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Physicians prescribe fewer analgesics during night shifts than day shifts

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Adequate pain management is one of the biggest challenges of the modern healthcare system. Physician perception of patient subjective pain, which is crucial to pain management, is susceptible to a host of potential biases. Here we explore the timing of physicians' work as a previously unrecognized source of systematic bias in pain management. We hypothesized that during night shifts, sleep deprivation, fatigue, and stress would reduce physicians' empathy for others' pain, leading to underprescription of analgesics for patient pain relief. In study 1, 67 resident physicians, either following a night shift or not, performed empathy for pain assessment tasks and simulated patient scenarios in laboratory conditions. As predicted, following a night shift, physicians showed reduced empathy for pain. In study 2, we explored this phenomenon in medical decisions in the field. We analyzed three emergency department datasets from Israel and the United States that included discharge notes of patients arriving with pain complaints during 2013 to 2020 (n = 13,482). Across all datasets, physicians were less likely to prescribe an analgesic during night shifts (compared to daytime shifts) and prescribed fewer analgesics than generally recommended by the World Health Organization. This effect remained significant after adjusting for patient, physician, type of complaint, and emergency department characteristics. Underprescription for pain during night shifts was particularly prominent for opioids. We conclude that night shift work is an important and previously unrecognized source of bias in pain management, likely stemming from impaired perception of pain. We consider the implications for hospitals and other organizations employing night shifts.

shift work | empathy | sleep deprivation | analgesics | pain management

Significance

Adequate pain management is critical for patient health and well-being. Here we use a laboratory-based experiment and an analysis of archival data over 7 y from Israeli and US hospitals to test the effects of night shifts on pain management. We show robust evidence that physicians' pain management decisions are impaired during night shifts. We argue that even medical experts, who try to provide the best care for their patients, are susceptible to the effects of night shifts. Our findings highlight the need to implement more structured pain management guidelines in hospitals and seek improved physician working schedules. We discuss implications for workplaces that involve shift work and empathic decision-making, including crisis centers, first responders, and the military.

Humanity is in pain. Almost 60% of US adults report having experienced pain in the past 3 months (1). Indeed, pain is one of the main reasons American adults seek medical care (2). Providing adequate pain management and relieving pain is thus a major task of the healthcare system. Inadequate pain management may have dire consequences on patient health and well-being (3). Patients with acute pain complaints who do not receive adequate pain management often develop chronic unrelieved pain (4, 5), which imposes great costs on the medical system (6). Yet pain management guidelines are not clear cut, leaving physicians with a challenging task. Physicians are required to make complex assessments of patient subjective pain and integrate various medical factors to determine whether to prescribe a pain medication and which one. The subjective nature of pain management decisions gives rise to a host of biases (e.g., race and gender) (7, 8).

Here we explored a previously undocumented source of bias in pain management: the timing of physicians' shifts. During their residency training, physicians work night shifts as well as day shifts. Night shift work entails sleep deprivation, circadian misalignment, fatigue, and stress (9, 10). It is associated with myriad deleterious consequences for physicians' health, including mental impairments (11). The consequences of night shifts on physician functioning may also extend to the health of their patients (12–14). We hypothesized that night shifts affect physician pain management decisions by impairing empathy, i.e., their ability to understand and share patients' pain (15). Empathy for pain plays a pivotal role in the physician–patient relationship and has a critical impact on healthcare delivery (16). Greater physician empathy is associated with improved clinical outcomes, higher patient satisfaction, and better patient adherence to treatment (17–19).

We suggest that night shift work may impact both the affective and the cognitive resources required for empathy (15). First, sleep deprivation and stress, common features of night shift work, hinder the processing of emotional information and heighten anxiety (20–23). Thus, sleep-deprived physicians may display impairments when tasked with identifying patient emotional states and importantly when attempting to assess

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patient pain. Second, sleep deprivation negatively affects fundamental cognitive functions by hurting attention, psychomotor vigilance, self-control, and working memory (24). Similarly, stress may negatively impact cognitive function (25). Indeed, we have recently observed that physicians working night shifts exhibit poorer cognitive executive functioning (26). Thus, night shifts may impair the cognitive ability of physicians to assess patient pain intensity. These two potential mechanisms led us to hypothesize that physicians' empathy for pain would be diminished during night shifts, which would make physicians less likely to prescribe analgesic medications to patients in need.

We tested this hypothesis via two complementary approaches. First, we administered a battery of ecological multifaceted tasks to measure empathy and pain management decisions of physicians following night shift or not. Second, we analyzed three electronic medical records (EMRs) from Israeli and American healthcare systems to test if the prescription of analgesics in the emergency department (ED) differed during night shifts versus daytime. Whereas the first study enabled us to measure empathy for pain directly and examine the hypothesis in a controlled environment, the second enabled us to test the implications of night shift work on pain management decisions in the field.

Results

Study 1. Study 1 tested whether night shift work affected physician pain assessment and empathy for pain. Resident physicians at Hadassah Medical Centers in Jerusalem were recruited between 8:00 AM and 10:00 AM. Physicians in the night shift group were toward the end of a 26-h shift that began at 8:00 AM the day before, whereas those in the control group were at the beginning of a new workday. First, physicians completed two tasks: an affective empathy for pain task (27), where they rated their emotional reaction to pictures of others in pain, and a cognitive empathic accuracy task (28), where they had to assess the feelings of targets telling emotional stories in a video clip. Finally, physicians were presented with one clinical scenario describing a female patient with a headache and another scenario describing a male patient with a backache. Physicians were asked to assess the magnitude of patients' pain and to report their likelihood to prescribe pain medications.

As expected, physicians in the night shift group slept less than those in the control group (2.93 vs. 5.97 h, respectively; difference = −3.04, CI 95%, −3.65 to −2.43, $P < 0.001$, Cohen's d = 2.39). There were no other significant differences in the demographic, sleep, or burnout measures between the groups (*SI Appendix*, Table S1).

