very much”). This scale was reverse-scored so that higher values indicate lower WTC. Job demands and control were measured using the Swedish Demand-Control-Support Questionnaire (DCSQ) (Fransson et al., 2012; Sanne et al., 2005). Items were scored on a Likert scale, from 1 “yes, often” to 4 “no, never or basically never”. Four items assessed job demands (work very fast, too much effort, enough time [reverse-coded], conflicting demands) and five items assessed job control (control over what to do at work, control over how to do the work, learn new skills, high level of skill or expertise, repetitive work [reverse-coded]). Higher values indicated higher job demands and lower control. Job strain was a dichotomous variable with 1 indicating people with above-the-median job demands and median-or-less job control and 0 otherwise (Karasek & Theorell, 1990).

Sociodemographic variables of gender, age, education (university educated or not), civil status (married/cohabiting or not) and log-income were also included in the analyses. All variables were measured in the last wave before retirement.
2.4 | Statistical analyses

All analyses were performed in Stata 16.1. First, summary statistics are calculated and the observed mean sleep difficulties over retirement are graphically shown. Next, we estimated two sets of trajectory models, which modelled time with polynomial and B-spline functions. Polynomial models were estimated using Nagin’s two-stage procedure (Nagin, 2005): we compared models with one to six groups and then identified the shape of each group (cubic, quadratic and linear) using the traj function (Andruff et al., 2009). Linear components were retained irrespective of statistical significance (Louvet et al., 2009). B-spline models were estimated following a two-step procedure (Francis et al., 2016). First we calculated the B-splines with four to eight knots using the bspline() function. We subsequently fitted a sequence of models with one to six groups using the traj function, where the polynomial order was zero and B-splines were included as time-varying covariates (cf. Note S1 for example syntax).

Model fit was examined using the Bayesian Information Criterion (BIC) (Schwarz, 1978). Trajectory models with large numbers of groups often give no minimum BIC (Francis et al., 2016; Nagin, 2005). In that case, a model with more groups was inferior to one with fewer groups if any trajectories contained <5% of the sample, the model did not capture additional distinctive feature of the data or entropy (index of classification accuracy ranging from 0 to 1, with values closer to 1 indicating better precision) declined (Andruff et al., 2009; Nagin, 2005). Polynomial or B-spline models’ fidelity between observed and estimated curves was examined by: (a) the chi-square statistic, with lower values indicating better fitting models and (b) visual inspection of observed and estimated trajectories.

Summary statistics of the sociodemographic and pre-retirement work environment variables for each trajectory were shown. Statistically differences between trajectory groups were tested using the chi-squared test for categorical variables and analysis of variance (ANOVA) for continuous variables. We estimated two sets of logistic regression models to predict membership of sleep difficulties groups in relation to work-related covariates: Model 1 presents bivariate associations, while Model 2 was adjusted for sociodemographic covariates. Log odds with 95% confidence intervals were reported.

3 | RESULTS

Table 1 presents characteristics of the sample. Women comprised 54% of the sample; the mean age at the wave before retirement was 64 years. Almost two-thirds (66%) of participants were working full-time before retiring.

3.1 | Average trends in sleep difficulties at retirement

Observed mean scores for sleep difficulties during the period from 11 years before retirement to 11 years after retirement are shown in Figure 1 and Figure S1. The average pre-retirement trend is observed to be stable, except for non-restorative sleep, where a decrease is observable in the lead-up to retirement. At retirement, corresponding to the years −1 to +1, improvements were observable in all sleep difficulty measures. Subsequent to retirement, various trends emerge. Several of the sleep disturbance measures (difficulties falling asleep, difficulties maintaining sleep and restless sleep) gradually returned to levels similar to those observed pre-retirement, corresponding to a loss of the retirement gain within 11 years after retirement. In contrast, most of the improvements in premature awakening and non-restorative sleep endured over the whole measurement period. The composite measure of sleep disturbance had an intermediate position, gradually approaching pre-retirement levels after 11 years subsequent to retirement.

3.2 | Model selection

The BIC values for polynomial models with one to six groups reached no minimum (Table S1). We selected the four-group models, which provided new distinctive features of the data compared to three-group models and superior entropy compared to the five-group models. According to the statistical significance of cubic, quadratic and linear components, the order of trajectories were (1 2 1 1) for the composite measure of disturbed sleep, (2 1 3 3) for difficulties falling asleep, (2 3 3 3) for premature awakening and (3 3 3 3) for all the other sleep outcomes (cf. Figures 2c,d and 3e–h).
Among the B-spline models, a minimum BIC was only obtained for restless sleep, suggesting a four-group model with six knots (Table S1). For the other outcomes, we selected four-group models as they provided trajectories with new characteristics when compared to three-group models, but also had slightly higher levels of entropy compared to five-group models. Examining the BIC values for the four-group models with increasing number of knots, we selected seven knots for non-restorative sleep and six knots for the other outcomes, as they had the lowest BIC value row wise.

