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The Longitudinal Course of Insomnia Symptoms: Inequalities by Sex and Occupational Class Among Two Different Age Cohorts Followed for 20 Years in the West of Scotland

Michael J. Green, MA[1]; Colin A. Espie, PhD[2]; Kate Hunt, PhD[1]; Michaela Benzeval, PhD[1]

[1]Medical Research Council/Chief Scientist Office: Social and Public Health Sciences Unit, Glasgow, United Kingdom; [2]University of Glasgow Sleep Centre, College of Medicine, Veterinary Medicine and Life Sciences, University of Glasgow, Glasgow, United Kingdom

Study Objectives: The natural history of insomnia symptomatology is poorly understood. Cross-sectional associations have been demonstrated among socioeconomic disadvantage, female sex, and poor sleep but it is unclear how these social factors predict patterns of insomnia symptoms over time. The aim of this article is to describe longitudinal patterns of insomnia symptoms as people age and investigate how they vary by sex and occupational class.
Design: A prospective cohort study with 20 yr of follow-up from 1987 to 1988.
Setting: West of Scotland.
Participants: One cohort approximately 36 yr of age at baseline aging to 57 yr (n = 1,444), and another aging from approximately 56 to 76 yr (n = 1,551).
Interventions: N/A.
Measurements and Results: At approximately 5-yr intervals, respondents self-reported trouble initiating and maintaining sleep. Latent class analysis identified 4 main sleep patterns: a healthy pattern with little sleeping trouble across the 20 yr; an episodic pattern, characterized by trouble maintaining sleep; a chronic pattern with trouble maintaining and initiating sleep throughout the study; and a pattern where symptoms developed during the 20-yr follow-up. Chronic patterns were more likely in the older cohort than the younger one, for women than men in the older cohort, and for those from a manual rather than a nonmanual occupational class in both cohorts. In the middle-aged cohort a developing pattern was more likely for women than men.
Conclusions*:* Chronic symptoms, characterized by both trouble maintaining and initiating sleep, are patterned by social factors.
Keywords: Insomnia, sleeplessness, sex, socioeconomic status, life course, prospective cohort
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INTRODUCTION

Problems getting to sleep and/or remaining asleep are very common in adults,[1] and have long been regarded as the core symptoms of insomnia.[2-3] In relation to mental health, there is firm evidence that insomnia is a risk factor for the evolution of, and relapse into, depression.[4-6] Likewise, insomnia has been associated with a higher prevalence of physical health conditions such as hypertension and type 2 diabetes,[7-8] with all-cause mortality,[9] and with other adverse outcomes such as a poor quality of life and problems with work performance and personal relationships.[10,11] It seems important, therefore, from a public health perspective, to understand who sleeps well, who has trouble sleeping, and whether particular groups in the community are more or less prone to the development or resolution of insomnia symptoms during adulthood.

So far, however, the natural history of insomnia remains relatively poorly understood. The few longitudinal studies that do exist suggest that insomnia symptoms tend to become chronic and persistent,[12-14] with evidence also of remitting and recurring patterns.[15] A 3-yr follow-up of people with insomnia symptoms showed more persistent symptoms among those with more severe, clinically significant symptoms,[15] and a 4-mo study showed greater stability of symptoms among patients who reported trouble both initiating and maintaining sleep,[16] but few studies have examined symptom patterns over a period of many years.

In terms of who experiences insomnia symptoms, the prevalence tends to increase with age.[1] A meta-analysis of cross-sectional data by sex concluded that women were more likely to experience symptoms than men and that this gender difference was stronger with increasing age.[17] Other cross-sectional research has also highlighted socioeconomic status (SES) as a correlate of insomnia symptoms.[18-19] Sex effects are attenuated but not fully explained by adjustment for socioeconomic factors, as socioeconomic disadvantage is associated with both poor sleep and being female.[20-21] Longitudinally, a pattern of persistent symptoms over 3 yr has been shown to be more likely for women than men.[15] Another study showed no significantly greater incidence or persistence in insomnia symptoms over 12 mo for those in manual rather than nonmanual occupations,[13] and a separate 12-mo incidence study showed a higher likelihood of developing symptoms for women than men, and either weak or no relationships for socioeconomic factors such as income and education.[22] The lack of an effect for socioeconomic factors in these longitudinal studies contrasts with findings from cross-sectional research where people in disadvantaged socioeconomic circumstances were more likely to experience insomnia symptoms than those who were more affluent. This may be because 12 mo of follow-up is too short a time period for socioeconomic differences to emerge. It is important to un-

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Address correspondence to: Michael J Green, MA, MRC/CSO Social and Public Health Sciences Unit, 4 Lilybank Gardens, Glasgow, G12 8RZ, United Kingdom; Tel: +441413573949; Fax: +441413372389; E-mail: michael-g@sphsu.mrc.ac.uk

Table 1—Comparison of sample characteristics at baseline and final interviews

	Baseline interview (1987/1988)	Final interview (2007/2008)
1950s Cohort		
n	1,444	999
Female (%)	788 (54.6)	542 (54.3)
Manual class at baseline (%)[a]	494 (34.6)	304 (30.7)
No symptoms at Baseline (%)[a]	789 (57.8)	577 (59.2)
1930s Cohort		
n	1,551	663
Female (%)	849 (54.7)	384 (57.9)
Manual class at baseline (%)[a]	710 (45.8)	227 (34.2)
No symptoms at baseline (%)[a]	729 (49.9)	353 (54.0)

[a]These values represent percentages of valid responses. Item missingness ranged from 0-1.2% for occupational class and from 1.4-5.8% for insomnia symptoms.

derstand how these various risk factors for insomnia are associated with long-term patterns of insomnia symptoms.

The aim of this article was, first, to identify the main longitudinal patterns of insomnia symptoms across the life course, and second, to investigate whether experience of these patterns varied by sex and occupational class. Two cohorts, 20 yr apart in age, were studied over a 20-yr period, allowing comparison of those in their mid-30s to mid-50s with those in their mid-50s to mid-70s. In light of previous research, it was hypothesized that women, older respondents, and those in disadvantaged occupational classes would be especially likely to experience more persistent patterns of insomnia symptoms.

METHODS

Sample and Measures

The Twenty-07 Study[23] has followed people in 3 age cohorts – born around 1932, 1952, and 1972 – for 20 yrs. It has 2 subsamples: the regional sample, a 2-stage stratified random sample of people living in the Central Clydeside Conurbation, West of Scotland, and the localities sample of people from 2 areas of the city of Glasgow. Baseline interviews were conducted in 1987/1988 and there have been 4 follow-ups (1990/1992; 1995/1997; 2000/2004; 2007/2008), with ethics approval gained for each wave from the National Health Service and/or Glasgow University Ethics Committees. At each wave of data collection, nurses trained in survey methods conducted face-to-face individual interviews supplemented by a suite of physical measurements. Because questions on sleep were not asked at all interviews in the 1970s cohort, only the 1950s and 1930s cohorts are examined here. The 1950s cohort aged from approximately 36 to 57 yr during the study period and the 1930s cohort from 56 to 76 yr. Baseline sample sizes for these cohorts were 1,444 and 1,551, respectively (original response rates were 88.9% and 87.1%)[23] and the achieved sample has been shown to be representative of the general population of the sampled area.[24]