In the empathy for pain task, physicians' empathy scores were significantly lower in the night shift group than in the control group (6.01 vs. 6.84, difference = −0.83, CI 95%, −1.55 to −0.10, $P = 0.026$, Cohen's d = 0.55; Fig. 1*A*). In the empathic accuracy task, there were no significant differences between the groups (0.75 vs. 0.77; difference = −0.02, CI 95%, −0.09 to 0.05, $P = 0.635$, Cohen's d = 0.14; Fig. 1*B*). We have also examined the relation between physicians' reported general sleep quality and empathy measures (*SI Appendix*, *Supplementary Results*).

In the headache scenario, physicians in the night shift group assessed the headache as significantly weaker than physicians in the control group (70.00 vs. 80.58, difference = −10.58, CI 95%, −17.58 to −3.58, $P = 0.004$, Cohen's d = 0.74; Fig. 1*C*), and their propensity to prescribe analgesics was directionally lower, but this difference was not statistically significant (night shift, 48.68 vs. control, 56.02; difference = −7.35, CI 95%, −14.83 to 0.14, $P = 0.054$, Cohen's d = 0.47; Fig. 1*D*). Overall, pain assessment was positively correlated with the propensity to prescribe analgesics ($r = 0.41$, $P < 0.001$; Fig. 1*E*). In the backache scenario, physicians in the night shift group assessed the backache as directionally weaker than physicians in the control group, but this difference was not statistically significant, (73.65 vs. 77.87, difference = −4.22, CI 95%, −8.52 to 0.08, $P = 0.054$, Cohen's d = 0.48; Fig. 1*F*). Physicians' propensity to prescribe analgesics was not significantly different between the groups (night shift, 56.57 vs. control, 62.43; difference = −5.86, CI 95%, −14.08 to 2.36, $P = 0.159$, Cohen's d = 0.35; Fig. 1*G*). There was a positive correlation between pain assessment and propensity to prescribe analgesics ($r = 0.33$, $P = 0.009$ [Fig. 1*H*]; for separate correlations by group, see *SI Appendix*).

In summary, study 1 documented a negative effect of night shift work on physician empathy for pain and a positive association between physician assessment of patient pain and the propensity to prescribe analgesics. Yet the effect of night shift work on physician pain management decisions was not statistically significant. To investigate whether or not night shift work affects real-life pain management decisions, in study 2, we analyzed a large archival database of analgesic prescriptions in the ED.

Study 2. In study 2, we aimed to test our hypothesis that night shifts affect physicians' pain management decisions. For this purpose, we collected three EMR datasets of ED patient discharge notes. We analyzed physician analgesic prescription patterns by time of day. The first dataset included 5,000 discharge notes between 2014 and 2019 from the Hadassah–Hebrew University Medical Center (HHUMC). The data included time of discharge from the ED, the medications the patient was prescribed upon discharge, the patient's subjective pain rating (visual analog scale [VAS] from 0 to 10), and demographic variables of the patient and the physician. Physicians worked from 8:00 AM to 4:00 PM or from 8:00 AM to 11:00 PM during day shifts and from 8:00 AM to 10:00 AM the next morning during night shifts (sleeping an estimated average of 3 h, based on the sample in study 1). Some physicians were residents who worked both night shifts and day shifts, and some were attending physicians who worked mostly day shifts. Physician work schedule remained unchanged during the years of the study. To cross-validate the results from the first dataset, in study 2b, we preregistered our analyses and hypotheses* and analyzed 4,157 remaining notes from HHUMC. Finally, to generalize our findings from Israel, in study 2c, we obtained a third EMR dataset of 4,325 ED discharge notes from several sites of the University of Missouri Health Center in Colombia, MO. Physicians worked from 8:00 AM to either 4:00 PM, 6:00 PM, or 8:00 PM during day shifts and from 8:00 AM to 8:00 AM the next morning during night shifts.

The characteristics for the first EMR dataset are presented in Table 1. Our primary outcome, the propensity to prescribe analgesics, was significantly lower during night shifts than during daytime (39% vs. 50%, odds ratio (OR) = 0.65, CI 95%, 0.58 to 0.74, $P < 0.001$). This effect was consistent across the years and different VAS scores (Fig. 2 *A* and *B*). Importantly, VAS scores did not differ between patients discharged during night shifts and daytime [$M_{\text{night shift}} = 6.68$ (2.65) vs. $M_{\text{daytime}} = 6.72$ (2.59); $P = 0.524$]. To examine whether the effect of night shifts was unique to pain-related prescriptions, we analyzed medications

*Following constructive feedback from the reviewing team, the analysis presented in the manuscript is slightly different than the one we originally preregistered. We present the preregistered analysis in the *SI Appendix*. The preregistered analysis yielded nearly identical results to the ones presented here.

