

Night-shift frequency and loneliness among NHS employees: a multi-site cross-sectional analysis of the INTERACT study

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Abstract

Background

Night work is fundamental to continuous healthcare delivery but may disrupt biological rhythms and participation in social and family life. Although shift work has been extensively studied in relation to sleep, fatigue, cardiovascular health and mental wellbeing, loneliness has received substantially less attention as a potential occupational-health outcome. We examined whether increasing monthly night-shift frequency was associated with loneliness among National Health Service (NHS) employees and explored whether social interaction frequency, social fulfilment, work-life balance and emotional exhaustion were associated with this relationship.

Methods

We conducted a secondary cross-sectional analysis of a multi-site online survey undertaken within the Measuring Loneliness in England (INTERACT) study. Monthly night-shift frequency was categorised as 0, 1–2, 3–5 and ≥ 6 shifts and analysed as an ordered exposure. The primary outcome was the three-item UCLA Loneliness Scale (range 3–9). Multivariable linear regression with HC3 heteroskedasticity-robust standard errors estimated the mean change in loneliness per one-category increase in night-shift frequency. The principal model adjusted for age, gender, study site, survey month, occupational group, department, NHS tenure, weekly working hours, overtime and employment status. Secondary ordered logistic models examined a direct loneliness item and an ordinal specification of the UCLA-3 score. Exploratory pathway analyses used coefficient-product estimates with bootstrap confidence intervals.

Results

The fully adjusted analytical sample comprised 809 NHS employees: 535 (66.1%) reported no night shifts, 36 (4.4%) 1–2 shifts, 101 (12.5%) 3–5 shifts and 137 (16.9%) ≥ 6 shifts per month. Mean UCLA-3 loneliness was 5.41 (SD 1.97) overall and 5.19, 5.94, 5.62 and 5.95 across increasing night-shift categories. In the fully adjusted model, each one-category increase in night-shift frequency was associated with a 0.211-point higher UCLA-3 score (95% CI 0.055 to 0.368; $P = 0.008$). Associations were directionally consistent when UCLA-3 was treated as an ordered outcome (OR 1.23, 95% CI 1.06 to 1.42; $P = 0.005$) and for the direct loneliness measure (OR 1.16, 95% CI 1.00 to 1.35; $P = 0.050$). However, the global proportional-odds test indicated departure from this assumption for the ordinal UCLA-3 model ($P = 0.022$), warranting cautious interpretation. Exploratory coefficient-product estimates, calculated without adjustment for multiple comparisons, had confidence intervals excluding zero for lower social fulfilment (0.085, 95% bootstrap CI 0.002 to 0.167) and poorer work-life balance (0.097, 95% bootstrap CI 0.038 to 0.161), but not for social-interaction frequency or emotional exhaustion; because all variables were measured contemporaneously, these estimates should not be interpreted as causal indirect effects.

Conclusions

Greater night-shift frequency was associated with higher loneliness among participating NHS employees after adjustment for demographic and occupational characteristics. Exploratory findings identified work-life balance and social fulfilment as candidate constructs for longitudinal investigation; they do not establish their relative importance or causal roles. Because the design is cross-sectional and the sample volunteer-based, the findings do not establish causality or population prevalence. Longitudinal studies using objectively recorded rosters and repeated measures of social wellbeing are needed to establish temporal relationships and identify modifiable organisational factors.

Introduction

Loneliness is a subjective and distressing experience that arises when a person's actual social relationships are perceived as falling short of those they want or need. It is conceptually distinct from objective social isolation: a person may have frequent contact yet experience insufficient closeness, belonging or relational quality, while another person with a smaller network may not feel lonely. Contemporary public-health frameworks therefore treat social connection as multidimensional, encompassing structural, functional and qualitative aspects of relationships [30]. The World Health Organization (WHO) Commission on Social Connection has identified loneliness and social isolation as major, under-recognised determinants of health and wellbeing and estimated that approximately one in six people globally experience loneliness [1].

The health significance of loneliness is supported by a substantial observational literature. In a meta-analysis of 70 prospective studies, loneliness was associated with 26% higher odds of mortality after adjustment for relevant covariates [2]. More recent synthesis has reinforced the importance of social connection as an independent correlate and potential determinant of mental and physical health [30]. In England, the INTERACT study was established to characterise loneliness, social connection and related contextual factors across a large volunteer sample spanning the adult life course [3]. Its initial national report described substantial loneliness among respondents while explicitly cautioning that the volunteer-based, non-probability sample should not be used to estimate population prevalence [3].

Employment is one of the principal settings in which social relationships are formed and maintained, but work can also constrain social participation. This tension is particularly salient in healthcare. Twenty-four-hour service provision requires many staff to work during evenings, nights and weekends, often in rotating or irregular patterns. The occupational-health consequences of shift work are well documented. Night and rotating shifts disrupt sleep timing and duration, create circadian misalignment and can increase fatigue [7]. Systematic reviews and meta-analyses have linked shift work with poorer mental health [8] [9], vascular events [10] and cardiovascular disease [11]. Among healthcare workers specifically, 20–30% of shift workers may experience prominent insomnia or excessive sleepiness consistent with shift-work disorder, although individual vulnerability varies [12].

The consequences of night work are not confined to sleep or physiology since night work also changes when workers are available to participate in family, friendship and community life. Danish intensive-care nurses reported that shift work constrained leisure activities and that some evening- and night-shift workers experienced social isolation [13]. Research among Greek nursing personnel identified social and domestic disruption as an important component of shift-work burden, particularly among workers with family responsibilities [14]. Qualitative interviews with night nurses similarly described strain on relationships, childcare arrangements and time with family and friends [15]. A systematic review of shift work and work-family conflict concluded that shift workers generally experience greater conflict than employees on regular daytime schedules, with night and weekend work especially implicated [16]. In a multi-site study of 1,563 hospital employees, night work remained associated with greater chronic fatigue and lower satisfaction with time available for daily tasks and family or social life after adjustment for other factors [17]. These observations provide a plausible basis for considering loneliness as a distinct outcome of night work. Yet loneliness has rarely been treated as the primary endpoint in shift-work research. The literature instead tends to focus on sleep, fatigue, burnout, depression, work-family conflict and job satisfaction. This gap matters because loneliness is not reducible to the amount of social contact.

A developing literature on healthcare workers suggests that relational features of work may matter. Workplace loneliness in nurses is associated with lower-quality leader-member exchange, reduced communication, lower trust and reduced work meaningfulness [19]. An integrative review identified consistent interconnections between loneliness, social support and burnout in nursing [20], while mixed-methods research during the COVID-19 period described loneliness and burnout as positively correlated and highlighted the perceived protective value of peer connection [21]. Longitudinal evidence has subsequently suggested that loneliness, insomnia and dimensions of burnout may be dynamically related over time [22]. In UK healthcare workers, loneliness and workplace isolation were cross-sectionally associated with lower wellbeing [23]. Most recently, a large Finnish nursing survey found workplace loneliness associated with adverse psychosocial work characteristics and burnout [24].

The NHS context makes this question particularly relevant. The 2025 national NHS Staff Survey continued to show substantial burnout across NHS trusts, with 31.5% of respondents reporting that they often or always felt burnt out because of their work [25]. Although those measures are not equivalent to loneliness, they emphasise the broader importance of understanding how working arrangements interact with staff wellbeing. Working-time research in healthcare also indicates that unhealthy schedules can affect employee health and may have implications for patient safety [18]. A better understanding of the social consequences of night work could therefore add a missing dimension to workforce-health research without assuming that night work itself can be removed from services that require continuous staffing.

