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# The Impact of Time at Work and Time Off From Work on Rule Compliance: The Case of Hand Hygiene in Health Care

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To deliver high-quality, reliable, and consistent services safely, organizations develop professional standards. Despite the communication and reinforcement of these standards, they are often not followed consistently. Although previous research suggests that high job demands are associated with declines in compliance over lengthy intervals, we hypothesized—drawing on theoretical arguments focused on fatigue and depletion—that the impact of job demands on routine compliance with professional standards might accumulate much more quickly. To test this hypothesis, we studied a problem that represents one of the most significant compliance challenges in health care today: hand hygiene. Using longitudinal field observations of over 4,157 caregivers working in 35 different hospitals and experiencing more than 13.7 million hand hygiene opportunities, we found that hand hygiene compliance rates dropped by a regression-estimated 8.7 percentage points on average from the beginning to the end of a typical 12-hr work shift. This decline in compliance was magnified by increased work intensity. Further, longer breaks between work shifts increased subsequent compliance rates, and such benefits were greater for individuals when they had ended their preceding shift with a lower compliance rate. In addition, (a) the decline in compliance over the course of a work shift and (b) the improvement in compliance following a longer break increased as individuals accumulated more total work hours the preceding week. The implications of these findings for patient safety and job design are discussed.

*Keywords:* workplace compliance, job demands, fatigue, work recovery, job design

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To deliver high-quality, reliable, and consistent services safely, organizations develop professional standards. These standards may be adopted from external agencies (e.g., professional industry groups, external regulators) or developed through the internal documentation and proliferation of best practices. There are often significant benefits associated with adopting professional standards. For instance, within health care, implementing a 19-item surgical safety checklist recommended by the World Health Organization (WHO) was found to reduce the rate of deaths and inpatient complications by 47% and 36%, respectively (Haynes et al., 2009). As such, the importance of complying with professional standards is frequently communicated, and actual compliance is reinforced and rewarded within organizations.

However, rates of compliance with professional standards are not always high. Task pursuit in organizations involves multiple and often competing goals, some of which may be perceived as more pressing, proximal, and urgent than others (e.g., Schmidt & DeShon, 2007). In addition, workers also experience physical, cognitive, and emotional demands that can deplete their self-regulatory resources (e.g., Demerouti, Bakker, Nachreiner, & Schaufeli, 2001). These realities of work can lead to the violation of professional standards, particularly those standards that may be perceived as relatively minor in importance and that require frequent, routine compliance (see, e.g., Hofmann & Frese, 2011; Hofmann & Stetzer, 1996; Turner, Chmiel, Hershcovis, & Walls, 2010).

Although previous research has linked job demands—such as work overload, time pressure, and emotional demands—to job performance, work engagement, absenteeism, and compliance with safety standards (e.g., Bakker, Demerouti, de Boer, &

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Schaufeli, 2003; Nahrgang, Morgeson, & Hofmann, 2011; Schaufeli, Bakker, & Van Rhenen, 2009), virtually all of this prior research has focused on the relationship between broad, long-term, self-reported perceptions of work demands and compliance.[1] Drawing on prior research and theories investigating fatigue and self-regulatory depletion, we investigated the degree to which the impact of job demands may accumulate quickly, perhaps even as quickly as over the course of a single work shift. To our knowledge, this is the first study investigating whether accumulated work demands can impact rule compliance over the course of a single day as opposed to over weeks, months, or years. If work demands have an immediate impact on routine compliance, then there are significant implications for work design, as interventions aimed at addressing long-term work engagement and demands (e.g., Campion, 1988) might need to be augmented with interventions designed to alter the daily pace of work.

If self-regulatory depletion and fatigue underlie the degradation of compliance, then time away from work allowing for recovery should improve subsequent compliance. Thus, we also investigated the impact of time off from work on compliance during the next work cycle. The implications of breaks for employee performance have only been explored in terms of employees' performance on their primary task (e.g., Binnewies, Sonnentag, & Mojza, 2010; Fritz & Sonnentag, 2006). Thus, little is known about how time away from work may affect employees' performance on important secondary tasks, including routine compliance with professional guidelines, which we explore in this article.

## Accumulated Work Demands and Performance on Secondary Task Compliance

As noted above, employees in contemporary organizations are expected to pursue multiple and sometimes competing goals simultaneously (Schmidt & DeShon, 2007) and to endure heavy work demands (e.g., time pressure, quality pressure, work overload, role ambiguity, and emotional strain; Bakker & Demerouti, 2007; Demerouti et al., 2001). Although high job demands have the potential to energize employees (Karasek & Theorell, 1990), they typically have significant psychological and physiological costs over time on job performance and employees' well-being (Crawford, LePine, & Rich, 2010; Demerouti et al., 2001; Schaufeli et al., 2009). We propose that these demands may take a more immediate toll on seemingly secondary tasks, including compliance with professional guidelines, for two reasons.

First, when workers are faced with the pursuit of multiple goals in the context of high job demands, past research suggests that they may focus their attention on the most salient, proximal, and rewarded goals (Schmidt & DeShon, 2007). Hockey (1993, 1997) termed this a *performance protection strategy*, suggesting that workers attempt to maintain effective primary task performance by increasing their effort expenditure and cognitive processing devoted to these tasks. With greater effort expended on primary tasks, performance on secondary tasks may suffer as effort and resources are directed away from these tasks. Consequently, although performance on primary tasks can be maintained as employees become increasingly fatigued, past research has shown that employees exhibit selective impairment on low-priority task components ("subsidiary task failure"), such as the neglect of subsidiary activities and narrowing of attention (Hockey, 1993, 1997). In most organizations, primary tasks are those that directly contribute to production (e.g., on-time delivery for transportation companies, maximizing investment returns for asset management companies). We propose that compliance with professional standards that are designed to maintain the safety or integrity of the work environment (e.g., driving the speed limit, avoiding insider trading), however, may be perceived as a secondary task and thus may be compromised when employees are faced with pressure for production (Hansez & Chmiel, 2010).

The second reason we predict job demands may take an immediate toll on secondary tasks is the fatigue induced by both the continuous pursuit of multiple goals and the exposure to high work demands, which can tax and deplete self-regulatory resources (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Inzlicht & Schmeichel, 2012). Just as the repeated exercise of muscles leads to physical fatigue, repeated use of *executive resources* (cognitive resources that allow people to control their behaviors, desires, and emotions) produces a decline in an individual's self-regulatory capacity (Baumeister et al., 1998; Hagger, Wood, Stiff, & Chatzisarantis, 2010).[2] It is important to note that impaired self-regulatory capacity diminishes one's ability to resist temptation and control one's impulses (Barnes, Schaubroeck, Huth, & Ghumman, 2011; Kouchaki & Smith, 2014; Linder et al., 2013) and increases one's desire to avoid exerting further effort (Baumeister et al., 1998; Danziger, Levav, & Avnaim-Pesso, 2011). Notably, this avoidance of effort has been linked to employees' routine violations of organizational rules and their tendency to cut corners (Reason, 1995; Reason, Parker, & Lawton, 1998). Thus, we argue that performing secondary tasks requires some combination of effort and self-regulatory resources and that when individuals are fatigued and these resources are depleted, performance on secondary tasks will decline.

