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Associations between sleep disturbances, mental health outcomes and burnout in firefighters, and the mediating role of sleep during overnight work: A cross-sectional study

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Summary

This study investigated whether sleep disorder risk and mental health outcomes in firefighters were associated with burnout, particularly emotional exhaustion, and examined the mediating role of sleep at work in these relationships. A secondary aim was to investigate associations between habitual sleep characteristics and burnout. North American firefighters (n=6,307) completed the Maslach Burnout Inventory (emotional exhaustion, depersonalisation, personal accomplishment) and were screened for sleep disorders and self-reported current mental health conditions and sleep characteristics. Multiple logistic regression analyses examined associations between sleep, mental health outcomes and burnout. Firefighters screening positive for a sleep disorder, particularly insomnia, had increased risk of emotional exhaustion (adjusted odds ratio [AOR] 3.78, 95% CI 2.97–4.79). Firefighters self-reporting a current mental health condition were at greater risk of emotional exhaustion (AOR 3.45, 95% CI 2.79–4.27). Sleep during overnight work mediated the impact of having a sleep disorder and mental health condition on high burnout. Sleepiness and sleep deficit (difference between required and actual sleep), even in firefighters without sleep disorder risk, were associated with depersonalisation (AOR 1.65, 95% CI 1.34–2.03 and AOR 1.29, 95% CI 1.06–1.57, respectively) and low personal accomplishment (AOR 1.25, 95% CI 1.07–1.47 and AOR 1.17, 95% CI 1.01–1.35, respectively). Sleep and mental health problems were associated with increased risk of burnout in firefighters, and sleep during overnight work mediated these relationships. The results suggest the need to examine the effectiveness of occupational interventions that improve the opportunity for sleep, together with screening for and treating sleep disorders, to reduce burnout risk.

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Keywords

burnout; firefighters; insomnia; mental health

Introduction

Firefighting is a demanding occupation which exposes personnel to physical and psychological stressors (Barger *et al.* 2009). Chronic exposure to workplace stressors can lead to burnout. Burnout is a three-dimensional syndrome characterised by emotional exhaustion (EE), depersonalisation (DP; i.e., negative attitudes about one's clients and/or job) and low personal accomplishment (PA), which persist after a typical period of recovery from work (Maslach *et al.* 1996). If affected by burnout, personnel may experience increased health problems (Ahola *et al.* 2005) absenteeism, job turnover, and reduced performance (Fahrenkopf *et al.* 2008; Maslach *et al.* 1996). Consequently, the impact of workplace stress on organisations, and employee health and wellbeing, is estimated to cost the US economy \$120 billion annually (Goh *et al.* 2015).

Sleep loss and sleep disorders disrupt daily functioning and increase the risk of burnout (Chin *et al.* 2015; Rajaratnam *et al.* 2011). Firefighters are frequently exposed to sleep restriction due to their work schedules (Barger *et al.* 2009), which typically involve 24-hour shifts (Barger *et al.* 2015). These schedules prevent firefighters from obtaining the amount of sleep they need to feel well-rested. Insufficient sleep increases firefighters' risk of daytime sleepiness (Barger *et al.* 2009), which is shown in other occupations to associate with burnout (Ekstedt *et al.* 2006; Metlaine *et al.* 2017). Firefighters are also at high risk of sleep disorders (Barger *et al.* 2015). Indeed, among the cohort of firefighters reported herein, 28% screened positive for obstructive sleep apnoea (OSA), and 6% had high risk of insomnia (Barger *et al.* 2015). Although insomnia symptoms are closely related to, and may predict burnout (Armon *et al.* 2008), few studies have investigated this relationship in human service work such as nursing (Kousloglou *et al.* 2014), and emergency medicine (Bell *et al.* 2002), which many firefighters provide through their role as emergency medical technicians (EMTs). Like firefighters, police have a high risk of OSA, which was related to burnout in police (Rajaratnam *et al.* 2011). Shift work disorder (SWD) is another sleep disorder which affects 9% of firefighters (Barger *et al.* 2015), but its relationship to burnout has not been examined. In addition to sleep disorders, mental health conditions are also prevalent in firefighters, especially depression and post-traumatic stress disorder (PTSD) (Hom *et al.* 2016), which may further contribute to the risk of burnout (Ahola *et al.* 2007; Katsavouni *et al.* 2016; Mitani *et al.* 2006).

Firefighters are sometimes permitted to sleep while on-duty overnight, but these sleep opportunities are often disrupted, especially in personnel with sleep disorders (Jay *et al.* 2016) or mental health conditions (Hom *et al.* 2016). Sleep and mental health conditions have been associated with burnout in occupations involving night work (Katsavouni *et al.* 2016; Kousloglou *et al.* 2014; Rajaratnam *et al.* 2011; Wolf *et al.* 2017), and incomplete recovery from work demands, potentially in the form of short sleep, has been identified as a possible mediating factor in the development of burnout (Gluschkoff *et al.* 2016).

In the current study, we examined whether firefighters' sleep disorder risk and mental health outcomes are associated with burnout. The extent to which sleep attained during overnight work mediates the relationship between sleep disorder risk and mental health outcomes on burnout was also explored. We hypothesised sleep and mental health conditions would raise the risk of burnout in firefighters, and these relationships would be explained by shorter sleep during overnight work. A secondary aim was to investigate associations between habitual sleep characteristics (sleep duration, sleep deficit, sleepiness) and burnout, which we also hypothesised would increase burnout. Given sleep disorders and mental health conditions are prevalent in firefighters (Barger *et al.* 2015; Hom *et al.* 2016), and both impact sleep characteristics, we further explored associations between sleep characteristics and burnout independent of risk of sleep disorders and mental health conditions. Together, this will provide insight into how sleep and mental health disturbances influence burnout, while beginning to inform which aspects of sleep could be targeted to reduce these potentially negative effects.

Methods

Sixty-Six North American fire departments participated in a sleep health and sleep disorder screening program, which included a survey. All firefighters provided written informed consent and those who completed the Maslach Burnout Inventory (MBI) in the survey and sleep screening are included in this study. Details of the fire departments, the program, its implementation (Barger *et al.* 2015), and impact in one department have been described (Sullivan *et al.* 2016).

The survey assessed firefighters' habitual sleep characteristics. Questions included the amount of sleep needed every 24 hours to feel well-rested, and the typical sleep duration attained in 24 hours: (a) when working overnight, including 24-h shifts; (b) after working an overnight or 24-h shift; (c) when working day shifts, and; (d) following 2 days off work. Based on prior research (Yoo *et al.* 2013), short sleep was defined as ≤ 6 hours in the logistic regression analyses. A measure of sleep deficit was calculated as the difference in sleep duration after an overnight shift minus sleep required to feel well-rested. This difference was calculated as a continuous variable, from which a mean sleep deficit of 45 minutes was determined. Similar moderate levels of sleep deficit have been shown to induce a deterioration in mood (Motomura *et al.* 2017). Therefore, this mean value was applied as a cut-point to categorise firefighters with (≤ -45 minutes) and without a sleep deficit (> -45 minutes). In addition to sleep, job strain is another factor known to influence burnout (Ahola *et al.* 2007, Metlaine *et al.* 2017), but it was not specifically assessed in the current study. In the absence of this measure, participants reported the presence of a second job outside of being a firefighter, and total firefighting work hours (including any overtime hours) per week (over 4 weeks), which were included as covariates.

Firefighters completed self-report measures to screen for risk of insomnia (Athens Insomnia Scale) (Soldatos *et al.* 2003), OSA (Berlin Questionnaire) (Netzer *et al.* 1999), SWD (Rajaratnam *et al.* 2011) and restless legs syndrome (RLS; RLS Epidemiology, Symptoms and Treatment questionnaire) (Allen *et al.* 2005). Sleepiness was assessed using the Epworth Sleepiness Scale (Johns 2000). Further details of these measures are in Supplement 1.