The present study used data from NHS employees participating in INTERACT to examine whether monthly night-shift frequency was associated with loneliness. The primary hypothesis was that loneliness would increase across ordered categories of night-shift frequency. Secondary analyses

examined whether the direction of association was consistent using the ONS-style direct loneliness item and an ordinal specification of the UCLA-3 score. Exploratory analyses examined social interaction frequency, social fulfilment, work-life balance and emotional exhaustion as candidate pathways. We anticipated that the distinction between the frequency and perceived fulfilment of social contact could be particularly informative: if social disruption contributes to the observed association, the quality and compatibility of social life may matter more than the number of social encounters alone.

Methods

Study design and reporting

This study was a secondary cross-sectional analysis of a Qualtrics online survey of NHS employees recruited across participating sites from 15 April 2025 to 13 August 2026 within the INTERACT research programme. Participation was voluntary and non-probability based. The individual employee was the unit of analysis. The parent INTERACT study is a large observational programme designed to assess loneliness and social connection in England; its overall design, national recruitment approach and survey instrument are reported elsewhere [3]. In the NHS staff survey, IP addresses were not collected, and cookies were used to restrict repeat submissions from the same browser. No completion-time flags or time-based exclusion criteria were applied. The present paper focuses specifically on the NHS employee subset and on night-shift exposure. Reporting was informed by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cross-sectional studies [26]. The NHS staff reference questionnaire and analytical documentation are provided in **Supplementary Files 1–2**, with CHERRIES, STROBE and CROSS checklists in **Supplementary Files 3–5**.

Source population and analytical sample

The source dataset contained 911 NHS employees, of whom 904 had provided consent and 818 were classified as survey completers in the source data. No incentives were offered for participation. Survey-completer status was not used as an eligibility criterion for this secondary analysis; consented participants were eligible when monthly night-shift frequency and all three UCLA-3 items were available, yielding 831 participants before exclusions for missing covariate data. The primary analytical sample comprised 809 participants with complete information for night-shift frequency, the three UCLA loneliness items and all prespecified covariates in the fully adjusted model. The analytical sample size was determined by the number of available records meeting these criteria. This complete-case definition was specified in the analysis plan. Participant denominators are reported for all models and tables.

Survey measures

The NHS staff survey captured age, gender, study site, NHS occupational role, department, NHS tenure, weekly working hours, monthly overtime, employment status and a range of additional social and

demographic characteristics. The analytical site variable comprised three recruitment strata (Imperial College Healthcare NHS Trust (ICHT), Hull University Teaching Hospitals NHS Trust (HUHNT) and the South Central Ambulance Service (SCAS)); Table 1). Respondents from SCAS were either from the (i) NHS 111 Call Centre, (ii) 999 Call Centre, (iii) Ambulance Call Centre, (iv) the Corporate Team or (v) Transport Team. The primary adjusted model, role and department were analysed using the grouped categories shown in Table 1. The survey also included marital status, household composition, dependent-child status, ethnicity, education and long-term health status; these variables were not included in the prespecified primary model, although they could plausibly relate to both night-shift selection and loneliness.

Exposure: monthly night-shift frequency

Participants reported how many night shifts they worked per month. The response options were four categories: 0, 1–2, 3–5 and ≥ 6 night shifts. For the principal model these categories were coded 0, 1, 2 and 3 and analysed as a single ordinal exposure. The corresponding regression coefficient therefore estimates the average change in loneliness associated with moving one category higher in night-shift frequency. It does not estimate the effect of one additional night shift, although the model assumes an equal score increment between successive categories despite their unequal widths in actual shifts.

Primary outcome: three-item UCLA loneliness score

The primary outcome was the three-item UCLA Loneliness Scale (UCLA-3), a brief measure developed for large surveys [5] and derived from the wider UCLA Loneliness Scale family [6]. Participants were asked how often they felt that they lacked companionship, felt left out and felt isolated from others. Each item was scored from 1 to 3 and summed to a total score from 3 to 9, with higher values indicating greater loneliness. Office for National Statistics (ONS) guidance recommends use of the three indirect items together with a direct loneliness question where survey space permits [4]. In the analytical sample, all three component items were required to calculate the score.

Secondary loneliness outcome

Participants also answered the ONS direct measure of loneliness (DMOL), 'How often do you feel lonely?', using five ordered response categories: never, hardly ever, occasionally, some of the time, and often or always. This item was analysed as an ordered outcome in a secondary model. The direct item was treated as complementary rather than interchangeable with the UCLA-3 because direct self-identification of loneliness and indirect relational items can capture somewhat different facets of the construct [4] [5].

Exploratory pathway variables

Four candidate pathway variables were specified: social-interaction frequency, social fulfilment and work-life-balance satisfaction, each scored from 0 to 3, and a three-item emotional-exhaustion score, scored from 3 to 18. Higher scores indicated more frequent interaction, greater fulfilment, better work-life balance and greater emotional exhaustion, respectively. The emotional-exhaustion score summed the three Q19 items on feeling emotionally drained, used up at the end of the workday and burned out from work; each used six response categories scored 1–6. The composite was calculated only when all three items were completed; participants with any missing component item were assigned a missing composite score. Internal consistency was high (Cronbach's $\alpha = 0.918$). The item wording and response options are reproduced in **Supplementary File 1**. The pathway analyses were intentionally exploratory. Because night-shift exposure, pathway variables and loneliness were measured contemporaneously, temporal precedence could not be established. Cross-sectional coefficient-product analyses can generate misleading estimates of longitudinal mediation [27]; accordingly, these analyses are described as statistical pathway or decomposition analyses and not as evidence of causal mediation.

Covariates

The first adjusted model included age, gender, study site and survey month. The fully adjusted principal model additionally included occupational group, department, NHS tenure, weekly working hours, monthly overtime and employment status. Covariates were chosen before the principal modelling stage to address demographic, temporal and occupational differences that were plausibly related to both shift pattern and loneliness. No automated variable-selection procedure was used.

Statistical analysis

Participant characteristics and principal survey measures were summarised overall and by night-shift category using mean and standard deviation or frequency and percentage, as appropriate. These descriptive comparisons were not interpreted as adjusted effects. The primary outcome was analysed using multivariable linear regression with HC3 heteroskedasticity-robust standard errors. Three models were fitted: an unadjusted model; a model adjusted for age, gender, study site and survey month; and a fully adjusted model that additionally included occupational group, department, NHS tenure, weekly working hours, overtime and employment status. The fully adjusted model was the principal inferential model. Effect estimates are presented with 95% confidence intervals (CIs), P values, analytical sample size and model fit.

Secondary and sensitivity analyses

The direct five-category loneliness item and the ordinal UCLA-3 score were analysed using ordered logistic regression with robust standard errors, and the proportional-odds assumption was assessed separately for each model using an approximate likelihood-ratio test. In a sensitivity analysis, night-shift frequency was entered as a nominal categorical exposure in the fully adjusted linear model. Adjusted mean differences for 1–2, 3–5 and ≥ 6 monthly night shifts were estimated against the no-night-shift

reference group, and the exposure terms were assessed jointly using a Wald test. These analyses were used to assess sensitivity to outcome and exposure specifications and did not replace the primary linear-model estimate.

Exploratory pathway analyses

Each candidate pathway was examined separately. The adjusted association of night-shift category with the pathway variable was denoted as the *a* path, and the association of the pathway variable with loneliness conditional on night-shift category was denoted the *b* path. The product *a* x *b* was reported as an exploratory coefficient-product estimate. Percentile CIs for the product were obtained from up to 2,000 valid bootstrap replications. The percentage attenuation of the night-shift coefficient after including each pathway was also reported, using the corresponding model without that pathway in the same complete-case sample as the reference. A final model included all four pathway variables simultaneously among participants with complete data for all four. Confidence intervals were not adjusted for multiple comparisons. Given the cross-sectional design, the sign, magnitude and attenuation patterns were interpreted descriptively and not as causal mediation [27].