Connecting the above arguments, we propose that work demands result in a focus on accomplishing primary tasks and in depleted self-regulatory capacity, which together reduce individuals' capacity to expend effort on secondary tasks (e.g., complying with safety guidelines). We rely on the time an employee has spent at work as a proxy for how long he or she has been continuously exposed to a demanding work environment[3] and predict that workers will exhibit greater reductions in compliance with professional standards the longer they have been continuously exposed to work demands. Although not all employees in organizations work in shifts, in this article, we use the term *shift* broadly to refer to the

[1] For example, Hofmann and Stetzer (1996) investigated general perceptions of work overload and an aggregate measure of unsafe behavior over the preceding 12 months. Similarly, Turner, Chmiel, Hershcovis, and Walls (2010) investigated the relationship between general perceptions of role overload and safety events over a 12-month period.

[2] This effect is particularly potent when people believe that willpower is a limited resource (Job, Dweck, & Walton, 2010) and when they perceive that they are depleted of this resource (Clarkson, Hirt, Jia, & Alexander, 2010; Clarkson, Hirt, Chapman, & Jia, 2011).

[3] Past research suggests that the amount of time individuals spend performing tasks that require attention and mental resources is a reliable predictor of their subsequent ability to expend executive resources (Danziger, Levav, & Avnaim-Pesso, 2011; See, Howe, Warm, & Dember, 1995; Welsh & Ordóñez, 2014). In health care, which is the context where we conduct our study, surveys among caregivers have shown that they feel more exhausted at the end of a longer shift than a shorter shift (Rogers, Hwang, & Scott, 2004; Stimpfel, Sloane, & Aiken, 2012).

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period of time beginning when an employee arrives at work up until the moment he or she departs. Specifically, we hypothesized the following:

> *Hypothesis 1:* As employees advance through a shift, their compliance with professional standards will decrease.

As described previously, high job demands are produced by challenging conditions at work, such as time pressure, heavy workloads, fast-paced assignments, and long work hours. Dealing with these job demands requires physical and/or mental resources (Demerouti et al., 2001). For example, high-intensity work, as measured by heavy workloads and fast-paced jobs, has been shown to produce emotional exhaustion and burnout and to reduce task performance and work engagement (Hansez & Chmiel, 2010; Nahrgang et al., 2011; Sonnentag, Kuttler, & Fritz, 2010). These findings suggest that each hour of engagement in a high-intensity work environment should consume more resources than each hour of engagement in a lower intensity setting. Thus, as employees advance through their shifts in a more intense environment (relative to a less intense environment), their physical and mental resources should be drained at a faster rate. In other words, high work intensity (characterized by employees performing demanding tasks at a high frequency) will exacerbate the effects of time at work on fatigue and depletion. Given the aforementioned relationship between compliance and fatigue, as well as depletion, we expect a steeper decline in compliance with professional standards over the course of a shift in higher intensity work environments than in lower intensity work environments. We specifically hypothesized the following:

> *Hypothesis 2:* Work intensity will moderate the relationship between time at work and employees' compliance with professional standards. Specifically, compliance will decrease faster over the course of a work shift when employees experience greater work intensity.

## Time Off Between Shifts as Replenishment

When intense work environments focus employees' attention on primary tasks and deplete their self-regulatory capacity (Demerouti et al., 2001; Hockey, 1997), one way to recharge is by discontinuing physically or cognitively taxing activities and engaging in pursuits that promote recovery (e.g., taking a break to rest, sleeping, taking a vacation; Fritz & Sonnentag, 2006; Sonnentag, Binnewies, & Mojza, 2008; Trougakos, Beal, Green, & Weiss, 2008; Westman & Eden, 1997). Consistent with our focus on depletion over the course of a single shift, we investigate the recovery benefits of relatively short periods of time off between shifts (from several hours to a few days), as these capture the typical amount of time that most employees take off between shifts.

Considerable empirical evidence suggests that sleep and even short periods of time off can help employees overcome the fatigue they accumulate throughout their workdays, contributing to desirable performance-related outcomes, well-being, positive emotional experiences, and job satisfaction (Binnewies et al., 2010; Fritz & Sonnentag, 2005; Sonnentag et al., 2008; Westman & Eden, 1997). On the basis of this research, we predict that time off between successive shifts should replenish the executive resources that we have argued are needed to comply with professional standards, with longer breaks resulting in a greater degree of recovery. Specifically, we hypothesized the following:

> *Hypothesis 3:* The more time off between consecutive work shifts, the higher compliance will be with professional standards on the following shift.

Notably, numerous past studies have shown that although recovery activities (e.g., taking a break, experiencing positive emotions, or consuming a glucose drink) can have significant restorative benefits for individual who are depleted, these same activities have less impact for those individuals who are not depleted (Gailliot et al., 2007; Tice, Baumeister, Shmueli, & Muraven, 2007; Tyler & Burns, 2008). For example, in a recent review of research on the relationship between blood glucose levels and depletion, Gailliot and Baumeister (2007) posited that increased blood glucose levels are better facilitators of self-regulation for individuals who are more depleted but do not have noticeable benefits for individuals who are not depleted.

Notably, this literature has focused on comparing the benefits of recovery processes for individuals who have been substantially depleted with those individuals who have not been depleted at all in laboratory settings. However, in real work environments, most employees experience varying levels of fatigue and few (if any) likely experience zero depletion. Still, we expect that the previously documented difference in recovery rates for individuals with high levels of depletion and those who are not depleted will generalize to individuals experiencing varying levels of depletion at the end of a shift. Specifically, the more depleted an employee feels, the more effective recovery activities (e.g., taking time off from work) should be at restoring mental resources. Using compliance levels at the end of a shift as a proxy for depletion, we predicted that employees with lower compliance rates at the end of one shift should benefit more from time off between shifts. Specifically, we hypothesized the following:

> *Hypothesis 4:* The level of compliance at the end of a shift will moderate the positive relationship between time off work and compliance on an employee's next shift. Specifically, the positive effect of time off work will be stronger when compliance at the end of the previous shift was lower.