Examination of the chi-square tests (Table S2) indicated lowest values for the B-spline over the polynomial models and therefore superior fidelity among observed and estimated trajectories, for all outcomes. This conclusion was also supported by visual inspection of the observed and estimated trajectories (Figure 2 and Figure 3). The polynomial models fitted the data poorly in two main ways. For the composite scale of sleep disturbance, the estimated trajectories modelled a linear decreasing trend, failing to model the marked changes taking place at retirement (Figure 1c). For non-restorative sleep, the inclusion of cubic order polynomials enabled the decline at retirement to be modelled to some degree, but at the cost of artificially lengthening the timing of the retirement transition and generating uplifts at the ends of the time axis not supported by the observed data (Figure 1d). Similar problems existed for the remaining outcomes (Figure 3). The B-spline models provided more flexible and accurate trajectories, and these will be used in the coming analyses.

3.3 Individual differences in the development of sleep difficulties at retirement: Results from B-spline modelling

For each of the sleep outcomes, the four groups are differentiated by the overall frequency of symptoms and the degree of change at retirement (waves -1 to +1). From bottom to top, we describe them as Group 1: almost never having sleep difficulties – small to no retirement drop in symptom frequency, Group 2: seldom having sleep difficulties – small retirement drop, Group 3: sometimes having sleep difficulties – substantial retirement drop, and Group 4: often having sleep difficulties – substantial retirement drop (Figures 2a,b and 3a–d). Although group allocations varied slightly across the outcomes, the findings in terms of group size and characteristics differed little. About half of the sample was allocated to Group 2 seldom having sleep difficulties; one-quarter of the sample was allocated to Group 3 sometimes having difficulties; 12%–16% of participants to Group 1 almost never having sleep difficulties and the remaining 7%–10% of participants to Group 4 often having sleep difficulties. The groups were dispersed across most of the range of the scale: in the pre-retirement period the groups varied in level from 0.3 to almost 4 for non-restorative sleep, where 0 corresponds to never experiencing non-restorative sleep and 4 to experiencing non-restorative sleep “very often, 3–4 times weekly” and ranged over 0.3–3 for the composite measure of sleep disturbance. Similar large ranges were observed for the individual sleep disturbance items.

In the pre-retirement period, sleep disturbance (composite index) increased slightly, with larger increases for trajectories with a higher trajectory level (Figure 2a). Similar trends were observed...
(a) B-spline trajectories (4 groups) 6-knots

(b) B-spline trajectories (4 groups) 7-knots

(c) Polynomial trajectories (4 groups) order(1 2 1 1)

(d) Polynomial trajectories (4 groups) Order (3 3 3 3)
for the items comprising the composite sleep disturbance measure (Figure 3a–d). Over the same period, a stable or slightly decreasing trend in non-restorative sleep was observed in all groups (Figure 2b).

At retirement, −1 to +1, sleep difficulties (composite measure and individual items), except for difficulties falling asleep and maintaining sleep, tended to decrease, with the size of the decrease generally being proportionately larger for groups with higher pre-retirement levels of sleep difficulties (Figures 2a and 3a–d). Reductions at retirement were particularly pronounced for non-restorative sleep (Figure 2b).Observable across all the groups, reductions were proportionately larger for groups with higher levels of non-restorative sleep before retirement.

In the post-retirement period, sleep difficulties tended to slightly increase in a way that was broadly similar across the groups (Figures 2a and 3a–d). Non-restorative sleep increased proportionately more for those groups that had had higher levels before retirement (i.e. most for the "high" group) (Figure 2b).

3.4 | Characteristics of the groups in terms of sociodemographic covariates and work characteristics

In terms of sociodemographic factors, a higher proportion of women were in the trajectories with higher levels of the composite measure of sleep disturbance and non-restorative sleep and a higher proportion of people educated to university level were in the trajectories with higher levels of non-restorative sleep. Individuals with higher log-income were in trajectories with lower levels of the composite measure of sleep disturbance (Table 2). These tendencies were often replicated across the individual sleep disturbance items with the exception of log-income, where associations were statistically significant only for the items difficulties falling asleep and difficulties maintaining sleep (Table S3).

Table 3 presents the results from multinomial logistic regression analyses. Higher job demands in the wave before retirement were associated with higher odds of being in trajectory groups with more frequent sleep difficulties, across all six outcomes for both Model 1 and Model 2 (model adjusted for age, gender, education, civil status, and log-income). When comparing the associations between Groups 1 and 2, the above associations were not statistically significant for the outcomes of difficulties falling asleep, premature awakening, and non-restorative sleep. The magnitude of the estimates was observed to be lower in Model 2 (adjusted models) compared to Model 1.