Missing data and statistical software

The primary analysis used complete cases. Of the 831 records with exposure and UCLA-3 data, 22 (2.6%) lacked at least one primary-model covariate. Model-specific denominators are reported; item counts within the primary sample are in **Supplementary File 2, Table S4**. These counts do not describe missingness in records excluded before the primary sample was formed. The analysis plan stated that multiple imputation could be considered if the missing-data pattern was judged likely to materially affect inference; no multiple-imputation analysis is reported here. Analyses were conducted in StataNow 19.5 MP.

Ethics and consent

The Measuring Loneliness (INTERACT) study received a favourable opinion from the East of England – Essex Research Ethics Committee (REC reference 21/EE/0272; IRAS ID 305483) [29]. Participants provided electronic consent through the survey consent item; only consented records were eligible for this analysis. The parent INTERACT publication describes pseudonymised data handling and conformity with the Declaration of Helsinki [3]. The NHS staff instrument requested home postcodes and optional contact details for interview follow-up; these fields are excluded from the reported response distributions (**Supplementary Files 1–2**).

Results

Participant flow and night-shift exposure

The source dataset contained 911 NHS employees; 904 had provided consent and 818 were classified as survey completers (**Supplementary File 2, Figure S1**). Night-shift frequency and all three UCLA-3

items were available for 831 participants, and 809 had complete information for every variable in the fully adjusted primary model, excluding 22 (2.6%) of the 831 for missing covariate data. Among these 809 participants, 535 (66.1%) reported no night shifts per month, 36 (4.4%) reported 1–2 shifts, 101 (12.5%) reported 3–5 shifts and 137 (16.9%) reported ≥ 6 shifts (Table 1).

Participant characteristics

The mean age of the analytical sample was 43.9 years (SD 12.3; range 18–79), and 598 (73.9%) participants were women. Participants differed substantially across night-shift categories in age, site, occupational composition, department and working pattern (Table 1). Mean age was 45.9 years among employees reporting no nights and ranged from 37.6 to 40.7 years across the night-working groups. Emergency-department staff represented 10.7% of the no-night group compared with 50.0% of the 1–2 group, 58.4% of the 3–5 group and 59.9% of the ≥ 6 group. The proportion working more than 40 hours per week was 13.8% in the no-night group and 30.7% in the ≥ 6 group. Similarly, 89.8% of the ≥ 6 group worked full time compared with 72.1% of the no-night group. These imbalances motivated multivariable adjustment and mean that the unadjusted group summaries should not be read as causal contrasts.

Table 1
Participant characteristics overall and by monthly night-shift frequency.

Characteristic	Overall N = 809	0 n = 535	1-2 n = 36	3-5 n = 101	≥ 6n = 137
Age, years	43.9 (12.3)	45.9 (12.1)	37.6 (10.2)	39.5 (10.9)	40.7 (12.7)
Gender					
Man/Male	203 (25.1%)	105 (19.6%)	9 (25.0%)	32 (31.7%)	57 (41.6%)
Woman/Female	598 (73.9%)	424 (79.3%)	27 (75.0%)	68 (67.3%)	79 (57.7%)
Gender-diverse/prefer not	8 (1.0%)	6 (1.1%)	0 (0.0%)	1 (1.0%)	1 (0.7%)
Study site					
Hull	381 (47.1%)	330 (61.7%)	6 (16.7%)	12 (11.9%)	33 (24.1%)
ICHT	89 (11.0%)	69 (12.9%)	3 (8.3%)	8 (7.9%)	9 (6.6%)
SCAS 111	104 (12.9%)	62 (11.6%)	8 (22.2%)	23 (22.8%)	11 (8.0%)
SCAS 999	38 (4.7%)	8 (1.5%)	3 (8.3%)	4 (4.0%)	23 (16.8%)
SCAS Ambulance	155 (19.2%)	30 (5.6%)	14 (38.9%)	50 (49.5%)	61 (44.5%)
SCAS Corporate	32 (4.0%)	29 (5.4%)	2 (5.6%)	1 (1.0%)	0 (0.0%)
SCAS Transport	10 (1.2%)	7 (1.3%)	0 (0.0%)	3 (3.0%)	0 (0.0%)
Occupational group					
Administrative/managerial	204 (25.2%)	176 (32.9%)	7 (19.4%)	9 (8.9%)	12 (8.8%)
Core clinical	353 (43.6%)	229 (42.8%)	15 (41.7%)	45 (44.6%)	64 (46.7%)
Support staff	16 (2.0%)	13 (2.4%)	0 (0.0%)	1 (1.0%)	2 (1.5%)
Other role	236 (29.2%)	117 (21.9%)	14 (38.9%)	46 (45.5%)	59 (43.1%)
Department					
Administration/research	141 (17.4%)	135 (25.2%)	1 (2.8%)	1 (1.0%)	4 (2.9%)

Characteristic	Overall N = 809	0 n = 535	1-2 n = 36	3-5 n = 101	≥ 6n = 137
Emergency	216 (26.7%)	57 (10.7%)	18 (50.0%)	59 (58.4%)	82 (59.9%)
Other clinical	197 (24.4%)	164 (30.7%)	5 (13.9%)	11 (10.9%)	17 (12.4%)
Other department	255 (31.5%)	179 (33.5%)	12 (33.3%)	30 (29.7%)	34 (24.8%)
NHS tenure					
1–3 years	105 (13.0%)	59 (11.0%)	5 (13.9%)	21 (20.8%)	20 (14.6%)
3–5 years	114 (14.1%)	65 (12.1%)	7 (19.4%)	18 (17.8%)	24 (17.5%)
5–10 years	164 (20.3%)	93 (17.4%)	7 (19.4%)	26 (25.7%)	38 (27.7%)
Less than 1 year	50 (6.2%)	37 (6.9%)	2 (5.6%)	4 (4.0%)	7 (5.1%)
More than 10 years	376 (46.5%)	281 (52.5%)	15 (41.7%)	32 (31.7%)	48 (35.0%)
Weekly working hours					
20–30 hours	120 (14.8%)	89 (16.6%)	9 (25.0%)	12 (11.9%)	10 (7.3%)
31–40 hours	497 (61.4%)	329 (61.5%)	20 (55.6%)	66 (65.3%)	82 (59.9%)
Less than 20 hours	50 (6.2%)	43 (8.0%)	3 (8.3%)	1 (1.0%)	3 (2.2%)
> 40 hours	142 (17.6%)	74 (13.8%)	4 (11.1%)	22 (21.8%)	42 (30.7%)
Overtime					
1–5 hours	235 (29.0%)	154 (28.8%)	14 (38.9%)	35 (34.7%)	32 (23.4%)
11–20 hours	82 (10.1%)	37 (6.9%)	4 (11.1%)	12 (11.9%)	29 (21.2%)
6–10 hours	118 (14.6%)	58 (10.8%)	9 (25.0%)	18 (17.8%)	33 (24.1%)
> 20 hours	49 (6.1%)	30 (5.6%)	2 (5.6%)	3 (3.0%)	14 (10.2%)
No overtime	325 (40.2%)	256 (47.9%)	7 (19.4%)	33 (32.7%)	29 (21.2%)
Employment status					

Characteristic	Overall N = 809	0 n = 535	1-2 n = 36	3-5 n = 101	≥ 6n = 137
Full-time	615 (76.0%)	386 (72.1%)	22 (61.1%)	84 (83.2%)	123 (89.8%)
Part-time	172 (21.3%)	130 (24.3%)	13 (36.1%)	16 (15.8%)	13 (9.5%)
Other employment	22 (2.7%)	19 (3.6%)	1 (2.8%)	1 (1.0%)	1 (0.7%)

Values are mean (SD) or n (%). Percentages use non-missing denominators within each night-shift group. All variables shown were included in the fully adjusted primary model, which also included survey month. "Study site" denotes the seven recruitment/service strata shown, rather than seven independent NHS organisations.