Insomnia symptom questions were asked at all 5 interviews over 20 yr of the study for both sleep latency (trouble getting to sleep) and sleep maintenance (waking early or during the night). Unfortunately, the specific questions asked changed during the study; nevertheless, it is possible to create broadly comparable insomnia variables over time for both dimensions (latency and maintenance). In the baseline and the first 2 follow-up interviews, respondents were asked 2 questions: "How often do you have trouble getting to sleep?" and "How often are you bothered by waking earlier than you would like to, or by waking up in the middle of the night?" Both questions had 6 response categories: *never, less than monthly, at least once a month, at least once a week, most days,* and *every day.* In waves 4 and 5, as part of the Pittsburgh Sleep Quality Index,[25] respondents were asked, "During the past month how often have you had trouble sleeping because you cannot get to sleep within 30 minutes?" and "During the past month how often have you had trouble sleeping because you wake up in the middle of the night or early morning?" Both questions had 4 categories: *not during the past month, less than once a week, once or twice a week* ,and *3 or more times a week*. To define the frequency of insomnia symptoms consistently across all 5 interviews for each symptom type – latency and maintenance – the questions have been recoded for each interview into 2 binary variables, respectively representing latency and maintenance problems, with 0 representing either no problems or a less than weekly frequency, and 1 representing sleep problems occurring at least weekly. Note, however, that the respondents were asked specifically about their sleep within the past month in the 4th and 5th interviews as opposed to being asked about their sleep generally in the earlier interviews. In addition, at each interview respondents were also shown cards with lists of common medical symptoms, including "difficulty sleeping", and asked whether they had experienced this symptom in the past 4 wk or 1 mo (yes or no). Although this question does not contain comparable information on how frequently symptoms occurred and makes no distinction between sleep latency and sleep maintenance, the question wording was consistent throughout the study, and so we took the opportunity to validate findings from the questions on sleep latency and sleep maintenance in separate sensitivity analyses using this variable, as discussed in the next sections.

Sex was coded 0 for males and 1 for females. Baseline household occupational class was used as a measure of SES. This measure is common in British health research, and represents both social standing and material resources.[26-27] Here it is coded according to the British Registrar General's 1980 classification[28] using the higher status occupation in couple households. If neither the respondent nor their partner had a current occupation then the higher class from their most recent previous occupations was used. This variable was then dichotomised with 0 for nonmanual (I through to III nonmanual) and 1 for manual (III manual through to V) classes. Twenty respondents were excluded from the analysis because of missing data on baseline occupational class.

In the most recent follow-up (2007/2008), 999 of the 1950s cohort and 663 of the 1930s cohort took part (73.2% and 65.5% of the living baseline sample). Of the 445 respondents from the 1950s cohort who were lost to follow-up by this point, 88 had died (19.8%), whereas 562 of the 888 respondents who were lost to follow-up in the 1930s cohort had died (63.3%),[29] so mortality was the most common reason for drop-out in the oldest cohort. Table 1 compares sample characteristics at the

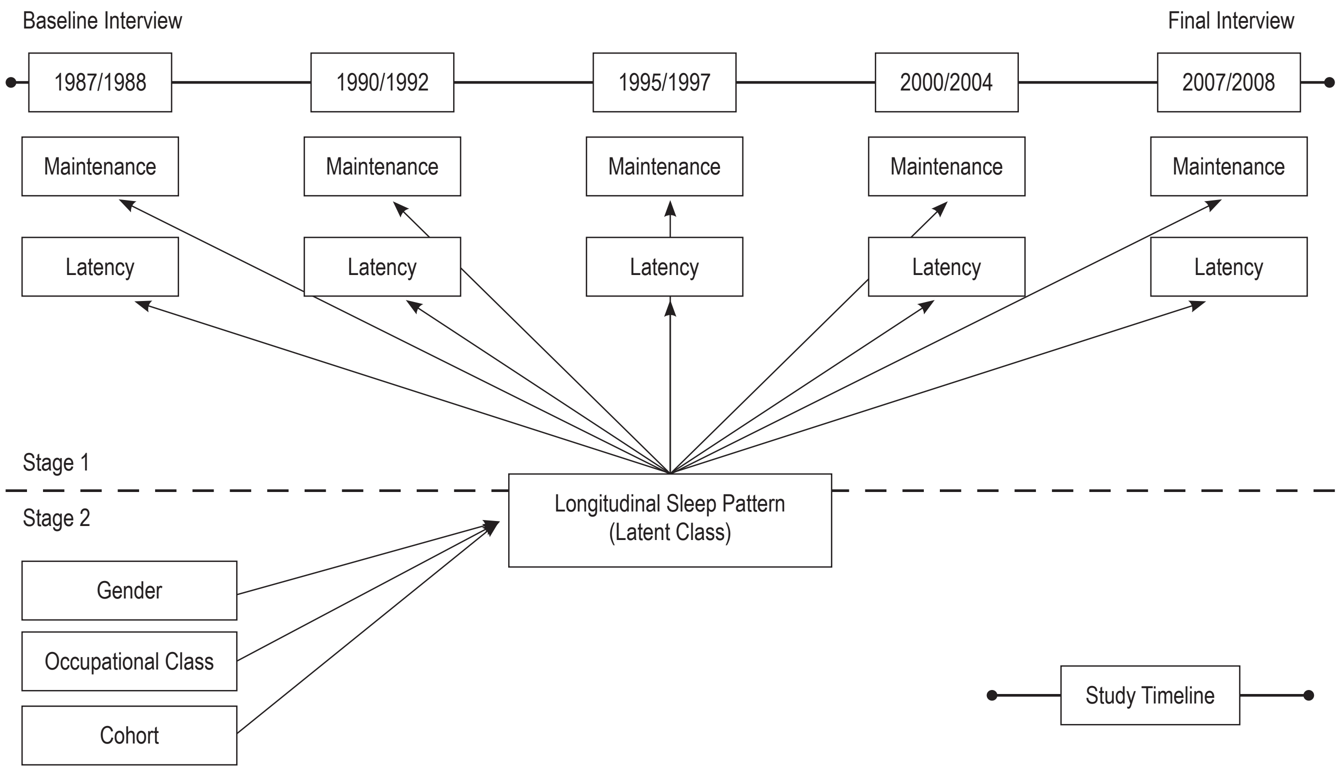

Figure 1—Latent class analysis diagram.

baseline and final interviews. Loss to follow-up was especially likely among those who reported sleep problems at baseline in both cohorts and among those who were in a manual class at baseline, especially in the older cohort. This uneven loss to follow-up is addressed using maximum likelihood estimation as discussed in the statistical analysis section.

Statistical Analysis

This article uses a repeated measures latent class analysis,[30] which identifies clusters of categorical responses (termed latent classes) across repeated measurements. It estimates the overall probability of membership in each latent class (class membership probabilities), the probability of reporting each sleep problem at each time point given latent class membership (response probabilities), and can also be used to explore associations between covariates and latent class membership. The latent class analysis is depicted diagrammatically in Figure 1. Modeling proceeded in 2 main stages relating to the 2 main aims of the study. In stage 1 the aim was to identify the most common longitudinal patterns of insomnia symptoms present within the data. Although the data contained a wide variety of different combinations of responses across the study period, the aim of the latent class analysis was to identify a smaller number of dominant groupings, representing different longitudinal patterns of insomnia symptoms. The number of latent classes was determined by estimating a series of latent class models, each with an incrementally greater number of latent classes, and then comparing these models on the basis of various model fit statistics (for details see supplementary information, part I).