To measure burnout, the survey included the MBI–Human Services Survey (MBI–HSS) (Maslach *et al.* 1996), which defines burnout across three dimensions including; EE, DP and PA (see Supplement 1 for further MBI–HSS details). Similar to previous research (Rajaratnam *et al.* 2011), a categorical definition of burnout was used for logistic regressions, in which a high (vs. low or moderate) risk score for each dimension was determined (High EE 27 points; High DP 13 points; Low PA 31 points) (Maslach *et al.* 1996). Cronbach’s alpha for the burnout dimensions were between 0.76 to 0.90. An overall *High degree* of burnout measure was also included, defined as high EE, high DP, with low PA (Maslach *et al.* 1996). Participants self-reported if they had a current diagnosis of depression, anxiety and PTSD. All procedures were approved by the Institutional Human Research Committee.

Statistical Analysis

Multiple logistic regression models were used for cross-sectional analysis of associations between sleep disorders, mental health conditions, sleep characteristics and burnout outcomes. A multicollinearity assessment using variance inflation factor and tolerance levels revealed no collinearity in the predictor variables (Supplement 1). We adjusted for age, gender, body mass index (BMI), smoking, alcohol, second job and mean total firefighting work hours per week. We tested these confounders individually and included those that were significant ($p < 0.10$) in the initial models. A backward elimination method was applied to remove those that were not significant in the final model. Unadjusted and adjusted odds ratios (AOR) with 95% confidence intervals (CI) are reported. Statistical analyses were conducted using SPSS (IBM Corp, Version 24.0, Armonk, NY) and significance set at $p < 0.05$.

Sleep duration when working an overnight shift (as a continuous variable) was examined as a mediator in the relations between screening positive for any sleep disorder, self-reporting a current diagnosis of any mental health condition and each burnout dimension. This analysis was conducted using PROCESS with SPSS. Direct effects of sleep disorders and mental health outcomes on burnout were determined. Indirect effects of sleep disorders and mental health conditions on burnout via the mediator were examined. Bootstrapped CI were generated from repeated resampling (10,000 samples) of the data, and mediation considered significant when the 95% CI did not span zero. We also compared the difference between the indirect effect for sleep duration when working overnight against other potential sleep mediators.

Results

Of the 11,836 firefighters who participated in the sleep health program, 6,933 were verified firefighters who completed the sleep screening and survey (58.6% cooperation, i.e., 6,933/11,836). Of those, 6,307 completed the MBI–HSS and were eligible for the analyses. The mean age of the sample was 40.4 (8.9) years and 92.2% male (Table 1). Race and ethnicity of the sample were similar to the larger firefighter study and comparable to US national statistics (Barger *et al.* 2015). Based on BMI, 51.9% of firefighters were

overweight, which is higher than US adults (34.1%), but the percentage of obese firefighters (29.6%) was lower than US adults (32.2%) (Ogden *et al.* 2006).

Almost half (48.8%) of firefighters reported 6 hours sleep in 24 hours when working overnight (i.e., 6 hours work between 22:00–08:00) including 24-hour shifts, and 31.5% reported short sleep in the 24 hours after overnight work or 24-hour shift (Table 1). Thirty-eight percent of firefighters screened positive for any sleep disorder, including OSA, 29.0%; SWD, 7.8%; insomnia, 6.1%; and RLS, 3.5%. Nearly half (48.1%) the firefighters exhibited high burnout on at least one dimension. Eleven percent (11.4%) had high EE, 17.7% had high DP, 38.1% had low PA and 4.0% had a high degree of burnout. Firefighters self-reported a current diagnosis of depression (6.0%), anxiety (3.6%) and PTSD (1.8%). The percentage of comorbid sleep disorders, mental health conditions and high burnout dimensions in firefighters was small (3.7%).

Sleep disorders and burnout

Firefighters screening positive for insomnia were more likely to have high EE (AOR 3.78, 95% CI 2.97–4.79), DP (AOR 2.15, 95% CI 1.71–2.71), low PA (AOR 2.15, 95% CI 1.74–2.65) and a high degree of burnout (AOR 3.60, 95% CI 2.55–5.08) than those who did not screen positive. Firefighters screening positive for OSA were more likely to have a high degree of burnout (AOR 2.49, 95% CI 1.85–3.34), and each of the burnout dimensions, with the highest odds found for EE (AOR 3.08, 95% CI 2.56–3.71; Table 2a). Those screening positive for SWD were at increased risk of a high degree of burnout (AOR 3.48, 95% CI 2.51–4.82), as well as each of the dimensions, with the greatest risk demonstrated for EE (AOR 2.60, 95% CI 2.01–3.35; Table 2a). RLS was associated with a high degree of burnout (AOR 2.30, 95% CI 1.41–3.75), high EE (AOR 2.13, 95% CI 1.51–2.99) and DP (AOR 2.22, 95% CI 1.65–2.99).

Mental health and burnout

Firefighters reporting current PTSD or anxiety were at greater risk of a high degree of burnout (PTSD, AOR 5.12, 95% CI 3.07–8.56; Anxiety, AOR 3.52, 95% CI 2.30–5.39) than those who had never or did not currently have these conditions. PTSD and anxiety were associated with high EE (PTSD, AOR 4.88, 95% CI 3.27–7.29; Anxiety, AOR 4.17, 95% CI 3.11–5.60) and DP (PTSD, AOR 3.32, 95% CI 2.22–4.95; Anxiety, AOR 2.07, 95% CI 1.54–2.78). Firefighters reporting current depression were at increased risk of a high degree of burnout (AOR 4.18, 95% CI 3.00–5.84), and each of the dimensions, with the greatest odds found for EE (AOR 3.61, 95% CI 2.84–4.59; Table 2b).

Sleep, sleepiness, sleep deficit and burnout

Firefighters reporting short sleep when working an overnight shift were more likely to have high EE (AOR 2.26, 95% CI 1.87–2.73), DP (AOR 2.11, 95% CI 1.83–2.43) and a high degree of burnout (AOR 2.52, 95% CI 1.88–3.37). After working an overnight shift, firefighters reporting short sleep were more likely to have a high degree of burnout (AOR 1.78, 95% CI 1.37–2.31) and high burnout across each dimension with the strongest association found for EE (AOR 1.88, 95% CI 1.59–2.23; Table 3). Short sleep when working a day shift was associated with high EE (AOR 1.96, 95% CI 1.56–2.47), DP (AOR 1.51,

95% CI 1.24–1.84) and a high degree of burnout (AOR 1.72, 95% CI 1.15–2.58). Those reporting short sleep following 2 days off from work were more likely to have high EE (AOR 1.56, 95% CI 1.29–1.90) and DP (AOR 1.19, 95% CI 1.00–1.41). Firefighters experiencing a sleep deficit had an increased risk of high burnout across dimensions (Table 4), and a 2.22-fold (95% CI 1.71–2.89) risk of a high degree of burnout. Likewise, sleepiness was associated with high burnout across dimensions (Table 4) and a high degree of burnout (AOR 2.63, 95% CI 2.03–3.40).

Among firefighters who did not screen positive for any sleep disorder, referred to as *Low-risk sleep disorder participants*, short sleep when working overnight was associated with high EE (AOR 1.74, 95% CI 1.32–2.31) and DP (AOR 1.74, 95% CI 1.43–2.11). There was a greater risk of high EE in *low-risk sleep disorder firefighters* reporting short sleep after overnight work (AOR 1.53, 95% CI 1.16–2.02) or when working a day shift (AOR 1.68, 95% CI 1.17–2.42), but not following 2 days off work (Table 3). *Low-risk firefighters* with a sleep deficit had an increased risk of a high degree of burnout (AOR 1.77, 95% CI 1.11–2.81) and each dimension, including 2.09-fold risk of EE (95% CI 1.59–2.74; Table 4). In this subsample, those with sleepiness had greater risk of high burnout across dimensions (Table 4).

Mediators of burnout

Direct effects showed higher scores for EE and DP and lower PA were predicted by sleep disorders and mental health conditions (Table S.9). Indirect effects of screening positive for any sleep disorder on burnout indicated significant mediation through *sleep duration when working an overnight shift* (Fig 1; Tables S.10, S.11). A multiple mediator model confirmed the effects through *sleep duration when working overnight shifts* were stronger than those through *sleep after an overnight shift*, *sleep when working a day shift* and *sleep following 2 days off work* for screening positive for a sleep disorder (Fig S.1, Tables S.12, S.13). *Sleep duration when working an overnight shift* mediated the effect of mental health conditions on burnout (Tables S.14, S.15), with pairwise contrasts showing the effects through this mediator were stronger compared to *sleep after an overnight shift*, *sleep when working a day shift* and *sleep following 2 days off work* (Fig S.2, Tables S.16, S.17).