Loneliness and related survey findings

The mean UCLA-3 loneliness score was 5.41 (SD 1.97) overall. The unadjusted group means were 5.19 (SD 1.89) among staff reporting no night shifts, 5.94 (SD 1.82) among those reporting 1–2, 5.62 (SD 2.06) among those reporting 3–5 and 5.95 (SD 2.11) among those reporting ≥ 6 night shifts per month (Table 2). The pattern therefore suggested higher loneliness among night-working groups overall but was not strictly monotonic: the small 1-2-shift group had a higher observed mean than the 3-5-shift group.

On the direct loneliness item, 332 of 809 respondents (41.0%) reported feeling lonely 'some of the time', 'often' or 'always'. The corresponding proportion was 37.2% among those reporting no night work and 51.8% among those reporting ≥ 6 night shifts. Individual UCLA items showed a broadly similar pattern: in the ≥ 6 group, 28.5% often lacked companionship, 29.2% often felt left out and 30.7% often felt isolated, compared with 14.8%, 15.0% and 15.0%, respectively, in the no-night group.

Work-life balance showed the clearest graded descriptive pattern across night-shift exposure. Mean work-life balance satisfaction declined from 1.93 in the no-night group to 1.61, 1.48 and 1.31 across the 1–2, 3–5 and ≥ 6 groups. Social fulfilment was lowest among those reporting ≥ 6 night shifts (mean 1.65 compared with 1.92 among non-night workers). In contrast, mean social interaction frequency differed relatively little across categories, ranging from 1.43 to 1.58. Mean emotional exhaustion was 11.44 among non-night workers and 13.00 among those reporting ≥ 6 nights, but the pattern across intermediate categories was not monotonic.

Table 2
Main survey findings overall and by monthly night-shift frequency.

Survey finding	Overall	0	1–2	3–5	≥ 6
Three-item loneliness score, mean (SD)	5.41 (1.97)	5.19 (1.89)	5.94 (1.82)	5.62 (2.06)	5.95 (2.11)
Social interactions outside work, mean (SD)	1.53 (0.93)	1.58 (0.93)	1.44 (0.97)	1.43 (0.92)	1.45 (0.89)
Social fulfilment, mean (SD)	1.86 (0.86)	1.92 (0.85)	1.72 (0.81)	1.88 (0.88)	1.65 (0.87)
Work-life balance satisfaction, mean (SD)	1.75 (0.88)	1.93 (0.79)	1.61 (0.77)	1.48 (0.91)	1.31 (0.98)
Three-item emotional-exhaustion score, mean (SD)	11.82 (4.64)	11.44 (4.66)	12.58 (3.97)	11.96 (4.59)	13.00 (4.57)
Often lacked companionship, n (%)	150 (18.5%)	79 (14.8%)	9 (25.0%)	23 (22.8%)	39 (28.5%)
Often felt left out, n (%)	154 (19.0%)	80 (15.0%)	8 (22.2%)	26 (25.7%)	40 (29.2%)
Often felt isolated, n (%)	153 (18.9%)	80 (15.0%)	8 (22.2%)	23 (22.8%)	42 (30.7%)
Direct loneliness: some of the time/often or always, n (%)	332 (41.0%)	199 (37.2%)	22 (61.1%)	40 (39.6%)	71 (51.8%)

Higher scores indicate greater loneliness, more frequent social interactions, greater social fulfilment, better work-life balance and greater emotional exhaustion, respectively. Group summaries are descriptive and unadjusted. Valid denominators are reported in the order overall, 0, 1–2, 3–5 and ≥ 6 night shifts: UCLA-3, 809/535/36/101/137; social interactions, 808/535/36/101/136; social fulfilment, 808/535/36/101/136; work–life balance, 808/534/36/101/137; and emotional exhaustion, 805/532/36/101/136.

Association between night-shift frequency and loneliness

In the unadjusted linear model, each one-category increase in monthly night-shift frequency was associated with a 0.249-point higher UCLA-3 score (95% CI 0.131 to 0.367; $P < 0.001$; $N = 809$); Table 3. Adjustment for age, gender, study site and survey month did not materially reduce the estimate (beta = 0.257, 95% CI 0.109 to 0.404; $P < 0.001$); Fig. 1.

Table 3

Association between night-shift frequency and loneliness per one-category increase in exposure.

Model	Scale	Estimate	95% CI	P	N	Model fit
Unadjusted linear model	β	0.249	0.131 to 0.367	< 0.001	809	R ² =0.023
Demographic, site and survey-time adjusted	β	0.257	0.109 to 0.404	< 0.001	809	R ² =0.057
Fully adjusted primary linear model	β	0.211	0.055 to 0.368	0.008	809	R ² =0.079
Direct loneliness item, ordered logistic model	OR	1.16	1.00 to 1.35	0.050	809	Pseudo-R ² =0.030
Loneliness score treated as ordered, sensitivity model	OR	1.23	1.06 to 1.42	0.005	809	Pseudo-R ² =0.022

Linear models used HC3 robust standard errors. Model 2 adjusted for age, gender, study site and survey month; the fully adjusted models additionally included occupational group, department, NHS tenure, weekly working hours, overtime and employment status. OR, odds ratio. The global proportional-odds test was not significant for the direct loneliness model ($P = 0.409$), but indicated departure from the assumption for the ordinal UCLA-3 model ($P = 0.022$); the latter odds ratio should be interpreted cautiously.

In the fully adjusted principal model, which additionally controlled for occupational group, department, NHS tenure, weekly working hours, overtime and employment status, the estimated mean increase in UCLA-3 score was 0.211 points per one-category increase in night-shift frequency (95% CI 0.055 to 0.368; $P = 0.008$; $N = 809$). Model R² was 0.079. The coefficient should be interpreted as an average trend across the four ordered exposure categories, not as the effect of one additional night shift and not as evidence that the category-specific relationship is perfectly linear.

The secondary analyses produced estimates in the same direction as the primary result. For the direct five-category loneliness item, the adjusted odds ratio for being in a higher loneliness category was 1.16 per one-category increase in night-shift frequency (95% CI 1.00 to 1.35; $P = 0.050$). When the UCLA-3 score was analysed as an ordered outcome, the corresponding odds ratio was 1.23 (95% CI 1.06 to 1.42; $P = 0.005$). The proportional-odds assumption was not rejected for the direct loneliness model (approximate likelihood-ratio test: $\chi^2(90) = 92.46$; $P = 0.409$). However, the global test indicated departure from this assumption for the ordinal UCLA-3 model ($\chi^2(149) = 185.64$; $P = 0.022$). The latter estimate was directionally consistent with the primary linear model but should be interpreted cautiously. When night-shift frequency was modelled categorically, the adjusted mean UCLA-3 score was 0.731 points higher among employees reporting 1–2 night shifts per month than among those reporting none (95% CI 0.118 to 1.344; $P = 0.019$). The corresponding differences were 0.324 points for 3–5 shifts (95% CI – 0.184 to 0.832; $P = 0.211$) and 0.689 points for ≥ 6 shifts (95% CI 0.199 to 1.179; $P = 0.006$). Although the estimates did not increase monotonically across categories, the exposure terms were jointly associated with UCLA-3 score ($F(3, 776) = 3.51$; $P = 0.015$).