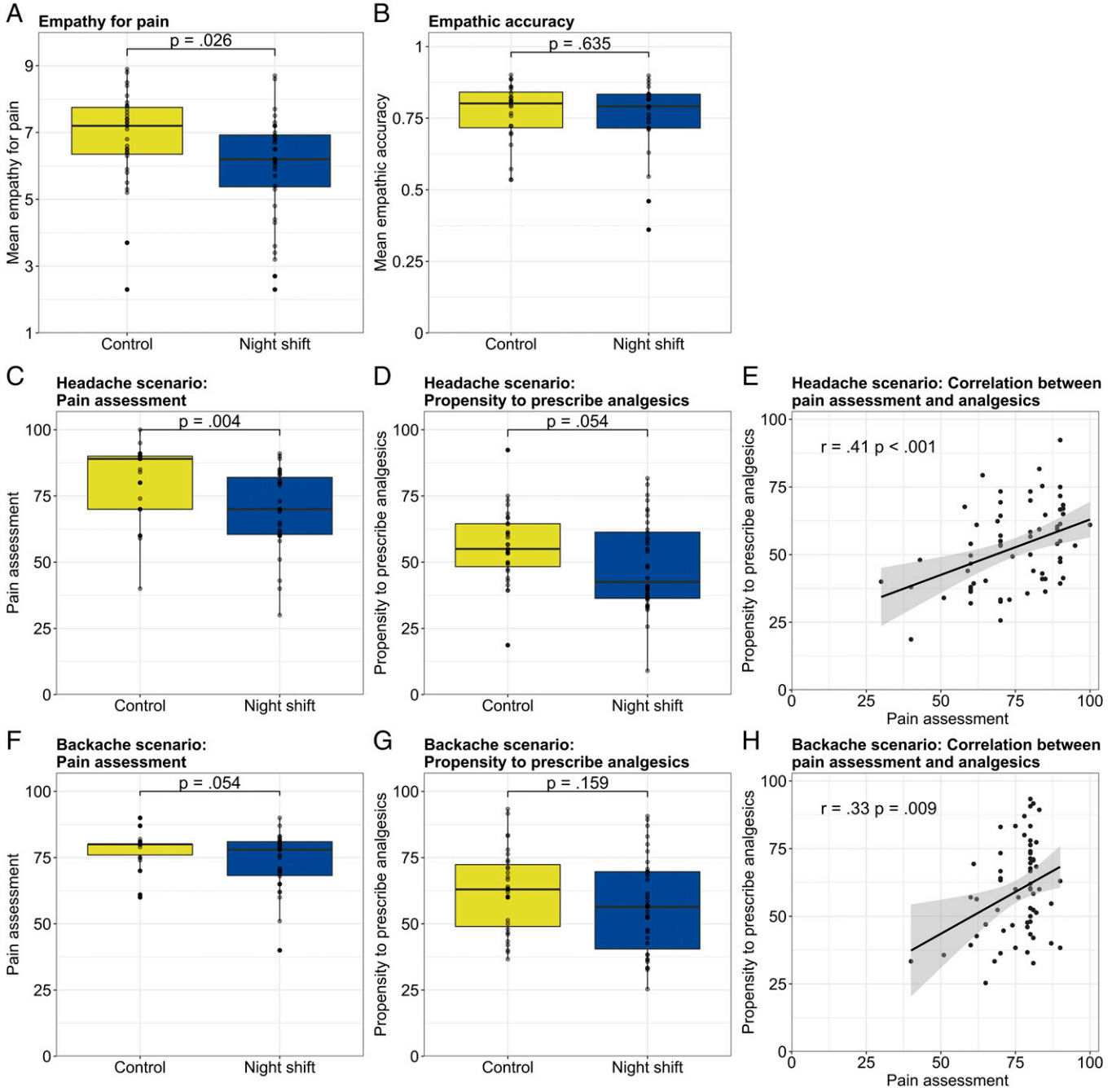

Fig. 1. Results of study 1: empathy measures and pain management scenarios. (*A*) Empathy for pain and (*B*) empathic accuracy scores comparison between resident physicians in the control and the night shift groups. (*C*–*H*) Pain management scenarios. *C* and *F* show pain assessment, *D* and *G* show propensity to prescribe analgesics, and *E* and *H* show the correlation between pain assessment and propensity to prescribe analgesics.

prescribed in the discharge notes which were not aimed at relieving pain (e.g., diabetes or blood pressure medications). The propensity to prescribe nonanalgesic medications was similar during night shifts and daytime (22% vs. 23%; $P = 0.401$), suggesting that the effect was specific to pain.

To test if this effect could be explained by potential confounders, we conducted a hierarchical logistic regression including the night shift variable only (Table 2, model 1); night shift with patient (VAS, age, sex, ethnicity, type of pain complaint [headache/backache/other, with other as reference], and potential contraindication to analgesic treatment), physician (age and sex), ED (number of patients waiting and type of ED [medical/surgical/other, with other as reference]), and year (with 2014 as reference) variables (Table 2, model 2); and the relevant interactions (Table 2, model 3). The effect of night shifts on analgesic prescription remained significant after controlling for these potential confounders (Wald $\chi^2 = 9.70$, OR = 0.79, CI 95%, 0.68 to 0.91, $P = 0.002$). In accordance with previous studies (8), the propensity to prescribe analgesics to women was lower than to men (Wald $\chi^2 = 11.29$, OR = 0.79, CI 95%, 0.69 to 0.91, $P < 0.001$).

Next, we assessed how prescription patterns compared to the current ED pain management guidelines (29), which suggest considering nonopioid analgesics for mild pain (VAS 0 to 3) and opioids for moderate–severe pain (VAS 4 to 10). The propensity to prescribe an opioid analgesic was lower during night shifts than during daytime (20% vs. 28%, OR = 0.66, CI 95%, 0.57 to 0.76, $P < 0.001$). This effect was apparent mainly for moderate (12% vs. 19%, OR = 0.54, CI 95%,

Table 1. EMR first dataset characteristics: Study 2a

	Total (n = 5,000)	Daytime (n = 3,513)	Night shift (n = 1,487)	P value
Discharged with an analgesic, n (%)	2,329 (46.58)	1,746 (49.73)	583 (39.21)	<0.001
Discharged with a nonanalgesic, n (%)	1,131 (22.62)	806 (22.94)	325 (21.86)	0.401
Year, n (%) of visits				
2014	633 (12.66)	463 (13.18)	170 (11.43)	
2015	633 (12.66)	459 (13.07)	174 (11.70)	
2016	793 (15.86)	560 (15.94)	233 (15.67)	
2017	873 (17.46)	602 (17.14)	271 (18.22)	
2018	1,004 (20.08)	699 (19.90)	305 (20.51)	
2019	1,064 (21.28)	730 (20.78)	334 (22.46)	
Age, y (SD)	38.52 (16.70)	40.02 (17.05)	34.99 (15.29)	<0.001
Male sex, n (%)	2,503 (50.06)	1,767 (50.30)	736 (49.50)	0.604
Jewish ethnicity, n (%)	1,961 (39.22)	1,489 (42.38)	472 (31.74)	<0.001
VAS (SD)	6.71 (2.61)	6.72 (2.59)	6.68 (2.65)	0.524
Number of patients in the ED upon discharge (SD)	18.08 (7.86)	18.55 (8.03)	16.97 (7.34)	<0.001

0.38 to 0.77, $P < 0.001$) and for severe pain levels (27% vs. 35%, OR = 0.67, CI 95%, 0.56 to 0.79, $P < 0.001$) (Fig. 3). Note that across day and night, 45% of patients presenting with severe pain did not receive any analgesic prescription in the discharge notes, and only 33% received opioids, which are recommended for severe pain by the guidelines.