The second stage of modeling investigated whether the longitudinal patterning of insomnia symptoms varied by cohort, sex, and occupational class. This was done using the optimal latent class model identified in the first stage. There are 2 main ways in which longitudinal response patterns may vary in line with covariates. First, an entirely different set of latent classes might be experienced in different groups, or second, different groups might experience similar patterns at different frequencies. It is meaningless to investigate the second type of variation unless the first type is either absent or negligible, as like cannot be compared with like.[30] Detailed analyses (see supplementary information, part II) investigating the first type of variation suggested that differences in the response probabilities for each latent class by sex, occupational class, or cohort were minor. We therefore tested for differences in the odds of class membership between sexes, occupational classes, and cohorts by adding these variables to the latent class model as predictors in a multinomial logistic regression of latent class membership. Because latent class membership was the outcome here, the odds ratios associated with each covariate represent the odds of experiencing a particular longitudinal pattern of insomnia symptoms over 20 yr, rather than the odds of symptoms at any 1 time point. Because the latent classes were based on longitudinal data that included symptoms from the baseline interviews, measured concurrently with the covariates, there is a partially cross-sectional element to the estimated associations and reverse causation is possible. Interactions between covariates in predicting latent class membership were also tested and retained if significant at the $P < 0.05$ level. Age was incorporated into the model in 2 ways: first, differences in the experience of the two cohorts, 20 years apart in age, were examined by including cohort as a proxy for age (because respondents within the same cohort were approximately the same age); second, ag-

Table 2—Co-occurrence of sleep problems over study

	Interview 1	Interview 2	Interview 3	Interview 4	Interview 5
1950s Cohort					
Mean age (standard deviation)	36.2 (0.8)	40.5 (0.9)	45.2 (1.2)	50.2 (1.3)	57.1 (0.8)
No symptoms[a]: n (%)	789 (57.8)	823 (67.4)	461 (61.4)	464 (49.8)	415 (42.6)
Latency only[a]: n (%)	109 (8.0)	61 (5.0)	39 (5.2)	39 (4.2)	48 (4.9)
Maintenance only[a]: n (%)	297 (21.7)	182 (14.9)	118 (15.7)	194 (20.8)	248 (25.4)
Both symptoms[a]: n (%)	171 (12.5)	155 (12.7)	133 (17.7)	234 (25.1)	264 (27.1)
Missing sleep data: n (%)	78 (5.4)	4 (0.3)	275 (26.8)[b]	49 (5.0)	24 (2.4)
Total n (% of baseline sample)	1,444 (100.0)	1,225 (84.8)	1,026 (71.1)	980 (67.9)	999 (69.2)
1930s Cohort					
Mean Age (standard deviation)	56.2 (0.6)	59.6 (0.8)	64.4 (1.2)	69.1 (1.0)	76.2 (0.6)
No symptoms[a]: n (%)	729 (49.9)	626 (49.5)	350 (48.5)	321 (41.4)	230 (36.7)
Latency only[a]: n (%)	133 (9.1)	97 (7.7)	52 (7.2)	40 (5.2)	41 (6.5)
Maintenance only[a]: n (%)	296 (20.3)	267 (21.1)	156 (21.6)	139 (17.9)	142 (22.6)
Both symptoms[a]: n (%)	303 (20.7)	275 (21.7)	163 (22.6)	276 (35.6)	214 (34.1)
Missing sleep data: n (%)	90 (5.8)	1 (0.1)	309 (30.0)[b]	62 (7.4)	36 (5.4)
Total n (% of baseline sample)	1,551 (100.0)	1,266 (81.6)	1,030 (66.4)	838 (54.0)	663 (42.7)

[a]To facilitate comparison across the study, percentages here are presented as proportions of those with valid sleep data. [b]Missingness is higher here because at this stage the 2 locality subsamples only received a shortened postal questionnaire that did not include the sleep questions (n = 272 for the 1950s cohort; n = 307 for the 1930s cohort).

ing effects within a cohort, i.e., from 1 interview to the next, are represented by the probabilities of symptoms at each interview as predicted by latent class membership.

All analyses were performed in Mplus version 6.1.[31] Maximum likelihood estimation was used, using all available sleep data for each respondent (n = 2,867; 1,383 from the 1950s cohort and 1,484 from the 1930s cohort), and hence these analyses are robust to sample attrition under the assumption that data are missing at random.[32] This assumes that the missingness of a variable can be predicted by the other variables in the model, i.e., if nonparticipation at later waves was related to later insomnia symptoms, but those symptoms could be predicted by cohort, sex, occupational class, and the sleep data from other waves (e.g., baseline symptoms), then the model estimates would be unbiased. For example, the model would be robust to the slightly higher rates of drop-out among those with baseline symptoms unless those who later recovered were more or less likely to be retained than those who did not recover (and then only if these differences were not explained by cohort, sex, and/or occupational class). In the third wave of interviews the 2 locality subsamples only received a postal questionnaire that did not include the questions on sleep; however, being in the locality subsamples was not related to having sleep problems at any of the other waves (chi-square test, $P > 0.05$), so there is no reason to believe that this missingness-by-design would bias the results.

As a sensitivity analysis, the latent class modeling was repeated for each type of insomnia symptom separately, to ensure no distortions had resulted from modeling the 2 symptom dimensions together. For validation purposes, given the change in wording for the 2 insomnia symptom questions between the 3rd and 4th interviews, the latent class analysis was also repeated separately for the general question on sleep difficulty. Because the general question on sleep difficulty was worded consistently over the course of the study, observation of similar latent classes for this question would suggest that the observed patterns were genuine and not an artefact of the question change (for details see supplementary information, part III).

RESULTS

Table 2 shows the prevalence of latency symptoms alone, maintenance symptoms alone, co-occurring latency and maintenance symptoms, and the proportion reporting no symptoms, at each of the 5 interviews by cohort. The co-occurrence of latency and maintenance symptoms was common, varying from 12.5% to 27.1% of respondents in the 1950s cohort as they aged from 36 to 57 yr, and 20.7% to 35.6% in the older cohort as they aged from 56 to 76 yr. Sleep maintenance problems were also frequently reported, but it was relatively rare for respondents to report latency symptoms without accompanying maintenance problems. There was a marked reduction in the prevalence of those reporting no sleep problems across the study as both cohorts aged, and a marked increase in the prevalence of sleep problems between waves 3 and 4 when the question wording changed. Comparing the cross-sectional prevalence of symptoms at the baseline interviews in the 1930s cohort with that from the final interview in the 1950s cohort, where respondents were approximately the same age, suggests a lower symptom prevalence in the older cohort (42.6% with no symptoms compared to 49.9%).