Exploratory pathway analyses

Social fulfilment and work-life balance produced positive coefficient-product estimates with bootstrap intervals that excluded zero (Table 4; Fig. 2). For social fulfilment, the adjusted a path relating increasing night-shift category to social fulfilment was -0.068 and the b path relating social fulfilment to loneliness conditional on night-shift category was -1.250 . Their product was 0.085 (95% bootstrap CI 0.002 to 0.167). Adding social fulfilment to the night-shift model reduced the night-shift coefficient to 0.122 , corresponding to 41.1% attenuation.

For work-life balance, the a path was -0.109 and the b path was -0.894 , producing a coefficient-product estimate of 0.097 (95% bootstrap CI 0.038 to 0.161). Including work-life balance reduced the night-shift coefficient to 0.115 , corresponding to 45.8% attenuation. These two patterns were therefore compatible with the possibility that social fulfilment and work-life balance are statistically relevant to the night-shift-loneliness association, while remaining non-causal because all variables were measured at the same time.

Social interaction frequency showed little evidence of a comparable pathway: the coefficient-product estimate was -0.007 (95% bootstrap CI -0.067 to 0.056), and the night-shift coefficient was not attenuated. Emotional exhaustion was positively associated with loneliness conditional on night-shift frequency ($b = 0.151$), but the adjusted a path from night-shift category to emotional exhaustion was negative (-0.185), yielding a coefficient-product estimate of -0.028 (95% bootstrap CI -0.080 to 0.026). This adjusted pattern differs from the raw group means and should not be interpreted as evidence that night work reduces emotional exhaustion; rather, it underscores the sensitivity of cross-sectional pathway estimates to covariate adjustment, exposure coding and underlying non-linearity.

Among 802 participants with complete data for all four candidate pathways, the night-shift coefficient decreased from 0.219 to 0.138 after simultaneous inclusion of the pathway variables (95% CI for the remaining coefficient 0.015 to 0.261 ; $P = 0.028$), equivalent to 37.2% attenuation. The residual association and the cross-sectional design both argue against interpreting the decomposition as a complete explanatory model.

Table 4
Exploratory pathway analyses.

Pathway	N	a path	b path	Night-shift coefficient after pathway adjustment	Attenuation	Coefficient product (95% bootstrap CI)	Valid reps
Social interactions outside work	808	0.008	-0.877	0.211	-3.3%	-0.007 (-0.067 to 0.056)	1999
Social fulfilment	808	-0.068	-1.250	0.122	41.1%	0.085 (0.002 to 0.167)	2000
Work-life balance	808	-0.109	-0.894	0.115	45.8%	0.097 (0.038 to 0.161)	1999
Emotional exhaustion	805	-0.185	0.151	0.258	-12.1%	-0.028 (-0.080 to 0.026)	2000

The a path estimates the adjusted association of night-shift frequency with the pathway variable; the b path estimates the association of the pathway variable with loneliness conditional on night-shift frequency. Coefficient-product estimates are presented with percentile bootstrap confidence intervals from up to 2,000 valid replications, and percentage attenuation is calculated against the night-shift coefficient estimated in the same pathway-specific complete-case sample. Negative attenuation denotes an increase in the coefficient; percentages from separate models are not additive. The intervals are unadjusted for multiplicity. These cross-sectional analyses do not establish causal mediation.

Discussion

Principal findings

In this multi-site cross-sectional study of 809 NHS employees, increasing monthly night-shift frequency was associated with greater loneliness after adjustment for demographic, temporal and occupational characteristics. The principal estimate indicated a 0.211-point increase in UCLA-3 score for each one-category increase across the ordered exposure groups of 0, 1–2, 3–5 and ≥ 6 monthly night shifts. Both alternative outcome specifications produced estimates in the same direction as the primary analysis. However, the global proportional-odds test indicated departure from the assumption for the ordinal UCLA-3 model, limiting the support provided by its common odds ratio. Taken together, the analyses provide evidence of an association within respondents while remaining insufficient to establish a causal effect of night work.

The descriptive findings are important for interpreting the model. Mean UCLA-3 scores were higher in all three night-working groups than in the no-night group, but they did not rise monotonically at every exposure step: the 1-2-shift group had a higher mean than the 3-5-shift group and contained only 36 participants. The primary model therefore captures an average ordinal trend rather than a literal dose-

response curve. This distinction is methodologically important because the exposure categories represent unequal ranges of actual nights worked. It also argues for restraint in translating the coefficient into an effect for a specific additional shift. Statistical evidence of an association does not establish the clinical or occupational importance of the observed score difference.

The exploratory pathway results generate hypotheses for subsequent investigation. Lower social fulfilment and poorer work-life balance produced coefficient-product estimates whose bootstrap intervals excluded zero and substantially attenuated the night-shift coefficient when entered separately. In contrast, the frequency of social interactions outside work changed little across shift categories and did not show a corresponding coefficient-product pattern. This suggests that the social dimension potentially relevant to night-work-related loneliness may concern the compatibility, timing or perceived quality of social life rather than the simple count of social encounters. The emotional-exhaustion coefficient-product interval included zero.

Relationship to the wider shift-work literature

The principal association is compatible with a much larger literature showing that working outside conventional daytime hours can affect health and life beyond work. Shift work disrupts sleep-wake timing and is associated with sleep restriction, fatigue and circadian misalignment [7]. Meta-analytic evidence links shift work with adverse mental-health outcomes [8] [9], while systematic reviews also associate prolonged shift-work exposure with cardiovascular outcomes [10] [11]. Among healthcare workers, individual vulnerability to shift-work-related insomnia and excessive sleepiness is substantial [12]. These established effects provide biological and psychological context, but they do not by themselves explain loneliness.

More directly relevant are studies examining family and social life. Jensen and colleagues found that intensive-care shift workers reported constrained participation in leisure activities and that a proportion of evening- and night-shift nurses experienced social isolation [13]. Korompeli and colleagues identified social and domestic disruption among the burdens of rotating shifts in nursing personnel [14]. Qualitative work with night nurses has described conflict with childcare, relationships and time with family and friends [15], whereas a systematic review concluded that shift workers generally report greater work-family conflict than employees on regular daytime schedules, particularly when night and weekend work are involved [16]. McElroy and colleagues likewise found that night work predicted lower satisfaction with time available for daily tasks and family or social life in a multi-site hospital workforce [17]. The present findings extend this literature by making subjective loneliness, rather than work-family conflict or social disruption alone, the central outcome.

This distinction is not semantic. Loneliness concerns perceived sufficiency and quality of relationships, and not merely the amount of contact; Hughes and colleagues showed that the brief UCLA measure captures subjective isolation and is only modestly related to objective social-contact measures [5]. Contemporary social-connection frameworks similarly distinguish structural features of relationships, the functions they provide and their quality [30]. The contrast in our data between relatively stable social-

interaction frequency and lower social fulfilment at higher night-shift exposure is therefore theoretically coherent: the number of interactions can remain similar while the extent to which those interactions meet social needs changes.

A social-timing interpretation

One plausible conceptual interpretation is *social desynchronisation*. Healthcare staff who work nights may be sleeping, recovering or preparing for work during periods when partners, children, friends and community networks are most available. Conversely, their periods of wakefulness and work may occur when non-night-working contacts are unavailable. This could reduce opportunities for shared meals, evening activities, spontaneous contact, weekend participation or continuity of household routines without necessarily reducing the total number of recorded social encounters.