To test whether the night shift effect could be attributed to decision fatigue (30, 31) that builds up gradually over time, we ran two multivariate logistic regression analyses with the hour of discharge as a continuous variable, controlling for patient, physician, ED, and year variables, separately for daytime and night shift. During the daytime (8:00 AM to 11:00 PM) the regression revealed no effect for the hour (Wald $\chi^2 = 1.22$, OR = 1.01, CI 95%, 0.99 to 1.03, $P = 0.269$). Because the period between 8:00 AM and 10:00 AM includes data from physicians finishing the 26-h shift as well as from physicians arriving from home, we ran the regression only for the hours 10:00 AM to 11:00 PM. Again, there was no effect for the hour (Wald $\chi^2 = 0.04$, OR = 1.00, CI 95%, 0.97 to 1.02, $P = 0.844$). During the night shift, the regression analysis revealed a negative trend for the hour (Wald $\chi^2 = 4.97$, OR = 0.93, CI 95%, 0.88 to 0.99, $P = 0.026$). *SI Appendix*, Fig. S4*A*, presents the propensity to prescribe analgesics by the hour, across 24 h.

Study 2b replicated the main results: the propensity to prescribe analgesics was lower during night shifts than during daytime (34% vs. 43%, OR = 0.69, CI 95%, 0.60 to 0.79, $P < 0.001$). The multivariable regression analysis reproduced the findings of study 2a (see *SI Appendix*, *Study 2b*, Tables S2 and S3, and Figs. S2 *A* and *B*, S3, and S4*B*, for methods and detailed results).

Finally, study 2c demonstrated the same effect of reduced propensity to prescribe analgesics during night shifts as compared to daytime (24% vs. 28%, OR = 0.82, CI 95%, 0.70 to 0.95, $P = 0.008$) (see *SI Appendix*, *Study 2c*, and Figs. S5 and S6, for methods and detailed results).

In summary, the three datasets of study 2 provide converging evidence for a night shift bias in pain management decisions. The bias was present even after controlling for various patient, physician, type of pain complaint, and ED characteristics. Most importantly, a patient with a given VAS rating was less likely to receive an analgesic prescription during night shifts than during daytime. The fact that divergence of analgesic prescription from the general World Health Organization guidelines is greater during night shifts suggests that there is indeed an underprescription during night shifts, rather than an overprescription during daytime. Finally, the fact that non–pain medication prescription was not affected by night shifts strengthens the proposed link to physician pain perception and empathy (documented in study 1).

Discussion

The current research reveals a previously undocumented bias in pain management. A seemingly arbitrary factor—whether or

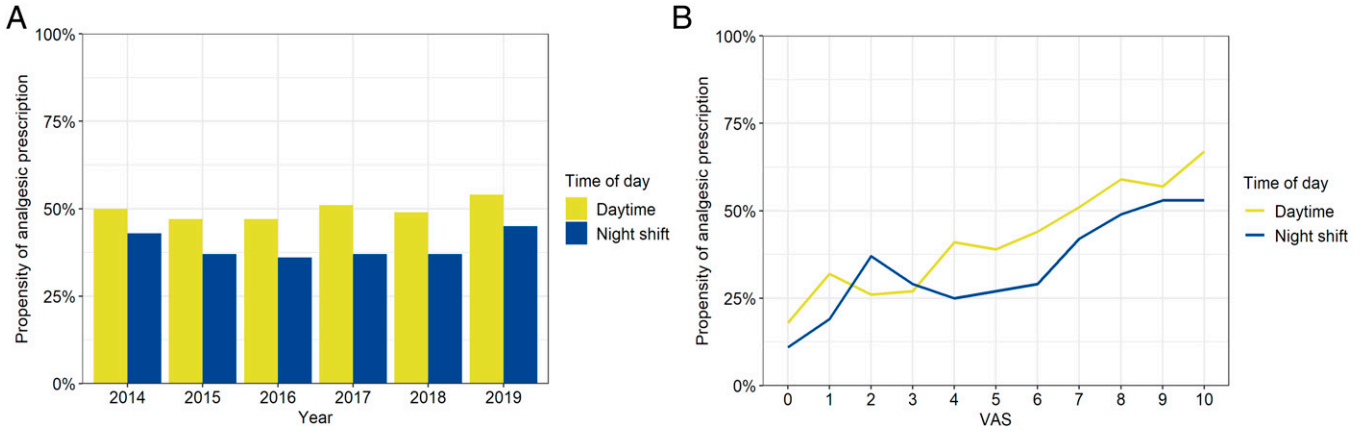

Fig. 2. Propensity of analgesic prescription during daytime or night shift (*A*) by year and (*B*) by VAS, for study 2a. *A* shows propensity of analgesic prescription by year and time of day, for study 2a. *B* shows propensity of analgesic prescription by VAS and time of day, for study 2a.

Table 2. Logistic regression predicting propensity to prescribe analgesics: Study 2a

	Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI
Night shift (1 = night shift)	0.66***	0.58, 0.75	0.79**	0.68, 0.91	0.80**	0.69, 0.93
VAS			1.14***	1.11, 1.18	1.14***	1.11, 1.18
Patient's age			1.01***	1.01, 1.02	1.01***	1.01, 1.02
Patient's sex (1 = female)			0.79***	0.69, 0.91	0.79***	0.69, 0.91
Patient's ethnicity (1 = non-Jewish)			0.97	0.85, 1.12	0.97	0.85, 1.11
Physician's age			1.01	1.00, 1.02	1.01	1.00, 1.02
Physician's sex (1 = female)			0.77**	0.64, 0.92	0.77***	0.64, 0.92
Number of patients in ED			1.00	0.99, 1.01	1.00	0.99, 1.01
Headache			1.06	0.87, 1.29	1.06	0.87, 1.29
Backache			3.24***	2.60, 4.03	3.25***	2.61, 4.05
Year 2015			0.73*	0.56, 0.95	0.73*	0.56, 0.95
Year 2016			0.74*	0.57, 0.95	0.74*	0.58, 0.95
Year 2017			0.78*	0.61, 0.99	0.78*	0.61, 1.00
Year 2018			0.82	0.65, 1.05	0.82	0.65, 1.05
Year 2019			1.08	0.85, 1.38	1.09	0.85, 1.39
Medical ED			3.19***	2.22, 4.58	3.20***	2.23, 4.61
Surgical ED			6.68***	4.58, 9.74	6.71***	4.60, 9.80
Potential contraindication to analgesics			0.60*	0.38, 0.96	0.60*	0.38, 0.95
Night shift × VAS					1.01	0.95, 1.07
Night shift × patient's age					1.01	1.00, 1.02
Night shift × patient's sex					0.99	0.73, 1.33
Night shift × patient's ethnicity					0.81	0.59, 1.11