Discussion

Almost half (48.1%) of firefighters exhibited high burnout on at least one dimension. Those firefighters with a sleep disorder, in particular insomnia, had a 2- to 3-fold increased risk of high burnout on each dimension, most notably EE. Similarly, firefighters self-reporting a current diagnosis of PTSD, depression or anxiety had a 2- to 4-fold increased risk of burnout across most dimensions. Sleepiness, short sleep and sleep deficit, even in firefighters who did not screen positive for a sleep disorder, were associated with high burnout. In addition to increasing the risk of burnout, importantly, sleep during overnight work was shown to mediate the association between both sleep disorder risk and having a mental health condition on high burnout.

A large proportion of firefighters screened positive for OSA, which was associated with greater risk of high EE and DP. These associations and the high, largely untreated prevalence

of OSA in this sample of firefighters (see Supplement 1) are consistent with findings for OSA in police (Rajaratnam *et al.* 2011). Our findings indicate that OSA screening should be an important component of occupational health and safety programs. Firefighters screening positive for insomnia were also at risk of high EE and DP, which is similar to findings in nurses (Kousloglou *et al.* 2014). Both insomnia and OSA can result in fragmented sleep and rapid eye movement sleep disruption, which is a stage of sleep important for emotional regulation (Bianchi *et al.* 2010; Riemann *et al.* 2012), and found to be disturbed in patients with burnout (Ekstedt *et al.* 2006). The percentage of firefighters screening at risk of SWD (6.1%) was similar (5.4%, Rajaratnam *et al.* 2011), or slightly below levels previously reported among emergency service (9.1%, Barger *et al.* 2015) and nursing personnel (32.4–37.6%; Flo *et al.* 2012). The slightly lower than expected prevalence of SWD is most likely explained by the use of stringent screening criteria for this disorder, which required both symptoms of insomnia and excessive sleepiness to be present (Czeisler *et al.* 2005). Despite this, screening positive for SWD, as well as RLS, was found to be associated with high burnout in firefighters. Like insomnia and OSA, sleep can be fragmented in RLS (Brand *et al.* 2010) and SWD (Gumenyuk *et al.* 2010), which may impair the ability to cope and recover from work demands, potentially leading to burnout. Indeed, in an important step forward, we provide evidence that short sleep during an overnight shift mediates the link between sleep disorder risk and high burnout on the EE and DP dimensions. Given that 84.4% of our sample worked extended duration shifts (24 h) our findings highlight the need to maximise sleep opportunities *during* overnight shifts to reduce burnout. For instance, fire department policies that encourage sleep (e.g., permitting and encouraging napping, black-out shades for sleep quarters) may increase firefighters sleep at work (Barger *et al.* 2017). Modifying shift schedules should be a primary strategy to improve the opportunity for sleep and lower burnout risk, however, this was not the focus of the present study. For instance, changing EMTs work schedules from a 24-hour shift (common in firefighting) to a 12-hour shift was found to lower EE at 2 months post-schedule change (Boudreaux *et al.* 1998). Conversely, no change in burnout rates were found in resident physicians following the introduction of duty hour restrictions (limiting shift length to 16 h), though there was also no difference in self-reported work hours before and after the mandated schedule change (Ripp *et al.* 2015). Further longitudinal studies incorporating objective sleep measures, including prospective studies using polysomnography to examine different sleep stages and sleep disorder severity, also proposed by Metlaine and colleagues (2017), are vital to determine causality within our mediation findings, and test the efficacy of sleep-related interventions in reducing burnout.

Firefighters self-reporting an existing diagnosis of a mental health condition, particularly PTSD and anxiety, were more likely to have high EE and DP, but not low PA. Conversely, depression increased the risk of low PA, along with high EE and DP. These findings are consistent with previous studies in firefighters (Katsavouni *et al.* 2016; Mitani *et al.* 2006) and other occupations (Wolf *et al.* 2017) indicating a positive relationship between mental health symptoms and burnout. The majority of research has focused on depression, which is hypothesised to reduce an individual's perception of self-worth and ability to cope with work demands, which in turn, may increase burnout (Ahola *et al.* 2007; Bianchi *et al.* 2015; Toker *et al.* 2012). Other research suggests burnout represents a stage in the development of

depression (Ahola *et al.* 2007; Bianchi *et al.* 2015). Longitudinal evidence of this reciprocal causation exists (Ahola *et al.* 2007; Ahola *et al.* 2005; Toker *et al.* 2012), demonstrating potential burnout-depression overlap (Bianchi *et al.* 2015), yet it is less clear if a similar bi-directional relationship also exists for burnout and PTSD or anxiety. A consistent finding for each of these mental health conditions, however, is the co-occurrence of sleep disturbances (Hom *et al.* 2016; Wolf *et al.* 2017; Yoo *et al.* 2013), which could be worsened with night work. In the current study we demonstrate that shorter sleep duration during an overnight shift contributes to high EE and DP in firefighters with a mental health condition, supporting a focus on reducing sleep loss to address burnout risk in vulnerable personnel. It should be noted, however, that additional mediation analysis revealed that mental health conditions may also mediate the effects of sleep duration when working an overnight shift on burnout (see Supplement 1). Future studies that prospectively examine the impact of improving mental health, as well as exposure to night work (through work schedule modifications that aim to increase sleep opportunity) on burnout risk will enhance our understanding of these complex interactions between mental health, sleep and burnout in emergency personnel.

In addition to mediating the effect of sleep and mental health disorders on burnout, short sleep was independently associated with high EE and DP. Our findings for short sleep during, as well as after overnight work and when working day shifts are consistent with research showing sleep loss on work days to increase the risk of overall burnout in police (Yoo *et al.* 2013) and nurses (Chin *et al.* 2015), and EE in medical students (Wolf *et al.* 2017). It is noted that the odds for increased EE and DP among firefighters with short sleep during and after overnight work and on days off (EE, AOR between 1.56 and 2.26; DP, AOR between 1.19 and 2.11; Table 3) were slightly lower than what was observed for personnel with a sleep disorder (EE, AOR 3.37; DP, AOR 2.44; Table 2a) or mental health condition (EE, AOR 3.45; DP, AOR 2.52; Table 2b), suggesting that sleep loss made a slightly weaker contribution to burnout risk compared to mental health conditions and sleep disorders. In medical residents, however, burnout was not associated with sleep reported over a one-and-a-half-month period of work (Fahrenkopf *et al.* 2008). We extend these findings by demonstrating that in addition to work days, short sleep following 2 days off from work was associated with high EE and DP in firefighters. Inadequate sleep during and after work, and into rest periods, may impair firefighters' ability to recover from occupational demands, potentially explaining the heightened burnout risk in those reporting short sleep in the current study.

Research has demonstrated the adverse impact of sleep deficit on mental health (Regestein *et al.* 2010). In the current study we found sleep deficit also increases risk of burnout. Firefighters with daytime sleepiness were at 2.5-, 2.1- and 1.2-fold risk of high EE, high DP and low PA respectively, which is consistent with medical students (Wolf *et al.* 2017). A similar association between sleepiness and burnout was found in OSA patients, but only for EE and DP (Guglielmi *et al.* 2014). Sleepiness, and related symptoms (e.g., fatigue, nonrestorative sleep) are common in OSA (Guglielmi *et al.* 2014), as well as specific insomnia phenotypes (Pillai *et al.* 2015) and other sleep disorders (SWD, RLS) (Allen *et al.* 2005; Wright *et al.* 2013) prevalent among firefighters (Barger *et al.* 2015). When removing firefighters in the current study who screened positive for a sleep disorder, however, sleepiness, sleep deficit and short sleep (during and after a shift) were still associated with

burnout. Sleep disorders can also overlap with mental health conditions, but in the current study we did not observe an interaction effect between sleep disorders and mental health conditions on high burnout (see Supplement 1). Further analysis confirmed, however, that short sleep was associated with EE among firefighters who did not report a mental health condition (see Supplement 1). Together, these results highlight the health burden of sleepiness and sleep loss in firefighting, and the potential need for targeted sleep interventions to address these factors.