This idea resembles, but is not identical to, the chronobiological concept of 'social jetlag' which describes misalignment between biological timing and socially imposed schedules [28]. The present study did not measure chronotype or social jetlag and therefore cannot test that mechanism. Our proposed social desynchronisation interpretation instead concerns the temporal alignment of a worker's availability with the availability of other people and valued social activities. It should be treated as a hypothesis generated by the observed pattern, particularly the contrast between interaction frequency and social fulfilment.

Work-life balance provides a related but broader lens. Participants in this NHS staff sample reported progressively lower mean work-life balance satisfaction across the four exposure categories. Shift-work research consistently identifies working-time arrangements as relevant to work-family conflict [16], and hospital research has linked night work with reduced satisfaction with time for family and social life [17]. Systematic evidence on healthcare working arrangements also suggests that schedules affecting employee health can have wider organisational consequences [18]. The pathway result for work-life balance is therefore plausible, although the cross-sectional design prevents determination of whether night work preceded poorer balance, poorer balance influenced perceptions of loneliness or other factors shaped both.

Loneliness, workplace relationships and burnout

The findings should also be considered alongside the emerging literature on workplace loneliness. Arslan and colleagues found that workplace loneliness among nurses was associated with lower-quality leader-member relationships, reduced communication, lower trust and diminished work meaningfulness [19]. O'Hare and colleagues reported associations between loneliness, workplace isolation, social support and wellbeing among UK healthcare workers [23]. A large 2026 Finnish nursing study similarly identified psychosocial work factors, including low co-worker and supervisory support, as strong correlates of workplace loneliness and found loneliness associated with core burnout symptoms [24]. The UCLA-3 used here measures general loneliness rather than workplace-specific loneliness. Together,

these studies suggest that loneliness in healthcare may be influenced by both life outside work and the relational environment within work.

Burnout requires separate consideration. An integrative review found consistent links among nurse loneliness, social support and burnout [20], and mixed-methods research has described a positive correlation between nurse loneliness and burnout together with qualitative accounts of feeling unseen or emotionally detached [21]. More recent longitudinal evidence suggests that insomnia may mediate associations between loneliness and dimensions of burnout among nurses [22]. In our data, however, emotional exhaustion did not produce an exploratory pathway pattern analogous to social fulfilment or work-life balance. Although the unadjusted emotional-exhaustion score was highest in the ≥ 6 -night group, the adjusted a path from night-shift category to emotional exhaustion was negative and the coefficient-product CI included zero. This discrepancy indicates that the relationship among night work, burnout and loneliness may be more complex than a simple linear pathway and may be sensitive to confounding, schedule configuration and model specification. However, an interval including zero for the emotional-exhaustion pathway should not be interpreted as evidence that burnout is unimportant; the NHS Staff Survey continues to identify substantial emotional exhaustion and work-related burnout across the workforce [25]. Rather, the current analysis suggests that, within this cross-sectional model, the estimated product for emotional exhaustion was imprecise and differed in sign from those for social fulfilment and work-life balance.

Interpretation of the pathway analyses

The pathway analyses deliberately stop short of causal mediation, because mediation is a temporal causal concept: exposure must precede the mediator, which in turn must precede the outcome, alongside strong assumptions about confounding. Cross-sectional coefficient-product models cannot establish that temporal sequence and may be substantially biased when used to approximate longitudinal mediation processes [27]. Although our bootstrap intervals quantify uncertainty in the products estimated from these cross-sectional data, they do not convert those products into causal indirect effects.

This distinction matters especially for social fulfilment. People who are lonely may evaluate their interactions as less fulfilling, so reverse directionality from loneliness to perceived social fulfilment is highly plausible. Similarly, loneliness could influence perceived work-life balance, while workers experiencing poor work-life balance may be more likely to notice or report loneliness. Selection into shift patterns is also non-random: staff choose or are allocated schedules according to occupation, department, family circumstances, preferences, seniority and service need. Consequently, the pathway findings are best viewed as identifying candidate constructs for longitudinal testing, not as demonstrating mechanisms. Intervals were not adjusted for multiple comparisons, and a difference in whether intervals include zero is not evidence that pathway estimates differ from one another. Even under that restricted interpretation, the descriptive pattern across candidate pathways is informative. Social interaction frequency showed a coefficient-product estimate near zero, whereas social fulfilment and work-life balance produced positive estimates and substantial attenuation. That pattern suggests

hypotheses for prospective investigation without ranking their causal importance. Future studies could measure roster exposure repeatedly, capture the timing and quality of social contacts, and test whether within-person changes in night-work intensity precede changes in social fulfilment and loneliness.

Implications for NHS workforce research and practice

Night work is indispensable to acute, emergency, ambulance and many other NHS services. The present findings therefore do not support a simplistic recommendation to eliminate night shifts. A more realistic implication is that the social sustainability of working-time arrangements deserves consideration alongside sleep, fatigue and operational requirements. Healthier working-time research already emphasises schedule design, recovery opportunities and employee health [18]. The present study suggests that future roster research could additionally evaluate whether schedule predictability, clustering of nights, recovery days, short-notice changes and employee control over rosters influence social wellbeing.

The pathway pattern raises a question about whether interventions focused only on increasing the number of social contacts would address the relevant problem. If future longitudinal work confirms that social fulfilment and work-life integration are important, potentially modifiable organisational targets could include predictable rosters, opportunities for schedule input, protection of recovery time, equitable access to team communication for night staff, and support for participation in important family or social commitments. These are hypotheses for evaluation, not interventions shown to reduce loneliness by the current study.

Workplace connection also warrants attention, since night workers can be structurally separated from managers, educators and day-based multidisciplinary teams, even while working closely with immediate colleagues. Research linking workplace loneliness with communication, trust and meaningfulness [19] suggests that organisational practices should consider whether staff working non-standard hours receive comparable access to supervision, team information, development opportunities and peer support. Such approaches could be evaluated alongside traditional fatigue-management strategies rather than positioned as substitutes for them. From a research perspective, loneliness may add value as a workforce-health outcome precisely because it captures a relational dimension not represented fully by burnout, stress or sleep measures. The NHS already monitors work-related exhaustion extensively [25]. Incorporating validated measures of social connection in selected workforce studies could help determine whether schedule-related social effects predict retention, sickness absence, wellbeing or occupational functioning. Although the current study cannot address those downstream outcomes, it provides a rationale for doing so.

Strengths and limitations

A key strength of this study is that it examined an occupational-health outcome that has received comparatively little attention in shift-work research. Second, the sample included a heterogeneous NHS workforce rather than a single profession, allowing the question to be considered across different occupational and service contexts. Third, exposure was graded across four monthly night-shift

categories rather than reduced to a simple night-versus-day dichotomy. Fourth, loneliness was measured using the established UCLA-3 instrument [5] [6] together with a complementary direct item recommended in UK measurement guidance [4]. The estimates were directionally consistent across the primary linear model and two ordinal outcome specifications, although the ordinal UCLA-3 result requires caution because the global test indicated departure from the proportional-odds assumption. Fifth, the fully adjusted model accounted for major differences in site and occupational composition, NHS tenure, hours, overtime and employment status. This is important because night-work exposure was strongly patterned by department and working arrangement. Sixth, the analysis explicitly distinguished social-interaction frequency from social fulfilment. This distinction enabled a more nuanced interpretation of the social data and aligns with broader evidence that social connection has structural, functional and qualitative dimensions [30]. Finally, the reporting and interpretation deliberately preserve the limits of a cross-sectional volunteer sample, consistent with the broader INTERACT programme's emphasis on describing respondents rather than estimating population prevalence [3].