## Spillover Effects of Accumulated Work Demands

Not only may work demands within a day affect performance negatively, but recent studies suggest that work demands can accumulate over short periods—such as the work week—to produce harmful spillover effects, damaging employees' performance on subsequent work shifts (e.g., Kc & Terwiesch, 2009; Staats & Gino, 2012). For example, Kc and Terwiesch (2009) showed that operational performance in a cardiac care unit was negatively impacted by the accumulated load that the unit experienced over the days preceding the current shift. Although previously unexplored, this line of thought suggests that within-shift degradation of performance may be further accelerated by heavy work demands in the recent past. As a result, we expect that working for 1 hr on a given shift would be more exhausting if an employee has worked more hours and thus been exposed to more work demands over the preceding several days (e.g., over the past week). In other

words, as an employee advances through a shift, the capacity to expend effort on secondary tasks should decrease at a faster rate as more hours have been accumulated in the recent past (e.g., over the last week). Thus, we hypothesized the following:

> *Hypothesis 5:* The accumulated number of hours worked over the past week will moderate the relationship between time at work and compliance with professional standards. Specifically, compliance will decrease faster over the course of a given shift the more total hours an employee has worked over the week preceding that shift.[4]

As described above, past research has shown that recovery activities (e.g., taking a break, consuming a sugary drink) tend to benefit depleted individuals but have minimal impact on individuals who are not depleted (e.g., Gailliot et al., 2007; Tice et al., 2007). Building on this finding, we have raised the possibility that relaxing activities will have a stronger restorative effect on individuals who are more depleted than individuals who are less depleted. We expect this logic should apply not only to the work demands within a single shift but also to the demands accumulated over recent shifts. Because employees who had greater exposure to work demands across their previous shifts are likely to feel more fatigued than employees who had less exposure to work demands, we predicted that the total amount of time employees spent at work in the days leading up to a given shift (e.g., in the last week) would increase the benefits of lengthier breaks from work. Specifically, we hypothesized the following:

> *Hypothesis 6:* The total number of hours worked over the past week will moderate the relationship between time off work and subsequent compliance with professional standards. Specifically, the compliance improvement gained from time off from work will be larger the more hours an individual worked over the preceding week.

## Hand Hygiene Compliance in Health Care

Prior to discussing how we tested these hypotheses, it is important to introduce the organizational context of the current research. For this research, we chose to examine a specific violation of professional standards that has the potential to harm both employees and service recipients, namely, deviation from hand hygiene standards in health care settings. Maintaining hand hygiene among health care workers is widely accepted as one of the most effective means of reducing patients' health care–associated infections, which affect one in every 20 hospitalized patients and are one contributing factor to the estimated 100,000 health care–related deaths in the United States each year (Boyce & Pittet, 2002; WHO, 2009). Nevertheless, systematic reviews of hand hygiene guideline compliance suggest that compliance rates are below 50% in most health care settings (Boyce & Pittet, 2002).

Health care service workers (e.g., nurses and physicians) are among the many professionals whose occupations are characterized by high job demands (Dollard & McTernan, 2011; Houtman & Kompier, 1995). For example, health care workers frequently make consequential, life-and-death decisions and are required to take action under time pressure. Also, emotional demands are common in the health care industry: Caregivers interact regularly with vulnerable patients and must frequently engage in emotion regulation (e.g., taking care to display only appropriate emotions; Bakker, Schaufeli, Sixma, Bosveld, & Van Dierendonck, 2000).

Given their continuous exposure to intensive daily demands, it is anticipated that as their work shifts proceed, health care workers become increasingly focused on their primary tasks and most pressing goals while simultaneously being drained of the self-regulatory resources required to attend to seemingly more minor tasks. In health care settings, primary tasks are those that directly contribute to patient care, such as disease diagnosis, patient assessment, and medication distribution, whereas hand hygiene is perceived to be one of many secondary tasks. Further evidence suggests that health care professionals do not view hand hygiene as a primary goal. First, low rates of compliance suggest this. Second, industry guidelines advise caregivers to sanitize their hands at an extremely high daily frequency, so each hand cleansing likely feels as though it has a trivial impact on infection rates (Erasmus et al., 2009; Hugonnet & Pittet, 2000). Thus, in this article, we test our hypotheses about compliance with professional standards by examining how time at work (both within a shift and aggregated over the week preceding a shift), work intensity, and time off between work shifts affect caregivers' compliance with hand hygiene guidelines in hospitals.

## Organizational Setting and Data

### Setting

To explore our research questions, we use data from Proventix, a company that focuses on helping health care providers improve their hand hygiene. Proventix uses radio frequency identification (RFID) technology to monitor hand hygiene activity in health care settings by attaching a communication unit (CU) to conventional dispensers of hand soap and hand sanitizer. Caregivers wear active RFID badges along with their standard hospital identification, which track their location and behavior. Both the date and the time when a caregiver enters the area monitored by a given dispenser as well as whether the caregiver uses the corresponding dispenser are recorded.

Hand hygiene is expected on both entry into and exit from patient rooms (Steed et al., 2011), on the basis of recommendations from the WHO (2009) and the Joint Commission Center for Transforming Healthcare (2013). Following these recommendations, Proventix has developed a standardized measurement system to identify hand hygiene opportunities and calculate compliance rates among health care professionals. The basic unit of observation when calculating compliance, which we call an *episode*, requires a caregiver to stay in a patient's room for 20 s or longer—a length of time that Proventix has deemed, through expert consultation, sufficient for hand hygiene to be clinically

[4] Hypotheses 5 and 6 specify a time window of 1 week because employees typically work weekly schedules. This time window is also consistent with Kc and Terwiesch (2009), who examined the effect of accumulated workloads in hospitals (the same empirical context we study in this article). However, there is nothing special about 1 week. Consistent with our theory that work demands accumulated in the recent past may produce spillover effects, we found qualitatively similar results when we used different time windows to test Hypotheses 5 and 6 (see the Results section for details).

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relevant. The room entry and room exit associated with an episode are classified as hand hygiene opportunities. To be deemed compliant for a given opportunity, caregivers are required to sanitize their hands within a 90-s window surrounding the hand hygiene opportunity in question (i.e., 60 s before and 30 s after a room entry; 30 s before and 60 s after a room exit). Proventix thoroughly briefs caregivers on how to be credited for hand cleansings.

## Data

Proventix provided us with data collected from all of the 60 units at 37 hospitals that had installed their technology as of February 2013. These data were part of a broader data collection effort and tracked each of the 4,211 unique caregivers in these hospital units who had received an active RFID badge to track their hand hygiene compliance prior to February 28, 2013. The dates when the Proventix electronic monitoring system was rolled out varied across hospital units and ranged from January 2010 to October 2012. For each hand hygiene opportunity (either a room entry or a room exit) experienced by each caregiver, the monitoring system recorded (a) the date and time the hand hygiene opportunity occurred, (b) whether a given caregiver sanitized her hands, and (c) how many times the caregiver sanitized his or her hands during the 90-s compliance window associated with the given hand hygiene opportunity. In total, our data set documents 14,286,448 unique hand hygiene opportunities. Prior to releasing these data, Proventix deleted all caregiver names and hospital names and assigned unique, anonymous identification numbers to each caregiver within each hospital. We dropped a number of problematic observations ($n = 76{,}298$) before analyzing these data (e.g., duplicate observations, observations that did not involve caregivers). See the online supplemental materials for details on our data exclusion criteria. Note that relaxing any of our criteria for improving the quality and reliability of our data would not qualitatively alter our results in significance or magnitude.

Because we did not have access to caregivers' shift schedules, we inferred the start and end time of each shift by calculating the interval separating each room exit from the next room entrance for each caregiver. When two consecutive episodes were at least 7 hr apart, we identified the earlier episode as the last episode of the previous shift and the latter episode as the first episode of the next shift,[5] consistent with the prevailing view in sleep research that 7 or more hours of sleep in a 24-hr period is sufficient for most people (Ferrara & De Gennaro, 2001).[6]

Because we are interested in the effects of work-generated fatigue on hand hygiene compliance under normal work conditions, we excluded shifts lasting more than 13 hr from our analyses ($n = 438{,}128$) in light of differences in workload and patient conditions between normal shifts and extreme overtime shifts.[7] When we examined shifts up to 36 hr as a robustness check, our results did not change meaningfully.