The best latent class model in terms of balancing model fit and parsimony identified 4 latent classes (see supplementary information, part I). The probabilities of problems initiating and maintaining sleep at each wave of the study for the 4 latent classes are shown in Figure 2. Error bars show 95% confidence intervals for estimates. Respondents in class 1 had a low probability of latency or maintenance problems at all of the study waves and so were labeled the *Healthy* class. The overall probability of membership in this class was 0.37. Those in class 2 had a low probability of latency problems at all time points but a relatively high probability of maintenance problems. These were labeled the *Episodic Maintenance* class (overall membership

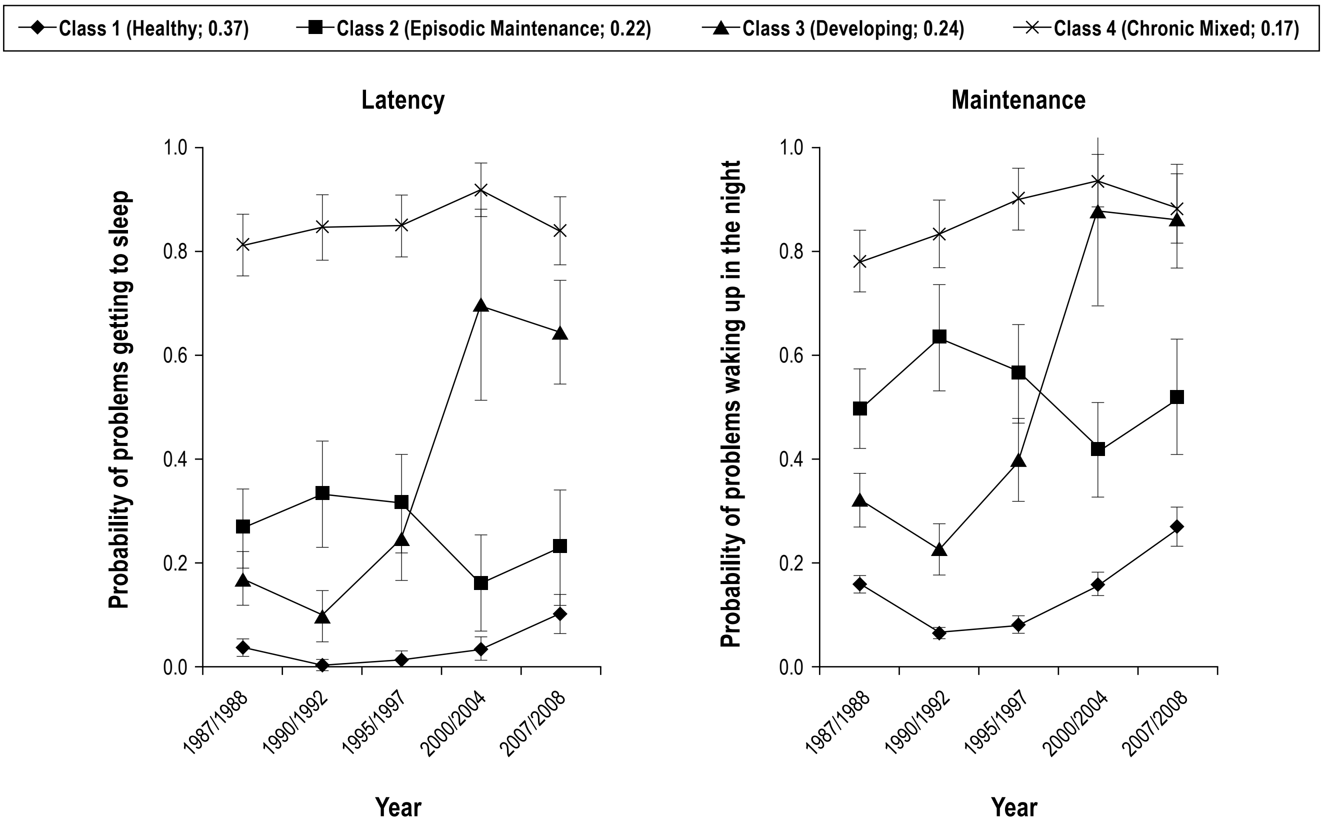

Figure 2—Probability of latency and maintenance problems at each study wave given latent class membership.

probability: 0.22). The members of class 3 had a low probability of reporting either symptom in earlier study waves, but then a high probability of both symptoms, especially maintenance problems, at waves 4 and 5. These were labeled the *Developing* class as they appeared to be developing insomnia symptoms (overall membership probability: 0.24). Finally, those in class 4 had a high probability of trouble both initiating and maintaining sleep at all time points, and were labeled the *Chronic Mixed* class (overall membership probability: 0.17). Those in the *Episodic Maintenance* class tended toward a lower probability of trouble maintaining sleep than those in the *Chronic Mixed* class; probabilities at each wave were all approximately 0.4-0.6, indicating that maintenance symptoms would be reported in approximately half of the study waves for each individual in this class. This suggests less stable or more episodic problems than in the *Chronic Mixed* class where the response probabilities for maintenance symptoms are approximately 0.8-0.9 and symptoms would be reported at most interviews. Those in the *Episodic Maintenance* class also tended to experience a higher probability of latency problems than those in the *Healthy* class, indicating that although maintenance is the primary or dominant problem in this class, latency problems also occurred occasionally and with greater frequency than where maintenance problems were not present. The absence of other potential patterns in the latent class solution, e.g., a full recovery pattern, or a pattern where latency symptoms were dominant, indicates that such patterns were relatively rare.[30]

Table 3 displays the odds ratios (OR) and 95% confidence intervals from a multinomial logistic regression of latent class

Table 3—Multinomial logistic regression of latent class membership on sex, occupational class, and cohort

	Odds ratios	95% Confidence intervals
Episodic maintenance (ref: Healthy)		
Female in 1950s cohort (ref: male)[a]	0.78	(0.43-1.41)
Female in 1930s cohort (ref: male)[a]	2.22	(1.36-3.63)
Manual (ref: Non-manual)	1.28	(0.89-1.85)
1930s cohort for males (ref: 1950s)[a]	1.45	(0.91-2.32)
1930s cohort for females (ref: 1950s)[a]	4.14	(2.24-7.66)
Developing (ref: Healthy)		
Female in 1950s cohort (ref: male)[a]	4.30	(2.65-6.98)
Female in 1930s cohort (ref: male)[a]	1.59	(1.00-2.51)
Manual (ref: Non-manual)	1.61	(1.14-2.28)
1930s cohort for males (ref: 1950s)[a]	3.55	(2.11-5.97)
1930s cohort for females (ref: 1950s)[a]	1.31	(0.85-2.02)
Chronic Mixed (ref: Healthy)		
Female in 1950s cohort (ref: male)[a]	1.20	(0.78-1.85)
Female in 1930s cohort (ref: male)[a]	3.10	(2.15-4.49)
Manual (ref: Non-manual)	3.22	(2.46-4.21)
1930s cohort for males (ref: 1950s)[a]	1.61	(1.08-2.38)
1930s cohort for females (ref: 1950s)[a]	4.16	(2.79-6.19)

[a]This odds ratio is calculated by combining the relevant main and interaction effects for sex and cohort.