The principal limitation is the cross-sectional design: because exposure, candidate pathways and loneliness were measured at the same survey occasion, temporal ordering cannot be established. Reverse causation is plausible, and the pathway analyses must not be interpreted as causal mediation [27]. Longitudinal studies with repeated measures are required to determine whether changes in night-work exposure precede changes in loneliness.

Second, because participation was voluntary, the analytical sample cannot be assumed to represent the NHS workforce, and the proportion of respondents reporting loneliness should not be labelled NHS prevalence. It is also possible that people with particular experiences of loneliness, wellbeing or working patterns may have been more or less likely to participate. The parent INTERACT study is itself a volunteer-based non-probability survey and explicitly applies the same interpretive limitation [3]. Complete-case restriction may introduce additional selection; the direction and magnitude of these biases cannot be determined from the reported data.

Third, night-shift exposure was self-reported using broad categories. The study did not distinguish permanent nights from rotating nights, consecutive from isolated nights, forward from backward rotation, shift duration, quick returns, weekend nights, roster predictability, schedule control or cumulative years of night work. These features may influence sleep, work-family conflict and social participation differently. The ordered coding also assumes a common average increment across categories even though the categories represent unequal numbers of shifts. Further, given that the observed UCLA-3 means were not perfectly monotonic, and the 1-2-shift category was small ($n = 36$), the primary coefficient should not be interpreted as a precise dose-response estimate.

Fourth, substantial baseline differences existed between exposure groups. Night workers were younger and differed markedly by site, department, hours, overtime and employment status. Although these variables were included in the principal model, we acknowledge that residual confounding remains possible. Further, although the survey also captured marital status, household composition, dependent

children, ethnicity, education and long-term health conditions, these factors were not part of the prespecified adjustment set reported here and could be relevant to both shift selection and loneliness. Their omission leaves important potential confounding unresolved. HC3 standard errors address heteroskedasticity, but do not account for dependence between participants within the same site; adjustment for site indicators is not a substitute for assessing this uncertainty.

Fifth, all key variables were self-reported. Common-method variance and differential perception may contribute to associations among loneliness, social fulfilment, work-life balance and burnout. The emotional-exhaustion measure comprised three survey items and did not assess the full multidimensional burnout construct; its high internal consistency does not establish construct validity. Social fulfilment also overlaps conceptually with subjective loneliness, which may contribute to their association. Similarly, social-interaction frequency was recorded in broad weekly categories and did not measure duration, timing, who the interaction was with, whether it was desired, or whether digital and in-person contacts differed in quality.

Sixth, model fit for the fully adjusted linear model was modest ($R^2 = 0.079$), which is unsurprising for a multifactorial psychosocial outcome but indicates that most variation in loneliness was not explained by the included occupational and demographic variables. The study therefore should not be read as proposing night work as a dominant determinant of loneliness.

Finally, the direct loneliness estimate had a confidence interval with a rounded lower limit of 1.00 (OR 1.16, 95% CI 1.00 to 1.35; $P = 0.050$), and statistical significance was not used as the sole criterion for interpretation. The direct loneliness estimate was consistent in direction with the primary analysis. The ordinal UCLA-3 model also yielded a positive association, but the global proportional-odds test indicated departure from the assumption ($P = 0.022$). Its common odds ratio may obscure differences across outcome thresholds and should be interpreted cautiously.

Future research

The next analytical step should be longitudinal rather than simply more cross-sectional adjustment. Linking objective electronic rosters with repeated UCLA-3 or equivalent loneliness measures would reduce exposure misclassification and establish temporal ordering. A design with measurements before and after changes in shift intensity, rotation or roster policy could help separate between-person differences from within-person change. Recording chronotype and sleep would also permit testing of circadian pathways, while time-use diaries or ecological momentary assessment could capture when social interactions occur, with whom, and how fulfilling they are.

Future studies should also distinguish social life outside work from connection within work. Night shifts may simultaneously disrupt family and friendship schedules while promoting strong bonds within night teams; the net effect on loneliness may depend on which relationships are most valued and whether

workplace connection compensates for losses elsewhere. Qualitative research with night-working NHS staff could clarify these processes and improve interpretation of quantitative pathway measures.

Finally, we propose that organisational interventions should be evaluated prospectively. Candidate strategies might include greater roster predictability, staff input into schedules, protected recovery periods and enhanced inclusion of night workers in communication and support structures. However, the relevant outcome should not be assumed to be loneliness alone: work-life balance, sleep, burnout, retention and patient-safety indicators may move together or in different directions. Pragmatic evaluation would therefore benefit from a multidimensional workforce-health framework.

Conclusion

In this multi-site sample of NHS employees, greater monthly night-shift frequency was associated with higher loneliness after adjustment for demographic, temporal and occupational characteristics. The estimates were directionally consistent across complementary outcome specifications, although the ordinal UCLA-3 result requires caution because the global test indicated departure from the proportional-odds assumption. The observed category means were not perfectly monotonic, and the exposure coefficient represents an average ordinal trend rather than the effect of one additional night shift.

The exploratory pathway findings provide a more differentiated interpretation. Higher night-shift exposure was associated with poorer work-life balance and lower social fulfilment, and these constructs statistically attenuated the night-shift-loneliness association. By contrast, frequency of social interaction outside work showed little evidence of a comparable pathway. This pattern raises the hypothesis that the social consequences of night work may relate more to temporal compatibility and the perceived quality of social life than to the number of social contacts alone.

These findings are associative, not causal, and they describe respondents rather than the entire NHS workforce. Nonetheless, they identify loneliness as a potentially relevant and under-recognised dimension of night-work research. Longitudinal studies linking objective roster data with repeated measures of social connection, work-life balance, sleep and occupational outcomes are needed to determine whether night-work patterns prospectively shape loneliness and whether modifiable scheduling or organisational factors can improve social wellbeing.

Declarations

Ethics approval and consent to participate

The Measuring Loneliness (INTERACT) study was approved by the East of England – Essex Research Ethics Committee (REC reference 21/EE/0272; IRAS ID 305483) [29]. The study was conducted in accordance with the Declaration of Helsinki [3]. All participants included in this analysis provided electronic consent to participate through the survey consent item.

Clinical trial number

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare they have no competing interests.

Patient and public involvement

Patients and members of the public were not involved in the design, conduct, reporting or dissemination plans of this analysis. Three NHS collaborators working in NHS secondary care trusts supported the development, refinement and beta testing of the data collection tool.

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Author Contribution

AEO conceived the study. AEO, LH, SA and SP contributed to study design. LH led the data analysis with support from SA. All authors supported interpretation of findings. AEO developed the first draft of the manuscript. All authors critically revised the manuscript and approved the final version. AEO is the guarantor.

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Data Availability

Individual-level INTERACT data are not publicly shared because of ethical and data-protection constraints. Consistent with the parent study's published data-availability statement, a de-identified

dataset and codebook may be made available on reasonable request to the corresponding author, subject to institutional approvals and applicable data-protection requirements.