Limitations of the study were the cross-sectional design from which we cannot determine causality, and the use of self-report measures. In particular, relying on self-report mental health diagnoses may have reduced the overall proportion of firefighters that meet positive screening criteria for mental health conditions in our sample given previous research in both the US general population (Brody *et al.* 2018) and firefighters (Hom *et al.* 2016) that has shown higher levels of clinically significant mental health symptoms assessed using common screening tools. Further research in firefighters using objective sleep measures and mental health screening tools is needed to assess prospectively the relationships between sleep, mental health and burnout, for example in trainees as they progress through their career and exposure to shift work. BMI was also based on self-report in the current study. Although the observed percentage of overweight and obese firefighters (81.5%) were similar to a prior study in US firefighters (79.5%, Poston *et al.* 2011), research using more robust measures of body composition are needed (e.g., percent body fat). Future research in firefighters should also consider measuring and adjusting for job strain, which is known to influence burnout (Ahola *et al.* 2007, Metlaine *et al.* 2017). Finally, this study did not assess on duty workload (e.g., frequency of emergency call-outs), which may impact sleep opportunities at work, especially during overnight shifts, and may be an additional factor influencing burnout for consideration in future studies.

Sleep and mental health problems were associated with high burnout in firefighters, and sleep during overnight work explained the relationship between sleep disorder risk and burnout, and mental health outcomes and burnout. Given the high cost of burnout to the individual and organisation, our findings suggest that reducing sleep and mental health disturbances should be a focus of fire departments' occupational health screening programs, along with trialling interventions designed to maximise sleep.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Conflict of interests

APW, CSB, JPS, SQ and SMWR report no conflicts of interest. LKB reports research support from Cephalon, NFL charities, Sysco and San Francisco Bar Pilots. LKB has received consulting/lecture fees or served as a board member for Alertness Solution, Ceridian, Davis Joint Unified School Board, San Jose State University Foundation, Pugot Sound Pilots, Sygma and Torvec. SWL has no conflicts of interests directly related to the research or results

reported in this paper. SWL holds a process patent for ‘Systems and methods for determining and/or controlling sleep quality’, which is assigned to the Brigham and Women’s Hospital per Hospital policy. SWL has also served as a paid expert for legal proceedings related to light, sleep and health. SWL is a Program Leader for the CRC for Alertness, Safety and Productivity, Australia. CAC reports grants from Cephalon Inc., grants from Mary Ann & Stanley Snider via Combined Jewish Philanthropies, grants from National Football League Charities, grants from Optum, grants from Philips Respironics, Inc., grants from ResMed Foundation, grants from San Francisco Bar Pilots, grants from Schneider Inc., grants from Sysco, grants from Cephalon, Inc, grants from Jazz Pharmaceuticals, grants from Takeda Pharmaceuticals, grants from Teva Pharmaceuticals Industries, Ltd, grants from Sanofi-Aventis, Inc, grants from Sepracor, Inc, grants from Wake Up Narcolepsy, personal fees from Bose Corporation, personal fees from Boston Celtics, personal fees from Boston Red Sox, personal fees from Columbia River Bar Pilots, personal fees from Institute of Digital Media and Child Development, personal fees from Klarman Family Foundation, personal fees from Samsung Electronics, personal fees from Quest Diagnostics, Inc, personal fees from Vanda Pharmaceuticals, personal fees from American Academy of Sleep Medicine (AADSM), personal fees from CurtCo Media Labs LLC, personal fees from Global Council on Brain Health/AARP, personal fees from Hawaii Sleep Health and Wellness Foundation, personal fees from Harvard School of Public Health (HSPH), personal fees from Maryland Sleep Society, personal fees from National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), personal fees from National Sleep Foundation (NSF), personal fees from New England College of Optometry, personal fees from University of Michigan, personal fees from University of Washington, personal fees from Zurich Insurance Company, Ltd, personal fees from Purdue Pharma, LP, personal fees from McGraw Hill, personal fees from Houghton Mifflin Harcourt/Penguin, personal fees from Koninklijke Philips Electronics, N.V., personal fees from Cephalon, Inc, personal fees from State of Washington Board of Pilotage Commissioners, personal fees from Ganesco Inc., holds an equity interest in Vanda Pharmaceuticals, outside the submitted work. In addition, CAC holds a number of process patents in the field of sleep/circadian rhythms (e.g., photic resetting of the human circadian pacemaker).

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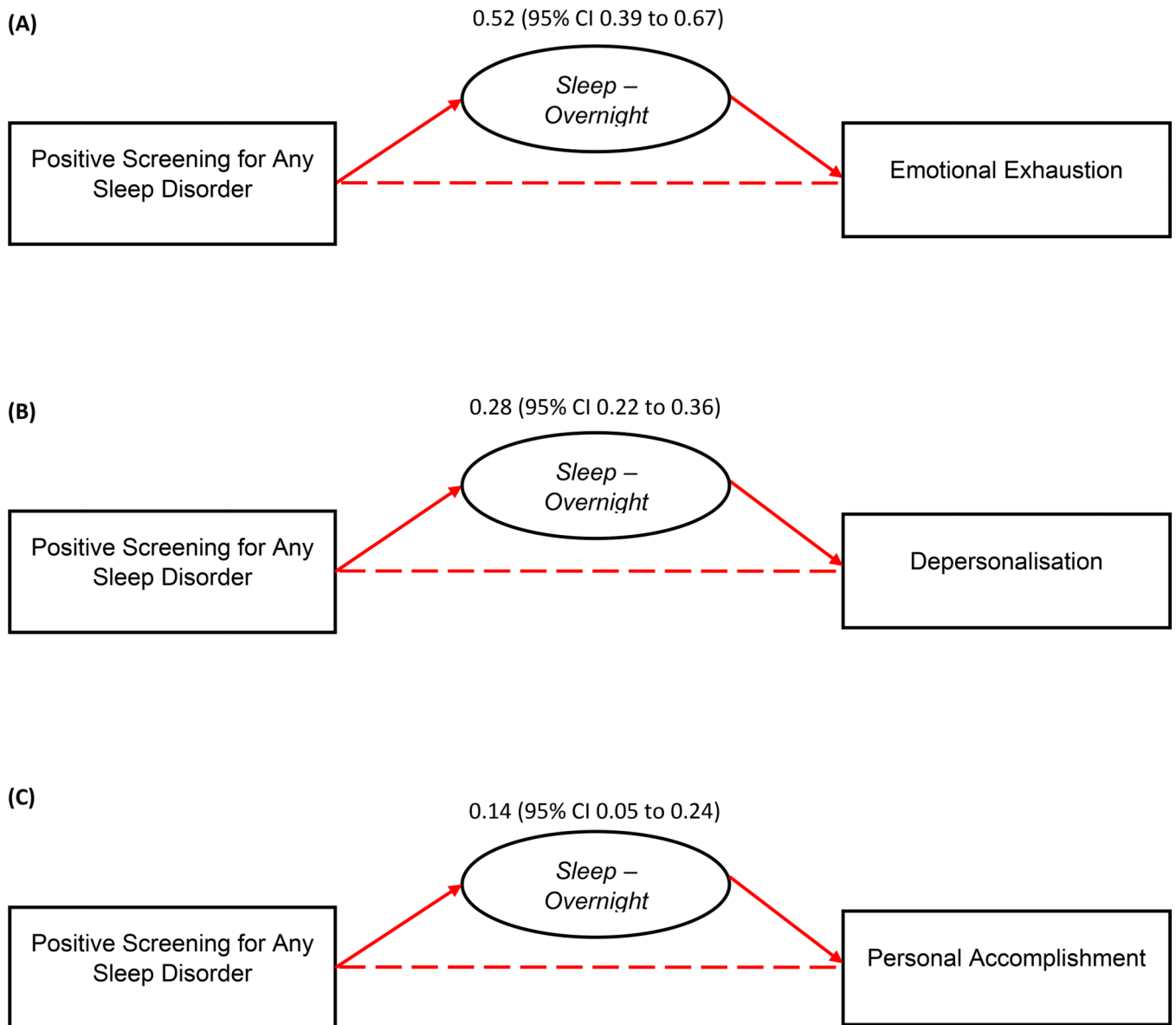


Fig 1. Indirect effects of positive screening for any sleep disorder on Emotional Exhaustion (A), Depersonalisation (B) and Personal Accomplishment (C) through the mediator of Sleep–Overnight work (i.e., sleep duration when working overnight shifts). Path coefficients (95% confidence interval) are shown. Long dashed lines indicate significant direct effect paths. Solid lines indicate significant indirect effect paths. For further indirect effect details see Table S.10. Adjusted for age, gender, body mass index, cigarette smoking, alcohol consumption, second job and mean weekly work hours. For full model details and variables included in the model see Table S.11.