*$P < 0.05$, **$P < 0.01$, and ***$P < 0.001$.

not a physician is on a night shift—appears to dramatically affect physicians' sensitivity to patient pain and their propensity to prescribe analgesics. The first set of evidence comes from a controlled experiment conducted at the hospital in the morning (study 1). Resident physicians who were at the end of a night shift rated other people's pain as less intense than residents who just started their workday. Physicians' assessment of patient pain was strongly associated with their reported likelihood to prescribe analgesics to patients in hypothetical clinical scenarios. The effect of night shift on medical decisions was inconclusive in this experiment. Nonetheless, a broader analysis of three datasets of real-world medical decisions from Israel and the United States, with a total sample size of 13,482 decisions, revealed a consistent night shift bias (study 2). In each of the three datasets, the odds ratios of physicians to prescribe analgesics to patients upon discharge from the ED were 20 to 30% lower during night shifts than during daytime, even after controlling for subjectively reported pain (VAS) and numerous patient, physician, type of complaint, and ED factors. This substantial effect is comparable in magnitude to previously described racial and gender biases in analgesic prescription (32), for which we also find evidence in the current datasets.

Overall, physician propensity to prescribe analgesics to patients with moderate–severe levels of pain was lower than typically recommended by pain management guidelines (29), replicating prior reports (3). Importantly, the divergence from the general guideline recommendations was particularly pronounced during night shifts and most apparent in opioids. Thus, our findings suggest that the existing inadequate pain management in the ED is exacerbated during the night. Inadequate pain management leads to unnecessary patient suffering: it may lead to an increase in avoidable hospitalizations, hospital readmissions, and chronic pain—not to mention the greater financial costs (4, 5, 33). Additionally, such inadvertent underprescription of analgesics may expose physicians to increased malpractice liability (32). That said, underprescription of opioids may also confer some advantages to patients as opioid overprescription is a pervasive public health problem that exposes patients to increased risk for addiction (34).

Our laboratory-based results (study 1) suggest that the night shift bias may arise in part due to reduced physician empathy for patient pain. The fact that the night shift effect was obtained in the EMR datasets only for analgesic prescriptions, but not for nonanalgesic ones (study 2), also supports the argument that the effect is driven by changes in empathy, rather than by general fatigue or laziness during the night. These results link empathic perception—the physician's vicarious experience of the patient's pain—to the physician's pain management decisions. This suggests that physician empathy is associated with better pain management. It expands on previous findings highlighting other benefits of empathy in the medical field, mainly greater patient satisfaction and compliance with medical treatment (17–19), lower malpractice liability (35), and reduced physician burnout (36). At the same time, it has also been shown that empathy can be taxing and that some distancing from patient pain may help reduce physician burnout (16). We conclude that the consequences for pain management should be taken into account when considering the pros and cons of "feeling with" the patient.

Our findings are consistent with the following putative mechanism by which night shifts reduce empathy for pain. It is known that sleep deprivation induces a more self-centered and socially withdrawn state (37), accompanied by impaired communication and understanding of other people (38). Sleep deprivation may also impair emotional perception and lead individuals to perceive other people's negative emotions as less intense (39, 40). Finally, personal distress that also accompanies night shifts may undermine empathic abilities as well. Elevated distress has been associated with reduced empathic care and prosocial behavior (41). A self-centered state during night shifts

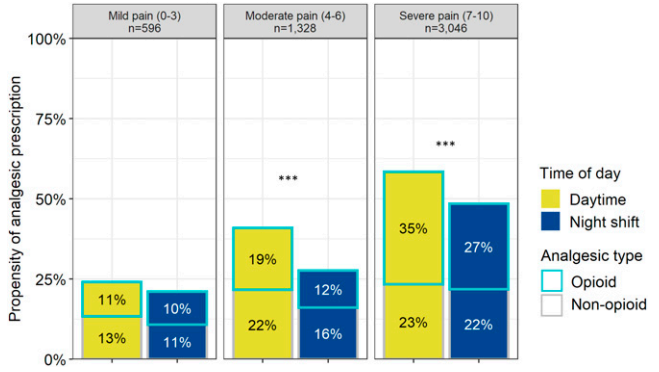

Fig. 3. Propensity of analgesic prescription by time of day, pain level, and analgesic type, for study 2a. (*Left*) Mild pain, (*Middle*) moderate pain, and (*Right*) severe pain. Physicians were overall less likely to discharge patients with an opioid prescription during night shifts than during daytime. This effect was apparent mainly for moderate and severe pain levels (*Middle* and *Right*, respectively; ***$P < 0.001$).

may prevent physicians from fully relating to the pain experienced by their patients. The focus on the self may also help to explain why sleep deprivation lowers tolerance for one's own pain. In particular, increased prevalence of pain complaints has been documented among night shift workers (42, 43).

An additional mechanism that could contribute to the effect of night shifts on analgesic prescription is decision fatigue, namely, the erosion of self-control and initiative following repetitive decisions (30, 31). During the daytime, when physicians become more and more fatigued, there was no decline in the analgesic prescription propensity as a function of the hour. However, during night shifts (in study 2a but not in study 2b), there was a negative trend for the hour, which may support the idea that fatigue buildup during the night may also be involved in the night shift bias. It should be noted that physicians on night shifts had already worked during the day, allowing fatigue to build up. Yet the lack of effect of night shifts on nonanalgesic prescriptions speaks against a general decision fatigue account.