For job control, differences between the trajectory groups with low and high levels of sleep difficulties were less consistent. Generally differences between Group 1 (almost never having sleep difficulties) and Group 4 (often having sleep difficulties) were not significant. In contrast, participants reporting lower job control were more likely to be in Group 3 (sometimes having sleep difficulties) than Group 1 in the case of the following outcomes both before and after adjustment: the composite scale of sleep disturbance, premature awakening, and restless sleep.

In the case of job strain, differences between trajectory Group 1 and Groups 3 and 4 tended to be statistically significant, with the exception of difficulties maintaining sleep and in the fully adjusted model for difficulties falling asleep. In other words, job strain in the wave before retirement tended to be associated with higher odds of being in trajectory groups that reported more frequent sleep difficulties and larger declines in sleep difficulties at retirement. No associations between Groups 2 and 1 were significant at the 5% level after adjustment.

For almost all outcomes, participants reporting lower WTC tended to be associated with higher risk of belonging in Groups 3 or 4, sometimes or often having sleep difficulties, compared to the reference Group 1 of almost never having sleep difficulties. Most associations between Groups 2 and 1 were not significant at the 5% level. For the outcomes sleep disturbances, premature awakening and non-restorative sleep, lower WTC was associated with being in Groups 3 and 4 in both unadjusted and fully adjusted models. Findings were less consistent for the other outcomes.

Working full-time tended to be associated with higher risk of being in Group 3 compared to the reference group, except for the adjusted models of sleep disturbances and non-restorative sleep. A mixed picture was identified for the associations of different outcomes for those in group 2: associations were statistically significant both before and after full adjustment for the outcomes premature awakening and restless sleep, but only before adjustment in the case of sleep disturbances, difficulties maintaining sleep, and non-restorative sleep. Only for the outcome difficulties falling asleep were those who were working full-time more likely to be classified into Group 4 than the reference Group 1 after adjustment for covariates.

4 | DISCUSSION

In the present study, we examined the individual development of sleep difficulties over retirement in order to investigate how universal improvements in sleep after retirement are, how long they last, and whether they relate to the work environment. To this end, we studied a range of measures of sleep difficulties, including difficulties falling asleep, difficulties maintaining sleep, premature
Figure 3 B-spline estimated (solid lines) and observed (dashed lines) means of (a) difficulties falling asleep, (b) difficulties maintaining sleep, (c) premature awakening, (d) restless sleep; polynomial estimated (solid lines) and observed (dashed lines) means of (e) difficulties falling asleep, (f) difficulties maintaining sleep, (g) premature awakening, (h) restless sleep. Swedish Longitudinal Occupational Survey of Health, 2006–2018, n = 2,148