Our final data set included 13,772,022 unique hand hygiene opportunities generated by 4,157 caregivers ($N_{\text{shifts}} = 265{,}942$) distributed across 35 hospitals and 56 hospital units. See the online supplemental materials for summary statistics describing hospital characteristics (e.g., location, size). Sixty-five percent of the caregivers in our sample were nurses. The remaining caregivers included patient care technicians (12%), therapists (7%), physicians (4%), and a handful of other types of employees (e.g., clinical directors, infection preventionists).

# Variables and Analyses

## Variables

**Outcome variable.**

***Compliance.*** Compliance was operationalized with a dichotomous indicator variable recording whether a caregiver washed his or her hands during a given hand hygiene opportunity. The mean compliance rate in our data set was 38%, which is nearly identical to the average compliance rate across hospitals reported by the WHO (2009) of 39%.

**Primary predictor variables.**

***Hours at work.*** We calculated the time elapsed (in hours) since the start of a caregiver's work shift at the time of a given hand hygiene opportunity.

***Hours off work.*** We calculated the time elapsed (in hours) between two consecutive shifts for a given caregiver.

**Moderator variables.** As would be expected given their frequent interactions with patients, nurses and patient care technicians generated 91% of all observed hand hygiene opportunities. Past research highlights that patient care is the most taxing component of a nurse's workload (Delucia, Ott, & Palmieri, 2009; Battisto, Pak, Vander Wood, & Pilcher, 2009).[8] To test the hypothesis that work intensity moderates the effects of hours at work on compliance (Hypothesis 2), we measured work intensity in two ways.

***Cumulative average frequency of patient encounters.*** First, to calculate the hourly frequency at which a caregiver visited patient rooms leading up to a given hand hygiene opportunity, we divided the total number of episodes (or room visits) a caregiver had experienced by the number of hours the caregiver had been at work since he or she began a given shift.

[5] A limitation of this data set is that we do not have information about what caregivers do when they are outside of patient rooms. They could theoretically still be at work following a 7-hr gap in visits to patient rooms, although this is unlikely because the primary role of caregivers in the hospital units we study is to provide patient care, which requires entering and exiting patient rooms with relatively high frequency. However, if it were the case that some hour-hr gaps in patient room visits did not signal time off between shifts, this would only attenuate our effects and result in a more conservative test of our Hypothesis 1. We also varied the time interval used to segment successive shifts and found that our results were robust to alternative definitions (see the document titled *Robustness Tests* in the online supplemental materials for details).

[6] Of the 269,877 shifts identified in our data set, 46% began between 6 a.m. and 8 a.m., and 28% began between 6 p.m. and 8 p.m. This suggests that our shift definitions were well-calibrated, as 7 a.m. and 7 p.m. are the most common times for shift switches in hospitals (Rogers et al., 2004).

[7] Work shifts assigned to hospital nurses typically last either 8 or 12 hr, with 12-hr shifts becoming increasingly popular (Stimpfel et al., 2012). Health care work rotations usually also allow for a half-hour handoff period at the end of the previous caregiver's shift and the start of the incoming caregiver's shift (Rogers et al., 2004). Consistent with these common practices, more than 98% of the work shifts we observed lasted 13 hr or less.

[8] A common measure of workload for nurses is the number of patients that a nurse oversees (Page, 2004), and nurses reported that most problems they encounter during nursing tasks occur at patients' bedside (Battisto et al., 2009).

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***Cumulative average percentage of time in patient rooms.*** Second, to calculate the fraction of time a caregiver spent in patient rooms per hour leading up to a given hand hygiene opportunity, we divided the total time (in hours) a caregiver had spent in patient rooms since the beginning of a given shift by the number of hours since the caregiver began the shift in question.

When testing Hypothesis 2, we restricted our sample to hand hygiene opportunities that occurred after a given caregiver had been at work for more than 1 hr (following Batt & Terwiesch, in press).[9] Our measure of work intensity can take on extremely high values at the beginning of a shift, particularly when the first few episodes are very short. Thus, excluding the first hour of hand hygiene opportunities should result in more stable and reliable estimates of work intensity. It also makes sense from a theoretical perspective, because accumulated work intensity cannot influence compliance until some measurable work has actually accumulated.

***Compliance in the final hour of the preceding shift.*** To test the hypothesis that compliance at the end of an employee's previous shift moderates the effect of hours off work on his or her compliance during the subsequent shift (Hypothesis 4), we created the variable *compliance in the final hour of the preceding shift.* For this variable, we calculated for each shift the average compliance rate associated with the last hour of the caregiver's preceding shift.

***Total hours at work in the past week.*** To test our hypotheses that heavy exposure to work demands in the past week can produce spillover effects, exacerbating the impact of time at work (Hypothesis 5) and of time off from work (Hypothesis 6) on compliance, we created the variable *total hours at work in the past week.* For this variable, we calculated for each shift the total number of hours that a caregiver worked in the past 7 calendar days prior to the start of the shift.[10]

**Control variables.** For each hand hygiene opportunity, our analyses also included controls for (a) the duration of the corresponding episode (the time between room entry and exit); (b) an indicator for whether the episode involved a room entry (as opposed to a room exit); and (c) the hour of the day, the day of the week, the month of the year, and the year when the episode occurred. Additional controls included the number of days since a caregiver first appeared in the Proventix data set and an indicator for whether Proventix had yet rolled out its RFID technology to all workers in a given unit (some caregivers pilot tested the technology prior to the full unit rollout, and their pilot data were included in our analyses). See the online supplemental materials for detailed information about how each of these control variables was constructed.

Table 1 provides means, standard deviations, and correlations for all variables included in our analyses.

## Analysis Strategy

Because of our data's multilevel, nested structure (hand hygiene opportunities are nested within shifts, which are nested within caregivers, who are nested within hospitals) and our dichotomous dependent variable, we used Bernoulli distribution hierarchical linear models (HLM7; Raudenbush et al., 2011) to test our hypotheses. Specifically, we relied on four-level random intercept logistic regression models including random effects for shifts (Level 2), caregivers (Level 3), and hospitals (Level 4). Our dependent variable was an indicator of whether a given caregiver in a given hospital sanitized his or her hands at a given hand hygiene opportunity during a given shift. All continuous predictor variables (including our primary predictor variables, moderators, and control variables) were centered on the basis of their grand mean values before they were included in our regression models.[11]

We began by fitting a null model to assess how much variance resides within and between shifts, caregivers, and hospitals. The shift-level and caregiver-level intraclass correlations (ICCs) were .15 and .19, respectively (both $p$s $< .001$). This indicates that 15% of the variability in hand hygiene compliance was attributable to differences between shifts, whereas 19% was attributable to differences between caregivers. These values represent moderate to moderately high ICC values (Bliese & Hanges, 2004) and confirm the necessity of including random effects for shifts and caregivers. The hospital-level ICC was .05, indicating that 5% of the total variance in compliance was attributable to differences between hospitals. Although statistically significant ($p < .001$), the magnitude of this ICC suggests that, relative to the variance within and across shifts and caregivers, the between-hospital variance is smaller (Hox, 2002).