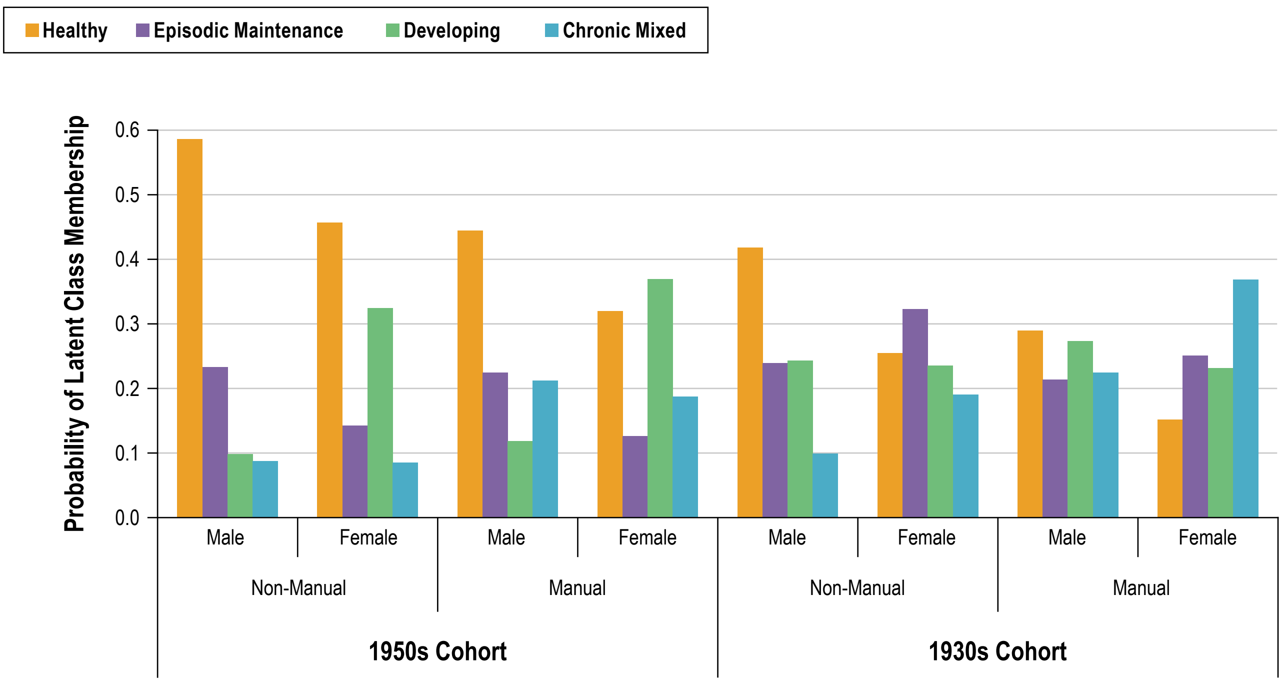

Figure 3—Latent class membership probabilities for both cohorts by sex and occupational class.

membership on sex, occupational class, and cohort (mutually adjusted). There was a significant interaction between cohort and sex ($P < 0.05$), so for ease of interpretation ORs combining the main and interaction effects have been calculated and are presented by cohort for sex, and by sex for cohort. No other interactions between sex, occupational class, and cohort were found to be significant. Women were more likely than men to be in the *Developing* class as opposed to the *Healthy* class, but the effect was larger in the 1950s than in the 1930s cohort (1950s OR 4.30, $P < 0.01$; 1930s OR 1.59, $P < 0.05$). In the 1930s cohort, but not in the 1950s cohort, women were more likely than men to be in the *Chronic Mixed* relative to the *Healthy* sleep class (OR 3.10, $P < 0.01$). Respondents from manual occupational classes in both cohorts were more likely than their nonmanual counterparts to be in the *Developing* or *Chronic Mixed* latent classes relative to the *Healthy* class, though the effect size for being in the *Chronic Mixed* class (OR 3.22, $P < 0.01$) was approximately twice that for being in the *Developing* class (OR 1.61, $P < 0.01$). Men in the 1930s cohort were more likely than men in the younger 1950s cohort to be in the *Developing* (OR 3.55, $P < 0.01$) or *Chronic Mixed* (OR 1.61, $P < 0.05$) classes as opposed to the *Healthy* sleep class. Women in the 1930s cohort were not significantly more likely than those in the 1950s cohort to be in the *Developing* rather than the *Healthy* sleep class (OR 1.31, $P = 0.22$), but there was an even stronger tendency than there was amongst men for those in the 1930s rather than the 1950s cohort to be in the *Chronic Mixed* class (OR 4.16, $P < 0.01$) rather than the *Healthy* sleep class.

Figure 3 is provided to aid interpretation and shows estimated probabilities of latent class membership for all the different combinations of these variables. Membership in the *Healthy* class was the most probable outcome for most respondents in the 1950s cohort, with the exception of women in a manual class, who were more likely to be in the *Developing* than the *Healthy* class. In the 1930s cohort, however, women were more likely to be in 1 of the symptomatic sleep classes than in the *Healthy* class, irrespective of occupational class. Women in the 1930s cohort who were in a manual class were particularly disadvantaged in that membership in the *Chronic Mixed* class was the most likely outcome for them and membership in the *Healthy* class was the least likely. Only men from nonmanual classes in the 1950s cohort had a greater than 50% chance of being in the *Healthy* sleep class.

Repeating the modeling for sleep latency and sleep maintenance problems separately revealed a 3-class solution as the best-fitting model for both types of insomnia symptom (see supplementary information, part III). In each case the 3 classes observed could be viewed as corresponding to the *Healthy*, *Developing*, and *Chronic Mixed* classes from the joint modeling. The *Episodic Maintenance* class appeared to have been subsumed into the class experiencing chronic difficulties when modeling maintenance only, and into the *Developing* class when modeling latency only. These results are therefore consistent with and support those from the joint modeling.

Given the change in question wording and concurrent increase in the prevalence of insomnia symptoms at interviews 4 and 5, it is possible that the *Developing* class represents sensitivity to question wording rather than symptom development. This issue was investigated by performing a further latent class analysis using the general question on sleep difficulty that had been worded consistently across the study, asking about symptoms within the past month at each interview. Because this question does not make the distinction between latency and maintenance problems, when modeling using these data it would be expected *a priori* not to find a class similar to the *Episodic Maintenance* class, but the other 3 classes, including the *Developing* class, should be fairly replicable. Results from this analysis (see supplementary information, part III) suggested a 3-class model similar to those observed for sleep latency and sleep maintenance separately. As well as classes with healthy and chronic patterns there was evidence of a class with symptoms developing toward the end of the study, albeit with a smoother slope, suggesting that the *Developing* class is more reflective of symptoms developing with increasing age within each cohort than of measurement differences.

Latent class membership probabilities for the general question on difficulty sleeping were also similar to those for the questions on sleep maintenance, with a slightly lower prevalence in both of the symptomatic categories. Finally, covariate effects were all in the same direction as in the main results, though there were some differences in whether or not particular effects were significant (some small differences would be expected with the reassignment of those in the *Episodic Maintenance* class into other categories). Overall, modeling of this alternative question revealed symptom patterning similar to that observed for the main measures used, validating the findings and suggesting that instrument effects associated with the change in question wording were minor.