**TABLE 2** Characteristics of the four trajectory groups obtained from B-spline modelling for the composite measure of mean sleep disturbance and the non-restorative sleep item. Swedish Longitudinal Occupational Survey of Health, 2006–2018, n = 2148

|                     | Sleep disturbances^a | Non-restorative sleep |
|---------------------|-----------------------|------------------------|
|                     | Group 1 | Group 2 | Group 3 | Group 4 | p-value^b | Group 1 | Group 2 | Group 3 | Group 4 |
| Low sleep complaints | Mean/n (s.d/%) | Mean/n (s.d/%) | Mean/n (s.d/%) | Mean/n (s.d/%) | | Mean/n (s.d/%) | Mean/n (s.d/%) | Mean/n (s.d/%) | Mean/n (s.d/%) | p-value^b |
| (n = 334)           | (n = 1055) | (n = 557) | (n = 202) | | | (n = 245) | (n = 1051) | (n = 659) | (n = 193) | |
| Age prior to retirement | 63.88 (2.52) | 64.02 (2.01) | 63.80 (2.34) | 63.81 (2.56) | 0.031 | 64.01 (2.57) | 64.04 (2.08) | 63.83 (2.24) | 63.48 (2.57) | 0.019 |
| Gender              | | | | | | | | | | |
| Male                | 116 (66) | 502 (48) | 204 (37) | 60 (30) | <0.001 | 133 (54) | 509 (48) | 263 (40) | 79 (41) | 0.003 |
| Female              | 218 (34) | 553 (52) | 353 (63) | 142 (70) | | 112 (46) | 543 (52) | 396 (60) | 114 (59) | |
| Civil status        | | | | | | | | | | |
| Married/cohabiting  | 267 (81) | 833 (81) | 432 (79) | 151 (75) | 0.381 | 194 (80) | 848 (82) | 494 (77) | 147 (77) | 0.055 |
| Single              | 62 (19) | 202 (19) | 117 (21) | 49 (25) | | 49 (20) | 186 (18) | 151 (23) | 44 (23) | |
| Education           | | | | | | | | | | |
| University          | 102 (31) | 388 (37) | 226 (41) | 89 (44) | 0.103 | 79 (32) | 355 (34) | 287 (44) | 84 (43) | <0.001 |
| Compulsory/secondary education | 231 (69) | 667 (63) | 330 (59) | 113 (56) | | 165 (68) | 695 (66) | 372 (56) | 109 (57) | |
| Log-income          | 12.77 (0.41) | 12.75 (0.43) | 12.70 (0.41) | 12.71 (0.37) | 0.028 | 12.74 (0.38) | 12.74 (0.45) | 12.73 (0.39) | 12.74 (0.38) | 0.713 |
| Work characteristics | | | | | | | | | | |
| Job demands^c       | 2.29 (0.57) | 2.41 (0.53) | 2.56 (0.58) | 2.69 (0.58) | <0.001 | 2.29 (0.55) | 2.37 (0.53) | 2.57 (0.57) | 2.71 (0.59) | <0.001 |
| Job control^c       | 1.65 (0.47) | 1.68 (0.44) | 1.71 (0.46) | 1.70 (0.43) | 0.553 | 1.62 (0.45) | 1.69 (0.48) | 1.69 (0.46) | 1.69 (0.73) | 0.934 |
| Job strain          | 0.65 (0.75) | 0.73 (0.70) | 0.85 (0.73) | 0.99 (0.71) | <0.001 | 0.67 (0.72) | 0.68 (0.71) | 0.88 (0.72) | 1.01 (0.73) | <0.001 |
| Lower work time control | 3.09 (1.14) | 2.94 (1.07) | 2.82 (1.07) | 2.68 (1.10) | 0.001 | 3.09 (1.14) | 2.96 (1.09) | 2.70 (1.05) | 2.82 (1.13) | 0.002 |
| Working time        | | | | | | | | | | |
| Full-time           | 233 (73) | 655 (66) | 322 (62) | 118 (62) | 0.279 | 165 (72) | 641 (65) | 405 (65) | 117 (64) | 0.916 |
| Part-time           | 86 (27) | 339 (34) | 196 (38) | 72 (38) | | 64 (28) | 346 (35) | 217 (35) | 66 (36) | |