Table 1.

Participant characteristics

| Characteristic | <i>n</i> | % | Mean | SD |
|---|----------|------|------|-----|
| <i>n</i> | 6,307 | | | |
| Age, years | | | 40.4 | 8.9 |
| Gender | | | | |
| Male | 5,812 | 92.2 | | |
| Female | 372 | 5.9 | | |
| Not known | 123 | 1.9 | | |
| Body Mass Index | | | | |
| < 25 kg/m ² | 1,164 | 18.5 | | |
| 25 and < 30 kg/m ² | 3,272 | 51.9 | | |
| 30 and < 35 kg/m ² | 1,427 | 22.6 | | |
| 35 kg/m ² | 444 | 7.0 | | |
| Second job | | | | |
| Yes | 2,495 | 39.6 | | |
| No | 3,231 | 51.2 | | |
| Unknown | 581 | 9.2 | | |
| Sleep required to feel well rested ^a , h | | | 7.6 | 1.1 |
| Sleep when working an overnight shift ^a , h | | | 5.4 | 1.5 |
| Sleep when working an overnight shift ^a | | | | |
| 6 h | 3,078 | 48.8 | | |
| > 6 h | 2,788 | 44.2 | | |
| Unknown | 50 | 0.8 | | |
| Not applicable ^b | 391 | 6.2 | | |
| Sleep after working an overnight shift ^a , h | | | 6.8 | 2.1 |
| Sleep after working an overnight shift ^a | | | | |
| 6 h | 1,988 | 31.5 | | |
| > 6 h | 3,860 | 61.2 | | |
| Unknown | 363 | 5.8 | | |
| Not applicable ^b | 96 | 1.5 | | |
| Sleep when working a day shift ^a | | | | |
| 6 h | 1,329 | 21.1 | | |
| > 6 h | 1,624 | 25.7 | | |
| Unknown | 913 | 14.5 | | |
| Not applicable ^b | 2,441 | 38.7 | | |
| Sleep following two or more days off from work ^a | | | | |
| 6 h | 1,086 | 17.2 | | |

| Characteristic | <i>n</i> | % | Mean | SD |
|--|----------|------|------|----|
| > 6 h | 4,530 | 71.8 | | |
| Unknown | 691 | 11.0 | | |
| Sleep disorders | | | | |
| Insomnia | 385 | 6.1 | | |
| Obstructive Sleep Apnoea | 1,830 | 29.0 | | |
| Restless Legs Syndrome | 219 | 3.5 | | |
| Shift Work Disorder | 491 | 7.8 | | |
| Burnout | | | | |
| High Emotional Exhaustion | 722 | 11.4 | | |
| High Depersonalisation | 1,118 | 17.7 | | |
| Low Personal Accomplishment | 2,402 | 38.1 | | |
| High degree ^c | 250 | 4.0 | | |
| Mental health condition | | | | |
| Depression | 378 | 6.0 | | |
| Anxiety | 224 | 3.6 | | |
| Post-traumatic Stress Disorder | 113 | 1.8 | | |
| Firefighters with a sleep disorder, mental health condition and burnout ^d | 233 | 3.7 | | |
| Firefighters without a sleep disorder, mental health condition or burnout ^e | 2155 | 34.2 | | |

^a per 24-hour period.

^b firefighters who indicated they do not work this shift type.

^c high EE, high DP, with low PA.

^d Included only firefighters who screened high risk for any sleep disorder, reported any mental health condition and had high burnout on one or more dimension.

^e Included only firefighters who did not screen high risk for any sleep disorder, did not report any mental health condition and did not have high burnout for any dimension.

Table 2a.

High burnout outcomes associated with positive sleep disorder screening result (n=6,307)

| Burnout Outcome ^a , <i>n</i> ^b | High Burnout Outcome in Participants with Positive Sleep Disorder Screening No./No. total (%) | | | | Unadjusted | | | Adjusted ^f | | |
|---|---|--------|---|--------|------------|-----------|----------------|-----------------------|-----------|---------|
| | OR | 95% CI | <i>P</i> Value | | OR | 95% CI | <i>P</i> Value | | | |
| | Insomnia Positive Screening | | Insomnia Negative Screening ^d | | | | | | | |
| EE <i>n</i> | 116/385 6261 | (30.1) | 593/5876 (10.1) | | 3.84 | 3.04-4.85 | <0.0001 | 3.78 | 2.97-4.79 | <0.0001 |
| DP <i>n</i> | 115/384 6221 | (29.9) | 989/5837 (16.9) | | 2.10 | 1.67-2.63 | <0.0001 | 2.15 | 1.71-2.71 | <0.0001 |
| PA <i>n</i> | 215/383 6233 | (56.1) | 2165/5850 (37.0) | | 2.18 | 1.77-2.68 | <0.0001 | 2.16 | 1.75-2.66 | <0.0001 |
| High degree ^c <i>n</i> | 44/383 6218 | (11.5) | 202/5835 (3.5) | | 3.62 | 2.56-5.11 | <0.0001 | 3.60 | 2.55-5.08 | <0.0001 |
| | Obstructive Sleep Apnea Positive Screening | | Obstructive Sleep Apnea Negative Screening ^d | | | | | | | |
| EE <i>n</i> | 349/1830 6205 | (19.1) | 362/4375 (8.3) | | 2.61 | 2.23-3.06 | <0.0001 | 3.09 | 2.56-3.71 | <0.0001 |
| DP <i>n</i> | 426/1824 6165 | (23.4) | 665/4341 (15.3) | | 1.68 | 1.47-1.93 | <0.0001 | 2.00 | 1.71-2.35 | <0.0001 |
| PA <i>n</i> | 758/1828 6178 | (41.5) | 1607/4350 (36.9) | | 1.21 | 1.08-1.35 | 0.001 | 1.20 | 1.07-1.34 | 0.002 |
| High degree ^c <i>n</i> | 112/1824 6163 | (6.1) | 133/4339 (3.1) | | 2.07 | 1.60-2.68 | <0.0001 | 2.49 | 1.85-3.34 | <0.0001 |
| | Shift Work Disorder Positive Screening | | Shift Work Disorder Negative Screening ^d | | | | | | | |
| EE <i>n</i> | 104/491 5260 | (21.2) | 442/4769 (9.3) | | 2.63 | 2.07-3.34 | <0.0001 | 2.60 | 2.01-3.35 | <0.0001 |
| DP <i>n</i> | 167/486 5234 | (34.4) | 810/4748 (17.1) | | 2.55 | 2.08-3.12 | <0.0001 | 2.49 | 2.03-3.05 | <0.0001 |
| PA <i>n</i> | 214/488 5241 | (43.9) | 1787/4753 (37.6) | | 1.30 | 1.07-1.57 | 0.007 | 1.30 | 1.07-1.57 | 0.007 |
| High degree ^c <i>n</i> | 54/486 5232 | (11.1) | 162/4746 (3.4) | | 3.54 | 2.56-4.89 | <0.0001 | 3.48 | 2.51-4.82 | <0.0001 |
| | Restless Leg Syndrome Positive Screening | | Restless Leg Syndrome Negative Screening ^d | | | | | | | |
| EE | 49/219 | (22.4) | 663/6025 | (11.0) | 2.33 | 1.68-3.24 | <0.0001 | 2.13 | 1.51-2.99 | <0.0001 |