Our findings have important implications for the ongoing debate regarding how to optimize physician training and working schedules. The existence of a night shift bias in pain management amplifies the conclusions of recent studies suggesting that long physician night shifts and attendant sleep deprivation are associated with adverse patient outcomes, such as medical errors (14, 44). In particular, our current data document a decrease in analgesic prescription at the ED starting around midnight (the beginning of the night shift) and suggest that empathy for pain is compromised during night shifts. It is possible, therefore, that shortening physician shifts (45) may improve pain management in the ED. We hope our findings inspire more work to weigh the benefits of shorter shifts with the unwanted consequences due to loss of education opportunities for physicians, greater workload, and interruptions in the continuity of care (46–49). Future research will also need to assess if these findings extend more broadly beyond the current setting to additional fields requiring empathic skills (e.g., military, nursing, first responders, customer service, and hospitality) (50).

Strengths and Limitations. In this study, we found that a seemingly arbitrary factor, the timing of physician work, consistently affected medical professionals' reactions to pain and their pain management decisions. We have tested this effect using comprehensive methodological approaches, including a controlled laboratory assessment with resident physicians and three EMR datasets. We replicated the findings identified in the first dataset in a preregistered analysis of a second dataset and again in an independent US-based dataset, attesting to the generalizability and robustness of the findings. Adding to the validity of our results is the fact that we replicated other known biases in pain management, such as gender biases. Importantly, our experimental findings also suggest a mechanism for the observed effect by linking empathy for pain and pain management decisions.

A central limitation in our data is that the data do not reveal the specific mechanism by which night shift work compromises empathy for pain. Potential contributors to the night shift bias are sleep deprivation, stress, workload, fatigue, or circadian misalignment (51). These factors are inextricable in the ED and should be examined in future controlled laboratory-based experiments.

The characteristics of the datasets that we have analyzed constitute another limitation. First, our data included only discharge notes and did not document the medications prescribed to patients during the ED stay. Thus, we could not test whether a night shift bias existed during the ED stay. Second, we examined pain management only in the ED. Whether pain management is affected during night shifts in other settings (anesthesia, intensive care, delivery room, etc.) is a subject for future research. Finally, our data included only pain-related complaints because we were interested in the consequences of reduced empathy for pain. Although we did not observe a difference in nonanalgesic prescriptions, a more general impairment in prescribing other types of medications might be observed during night shift in cases of nonpain diagnoses. Such night shift effects could be driven by reduced empathy for pain but also by a general cognitive impairment.

Conclusions. We identify night shifts as a significant and previously unrecognized source of bias in pain management, potentially stemming from impaired physician perception of patient pain. Our results highlight the need to address this bias by developing and implementing more structured pain management guidelines and by educating physicians about the bias.

Methods

Study 1.

Study population. Seventy-three resident physicians were recruited across multiple departments at Hadassah Medical Center, Jerusalem, Israel. Six nonnative speakers were excluded from the analysis due to difficulties in following the instructions. Residents completed tasks between 8:00 and 10:00 AM after signing an informed consent form. The night shift group were toward the end of a 26-h shift which began at 8:00 AM the day before ($n = 36$, 13 female). The control group were at the beginning of a new workday, after 3 consecutive days with no night shifts ($n = 31$, 13 female). Participants received a 50 NIS (~$15) gift card. The study was approved by the Institutional Review Board (IRB) Committee of Hadassah Medical Center (Protocol no. 0065-16 HMO).

Study procedure. Participants were seated at a hospital office and were asked to complete computerized tasks of empathy and pain management and provide information on their demographics, sleep, and burnout (*SI Appendix*).

Empathy measures. Participants completed two tasks. In the affective empathy for pain task (27), participants rated the intensity of their emotional reaction to 10 pictures of a hand or foot in a painful situation (*SI Appendix*, Fig. S1). The average of the ratings constituted the empathy for pain score. In the cognitive empathic accuracy task (28), participants watched three video clips of targets telling emotional autobiographical stories. Participants rated how positive or negative the targets had felt at each moment. The average correlation between the participants' ratings and the targets' original ratings constituted the empathic accuracy score.

Pain management measures. Participants were presented with two clinical scenarios adapted from Hirsh et al. (52). The headache scenario described a female patient with an acute headache and a VAS of 9/10 (for full scenarios, see

SI Appendix). The backache scenario described a male patient admitted to the ED with an acute idiopathic backache and a VAS of 8/10. For each scenario, participants were asked to rate the level of pain the patient was experiencing (on a 0 to 100 scale) and answer three questions on their likelihood (from 0 to 100) to prescribe each of the following: nonsteroidal antiinflammatory drug, oral opioid, or parenteral opioid. The likelihood to prescribe analgesics score was calculated as the average of the three ratings.

Statistical analysis. We compared physician characteristics (sleep quality, burnout, and demographic measures) and experimental measures (empathic accuracy, empathy for pain, pain assessment, and propensity to prescribe analgesics) between the night shift and control groups using two-sample Welch's *t* tests or χ^2 tests. For each task, we excluded outliers that were 3 SDs below or above the mean of the entire sample. This resulted in no outliers in the empathy for pain task, one outlier in the empathic accuracy task (night shift group), one outlier in the assessment of pain in the headache scenario (night shift group), three outliers in the assessment of pain in the backache scenario (1 from the control group), and no outliers in the propensity to prescribe analgesics. We then calculated Pearson's correlation between pain assessment and propensity to prescribe analgesics for each scenario.

Study 2.

Data collection. In study 2a, we obtained 5,000 deidentified discharge notes between 2014 and 2019 from the EMR of the ED of the HHUMC, a tertiary two-campus medical center serving the Jerusalem metropolis with ∼150,000 annual ED visits. We aimed to examine discharge notes where the appropriate pain management is not straightforward. These notes were randomly selected from all cases fulfilling our prespecified inclusion criteria: patients aged 7 to 80 y with a pain-related diagnosis (e.g., headache and backache); with no diagnosis of trauma, neoplasm, poisoning, or cerebrovascular accident; discharged directly from the ED and not hospitalized; and with a documented subjective rating of pain. The data included time of discharge from the ED, the medications the patient was prescribed upon discharge, the patient's subjective pain rating (VAS from 0 to 10), and demographic variables of the patients and the physicians. The data did not include medications prescribed during the stay in the ED. Thirty of the 5,000 notes had missing VAS values and were excluded from the regression analysis. No other data were missing or excluded.