In robustness checks, we have also reanalyzed our data in several other ways. First, we used three-level random intercept logistic regression models in which we included random effects for caregivers (Level 2) and hospitals (Level 3). Second, we used three-level random intercept logistic regression models in which we included random effects for shifts (Level 2) and caregivers (Level 3). Finally, we used ordinary least squares regression models including fixed effects for each caregiver to control for time-invariant characteristics of caregivers (e.g., an individual's propensity to comply). Whether we clustered our standard errors at the hospital level or at the caregiver level made little difference to our findings. Our results were all robust to each of these alternative modeling strategies (see the online supplemental materials for regression results).

[9] As a result, all models reported in Table 2 that include a test of Hypothesis 2 (i.e., Models 3–8) excluded shifts that were shorter than 1 hr.

[10] For shifts that occurred within 7 days of a worker's first shift tracked by Proventix, we do not know the total hours a given caregiver worked during the previous 7 days. Therefore, when we test Hypotheses 5 and 6, our regression models (i.e., Models 7 and 8 in Table 2) do not include shifts that occurred within 7 days of a worker's first shift. Note that all reported results remained meaningfully unchanged if we replaced total hours at work in the past week with the total number of hours at work in the past 14 days (i.e., 2 weeks), in the past 5 days (the typical number of workdays per week), or during an even shorter time window (including 2, 3, or 4 days) prior to the start of a given shift. It is interesting that the total hours at work on a caregiver's previous day was not a statistically significant moderator of hours at work, suggesting that the spillover effects of accumulated work demands on compliance during caregivers' subsequent work shifts may take more than 1 day to manifest.

[11] We conducted a robustness check on models that included tests of cross-level interactions (i.e., Models 7 and 8 in Table 2) to confirm that grand meaning centering did not generate a spurious cross-level interaction between the Level 1 variable hours at work and the Level 2 variable total hours at work in the past week. Specifically, following Hofmann and Gavin (1998), we centered hours at work on the basis of its group mean and reran Models 7 and 8 as four-level random slope logistic regression models where (a) total hours at work in the past week entered the slope of hours at work and (b) the group mean of hours at work was included as a Level 2 intercept. All of our hypotheses were supported.

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Table 1
*Means, Standard Deviations, and Correlations for All Variables Included in Our Analyses (N = 13,773,022)*

| Variable | *M* | *SD* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Compliance | 0.38 | 0.49 | — | | | | | | | | | | | | | | | | |
| 2. Hours at work | 5.02 | 3.57 | −.04* | — | | | | | | | | | | | | | | | |
| 3. Hours off work | 67.78 | 182.95 | −.02* | −.01* | — | | | | | | | | | | | | | | |
| 4. Cumulative average frequency of patient encounters | 6.44 | 9.28 | −.03* | −.27* | .01* | — | | | | | | | | | | | | | |
| 5. Cumulative average % of time in patient rooms | 0.37 | 0.21 | .08* | −.30* | .00* | .44* | — | | | | | | | | | | | | |
| 6. Compliance in the final hour of the preceding shift | 0.35 | 0.32 | .42* | .00* | −.05* | −.05* | .07* | — | | | | | | | | | | | |
| 7. Total hours at work in the past week | 24.49 | 12.94 | .05* | .04* | −.29* | .00* | .04* | .08* | — | | | | | | | | | | |
| 8. Episode duration | 0.09 | 0.13 | .04* | .01* | .00* | −.13* | .08* | .04* | −.01* | — | | | | | | | | | |
| 9. Room entry indicator | 0.50 | 0.50 | −.10* | −.01* | −.00 | −.09* | −.14* | .00 | .00 | .00 | — | | | | | | | | |
| 10. Days since first caregiver observation | 200.01 | 171.62 | .09* | .01* | .02* | −.02* | −.00 | .11* | .01* | .03* | .00 | — | | | | | | | |
| 11. Post-monitoring indicator | 0.98 | 0.12 | .05* | .01* | .00* | .00* | .00* | .06* | .03* | −.01* | .00 | .11* | — | | | | | | |
| 12. Compliance opportunities per hour | 11.70 | 9.05 | −.10* | −.11* | .00* | .32* | .20* | −.13* | .05* | −.23* | .00* | −.05* | .00* | — | | | | | |
| 13. Cumulative hand cleansings | 16.42 | 19.66 | .27* | .49* | −.03* | −.06* | .03* | .40* | .13* | −.04* | −.01* | .07* | .05* | .07* | — | | | | |
| 14. Hour of the day | 11.94 | 6.25 | −.01* | −.09* | .00 | .00* | .05* | .00* | .01* | .00* | −.01* | −.01* | .00* | .00* | −.02* | — | | | |
| 15. Day of the week | 3.89 | 1.95 | .00 | .01* | −.03* | .00* | .01* | .01* | −.06* | .00 | .00 | .00* | .01* | .00* | .01* | −.02* | — | | |
| 16. Month | 6.57 | 3.56 | .01* | −.00* | .00* | −.02* | −.01* | .02* | −.02* | .02* | .00 | −.02* | .05* | −.05* | .00* | .00* | .01* | — | |
| 17. Year | 2,011.94 | 0.63 | .23* | −.02* | −.02* | −.06* | .00* | .31* | .04* | .02* | .00 | .15* | .14* | −.14* | .20* | .00 | .00* | −.43* | — |

*Note.* In this table, hour of the day, day of the week, and month are treated as continuous variables set equal to 1 for the first hour of the day, the first day of the week, and the first month of the year in the Proventix data set, respectively. Year represents the calendar year (from 2010 to 2013) corresponding to a given observation. Our regression models include dummy indicators for these variables as described in the *Control Variables* section.
* $p < .05$.

## Results

We first describe the effects of consecutive hours worked on compliance and then discuss the restorative effects of time off between shifts on compliance. Finally, we describe the impact of the total hours worked in the past week on these effects. Note that all reported results are robust to numerous alternative specifications (see the online supplemental materials for a summary of the robustness checks we have conducted).

### Effect of Consecutive Hours Worked on Compliance

Figure 1 depicts the average compliance rate across all data included in our analyses as a function of hours into a shift. As can be seen, the average compliance rate dropped from 42.6% in the first hour of a shift to 34.8% in the last hour of a typical 12-hr shift (two sample test of proportions, $p < .0001$). Although the pattern described here and illustrated in Figure 1 is consistent with our hypothesis, it could be driven by other factors besides hours worked, so we turn to more controlled analyses.