| Burnout Outcome ^a , <i>n</i> ^b | High Burnout Outcome in Participants with Positive Sleep Disorder Screening No./No. total (%) | | | | Unadjusted | | | Adjusted ^f | | |
|---|---|--------|--|--------|------------|----------------|---------|-----------------------|-----------|---------|
| | OR | 95% CI | <i>P</i> Value | OR | 95% CI | <i>P</i> Value | | | | |
| <i>n</i> | 6244 | | | | | | | | | |
| DP | 66/218 | (30.3) | 1038/5987 | (17.3) | 2.07 | 1.54-2.79 | <0.0001 | 2.22 | 1.65-2.99 | <0.0001 |
| <i>n</i> | 6205 | | | | | | | | | |
| PA | 94/219 | (42.9) | 2272/5998 | (37.9) | 1.23 | 0.94-1.62 | 0.132 | 1.20 | 0.91-1.57 | 0.196 |
| <i>n</i> | 6217 | | | | | | | | | |
| High degree ^c | 19/218 | (8.7) | 229/5984 | (3.8) | 2.40 | 1.47-3.91 | <0.0001 | 2.30 | 1.41-3.75 | 0.001 |
| <i>n</i> | 6202 | | | | | | | | | |
| | Any Sleep Disorder Positive Screening | | Any Sleep Disorder Negative Screening ^d | | | | | | | |
| EE | 460/2398 | (19.2) | 262/3909 | (6.7) | 3.30 | 2.81-3.88 | <0.0001 | 3.37 | 2.86-3.97 | <0.0001 |
| <i>n</i> | 6307 | | | | | | | | | |
| DP | 599/2385 | (25.1) | 519/3882 | (13.4) | 2.17 | 1.91-2.48 | <0.0001 | 2.44 | 2.11-2.80 | <0.0001 |
| <i>n</i> | 6267 | | | | | | | | | |
| PA | 1033/2391 | (43.2) | 1369/3888 | (35.2) | 1.40 | 1.26-1.55 | <0.0001 | 1.39 | 1.25-1.54 | <0.0001 |
| <i>n</i> | 6279 | | | | | | | | | |
| High degree ^c | 171/2384 | (7.2) | 79/3880 | (2.0) | 3.72 | 2.83-4.88 | <0.0001 | 4.36 | 3.26-5.82 | <0.0001 |
| <i>n</i> | 6264 | | | | | | | | | |

EE, emotional exhaustion; DP, depersonalisation; PA, personal accomplishment; OR, Odds ratio; CI, Confidence interval; *n*, number.

^aHigh vs. low to moderate score on burnout dimension

^bThe *n* presented represents the sample for Unadjusted analyses. The *n* for Adjusted analyses for sleep disorders are in Table S.4.

^chigh EE, high DP and low PA.

^dMissing or not known outcomes not included.

^eYes vs. never or not now.

^fAdjusted for age, gender, body mass index, cigarette smoking, alcohol consumption, second job and mean weekly work hours. Variables included in each model for sleep disorders are in Tables S.4.

Table 2b.

High burnout outcomes associated with mental health outcomes (n=6,307)

| Burnout Outcome ^{a, n} | High Burnout Outcome in Participants with Mental Health Conditions ^e No./No. total (%) | | | | Unadjusted | | | Adjusted ^f | | |
|--------------------------------------|---|--------|--|--------|------------|-----------|---------|-----------------------|-----------|---------|
| | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | |
| | Depression | | No Depression ^d | | | | | | | |
| EE <i>n</i> | 113/378 6208 | (29.9) | 592/5830 6208 | (10.2) | 3.77 | 2.98-4.78 | <0.0001 | 3.61 | 2.84-4.59 | <0.0001 |
| DP <i>n</i> | 128/376 6168 | (34.0) | 965/5792 6168 | (16.7) | 2.58 | 2.06-3.23 | <0.0001 | 2.77 | 2.19-3.51 | <0.0001 |
| PA <i>n</i> | 173/377 6180 | (45.9) | 2186/5803 6180 | (37.7) | 1.40 | 1.14-1.73 | <0.0001 | 1.41 | 1.13-1.75 | 0.002 |
| High degree ^c <i>n</i> | 49/376 6165 | (13.0) | 196/5789 6165 | (3.4) | 4.28 | 3.07-5.96 | <0.0001 | 4.18 | 3.00-5.84 | <0.0001 |
| | Post-Traumatic Stress Disorder | | No Post-Traumatic Stress Disorder ^d | | | | | | | |
| EE <i>n</i> | 43/113 6197 | (38.1) | 659/6084 6197 | (10.8) | 5.06 | 3.43-7.46 | <0.0001 | 4.88 | 3.27-7.29 | <0.0001 |
| DP <i>n</i> | 46/113 6157 | (40.7) | 1044/6044 6157 | (17.3) | 3.29 | 2.25-4.81 | <0.001 | 3.32 | 2.22-4.95 | <0.0001 |
| PA <i>n</i> | 55/113 6169 | (48.7) | 2297/6056 6169 | (37.9) | 1.55 | 1.07-2.25 | 0.021 | 1.38 | 0.93-2.05 | 0.106 |
| High degree ^c <i>n</i> | 19/113 6154 | (16.8) | 224/6041 6154 | (3.7) | 5.25 | 3.15-8.75 | <0.0001 | 5.12 | 3.07-8.56 | <0.0001 |
| | Anxiety | | No Anxiety ^d | | | | | | | |
| EE <i>n</i> | 75/224 6201 | (33.5) | 629/5977 6201 | (10.5) | 4.28 | 3.20-5.72 | <0.0001 | 4.17 | 3.11-5.60 | <0.0001 |
| DP <i>n</i> | 66/223 6161 | (29.6) | 1027/5938 6161 | (17.3) | 2.01 | 1.50-2.70 | <0.0001 | 2.07 | 1.54-2.78 | <0.0001 |
| PA <i>n</i> | 97/223 6173 | (43.5) | 2254/5950 6173 | (37.9) | 1.26 | 0.96-1.65 | 0.091 | 1.33 | 1.00-1.76 | 0.051 |
| High degree ^c <i>n</i> | 27/223 6158 | (12.1) | 218/5935 6158 | (3.7) | 3.61 | 2.36-5.52 | <0.0001 | 3.52 | 2.30-5.39 | <0.0001 |
| | Any Mental Health Condition | | No Mental Health Condition ^d | | | | | | | |
| EE <i>n</i> | 148/526 6235 | (28.1) | 559/5709 6235 | (9.8) | 3.61 | 2.93-4.45 | <0.0001 | 3.45 | 2.79-4.27 | <0.0001 |
| DP | 166/523 | (31.7) | 933/5672 | (16.4) | 2.36 | 1.94-2.88 | <0.0001 | 2.52 | 2.04-3.10 | <0.0001 |

| Burnout Outcome ^{a, b} | High Burnout Outcome in Participants with Mental Health Conditions ^e | | | | Unadjusted | | | Adjusted ^f | | |
|---------------------------------|---|--------|-----------|--------|------------|-----------|---------|-----------------------|-----------|---------|
| | No./No. total (%) | | | | OR | 95% CI | P Value | OR | 95% CI | P Value |
| <i>n</i> | | | | 6195 | | | | | | |
| PA | 241/524 | (46.0) | 2126/5683 | (37.4) | 1.43 | 1.19-1.71 | <0.0001 | 1.42 | 1.17-1.72 | <0.0001 |
| <i>n</i> | | | | 6207 | | | | | | |
| High degree ^c | 63/523 | (12) | 182/5669 | (3.2) | 4.13 | 3.05-5.58 | <0.0001 | 4.05 | 2.99-5.48 | <0.0001 |
| <i>n</i> | | | | 6192 | | | | | | |

EE, emotional exhaustion; DP, depersonalisation; PA, personal accomplishment; OR, Odds ratio; CI, Confidence interval; *n*, number.

^aHigh vs. low to moderate score on burnout dimension

^bThe *n* presented represents the sample for Unadjusted analyses. The *n* for Adjusted analyses for mental health outcomes are in Table S.5.