To cross-validate the results from the first EMR dataset, in study 2b, we preregistered our analyses and hypotheses at https://osf.io/qam6d for a second EMR dataset with all the remaining HHUMC ED discharge notes fulfilling the same criteria, this time from 2013 to 2020, resulting in 4,157 additional notes. Finally, to generalize our findings from Israel, in study 2c, we obtained a third deidentified EMR dataset of 4,325 ED discharge notes from the University of Missouri Health Center in Colombia, MO. The studies were approved by the respective IRB Committees. Due to IRB constraints, this dataset included aggregated deidentified data. Due to the deidentified nature of the data, informed consent was waived.

Statistical analyses. The primary outcome of interest was the rate of prescription of analgesic medications. We compared the primary outcome between daytime (8:00 AM to 11:00 PM) and the night shift (11:00 PM to 8:00 AM). In a hierarchical logistic regression, we examined interactions and controlled for potential confounders: patient VAS and additional patient and physician characteristics (age, sex, ethnicity, type of pain complaint, contraindications to analgesics, ED patient load, type of ED, and year). In a secondary analysis we compared prescription of opioid (e.g., tramadol and oxycodone) or nonopioid (e.g., etodolac, dipyrone, and pregabalin) analgesics during night shifts versus daytime and looked at how these adhere to current ED pain management guidelines (29). Finally, to test whether the night shift effect could be attributed to decision fatigue that builds up gradually over time, we ran two multivariate logistic regression analyses with the hour of discharge as a continuous variable, controlling for patient, physician, ED, and year variables, separately for daytime and night shift.

All analyses were performed in IBM SPSS v25 or R package software.

Data Availability. Anonymized data materials from study 1 and study 2 have been deposited in Open Science Framework (https://osf.io/qam6d) (53).

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1. J. W. Lucas, E. M. Connor, J. Bose, Back, lower limb, and upper limb pain among U.S. adults, 2019. *NCHS Data Brief* **415**, 1–8 (2021).
2. J. L. St Sauver *et al.*, Why patients visit their doctors: Assessing the most prevalent conditions in a defined American population. *Mayo Clin. Proc.* **88**, 56–67 (2013).
3. T. Rupp, K. A. Delaney, Inadequate analgesia in emergency medicine. *Ann. Emerg. Med.* **43**, 494–503 (2004).
4. R. Sinatra, Causes and consequences of inadequate management of acute pain. *Pain Med.* **11**, 1859–1871 (2010).
5. R. Daoust *et al.*, Relationship between acute pain trajectories after an emergency department visit and chronic pain: A Canadian prospective cohort study. *BMJ Open* **10**, e040390 (2020).
6. T. J. Smith, B. E. Hillner, The cost of pain. *JAMA Netw. Open* **2**, e191532 (2019).
7. K. M. Hoffman, S. Trawalter, J. R. Axt, M. N. Oliver, Racial bias in pain assessment and treatment recommendations, and false beliefs about biological differences between blacks and whites. *Proc. Natl. Acad. Sci. U.S.A.* **113**, 4296–4301 (2016).
8. E. H. Chen *et al.*, Gender disparity in analgesic treatment of emergency department patients with acute abdominal pain. *Acad. Emerg. Med.* **15**, 414–418 (2008).
9. E. Field, L. Lingard, R. Cherry, J. A. Van Koughnett, S. DeLuca, T. Taylor, The fatigue paradox: Team perceptions of physician fatigue. *Med. Educ.* **55**, 1388–1393 (2021).
10. D. Rosa, S. Terzoni, F. Dellafiore, A. Destrebecq, Systematic review of shift work and nurses' health. *Occup. Med. (Lond.)* **69**, 237–243 (2019).
11. G. Kecklund, J. Axelsson, Health consequences of shift work and insufficient sleep. *BMJ* **355**, i5210 (2016).
12. L. K. Barger *et al.*, Impact of extended-duration shifts on medical errors, adverse events, and attentional failures. *PLoS Med.* **3**, e487 (2006).
13. S. M. Mustahsan *et al.*, Sleep deprivation and its consequences on house officers and postgraduate trainees. *J. Pak. Med. Assoc.* **63**, 540–543 (2013).
14. M. T. Trockel *et al.*, Assessment of physician sleep and wellness, burnout, and clinically significant medical errors. *JAMA Netw. Open* **3**, e2028111 (2020).
15. M. H. Davis, Measuring individual differences in empathy: Evidence for a multidimensional approach. *J. Pers. Soc. Psychol.* **44**, 113–126 (1983).
16. J. Decety, Empathy in medicine: What it is, and how much we really need it. *Am. J. Med.* **133**, 561–566 (2020).
17. S. S. Kim, S. Kaplowitz, M. V. Johnston, The effects of physician empathy on patient satisfaction and compliance. *Eval. Health Prof.* **27**, 237–251 (2004).
18. M. Hojat *et al.*, Physicians' empathy and clinical outcomes for diabetic patients. *Acad. Med.* **86**, 359–364 (2011).
19. D. P. Rakel *et al.*, Practitioner empathy and the duration of the common cold. *Fam. Med.* **41**, 494–501 (2009).
20. J. Dorrian, S. Centofanti, A. Smith, K. D. McDermott, Self-regulation and social behavior during sleep deprivation. *Prog. Brain Res.* **246**, 73–110 (2019).
21. E. Ben Simon, A. Rossi, A. G. Harvey, M. P. Walker, Overanxious and underslept. *Nat. Hum. Behav.* **4**, 100–110 (2020).
22. V. Guadagni, F. Burles, M. Ferrara, G. Iaria, The effects of sleep deprivation on emotional empathy. *J. Sleep Res.* **23**, 657–663 (2014).
23. G. Buruck, J. Wendsche, M. Melzer, A. Strobel, D. Dörfel, Acute psychosocial stress and emotion regulation skills modulate empathic reactions to pain in others. *Front. Psychol.* **5**, 517 (2014).
24. J. Lim, D. F. Dinges, A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. *Psychol. Bull.* **136**, 375–389 (2010).
25. M. F. Marin *et al.*, Chronic stress, cognitive functioning and mental health. *Neurobiol. Learn. Mem.* **96**, 583–595 (2011).
26. S. Choshen-Hillel *et al.*, Acute and chronic sleep deprivation in residents: Cognition and stress biomarkers. *Med. Educ.* **55**, 174–184 (2021).
27. P. L. Jackson, A. N. Meltzoff, J. Decety, How do we perceive the pain of others? A window into the neural processes involved in empathy. *Neuroimage* **24**, 771–779 (2005).
28. K. Jospe *et al.*, The contribution of linguistic and visual cues to physiological synchrony and empathic accuracy. *Cortex* **132**, 296–308 (2020).