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Figures

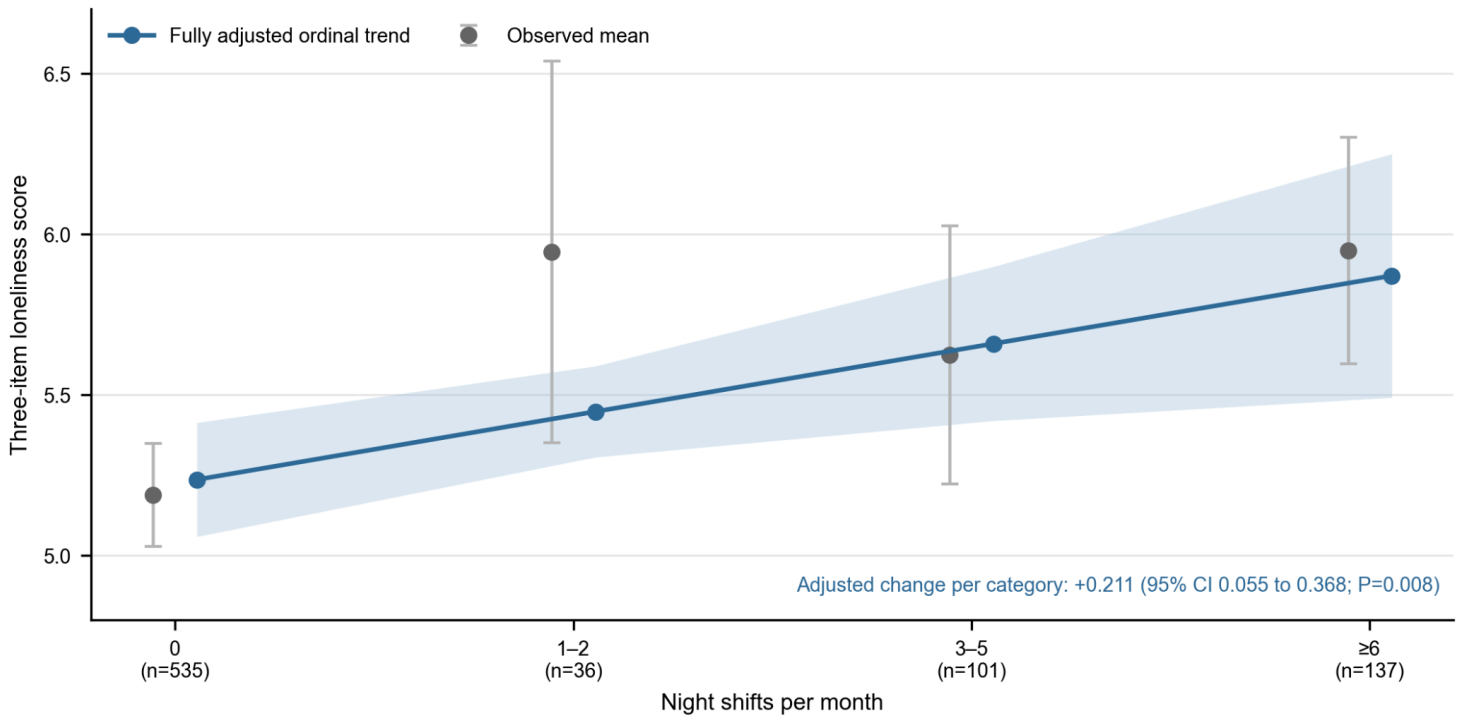


Figure 1

Observed means and fitted ordinal trend in loneliness by monthly night-shift frequency. Grey points show observed means with 95% confidence intervals. The blue line and shaded band show predicted means and 95% confidence intervals from the fully adjusted linear model treating night-shift frequency as an ordinal variable. The straight line reflects the imposed common increment across categories; it does not demonstrate a monotonic category-specific association. N=809.

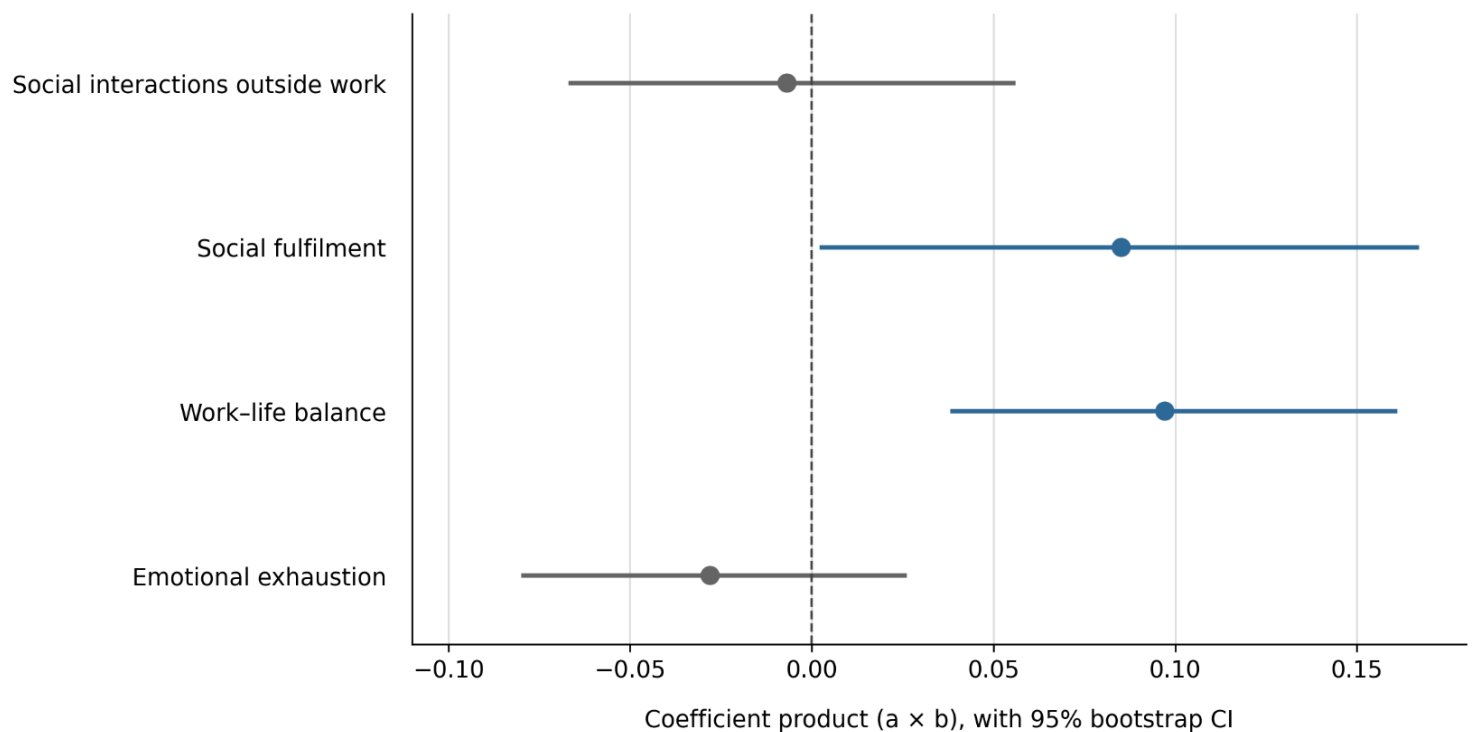


Figure 2

Exploratory coefficient-product estimates for candidate pathways. Points represent products of adjusted a- and b-path coefficients; horizontal lines are percentile 95% bootstrap confidence intervals from 1,999–2,000 valid replications (Table 4). Intervals are unadjusted for multiple comparisons. These statistical products are not identified causal indirect effects.

Supplementary Files

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- [SupplementaryFile1SurveyExport.docx](#)
- [SupplementaryFile2Supplementarytablesandanalyticaldocumentation.docx](#)
- [SupplementaryFile3CHERRIESChecklist.docx](#)
- [SupplementaryFile4STROBECrossSectionalChecklist.docx](#)
- [SupplementaryFile5CROSSChecklist.docx](#)