DISCUSSION

In this article we have presented longitudinal data on patterns of insomnia symptoms over a 20-yr period in 2 cohorts, aging from their mid-30s to mid-50s and from their mid-50s to mid-70s, respectively. Four distinct patterns of insomnia symptoms were apparent over the adult life course: a *Healthy* class with only occasional experience of sleeping trouble; an *Episodic Maintenance* class who had episodes dominated by trouble maintaining rather than initiating sleep; a *Developing* class who appeared to develop insomnia symptoms as they aged; and a *Chronic Mixed* class who had persistent trouble with both initiating and maintaining sleep. The only other study of insomnia of comparable length that we are aware of was in a cohort of young adults, age 19-20 yr at baseline, in Zûrich.[14] Our study adds information on the common trajectories of insomnia symptoms over 2 decades among older adults and shows patterning by sex, occupational class, and cohort.

Insomnia symptoms have traditionally been subtyped into problems with initiating sleep, maintaining sleep, or waking earlier than desired, though the latter may often be perceived as a maintenance problem. In a study examining all 3 symptom types over 4 mo, each symptom type in isolation had low stability, with higher stability for a combination of all 3.[16] A cross-sectional latent class analysis on data from patients with sleep disturbance also identified a class that experienced both initiation and maintenance symptoms, whereas maintenance problems predominated in other classes.[33] In this cross-sectional analysis, the class with mixed symptoms also reported more frequent symptoms of longer duration than other classes. The *Chronic Mixed* class we found is consistent with this previous research, particularly in associating chronicity with the combined experience of both initiation and maintenance problems. The *Episodic Maintenance* class may indicate a distinct vulnerability for intermittent troubled sleep. Inevitably, some of these individuals would also be captured as poor sleepers in cross-sectional studies. Differences in the social patterning of the *Chronic Mixed* and *Episodic Maintenance* classes suggest differences in etiology that could be confounded in cross-sectional research.

This study goes beyond cross-sectional associations between SES and insomnia symptoms[18,20-21,34] by showing that people in a manual occupational class were more likely than those in a nonmanual class to experience chronic insomnia symptoms. Occupational class differences may be attributable to differences in work and family characteristics,[35] in health behaviors such as smoking and drinking which are associated with poorer sleep,[1] or to socioeconomic inequalities in physical and mental health, which have both been prospectively associated with later insomnia.[13-14,22] Alternatively, people with consistently poor sleep may have experienced daytime fatigue, impairing work performance and making it difficult to obtain or retain higher status jobs. Respondents in manual classes were also more likely to be in the *Developing* class than those in nonmanual classes. Previous 12-mo incidence studies[13,22] found no SES differences, but this may have been due to the shorter follow-up period. Because occupational class preceded the development of symptoms in our analysis, this finding is broadly supportive of a causal role for occupational class, though the assumption that the *Developing* class is primarily made up of incident cases may be questionable; some may be relapsing after prolonged remission.

Respondents in the 1930s cohort were more likely than those in the 1950s cohort to experience *Chronic Mixed* or *Developing* relative to *Healthy* sleep patterns. Effects for the *Chronic Mixed* class were stronger in women, and for the *Developing* class were evident in men only. Because respondents in the same cohort were approximately the same age, these cohort differences could either be interpreted as differences in the patterning of insomnia symptoms with increasing age or as differences between birth cohorts, the former being consistent with conclusions from previous research that the prevalence of insomnia symptoms increases with age.[1] We suggest this may be underpinned by the persistence of (prior) insomnia into later years in some, plus the emergence of other incident new cases. Comparison between interviews where respondents were the same age suggested a lower prevalence of symptoms in the older cohort. Unless this is due to question wording or attrition this finding suggests that age differences may be underestimated due to an opposing cohort effect.

The common finding of poorer sleep among women[17,20-21,35] is replicated here, and is extended to show patterns of poorer sleep across the life course. Women appear more likely than men to develop insomnia symptoms in middle age (i.e. mid-30s to mid-50s), and then to retain the disadvantage as chronic symptoms in old age (i.e. mid-50s to mid-70s). This is consistent with meta-analytical findings that sex differences in insomnia increase with age.[17] Other studies have shown the effect of sex to be attenuated but not fully explained by adjustment for socioeconomic disadvantage,[20-21] and our findings concur, with distinct effects for both sex and occupational class. Biologic factors may also contribute to sex differences; the menopause transition, for example, is associated with deleterious effects on sleeping patterns.[36] This would be consistent with our observation of high risk for women developing symptoms as they move into their 50s. However, insomnia symptoms around menopause could be attributable to other experiences common to women in midlife such as the development of acute and chronic health conditions or life stresses with associated increases in depression.[37-38]

This study has various limitations. First, it examines a fairly restricted range of insomnia symptoms; no measures of daytime consequences of sleep disturbance or dissatisfaction with sleep were used.[1] The change in question wording meant that respondents were asked about their symptoms generally in the first 3 interviews, and then specifically about symptoms in the past month for the last 2 interviews. If people respond differently based on the timeframe of the question then this could result in spurious developmental patterns, but a parallel analysis of another question on sleep that was consistently worded revealed similar findings to those presented. There may also be some unaddressed heterogeneity in the severity of symptoms reported: symptoms reported could have been anything from nightly to weekly sleeping trouble. Moreover, self- reporting biases by variables of interest may have been present; other research has shown males with insomnia to be more likely to over-report sleep disturbance than women with insomnia,[39] which could mean the sex differences observed here are underestimated. Small studies of sleep quality using objective measurement provide mixed support for these findings with poorer sleep for those in socioeconomic disadvantage,[40-41] but either no sex differences or better sleep quality for women.[39,42-43] Furthermore, the data were based on repeated snapshots rather than complete histories and so symptoms were not necessarily stable between interviews and might have been experienced prior to baseline data collection. Differential drop-out may also have introduced some bias. For example, if those who recovered from baseline symptoms were more likely to participate in later waves than those who did not recover, then levels of chronicity may have been underestimated. Finally, if occupational class has a causal relationship with insomnia, then observed effects here will have been diluted as some respondents from the manual group will have moved into nonmanual occupations over time (and thus experienced better sleep than those remaining in manual occupations) and *vice versa*.

In conclusion, 4 main patterns of insomnia symptoms over a 20-yr period have been shown among middle-aged and older adults: a healthy pattern; an episodic pattern characterized by problems maintaining sleep; a more chronic pattern with trouble both maintaining and initiating sleep; and a pattern of developing sleep symptoms. Experience of these different longitudinal patterns was stratified by social factors, namely age, sex, and occupational class.

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DISCLOSURE STATEMENT

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Part I: Determining the Number of Classes

The objective at this stage was to find the latent class model that best represented the data, i.e., striking a balance between maximization of model fit and keeping the number of latent classes low (maximizing parsimony). A sequence of latent class models with ascending numbers of latent classes were computed in each cohort, and their model-fit statistics were compared to decide on the most appropriate number of classes (see Table S1). Model fit was assessed using the likelihood ratio χ^2 statistic, the Akaike Information Criterion (AIC),[1] and the Bayesian Information Criterion (BIC).[2] Lower values for the χ^2 likelihood ratio indicate improvements in model fit, and lower values for AIC and BIC suggest a more optimal balance between model fit and model parsimony. To check model identification 100 different sets of random start values were used for each latent class model. Where the best-fitting solution occurs with a high frequency (e.g., 100 times), then there can be greater confidence that the solution represents a global rather than a local maximization of model fit. We also examined entropy,[3] which indicates how distinctly respondents are being classified into latent classes by the models. Values closer to 1 are preferred as they suggest that respondents are being more definitively classified by the model. We stopped at 7 latent classes as model parsimony (measured by the BIC) and identification were clearly deteriorating with additional classes instead of improving.