29. S. Hachimi-Idrissi *et al.*, Approaching acute pain in emergency settings; European Society for Emergency Medicine (EUSEM) guidelines–Part 2: Management and recommendations. *Intern. Emerg. Med.* **15**, 1141–1155 (2020).
30. A. H. Oakes, S. Adusumalli, C. K. Snider, C. A. L. Rareshide, M. S. Patel, Variation in cardiologist statin prescribing by clinic appointment time. *J. Am. Coll. Cardiol.* **77**, 661–662 (2021).
31. J. A. Linder *et al.*, Time of day and the decision to prescribe antibiotics. *JAMA Intern. Med.* **174**, 2029–2031 (2014).
32. S. H. Meghani, E. Byun, R. M. Gallagher, Time to take stock: A meta-analysis and systematic review of analgesic treatment disparities for pain in the United States. *Pain Med.* **13**, 150–174 (2012).
33. J. A. McNeill, G. D. Sherwood, P. L. Starck, The hidden error of mismanaged pain: A systems approach. *J. Pain Symptom Manage.* **28**, 47–58 (2004).
34. A. Shah, C. J. Hayes, B. C. Martin, Characteristics of initial prescription episodes and likelihood of long-term opioid use–United States, 2006-2015. *MMWR Morb. Mortal. Wkly. Rep.* **66**, 265–269 (2017).
35. D. D. Smith *et al.*, Does emergency physician empathy reduce thoughts of litigation? A randomised trial. *Emerg. Med. J.* **33**, 548–552 (2016).
36. H. Wilkinson, R. Whittington, L. Perry, C. Eames, Examining the relationship between burnout and empathy in healthcare professionals: A systematic review. *Burn. Res.* **6**, 18–29 (2017).
37. E. Ben Simon, M. P. Walker, Sleep loss causes social withdrawal and loneliness. *Nat. Commun.* **9**, 3146 (2018).
38. B. C. Holding, T. Sundelin, M. Lekander, J. Axelsson, Sleep deprivation and its effects on communication during individual and collaborative tasks. *Sci. Rep.* **9**, 3131 (2019).
39. S. D. Kyle, L. Beattie, K. Spiegelhalder, Z. Rogers, C. A. Espie, Altered emotion perception in insomnia disorder. *Sleep* **37**, 775–783 (2014).
40. D. Tempesta, V. Socci, L. De Gennaro, M. Ferrara, Sleep and emotional processing. *Sleep Med. Rev.* **40**, 183–195 (2018).
41. N. Eisenberg, R. A. Fabes, Empathy: Conceptualization, measurement, and relation to prosocial behavior. *Motiv. Emot.* **14**, 131–149 (1990).
42. S. Lautenbacher, B. Kundermann, J. C. Krieg, Sleep deprivation and pain perception. *Sleep Med. Rev.* **10**, 357–369 (2006).
43. A. J. Krause, A. A. Prather, T. D. Wager, M. A. Lindquist, M. P. Walker, The pain of sleep loss: A brain characterization in humans. *J. Neurosci.* **39**, 2291–2300 (2019).
44. S. Choshen-Hillel, A. Gileles-Hillel, A wake-up call: Time to raise physicians' awareness of the consequences of fatigue (2021).
45. A. H. Garde, K. Nabe-Nielsen, M. A. Jensen, J. Kristiansen, J. K. Sørensen, Å. M. Hansen, The effects of the number of consecutive night shifts on sleep duration and quality. *Scand. J. Work. Environ. Health.* **46**, 446–453 (2020).
46. A. B. Jena, M. Farid, D. Blumenthal, J. Bhattacharya, Association of residency work hour reform with long term quality and costs of care of US physicians: Observational study. *BMJ* **366**, l4134 (2019).
47. S. V. Desai *et al.*, Effect of the 2011 vs 2003 duty hour regulation-compliant models on sleep duration, trainee education, and continuity of patient care among internal medicine house staff: A randomized trial. *JAMA Intern. Med.* **173**, 649–655 (2013).
48. C. P. Landrigan *et al.*; ROSTERS Study Group, Effect on patient safety of a resident physician schedule without 24-hour shifts. *N. Engl. J. Med.* **382**, 2514–2523 (2020).
49. V. Y. Chang, V. M. Arora, S. Lev-Ari, M. D'Arcy, B. Keysar, Interns overestimate the effectiveness of their hand-off communication. *Pediatrics* **125**, 491–496 (2010).
50. B. C. Gunia, A. B. Adler, P. D. Bliese, K. M. Sutcliffe, How are you sleeping? Leadership support, sleep health, and work-relevant outcomes. *Occup. Health Sci.* **5**, 563–580 (2021).
51. B. von Dawans, J. Strojny, G. Domes, The effects of acute stress and stress hormones on social cognition and behavior: Current state of research and future directions. *Neurosci. Biobehav. Rev.* **121**, 75–88 (2021).
52. A. T. Hirsh, N. A. Hollingshead, L. Ashburn-Nardo, K. Kroenke, The interaction of patient race, provider bias, and clinical ambiguity on pain management decisions. *J. Pain* **16**, 558–568 (2015).
53. T. Gordon-Hecker, S. Choshen-Hillel, A. Perry. Physicians prescribe fewer analgesics during nightshifts. Open Science Framework. https://osf.io/qam6d/. Deposited 3 March 2022.