Table 2 displays the results of a series of four-level random intercept logistic regressions predicting compliance. Model 1 includes all aforementioned control variables and demonstrates that the hours at work variable is significantly and negatively related to compliance. Specifically, for every additional hour worked, the fitted odds of compliance are estimated to decrease by a factor of 0.96 or 4% (accumulating to produce a 38% decrease in the fitted odds of compliance over the course of a 12-hr shift or an 8.7-percentage-point decrease in the rate of compliance for an average caregiver over the course of a 12-hr shift).

**Alternative explanations for our findings besides fatigue.** Besides work-generated fatigue, there are a number of potential alternative explanations for our finding that compliance decreases over the course of a caregiver's shift. One is that caregivers interact with patients less frequently later in their shifts and thus view hand washing as less important over time. Another potential alternative explanation is that as caregivers accumulate hand cleansings over the course of a shift, they might believe that additional hand cleansings are not as important or will dry out their skin. To address these alternative accounts, we controlled for both the number of hand hygiene opportunities at each hour of a given shift for a given caregiver (*compliance opportunities per hour*) and the total number of hand cleansings a given caregiver had performed prior to a given hand cleansing opportunity during a given shift (*cumulative hand cleansings*; see Table 2, Model 2). In fact, for an additional hour at work, the fitted odds of a caregiver complying with hand hygiene guidelines are estimated to decrease by a factor of 0.95 or 5%, supporting Hypothesis 1.

**Work intensity as a moderator.** We now turn to a test of our hypothesis that work intensity exacerbates the negative relationship between hours at work and compliance (Hypothesis 2). Models 3 and 4 in Table 2 include interactions between hours at work and each of the two work intensity measures described previously (cumulative average frequency of patient encounters and cumulative average percentage of time in patient rooms). The coefficient estimate associated with each of these interaction terms is negative and statistically significant. To examine the moderating effects of work intensity, following Preacher, Curran, and Bauer (2006), we plotted the fitted probability of compliance for an average caregiver as a function of hours at work at the 16th and 84th percentiles of the two work intensity moderators described above: cumulative

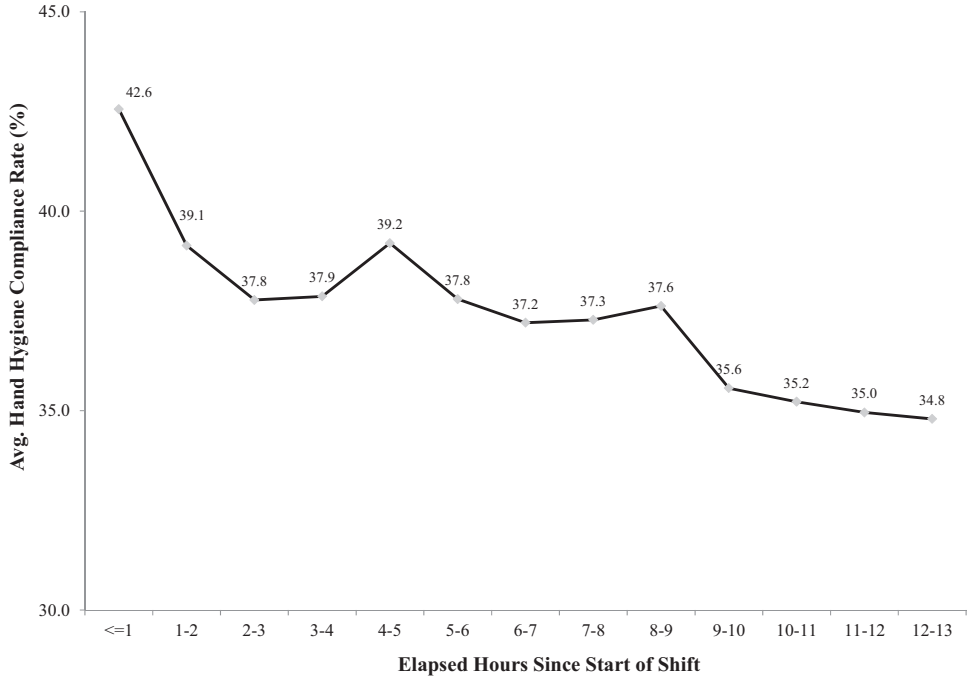



*Figure 1.* A plot of the relationship between the elapsed hours since a caregiver's shift began and the average rate of hand hygiene compliance among caregivers.

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Table 2
*Hand Hygiene Compliance Predicted Using Four-Level Random Intercept Logistic Regressions as a Function of Various Characteristics of a Given Hand Hygiene Opportunity*

| Variable or interaction | Model 1 | Model 2 | Model 3[a] | Model 4[a] | Model 5[a,b] | Model 6[a,b] | Model 7[a,b,c] | Model 8[a,b,c] |
|---|---|---|---|---|---|---|---|---|
| **Primary predictors** | | | | | | | | |
| Hours at work | −0.0394*** (0.0003) | −0.0465*** (0.0004) | −0.0640*** (0.0008) | −0.0572*** (0.0007) | −0.0568*** (0.0007) | −0.0548*** (0.0004) | −0.0549*** (0.0004) | −0.0549*** (0.0007) |
| Hours off work | | | | | 0.0011*** (0.0001) | 0.0014*** (0.0001) | 0.0015*** (0.0001) | 0.0015*** (0.0001) |
| **Moderators** | | | | | | | | |
| Cumulative average frequency of patient encounters | | | −0.0123*** (0.0008) | | | | | |
| Hours at Work × Cumulative Average Frequency of Patient Encounters | | | −0.0013*** (0.0001) | | | | | |
| Cumulative average % of time in patient rooms | | | | 0.1495*** (0.0107) | 0.1602*** (0.0118) | 0.1381*** (0.0115) | 0.1380*** (0.0117) | 0.1380*** (0.0117) |
| Hours at Work × Cumulative Average % of Time in Patient Rooms | | | | −0.0268*** (0.0019) | −0.0256*** (0.0021) | −0.0245*** (0.0021) | −0.0243*** (0.0021) | −0.0243*** (0.0021) |
| Compliance in the final hour of the preceding shift | | | | | | 1.3468*** (0.0078) | 1.3328*** (0.0079) | 1.3328*** (0.0079) |
| Hours Off Work × Compliance in the Final Hour of the Preceding Shift | | | | | | −0.0026*** (0.0002) | −0.0026*** (0.0002) | −0.0026*** (0.0002) |
| Total hours at work in the past week | | | | | | | 0.0020*** (0.0002) | 0.0021*** (0.0002) |
| Hours at Work × Total Hours at Work in the Past Week | | | | | | | −0.0001*** (2.4e−05) | −0.0001*** (2.4e−05) |
| Hours Off Work × Total Hours at Work in the Past Week | | | | | | | | 3.2e−05** (7.0e−06) |
| **Controls included to address alternative explanations** | | | | | | | | |
| Compliance opportunities/hour | | −0.0050*** (0.0001) | −0.0096* (0.0002) | −0.0102*** (0.0002) | −0.0100*** (0.0002) | −0.0101*** (0.0002) | −0.0100*** (0.0002) | −0.0100*** (0.0002) |
| Cumulative hand cleansings | | 0.0016*** (0.0001) | 0.0069*** (0.0001) | 0.0062*** (0.0001) | 0.0061*** (0.0001) | 0.0056*** (0.0001) | 0.0056*** (0.0001) | 0.0056*** (0.0001) |
| **Other statistics** | | | | | | | | |
| Observations | 13,773,022 | 13,773,022 | 11,455,165 | 11,455,165 | 9,518,955 | 9,518,955 | 9,252,251 | 9,252,251 |
| Number of caregivers | 4,157 | 4,157 | 3,916 | 3,916 | 3,647 | 3,647 | 3,519 | 3,519 |