^chigh EE, high DP and low PA.

^dMissing or not known outcomes not included.

^eYes vs. never or not now.

^fAdjusted for age, gender, body mass index, cigarette smoking, alcohol consumption, second job and mean weekly work hours. Variables included in each model for mental health outcomes are in Tables S.5.

Table 3.

High burnout associated with sleep duration in *All participants* (n=6,307) and participants who did not screen positive for a sleep disorder (*Low-risk sleep disorder participants*; n=3,909)

| Burnout Outcome ^a , n ^b | High Burnout Outcome in <i>All participants</i> with Short Sleep No./No. total (%) | | | Unadjusted | | | Adjusted ^e | | | High Burnout Outcome in <i>Low-risk sleep disorder participants</i> with Short Sleep No./No. total (%) | | | Unadjusted | | | Adjusted ^e | | | | |
|---|--|--------|-----------|---|--------|-----------|---|------------------------|-----------|--|----------|---------|---|--------|---------|---|---------|------------------------|-----------|---------|
| | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | | |
| EE | Sleep when working overnight ^d | | | Sleep when working overnight ^d | | | Sleep when working overnight ^d | | | Sleep when working overnight ^d | | | Sleep when working overnight ^d | | | Sleep when working overnight ^d | | | | |
| | 6 h | >6 h | | 6 h | >6 h | | 6 h | >6 h | | 6 h | >6 h | | 6 h | >6 h | | 6 h | >6 h | | | |
| EE | 579/3078 | (18.8) | 67/2788 | (2.4) | 2.32 | 1.94-2.77 | <0.0001 | 2.26 | 1.87-2.73 | <0.0001 | 139/1743 | (8.0) | 89/1891 | (4.7) | 1.76 | 1.33-2.31 | <0.0001 | 1.74 | 1.32-2.31 | <0.0001 |
| n | 5866 | | | | | | | | | | 3634 | | | | | | | | | |
| DP | 960/3062 | (31.4) | 110/2774 | (4.0) | 2.14 | 1.86-2.46 | <0.0001 | 2.11 | 1.83-2.43 | <0.0001 | 289/1736 | (16.6) | 194/1881 | (10.3) | 1.74 | 1.43-2.11 | <0.0001 | 1.74 | 1.43-2.11 | <0.0001 |
| n | 5836 | | | | | | | | | | 3617 | | | | | | | | | |
| PA | 1820/3065 | (59.4) | 455/2778 | (16.4) | 0.98 | 0.89-1.09 | 0.769 | Not sig in final model | | | 585/1736 | (33.7) | 686/1882 | (36.5) | 0.89 | 0.77-1.02 | 0.083 | 0.88 | 0.77-1.01 | 0.066 |
| n | 5843 | | | | | | | | | | 3618 | | | | | | | | | |
| High Degree ^c | 215/3059 | (7.0) | 25/2774 | (0.9) | 2.54 | 1.90-3.40 | <0.0001 | 2.52 | 1.88-3.37 | <0.0001 | 39/1734 | (2.2) | 35/1881 | (1.9) | 1.21 | 0.77-1.92 | 0.411 | Not sig in final model | | |
| n | 5833 | | | | | | | | | | 3615 | | | | | | | | | |
| EE | Sleep <i>after</i> working overnight ^d | | | Sleep <i>after</i> working overnight ^d | | | Sleep <i>after</i> working overnight ^d | | | Sleep <i>after</i> working overnight ^d | | | Sleep <i>after</i> working overnight ^d | | | Sleep <i>after</i> working overnight ^d | | | | |
| | 6 h | >6 h | | 6 h | >6 h | | 6 h | >6 h | | 6 h | >6 h | | 6 h | >6 h | | 6 h | >6 h | | 6 h | >6 h |
| EE | 301/1988 | (15.1) | 335/3860 | (8.7) | 1.88 | 1.59-2.22 | <0.0001 | 1.88 | 1.59-2.23 | <0.0001 | 89/1061 | (8.4) | 141/2562 | (5.5) | 1.57 | 1.19-2.07 | 0.001 | 1.53 | 1.16-2.02 | 0.003 |
| n | 5848 | | | | | | | | | | 3623 | | | | | | | | | |
| DP | 415/1974 | (21.0) | 641/3845 | 16.7) | 1.33 | 1.16-1.53 | <0.0001 | 1.34 | 1.17-1.54 | <0.0001 | 150/1056 | (14.2) | 338/2551 | (13.2) | 1.08 | 0.88-1.33 | 0.446 | Not sig in final model | | |
| n | 5819 | | | | | | | | | | 3607 | | | | | | | | | |
| PA | 807/1978 | (40.8) | 1427/3848 | (37.1) | 1.17 | 1.05-1.31 | 0.006 | 1.15 | 1.03-1.29 | 0.013 | 380/1057 | (36.0) | 886/2551 | (34.7) | 1.06 | 0.91-1.23 | 0.485 | Not sig in final model | | |
| n | 5826 | | | | | | | | | | 3608 | | | | | | | | | |
| High Degree ^c | 113/1973 | (5.7) | 126/3843 | (3.3) | 1.79 | 1.38-2.32 | <0.0001 | 1.78 | 1.37-2.31 | <0.0001 | 20/1056 | (1.9) | 55/2549 | (2.2) | 0.88 | 0.52-1.47 | 0.614 | Not sig in final model | | |
| n | 5816 | | | | | | | | | | 3605 | | | | | | | | | |

J Sleep Res. Author manuscript; available in PMC 2020 December 01.

Sleep when working a day shift^d

| Burnout Outcome ^a , <i>n</i> | High Burnout Outcome in All participants with Short Sleep No./No. total (%) | | Unadjusted | | Adjusted ^e | | High Burnout Outcome in Low-risk sleep disorder participants with Short Sleep No./No. total (%) | | Unadjusted | | Adjusted ^e | | | | | |
|--|---|------------------|------------|-----------|-----------------------|------|---|------------------------|----------------|-----------------|-----------------------|-----------|--------|---------|-----------|------------------------|
| | 6 h | >6 h | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | | |
| EE | 213/1329 (16.0) | 150/1624 (9.2) | 1.88 | 1.50-2.34 | <0.0001 | 1.96 | 1.56-2.47 | <0.0001 | 65/716 (9.1) | 66/1101 (6.0) | 1.57 | 1.10-2.24 | 0.014 | 1.68 | 1.17-2.42 | 0.005 |
| <i>n</i> | 2953 | | | | | | | | 1817 | | | | | | | |
| DP | 256/1320 (19.4) | 222/1616 (13.7) | 1.51 | 1.24-1.84 | <0.0001 | 1.51 | 1.24-1.84 | <0.0001 | 91/708 (12.9) | 118/1096 (10.8) | 1.22 | 0.91-1.64 | 0.177 | | | Not sig in final model |
| <i>n</i> | 2936 | | | | | | | | 1804 | | | | | | | Not sig in final model |
| PA | 496/1322 (37.5) | 620/1620 (38.3) | 0.97 | 0.83-1.13 | 0.676 | | | Not sig in final model | 242/710 (34.1) | 408/1098 (37.2) | 0.87 | 0.72-1.07 | 0.184 | | | Not sig in final model |
| <i>n</i> | 2942 | | | | | | | | 1808 | | | | | | | |
| High Degree ^c | 58/1320 (4.4) | 42/1615 (2.6) | 1.72 | 1.15-2.58 | 0.008 | 1.72 | 1.15-2.58 | 0.008 | 13/708 (1.8) | 19/1096 (1.7) | 1.06 | 0.52-2.16 | 0.872 | | | Not sig in final model |
| <i>n</i> | 2935 | | | | | | | | 1804 | | | | | | | |
| Sleep following 2 days off ^d | | | | | | | | | | | | | | | | |
| Sleep following 2 days off ^d | | | | | | | | | | | | | | | | |
| 6 h | | | | | | | | | | | | | | | | |
| >6 h | | | | | | | | | | | | | | | | |
| EE | 167/1086 (15.4) | 476/4530 (10.5) | 1.55 | 1.28-1.87 | <0.0001 | 1.56 | 1.29-1.90 | <0.0001 | 43/567 (7.6) | 189/2892 (6.5) | 1.17 | 0.83-1.66 | 0.362 | | | Not sig in final model |
| <i>n</i> | 5616 | | | | | | | | 3459 | | | | | | | |
| DP | 214/1081 (19.8) | 787/4506 (17.5) | 1.17 | 0.99-1.38 | 0.073 | 1.19 | 1.00-1.41 | 0.044 | 73/563 (13.0) | 385/2875 (13.4) | 0.96 | 0.74-1.26 | 0.786 | | | Not sig in final model |
| <i>n</i> | 5587 | | | | | | | | 3438 | | | | | | | |
| PA | 431/1082 (39.8) | 1661/4513 (36.8) | 1.14 | 0.99-1.30 | 0.065 | 1.12 | 0.98-1.29 | 0.097 | 206/564 (36.5) | 976/2879 (33.9) | 1.12 | 0.93-1.35 | 0.230 | | | Not sig in final model |
| <i>n</i> | 5595 | | | | | | | | 3443 | | | | | | | |
| High Degree ^c | 53/1081 (4.9) | 169/4504 (3.8) | 1.32 | 0.96-1.81 | 0.083 | 1.34 | 0.98-1.85 | 0.069 | 10/563 (1.8) | 60/2874 (2.1) | 0.85 | 0.43-1.67 | 0.633 | | | Not sig in final model |
| <i>n</i> | 5585 | | | | | | | | 3437 | | | | | | | |