In both cohorts, additional classes were at first associated with large increases in model fit (signified by large decreases in the χ^2, AIC, and BIC statistics). However, the improvement lessened with each additional class and the BIC, which offers the more stringent balance of model fit against parsimony, began to increase after a low at 4 classes. Model identification also decreased after 4 classes, suggesting that there can be less confidence in solutions that used greater numbers of classes. An increase from 4 to 5 classes, while only associated with a small rise in the BIC, also only offered a very marginal gain in terms of entropy. Taking all of these findings into consideration, the 4-class solution was seen as the best-fitting model. As this optimal 4-class model exhibited a very similar pattern of response probabilities in each cohort, it was thought sensible to combine the 2 cohorts so that statistical comparisons of latent class membership probabilities could be made between cohorts (see supplementary information, part II). As the models with more than 4 classes produced patterns of response probabilities with substantive differences between cohorts and were not well identified, models of both cohorts with more than 4 latent classes were not preferred despite increases in model fit.

Part II: Testing for Measurement Invariance Across Sex, Occupational Class, and Cohort Groups

After establishing that the 4-class model provided the best fit to the data, we then investigated covariate effects. The most

Table S1—Comparison of fit statistics and identification for models with different numbers of latent classes

No. of classes	Likelihood ratio χ^2	Degrees of freedom[a]	AIC	BIC	Identification[b]	Entropy
1950s Cohort (n = 1,383)						
1	1,822.32	993	12,368.10	12,420.42	100	1.00
2	1,054.01	998	10,925.19	11,035.07	100	0.72
3	803.26	983	10,731.08	10,898.50	96	0.67
4	723.23	974	10,655.01	10,879.98	83	0.64
5	656.97	962	10,610.82	10,893.36	10	0.68
6	606.19	950	10,585.01	10,925.09	8	0.70
7	582.27	941	10,565.52	10,963.15	3	0.72
1930s Cohort (n = 1,484)						
1	2,381.79	1,004	12,775.72	12,828.74	100	1.00
2	1,100.25	989	11,405.72	11,517.07	100	0.72
3	849.24	978	11,175.93	11,345.61	46	0.65
4	691.80	969	11,020.28	11,248.28	94	0.58
5	626.56	959	10,976.90	11,263.23	62	0.59
6	589.88	948	10,960.27	11,304.94	32	0.58
7	561.49	939	10,951.08	11,354.07	1	0.60
Both Cohorts (n = 2,867)						
2	2,307.41	2,009	26,404.51	26,541.61	100	0.85
3	1,719.48	1,993	25,871.82	26,080.45	99	0.79
4	1,496.30	1,985	25,643.75	25,923.92	99	0.73
5	1,398.77	1,975	25,552.08	25,903.78	33	0.74

[a]These values do not descend uniformly with the number of classes because between 4 and 20 cells in each latent class indicator table were deleted in the calculation of the chi-square due to extreme values. [b]Indicates how many times the best-fitting solution was found using 100 different sets of random starting values. AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion.

Table S2—Comparison of model fit statistics for variant and invariant latent class models across sex, occupational class, and cohort groupings

Model (n = 2,867)	Likelihood ratio χ^2	Degrees of freedom	P value	AIC	BIC	Identification[a]	Entropy
Sex							
Variant	1,389.75	1,945	–	25,661.81	26,180.41	53	0.74
Invariant	1,470.16	1,985	–	25,663.02	25,943.18	91	0.73
Difference	+80.41	+40	< 0.01	+1.21	-237.23	+38	-0.01
Occupational Class							
Variant	1,393.25	1,945	–	25,558.11	26,076.72	73	0.73
Invariant	1,442.63	1,984	–	25,531.29	25,811.46	92	0.73
Difference	+49.38	+39	< 0.01	-26.82	-265.26	+19	0.00
Cohort							
Variant	1,415.03	1,943	–	25,648.23	26,166.84	61	0.74
Invariant	1,496.30	1,985	–	25,643.75	25,923.92	99	0.73
Difference	+81.27	+42	< 0.01	-4.48	-242.92	+38	-0.01
Cross-Classified Sex, Class, and Cohort Groupings							
Variant	2,235.43	7,792	–	33,372.18	35,464.50	1	0.87
Invariant	2,753.79	8,081	–	33,278.54	33,701.77	97	0.84
Difference	+518.36	+289	< 0.01	-93.64	-1,762.73	+96	-0.03

[a]Indicates how many times the best-fitting solution was found using 100 different sets of random starting values. AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion.

parsimonious covariate model will be one in which the covariates influence class membership only, and not the probability of responses given class membership.[4] Such a condition is referred to as measurement invariance because the latent class definitions are constant across all levels of the covariates; that is, a latent class means the same thing for 1 group as it does for others. Measurement invariance indicates that different groups experience similar rather than entirely different latent class patterns.

Measurement invariance can be formally tested for by comparing a model where response probabilities for latent classes can vary across covariate groupings (the variant model) with a nested model where response probabilities for latent classes are constrained to be equal across covariate groupings (the invariant model). This is a sensitive test, however, and it may indicate that differences are statistically significant where they make little substantive difference to the interpretation of the latent classes. For this reason it is important to examine not only the outcome of this test, but also other model-fit statistics and the response probabilities for the latent classes from both models. Where measurement invariance is statistically significant, but does not alter the substantive interpretation of the classes, it can be more parsimonious to impose measurement invariance anyway, allowing for like-for-like comparisons of class membership probabilities.[4]

Table S2 displays fit statistics and chi-square difference tests for variant and invariant models across sex, occupational class, and cohort groupings, and also for a cross-classification identifying the 8 possible unique combinations of these variables. Each pair of models was tested on the whole sample (i.e., both cohorts). In each case the chi-square test showed significant group differences in response probabilities for latent classes. Inspection of the response probability estimates, however, revealed latent class patterns that were very similar and did not differ markedly in terms of interpretation (results not shown). Additionally, the invariant model was in each case better identified and had lower BIC values and the AIC was lower in most cases. Allowing response probabilities to vary across covariate groupings did not produce large improvements in the classification of respondents as indicated by the entropy statistic. Overall, it was thought that group differences were minor and imposing measurement invariance gained more in terms of parsimony than was lost in accuracy, or model fit. Particularly, this meant that like-for-like statistical comparisons could be made of latent class membership by sex, occupational class, and cohort.

Part III: Separate Modeling of Different Insomnia Symptom Questions

Table S3 displays information on model fit from models with 2, 3, and 4 classes for each of the sleep variables. In each case the 3-class model has the lowest value for the BIC, representing an optimal balance of model fit and parsimony.

Figure S1 shows the item-response probabilities for the 3-class model of each variable. As the difficulty sleeping question does not distinguish between problems with latency and maintenance, it was thought better to compare it with the 2 separate models of latency and maintenance symptoms rather than the combined model. Each of the 3 models shows classes similar to the *Developing, Chronic Mixed,* and *Healthy* classes shown in the main results. For the question on difficulty sleeping, the increase in the probability of a positive response over the study in the *Developing* pattern shows a smoother gradient than for the 2 variables where the question wording changed, but is notably still present. This suggests that the change in question wording may have accentuated the incline in symptom patterns, but that the incline is nevertheless genuine and not an artefact of question wording.