*Note*. Models 1–4 and 7 examine the effects of hours elapsed since the beginning of a caregiver's shift on compliance. Models 5, 6, and 8 also estimate the effects of the time off between shifts on hand hygiene compliance. Control variables include duration of a room visit, room entry indicator, days since first caregiver observation, and post-monitoring indicator, as well as fixed effects for hour of the day, day of the week, month, and year. Standard errors are reported in parentheses.
[a] Sample excluded observations occurring within the first hour of a shift (and thus excluded shifts shorter than 1 hr). [b] Sample included all shifts except a worker's first shift or shifts that followed 108 or more hours off from work. [c] Sample included all shifts except those that (a) occurred within 7 days of a worker's first shift or (b) followed 108 or more hours off from work.
* $p < .05$. ** $p < .01$. *** $p < .001$.

average frequency of patient encounters (see Figure 2A, based on Model 3) and cumulative average percentage of time in patient rooms (see Figure 2B, based on Model 4).[12] Consistent with Hypothesis 2, the interactions depicted in Figure 2 indicate that hours at work have a stronger negative relationship with compliance when caregivers have had more frequent interactions with patients during a shift and when caregivers have spent a larger proportion of their time in patient rooms ($ps < .001$ in simple slope tests for both moderators).

## Effect of Time Off Between Shifts on Compliance

We next turn to a test of the hypothesis that time off work will positively predict subsequent compliance (Hypothesis 3). Before investigating this hypothesis, however, we removed a subset of problematic observations from our data set. First, we excluded each caregiver's first shift in our data set because for the first shift, we do not know when a caregiver's previous shift ended ($n_{shifts}$ = 4,157, $n_{hygeine_opportunities}$ = 119,440).[13] Also, we are interested in whether time off from work can improve compliance with professional standards by restoring executive function for employees who are active members of the caregiver work force taking typical amounts of time off. Therefore, we focused on recovery benefits of ordinary breaks from work and excluded caregivers who took atypically long breaks between shifts. In health care settings, weekly full-time schedules for caregivers typically include (a) five 8-hr shifts or (b) three 12-hr shifts (Stimpfel & Aiken, 2013). A 108-hr (or 4.5 day) break corresponds to the maximum break length per week that full-time caregivers experience if their work conforms to either of these aforementioned, common schedules.[14] Thus, our final sample included 193,259 shifts that occurred within 108 hr (or 4.5 days) after the end of a caregiver's previous shift ($N$ = 9,518,955).[15]

To investigate the extent to which time away from work predicted subsequent hand hygiene compliance, for every person and every shift, we calculated the time elapsed in hours since a caregiver's last shift (hours off work). Note that all hand hygiene opportunities that occurred during a given shift followed the same period off and thus the value of hours off work did not vary within a caregiver shift. Model 5 in Table 2 relies on the same specification as Model 4, but it includes an additional predictor of interest—hours off work.[16] Model 5 shows that the coefficient on hours off work is positive and significant, indicating that, as predicted, more time off is associated with higher compliance rates. Specifically, taking an additional half a day off (12 hr) is associated with a 1.3% increase in the odds that a caregiver is compliant when faced with a given hand hygiene opportunity on her subsequent shift. Although this effect is fairly small in size, even small increases in hand hygiene are valuable given the significant impact of hand cleanliness on preventing infections (WHO, 2009).

**Compliance at the end of an employee's previous shift as a moderator of time off between shifts.** We now turn to the hypothesis that employees benefit more from time off the lower their compliance at the end of their previous shift (Hypothesis 4). As described above, for every shift, we calculated the average compliance rate associated with the final hour of a caregiver's preceding shift. Model 6 in Table 2 includes the interaction between hours off work and compliance in the final hour of the preceding shift and shows a significant and negative coefficient on this interaction term. Again using the Preacher et al. (2006) approach, we depicted the fitted probability of compliance as a function of hours off work at the 16th and 84th percentiles of the variable compliance in the final hour of the preceding shift, on the basis of Model 6 in Table 2. As depicted in Figure 3 and consistent with Hypothesis 4, time off between shifts is associated with a significantly greater boost in caregivers' hand hygiene compliance on their return to work when caregivers exhibited lower hand hygiene compliance at the end of their previous shift ($p < .001$ in a simple slope test).

## Spillover Effects of Accumulated Work Demands

So far, we have presented evidence suggesting that work demands take an immediate toll on compliance. We also hypothesized that greater accumulated exposure to work demands would create spillover effects, harming compliance on subsequent work shifts (Hypothesis 5). As described above, for every shift, we calculated the total number of hours that a caregiver spent at work in the 7 days prior to the start of the shift in question. As shown in Model 7 (Table 2), the interaction between hours at work and total hours at work in the past week is significant and negative. Again using the approach of Preacher et al. (2006) to examine the interaction effect, we depicted the fitted probability of compliance as a function of hours at work at the 16th and 84th percentiles of the variable total hours at work in the past week, on the basis of Model 7 in Table 2. Figure 4A indicated that the more total hours a caregiver had worked in the past week, the faster his or her

[12] Because the variable cumulative average frequency of patient encounters is so highly skewed that its standard deviation is bigger than its mean, we analyzed the 16th and 84th percentiles of this variable, which are the percentile values that would correspond to 1 standard deviation below and above the mean of a variable exhibiting of a normal distribution. Consistent with this practice, we used the 16th and 84th percentiles of all moderator variables when plotting the fitted probability of compliance. Also, please note that in all of our fitted models (Figures 2–4), our continuous control variables were assigned their mean value while categorical covariates (i.e., our room entry indicator variable; our post-monitoring indicator variable; and fixed effects for year, month, day of the week, and hour of the day) were assigned the value of the omitted reference group.