J Sleep Res. Author manuscript; available in PMC 2020 December 01.

EE, emotional exhaustion; DP, depersonalisation; PA, personal accomplishment; OR, Odds ratio; CI, Confidence interval; *n*, number.

^aHigh vs. low to moderate score on burnout dimension.

^bThe *n* presented represents the sample for Unadjusted analyses. The *n* for Adjusted analyses are in Table S.6.

^chigh EE, high DP, with low PA.

^dMissing or not known outcomes not included.

^e Adjusted for age, gender, body mass index, cigarette smoking, alcohol consumption, second job and mean weekly work hours. Variables included in each model are in Table S.6.

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Table 4.

High burnout associated with a sleep deficit and daytime sleepiness in *All participants* (n=6,307) and participants who did not screen positive for a sleep disorder (*Low-risk sleep disorder participants*; n=3,909)

| Burnout Outcome ^a , n ^b | High Burnout Outcome in <i>All participants</i> with Sleep Deficit and Sleepiness No./No. total (%) | | | Unadjusted | | | Adjusted ^d | | | High Burnout Outcome in <i>Low-risk sleep disorder participants</i> with Sleep Deficit and Sleepiness No./No. total (%) | | | Unadjusted | | | Adjusted ^e | | | | |
|--|---|--------|-----------|------------|--------|-----------|-----------------------|--------|-----------|---|-----------|---------|------------|--------|---------|-----------------------|---------|---------|-----------|---------|
| | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | | |
| EE | 351/2351 | (14.9) | 280/3479 | (8.0) | 2.00 | 1.70-2.37 | <0.0001 | 2.00 | 1.67-2.38 | <0.0001 | 120/1274 | (9.4) | 108/2336 | (4.6) | 2.15 | 1.64-2.81 | <0.0001 | 2.09 | 1.59-2.74 | <0.0001 |
| n | 5830 | | | | | | | | | 3610 | | | | | | | | | | |
| DP | 508/2338 | (21.7) | 544/3463 | (15.7) | 1.49 | 1.30-1.70 | <0.0001 | 1.48 | 1.29-1.69 | <0.0001 | 200/1270 | (15.7) | 288/2324 | (12.4) | 1.32 | 1.09-1.61 | 0.005 | 1.29 | 1.06-1.57 | 0.011 |
| n | 5801 | | | | | | | | | 3594 | | | | | | | | | | |
| PA | 965/2341 | (41.2) | 1261/3467 | (36.4) | 1.23 | 1.10-1.37 | <0.0001 | 1.23 | 1.10-1.37 | <0.0001 | 472/1270 | (37.2) | 787/2325 | (33.8) | 1.16 | 1.00-1.33 | 0.046 | 1.17 | 1.01-1.35 | 0.036 |
| n | 5808 | | | | | | | | | 3595 | | | | | | | | | | |
| High Degree | 141/2337 | (6.0) | 97/3461 | (2.8) | 2.23 | 1.71-2.90 | <0.0001 | 2.22 | 1.71-2.89 | <0.0001 | 37/1270 | (2.9) | 38/2322 | (1.6) | 1.80 | 1.14-2.85 | 0.012 | 1.77 | 1.11-2.81 | 0.017 |
| n | 5798 | | | | | | | | | 3592 | | | | | | | | | | |
| Sleep after overnight work minus sleep required to feel well rested ^d | | | | | | | | | | | | | | | | | | | | |
| ±45 mins | | | | | | | | | | | | | | | | | | | | |
| >±45 mins | | | | | | | | | | | | | | | | | | | | |
| Daytime Sleepiness ^d | | | | | | | | | | | | | | | | | | | | |
| <11 Epworth Sleepiness Scale | | | | | | | | | | | | | | | | | | | | |
| EE | 343/4235 | (8.1) | 356/1921 | (18.5) | 2.58 | 2.20-3.03 | <0.0001 | 2.53 | 2.15-2.98 | <0.0001 | 157/2957 | (5.3) | 99/858 | (11.5) | 2.33 | 1.79-3.03 | <0.0001 | 2.32 | 1.77-3.03 | <0.0001 |
| n | 6156 | | | | | | | | | 3815 | | | | | | | | | | |
| DP | 598/4212 | (14.2) | 492/1905 | (25.8) | 2.10 | 1.84-2.41 | <0.0001 | 2.08 | 1.82-2.38 | <0.0001 | 350/2938 | (11.9) | 161/850 | (18.9) | 1.73 | 1.41-2.12 | <0.0001 | 1.65 | 1.34-2.03 | <0.0001 |
| n | 6117 | | | | | | | | | 3788 | | | | | | | | | | |
| PA | 1549/4219 | (36.7) | 788/1910 | (41.3) | 1.21 | 1.08-1.35 | 0.001 | 1.20 | 1.08-1.35 | 0.001 | 1001/2943 | (34.0) | 329/851 | (38.7) | 1.22 | 1.04-1.43 | 0.012 | 1.25 | 1.07-1.47 | 0.006 |

J Sleep Res. Author manuscript; available in PMC 2020 December 01.

| Burnout Outcome ^a , n ^b | High Burnout Outcome in All participants with Sleep Deficit and Sleepiness No./No. total (%) | | | High Burnout Outcome in Low-risk sleep disorder participants with Sleep Deficit and Sleepiness No./No. total (%) | | | Adjusted ^d | | | Unadjusted | | | Adjusted ^e | | | | | | |
|--|--|----------------|--------|--|---------|--------|-----------------------|---------|--------|------------|---------|---------------|-----------------------|------|-----------|---------|------|-----------|-------|
| | n | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | OR | 95% CI | P Value | | | |
| High Degree ^c | 115/4209 (2.7) | 131/1905 (6.9) | 2.63 | 2.03-3.40 | <0.0001 | 2.63 | 2.03-3.40 | <0.0001 | 2.63 | 2.03-3.40 | <0.0001 | 54/2936 (1.8) | 24/850 (2.8) | 1.55 | 0.95-2.52 | 0.077 | 1.49 | 0.91-2.46 | 0.116 |
| n | 6129 | | | | | | | | | | | 3794 | | | | | | | |
| n | 6114 | | | | | | | | | | | 3786 | | | | | | | |

EE, emotional exhaustion; DP, depersonalisation; PA, personal accomplishment; OR, Odds ratio; CI, Confidence interval; n, number.

^a High vs. low to moderate score on burnout dimension or a high degree of burnout.

^b The n presented represents the sample for Unadjusted analyses. The n for Adjusted analyses are in Table S.8.

^c high EE, high DP, with low PA.

^d Missing or not known outcomes not included.

^e Adjusted for age, gender, body mass index, cigarette smoking, alcohol consumption, second job and mean weekly work hours. Variables included in each model are in Table S.8.