The mean or number of individuals are given in the Table while in parenthesis are given the SD or %.

^a Sleep disturbances is calculated from the mean of the items: difficulties falling as sleep, difficulties maintaining sleep, premature (final) awakening and disturbed/restless sleep.

^b Chi-squared test for categorical variables and analysis of variance (ANOVA) for continuous variables.

^c Job demands and job control were measured in a 1–4 scale, where higher values indicate higher job demands and lower job control.
### Table 3: Associations between psychosocial working characteristics and the trajectories of sleep difficulties for the six sleep outcomes.

Estimates are presented as odd ratios (ORs) with 95% confidence intervals (CIs) in brackets. Swedish Longitudinal Occupational Survey of Health, 2006–2018, n = 1,817. Statistically significant associations are in bold.

| Demands                          | Sleep disturbance | Difficulties falling asleep | Difficulties maintaining sleep |
|----------------------------------|-------------------|-----------------------------|--------------------------------|
|                                  | Model 1            | Model 2                     | Model 1                        | Model 2                        | Model 1                        |
|                                  | OR (95% CI)        | OR (95% CI)                 | OR (95% CI)                    | OR (95% CI)                    | OR (95% CI)                    |
| Job demands                      | Ref.               | Ref.                        | Ref.                           | Ref.                           | Ref.                           |
| Group 1: almost never having sleep difficulties—small to no retirement drop |                      |                             |                                |                                |                                |
| Group 2: seldom having sleep difficulties—small retirement drop | **1.54** (1.16; 2.04) | **1.44** (1.07; 1.94) | 1.20 (0.92; 1.56)       | 1.15 (0.87; 1.52)       | **1.34** (1.01; 1.78) |
| Group 3: sometimes having sleep difficulties—substantial retirement drop | **2.96** (2.18; 4.01) | **2.60** (1.89; 3.58) | **2.11** (1.59; 2.81) | **1.89** (1.39; 2.57) | **2.67** (1.95; 3.65) |
| Group 4: often having sleep difficulties—substantial retirement drop in symptom frequency | **5.01** (3.39; 7.42) | **4.33** (2.89; 6.48) | **4.01** (2.62; 6.12) | **3.42** (2.21; 5.3) | **3.17** (2.15; 4.66) |
| Low job control                  | Ref.               | Ref.                        | Ref.                           | Ref.                           | Ref.                           |
| Group 1: almost never having sleep difficulties—small to no retirement drop |                      |                             |                                |                                |                                |
| Group 2: seldom having sleep difficulties—small retirement drop | 1.39 (0.98; 1.96) | **1.56** (1.07; 2.25) | 1.21 (0.87; 1.68)       | 1.22 (0.86; 1.72)       | 1.13 (0.78; 1.62) |
| Group 3: sometimes having sleep difficulties—substantial retirement drop | **1.61** (1.11; 2.31) | **1.82** (1.23; 2.69) | 1.37 (0.96; 1.94)       | 1.38 (0.94; 2.02)       | 1.40 (0.96; 2.04) |
| Group 4: often having sleep difficulties—substantial retirement drop in symptom frequency | 1.43 (0.91; 2.27) | 1.62 (0.99; 2.65) | **1.70** (1.03; 2.81) | 1.62 (0.94; 2.78) | 1.32 (0.82; 2.10) |
| Job strain                       | Ref.               | Ref.                        | Ref.                           | Ref.                           | Ref.                           |
| Group 1: almost never having sleep difficulties—small to no retirement drop |                      |                             |                                |                                |                                |
| Group 2: seldom having sleep difficulties—small retirement drop | 1.05 (0.66; 1.67) | 0.95 (0.59; 1.52) | 1.16 (0.76; 1.77)       | 1.06 (0.69; 1.64)       | 0.68 (0.43; 1.07) |
| Group 3: sometimes having sleep difficulties—substantial retirement drop | **2.04** (1.30; 3.19) | **1.79** (1.13; 2.83) | **1.60** (1.04; 2.46) | 1.34 (0.85; 2.11) | 1.52 (0.98; 2.34) |
| Group 4: often having sleep difficulties—substantial retirement drop in symptom frequency | **2.03** (1.38; 3.95) | **1.97** (1.15; 3.39) | **2.87** (1.65; 4.97) | 1.26 (0.71; 2.25) | 1.58 (0.64; 3.89) |
| Lower work time control          | Ref.               | Ref.                        | Ref.                           | Ref.                           | Ref.                           |
| Group 1: almost never having sleep difficulties—small to no retirement drop |                      |                             |                                |                                |                                |
| Group 2: seldom having sleep difficulties—small retirement drop | **1.18** (1.03; 1.36) | 1.10 (0.96; 1.28) | 1.13 (0.99; 1.29)       | 1.01 (0.88; 1.18)       | 1.09 (0.93; 1.26) |
| Group 3: sometimes having sleep difficulties—substantial retirement drop | **1.43** (1.23; 1.66) | **1.24** (1.05; 1.46) | **1.28** (1.11; 1.48) | 1.04 (0.89; 1.22) | 1.08 (0.92; 1.26) |
| Group 4: often having sleep difficulties—substantial retirement drop in symptom frequency | **1.48** (1.22; 1.79) | **1.28** (1.04; 1.58) | **1.73** (1.38; 2.17) | **1.35** (1.06; 1.72) | **1.40** (1.15; 1.70) |
| Full-time work                   | Ref.               | Ref.                        | Ref.                           | Ref.                           | Ref.                           |
| Group 1: almost never having sleep difficulties—small to no retirement drop |                      |                             |                                |                                |                                |
| Group 2: seldom having sleep difficulties—small retirement drop | **1.59** (1.13; 2.24) | 1.34 (0.93; 1.92) | 1.19 (0.86; 1.63)       | 1.01 (0.72; 1.41)       | **1.49** (1.05; 2.13) |
| Group 3: sometimes having sleep difficulties—substantial retirement drop | **1.89** (1.32; 2.69) | 1.45 (0.99; 2.11) | **1.96** (1.40; 2.73) | **1.45** (1.01; 2.09) | **2.13** (1.47; 3.08) |
| Group 4: often having sleep difficulties—substantial retirement drop in symptom frequency | **1.94** (1.26; 2.99) | 1.50 (0.94; 2.39) | **2.50** (1.56; 4.01) | **1.77** (1.06; 2.95) | 1.54 (0.97; 2.45) |