Table S3—Comparison of fit statistics and identification for models of different insomnia symptom questions

No. of classes	Likelihood ratio χ^2	Degrees of freedom	AIC	BIC	Identification[a]	Entropy
Latency (n = 2,866)						
2	161.27	20	10,376.75	10,466.16	100	0.66
3	45.82	14	10,210.03	10,359.05	82	0.56
4	13.55	8	10,186.22	10,394.85	56	0.59
Maintenance (n = 2,867)						
2	126.17	20	12,548.15	12,637.56	100	0.53
3	28.12	14	12,419.76	12,568.78	90	0.51
4	13.07	8	12,410.96	12,619.60	66	0.57
Difficulty sleeping (n = 2,924)						
2	98.43	20	12,163.62	12,253.33	100	0.59
3	62.27	14	12,100.46	12,249.98	63	0.51
4	25.07	8	12,052.32	12,261.64	59	0.49

[a]Indicates how many times the best-fitting solution was found using 100 different sets of random starting values. AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion.

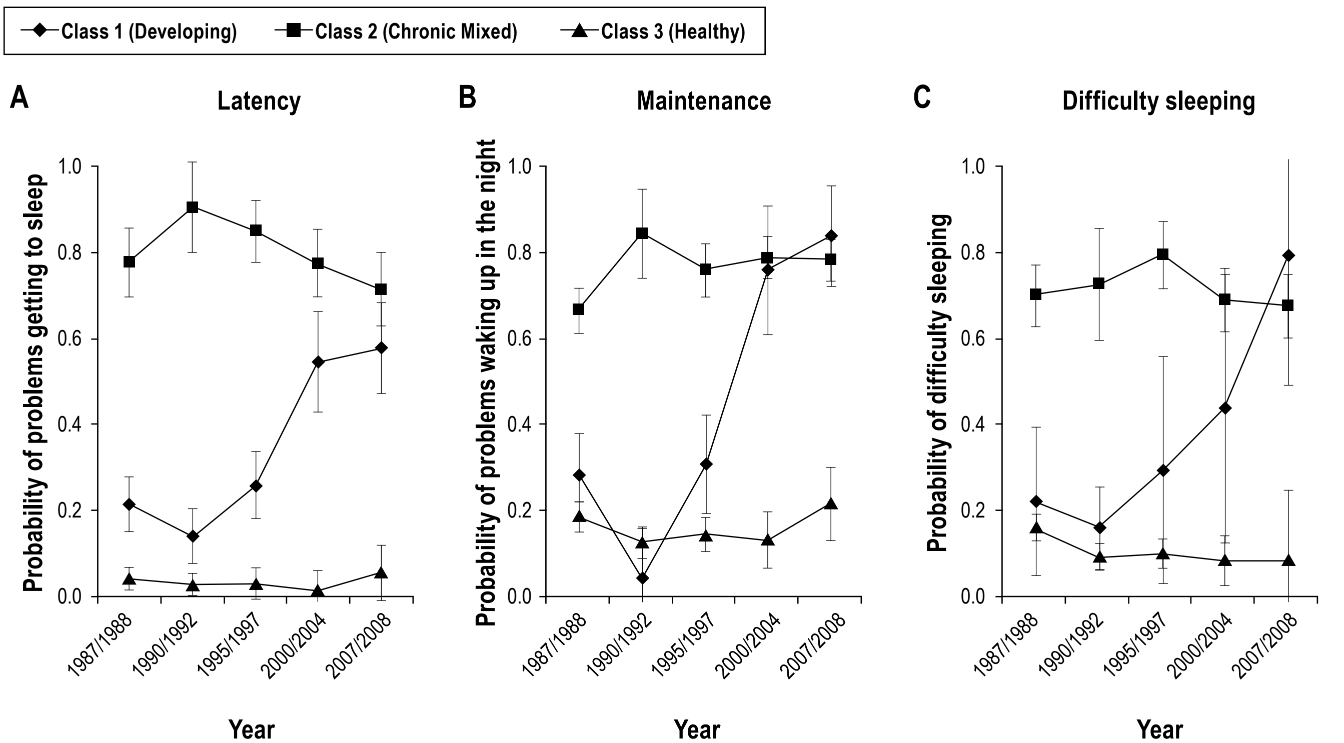

Figure S1—Response probabilities from separate 3-class models of each insomnia symptom question.

Table S4 compares the overall latent class membership probabilities and logistic regression effects of covariates in each of these 3 models. Some degree of variation would be expected here as those who would have been assigned to the *Episodic Maintenance* class in the main results will have been reclassified into other classes, affecting both membership probabilities and estimates of odds ratios. The membership probabilities for the maintenance and difficulty sleeping variables, however, did exhibit similar patterns, and covariate effects were also fairly consistent across all 3 models. Notably, the propensity for women to be in the *Developing* rather than the *Healthy* sleep class (relative to men) was consistent and significant across all models, as was the tendency for those in manual relative to nonmanual classes to be in the *Chronic Mixed* rather than the *Healthy* sleep class. Almost all of the other effects that were not significant for the question on difficulty sleeping were also not significant in either the latency-only or the maintenance-only model. These differences may therefore have more to do with only modeling a single dimension of sleep disturbance than with consistency in question wording.

Table S4—Comparison of class membership probabilities and covariate effects for different insomnia symptom questions

	Latency		Maintenance		Difficulty Sleeping	
	Value	95% Confidence intervals	Value	95% Confidence intervals	Value	95% Confidence intervals
Class membership probabilities						
Developing	0.40	–	0.24	–	0.20	–
Chronic	0.19	–	0.35	–	0.28	–
Healthy	0.41	–	0.41	–	0.52	–
Odds ratios for covariates						
Developing (ref: Healthy)						
Female (ref: Male)	3.34	(2.11-5.29)	5.13	(2.85-9.26)	5.21	(1.95-13.94)
Manual (ref: Non-Manual)	2.06	(1.49-2.85)	1.43	(0.90-2.27)	0.99	(0.40-2.43)
1930s Cohort (ref: 1950s)	1.98	(1.21-3.25)	3.24	(1.71-6.13)	1.23	(0.44-3.44)
Female*1930s Cohort	0.87	(0.42-1.83)	0.19	(0.08-0.44)	0.47	(0.13-1.64)
Chronic (ref: Healthy)						
Female (ref: Male)	0.99	(0.61-1.61)	1.61	(1.06-2.43)	1.40	(0.71-2.77)
Manual (ref: Non-Manual)	3.35	(2.50-4.50)	2.09	(1.63-2.66)	1.69	(1.33-2.15)
1930s Cohort (ref: 1950s)	1.30	(0.90-1.89)	2.04	(1.43-2.92)	1.16	(0.83-1.62)
Female*1930s Cohort	3.89	(2.16-7.02)	1.10	(0.64-1.89)	1.82	(0.93-3.57)

Expected differences aside, the data from the question on difficulty sleeping, which was consistently defined across the study, produces an overall pattern of results similar to those obtained by using the questions on maintenance and latency, which were not consistently worded. This suggests that the effect of the change in question wording was minor and that the observed results are reflective of actual population sleep patterns rather than artefacts of measurement.

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