Model 1 displays bivariate associations between work environment exposures and trajectory group membership; Model 2 is additionally adjusted for the sociodemographic variables (gender, age, education, civil status, and log-income). Work environment and sociodemographic variables were measured at the wave before retirement. Job demands and job control were measured in a 1–4 scale where higher values indicate higher job demands and lower job control. Job strain is a bivariate variable where zero is equal to no job strain and 1 is job strain. Work time control was measured in a 0–5 scale, which was reverse-scored such that higher values indicate lower control over working time.
| Model 2 | Premature awakening | Restless sleep | Non-restorative sleep |
|---------|---------------------|---------------|----------------------|
| OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| 1.29 (0.95; 1.76) | 1.29 (0.82; 1.79) | 1.33 (0.94; 1.86) | 1.91 (1.42; 2.57) | 1.81 (1.33; 2.47) | 1.21 (0.86; 1.72) | 1.22 (0.85; 1.77) |
| 2.42 (1.74; 3.56) | 2.91 (2.06; 4.12) | 2.87 (2.02; 4.07) | 3.45 (2.48; 4.79) | 3.09 (2.19; 4.36) | 3.20 (2.22; 4.63) | 2.74 (1.88; 4.01) |
| 2.74 (1.83; 4.09) | 3.90 (2.59; 5.87) | 3.80 (2.50; 5.78) | 7.25 (4.78; 10.99) | 6.38 (4.16; 9.78) | 4.87 (3.12; 7.58) | 4.61 (2.92; 7.25) |
| 1.28 (0.87; 1.87) | 1.51 (0.98; 2.32) | 1.73 (1.10; 2.71) | 1.45 (1.01; 2.07) | 1.59 (1.08; 2.32) | 1.47 (0.96; 2.26) | 1.62 (1.03; 2.56) |
| 1.60 (1.07; 2.41) | 1.58 (1.04; 2.41) | 1.75 (1.13; 2.71) | 1.63 (1.10; 2.40) | 1.89 (1.22; 2.81) | 1.62 (0.93; 2.18) | 1.75 (1.11; 2.78) |
| 1.55 (0.94; 2.56) | 1.35 (0.81; 2.24) | 1.61 (0.95; 2.74) | 1.30 (0.77; 2.19) | 1.46 (0.87; 2.45) | 1.41 (0.97; 2.69) | 1.97 (1.15; 3.38) |
| 0.64 (0.40; 1.03) | 1.19 (0.67; 2.10) | 1.24 (0.69; 2.21) | 2.27 (1.29; 3.97) | 2.13 (1.20; 3.77) | 1.45 (0.76; 2.76) | 1.49 (0.76; 2.92) |
| 1.41 (0.89; 2.22) | 2.26 (1.33; 3.84) | 2.26 (1.32; 3.87) | 2.82 (1.59; 5.01) | 2.53 (1.40; 4.55) | 2.14 (1.17; 3.94) | 2.11 (1.11; 4.01) |
| 1.36 (0.78; 2.34) | 1.95 (1.04; 3.66) | 2.02 (0.51; 8.07) | 4.73 (2.54; 8.81) | 4.24 (2.24; 8.01) | 3.62 (1.86; 7.04) | 3.69 (1.85; 7.36) |
| 1.05 (0.89; 1.23) | 1.08 (0.91; 1.27) | 1.13 (0.95; 1.35) | 1.10 (0.95; 1.27) | 1.05 (0.90; 1.23) | 1.10 (0.94; 1.29) | 1.09 (0.91; 1.31) |
| 1.21 (1.02; 1.44) | 1.37 (1.16; 1.62) | 1.35 (1.13; 1.62) | 1.35 (1.15; 1.58) | 1.22 (1.02; 1.44) | 1.35 (1.14; 1.58) | 1.28 (1.07; 1.53) |
| 1.28 (1.03; 1.59) | 1.27 (1.03; 1.56) | 1.29 (1.03; 1.61) | 1.35 (1.11; 1.64) | 1.23 (0.99; 1.52) | 1.28 (1.05; 1.56) | 1.25 (1.01; 1.55) |
| 1.32 (0.91; 1.91) | 1.80 (1.20; 2.70) | 1.95 (1.27; 2.97) | 1.65 (1.15; 2.35) | 1.61 (1.11; 2.35) | 1.49 (1.02; 2.16) | 1.46 (0.97; 2.19) |
| 1.59 (1.07; 2.35) | 1.77 (1.18; 2.66) | 1.70 (1.11; 2.61) | 1.79 (1.22; 2.61) | 1.55 (1.03; 2.32) | 1.52 (1.04; 2.20) | 1.47 (0.97; 2.14) |
| 1.26 (0.77; 2.06) | 1.46 (0.89; 2.38) | 1.51 (0.90; 2.5) | 1.72 (1.09; 2.73) | 1.57 (0.96; 2.57) | 1.51 (0.95; 2.38) | 1.61 (0.98; 2.64) |
awakening, restless sleep, a composite scale of these items and, lastly, non-restorative sleep. In seeking to make a methodological contribution, we explored whether time is best modelled with the standard approach using polynomial functions or whether a more flexible approach to modelling time is more suitable for studying abrupt changes such as retirement. We found that choices made in modelling time around retirement can have major impacts on the findings and demonstrated the importance of using B-spline rather than standard polynomial functions.

The present study contributes additional evidence that retirement is associated with improvements in sleep disturbance and non-restorative sleep (Myllyntausta et al., 2018, 2019; Straat et al., 2020). In contrast to earlier findings, we found improvements on average in difficulties falling asleep and difficulties maintaining sleep (Åkerstedt et al., 2002, 2015). For these two outcomes, the gains had been lost by 11 years after retirement. The fact that these changes were short-lived and small may explain why retirement-related improvements had not previously been observed. These findings for difficulties falling asleep and maintaining sleep are in line with those for self-rated health, which also improved only temporarily (Westerlund et al., 2009). Considering evidence that trends in increasing prevalence of chronic physical illness are unaffected by retirement (Westerlund et al., 2010), there may be a role for rising prevalence of ageing-related illnesses in relation to these outcomes.

In contrast, at 11 years after retirement, the benefits were mostly still retained for premature awakening, restless sleep, and non-restorative sleep. These findings demonstrating the lasting effects of retiring are consistent with prior research into sleep disturbance, as well as other outcomes including mental and physical fatigue and depressive symptoms (Vahtera et al., 2009; Westerlund et al., 2010). Research using subjective reports and actigraphy has shown that retirement leads to changes in the duration (lengthened), timing (closer to biological time) and weekly rhythms of sleep (reduced social jetlag) (Garefelt et al., 2020; Myllyntausta et al., 2017, 2020). The fact that work permanently ceases being a social Zeitgeber after retirement may explain why reductions in non-restorative sleep and some measures of sleep disturbance endure. To date, little research has examined longer-term consequences of retirement for sleep; in this vein, future work could profitably investigate which factors might predict the maintenance of retirement benefits.

Using a person-oriented approach, we showed that average trends hide distinctive patterns of change at retirement. Most participants experienced moderate reductions in sleep difficulties, a minority experienced relatively large reductions, and another minority little or no reduction at all. Those with low levels of sleep disturbance before retirement tended to be much less affected or were unaffected by the retirement transition, a finding that would be lost if only examining average trends. This is the first study that demonstrates group differences in sleep quality but is consistent with prior evidence from variable-oriented studies indicating that individuals with high (low) risk profiles experience large (small) improvements in sleep quality at retirement (Vahtera et al., 2009).

These findings have implications for policy and practice, indicating that retirement has differential effects such that those experiencing greatest pre-retirement sleep difficulties benefit most. Policies aiming to raise average age of retirement by increasing age of eligibility for state pensions typically apply the same pensionable age across the board. These extended working lives policies may accentuate inequalities in sleep quality by lengthening the period when those with poor sleep experience work-related sleep difficulties while having little impact on the sleep of those who experience few sleep difficulties. As reduced sleeping problems at retirement may lie behind the widely observed trend of improved mental health after retirement (Eibich, 2015), such policies may have implications for health inequalities as well as for population health more broadly.

In terms of mechanisms explaining retirement-related improvements, we found some support for both reduced need to sleep at fixed times and removal of work-related stressors. We extended existing evidence observing a link between improvements in sleep disturbance and needing to sleep at fixed times (Hagen et al., 2016; Straat et al., 2020) by showing that those with lower work-time control had higher probability of being assigned to trajectories characterised by high and reducing levels of non-restorative sleep, sleep disturbance, and premature awakening. Such findings likely have to do with reductions in social jet lag originating from differences in sleep timing on working and non-working days, as well as lengthening sleep time in the morning, as a result of not setting an alarm clock, reducing feelings of exhaustion (Garefelt et al., 2020). As for stress, retiring from high-demand jobs was associated with substantially higher odds of being placed in trajectories with high and reducing levels of sleep difficulties across all outcomes. These findings correspond to studies where psychosocial work predicted sleep disturbance or reductions in sleep disturbance at retirement (Åkerstedt et al., 2002; Van Laethem et al., 2013; Straat et al., 2020; Vahtera et al., 2009). Our present findings suggest the importance of removal of worry and hyper-arousal related to work stress at retirement and contribute to a developing picture indicating the importance of work stress for sleep quality (Halonen et al., 2017; Knudsen et al., 2007; Myllyntausta et al., 2018; Ota et al., 2005).

The final contribution of the present study is methodological and builds on an extremely limited literature that has identified problems with polynomial group-based trajectory models (Francis et al., 2016; Peristera et al., 2020). Polynomials over a sudden transition such as retirement produced several problems: artefactual uplifts at ends of trajectories, omitting abrupt changes entirely, and extension of abrupt transitions on the time axis. These problems are averted with B-splines, as they more faithfully match the real shapes of the observed data. Had we based our conclusions on the polynomial trajectories we would have erroneously concluded that there were no retirement effects for the composite measure of sleep disturbance, rather a variety of straight-line ageing effects, an invalid finding that
would have generated divergent policy and practice implications. These critical drawbacks of polynomial group-based trajectory models are rarely discussed in the empirical literature, due in part to most empirical applications only showing estimated trajectories and not comparing these with observed data.

4.1 Limitations

The present study has certain limitations. First, the generalisability of these results may be limited due to selective attrition from the SLOSH sample, in which workers who are female, older, born in Sweden, married and with university education are overrepresented compared to the population. Second, in the present study we did not examine sleep disturbance trajectories in relation to the work environment characteristic of shift work. This was for two reasons: few people in the SLOSH cohort are in shift work after the age of 60 years (Tucker et al., 2016) and those remaining in shift work may be a highly selected and healthy group because workers with health problems are likely to leave such jobs for daytime roles (Platts et al., 2017). Future work could investigate development of sleep-related symptoms for this group of workers. Third, selecting the number groups/knots in the models requires judgement to weigh up fit indices, rules-of-thumb, and visual inspection as an objective and reliable approach is still lacking. Fourth, participants were not asked about whether they had to sleep at fixed times, which meant that this concept was measured with proxies of control over working hours and whether working hours were part-time. The intuition is that if a person wishes to catch up on sleep, then they are more likely to be able to set the alarm for later if they have greater WTC or are working part-time. However, without a direct measure of the need to sleep at fixed times, we may have misclassified participants who had to wake up at fixed times for other work or non-work reasons such as caregiving, pets, or spousal rhythms (Garefelt et al., 2020). Fifth, benefits from retirement were most clearly marked among those who had high levels of sleep difficulties before retirement. Potentially, these results may to a degree result mechanically from floor effects for those who already seldom or never experienced sleeping problems before retirement. A final limitation concerns the long time series from −11 to +11 years where only one interval, −1 to +1, corresponds to the retirement transition. As information about level and change over the whole period are combined to assign individuals to groups, the trajectories will likely be increasingly parallel by design as the series lengthens. Descriptions of the groups in terms of covariates will similarly trade off level and change. Future work may address this modelling limitation by examining ways to overcome this, such as by demeaning the data.

5 CONCLUSION

The present study found reductions in sleep difficulties at retirement that were sudden and, in the case of non-restorative sleep, premature awakening and restless sleep, were sustained up to 11 years after retirement. These average trends masked distinct patterns of change at retirement transition in which groups reporting greater sleeping difficulties before retirement experienced larger reductions after retirement. Reduced need to sleep at fixed times and removal of work-related stressors were found to account for these retirement-related improvements. The B-splines more faithfully matched the shapes of the observed data. We consequently recommend that researchers seeking to understand the dynamics of symptoms-based data consider B-spline modelling rather than polynomial functions to estimate group-based trajectories.

AUTHOR CONTRIBUTIONS

PP conceived the study, performed the analyses, and drafted the manuscript. All authors contributed to the study design and interpretation of data. All authors contributed to critical revision of the work, gave final approval of the version to be published, and agreed to be accountable for all aspects of the work.

DATA AVAILABILITY STATEMENT

The data are not publicly available due to privacy or ethical restrictions.

ORCID

Paraskevi Peristera https://orcid.org/0000-0001-9910-1132
Linda L. Magnusson Hanson https://orcid.org/0000-0002-2908-1903

REFERENCES

Ahlin, J. K., Westerlund, H., Griep, Y., & Magnusson Hanson, L. L. (2018). Trajectories of job demands and control: Risk for subsequent symptoms of major depression in the nationally representative Swedish Longitudinal Occupational Survey of Health (SLOSH). International Archives of Occupational and Environmental Health, 91(3), 263–272. https://doi.org/10.1007/s00420-017-1277-0
Äkerstedt, T., Garefelt, J., Richter, A., Westerlund, H., Magnusson Hanson, L. L., Sverke, M., & Kecklund, G. (2015). Work and sleep—A prospective study of psychosocial work factors, physical work factors, and work scheduling. Sleep, 38(7), 1129–1136. https://doi.org/10.5665/sleep.4828
Äkerstedt, T., Knutsson, A., Westerholm, P., Theorell, T., Alfredsson, L., & Kecklund, G. (2002). Sleep disturbances, work stress and work hours: A cross-sectional study. Journal of Psychosomatic Research, 53(3), 741–748. https://doi.org/10.1016/S0022-3999(02)00333-1
Andruff, H., Carraro, N., Thompson, A., Gaudreau, P., & Louvet, B. (2009). Latent class growth modelling: A tutorial. Tutorials in Quantitative Methods for Psychology, 5(1), 11–24. https://doi.org/10.20982/tqmp.05.1.p011
Bergman, L. R., & Trost, K. (2006). The person-oriented versus the variable-oriented approach: Are they complementary, opposites, or exploring different worlds? Merrill Palmer Quarterly, 52(3), 601–632. https://doi.org/10.1353/mpq.2006.0023
Eibich, P. (2015). Understanding the effect of retirement on health: Mechanisms and heterogeneity. Journal of Health Economics, 43, 1–12. https://doi.org/10.1016/j.jhealeco.2015.05.001
Francis, B., Elliott, A., & Weldon, M. (2016). Smoothing group-based trajectory models through B-splines. Journal of Developmental and Life-Course Criminology, 2(1), 113–133. https://doi.org/10.1007/s40865-016-0025-6
Westerlund, H., Vahtera, J., Ferrie, J. E., Singh-Manoux, A., Pentti, J., Melchior, M., ... Kivimäki, M. (2010). Effect of retirement on major chronic conditions and fatigue: French GAZEL occupational cohort study. BMJ, 341, c6149. https://doi.org/10.1136/bmj.c6149

SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section.