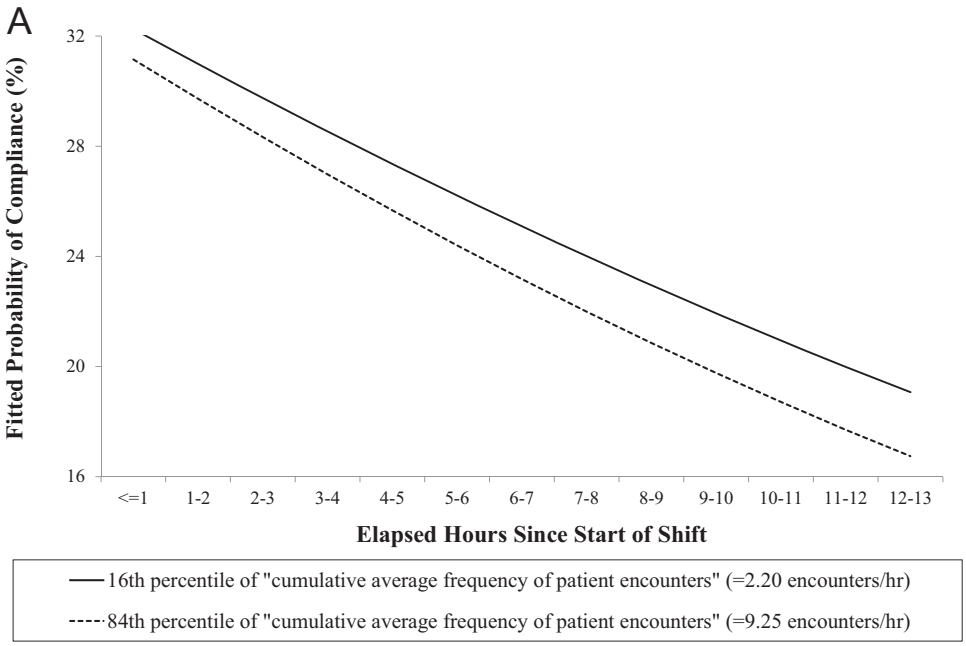
[13] Among the 119,474 hand hygiene opportunities associated with caregivers' first shifts, 2,654 opportunities were associated with 218 caregivers who were observed during just one shift. These caregivers were thus dropped from the analysis entirely when we excluded caregivers' first shifts.

[14] The 108 hr are calculated by assuming that a caregiver works three 12-hr shifts on 3 consecutive days and takes 4.5 days off. As a robustness check, we confined our analysis to different maximum lengths of breaks ranging from 2 weeks to 2 days, and our results remained qualitatively the same.

[15] Every model in Table 2 builds on the preceding model (with the exception of Model 4, which builds on Model 2 rather than Model 3 because Models 3 and 4 present different tests of the same hypothesis). This approach allows us to both focus on examining one hypothesis at a time and eventually test all hypotheses simultaneously. In all models that include a test of Hypothesis 2 (Models 3–8), we restricted our sample to hand hygiene opportunities that occurred after the first hour of a caregiver's shift (as explained in the Variables and Analyses section). All results except those directly related to our work intensity measures are robust to including the first hour of observations.

[16] If we replaced cumulative average percentage of time in patient rooms with our other measure of work intensity (cumulative average frequency of patient encounters) in Models 5–8, our hypotheses were still all supported.

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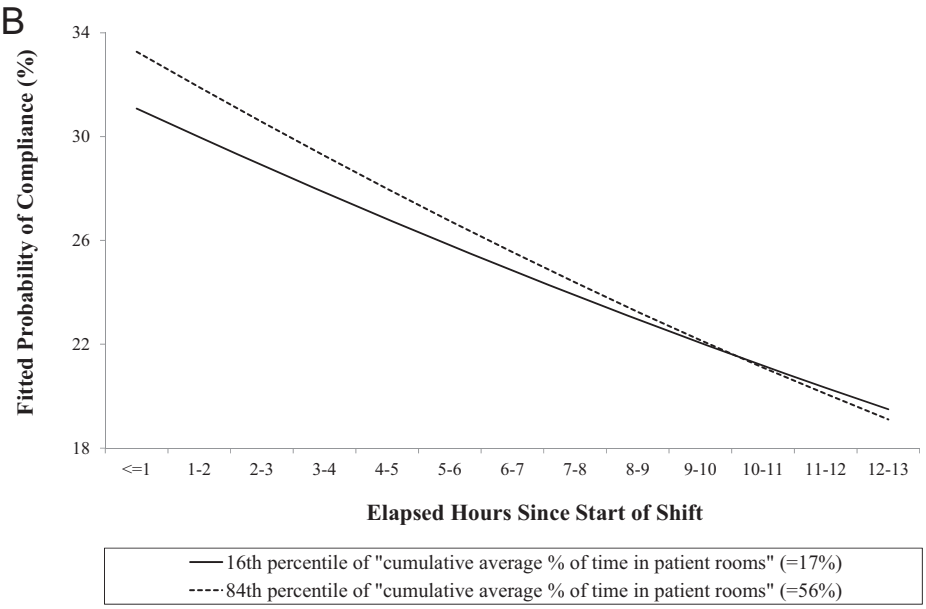




*Figure 2.* Plots of the fitted probability of compliance as a function of the interaction between the elapsed hours since the start of a caregiver's shift and work intensity measured as (a) the cumulative average frequency of patient encounters a caregiver has experienced up to a given hand hygiene opportunity (A: Model 3, Table 2) and (b) a caregiver's cumulative average percentage of time in patient rooms up to a given hand hygiene opportunity (B: Model 4, Table 2).

compliance decreased during a given shift ($p < .001$ in a simple slope test).

Furthermore, we predicted that accumulated work demands from recent shifts would affect the benefit of time off between shifts. Model 8 in Table 2 indicates that the coefficient on the interaction term between hours off work and total hours at work in the past week is positive and significant.[17] As illustrated in Figure 4B, this interaction suggests that the more hours a caregiver worked in the previous week, the stronger the positive association between a longer break between shifts and a caregiver's hand

[17] The correlation coefficient between hours off work and total hours at work in the past week is −.14, suggesting that the significant interaction between these variables is unlikely to be the spurious outcome of multicollinearity.

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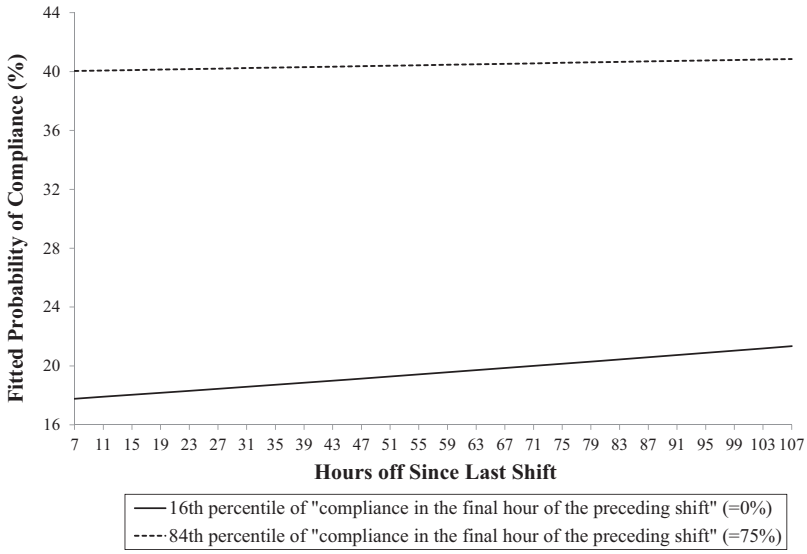



*Figure 3.* Plot of fitted probability of compliance as a function of the interaction between the hours off since a caregiver's previous shift and that caregiver's compliance rate at the end of her previous shift. This plot depicts the moderating effect of the compliance in the final hour of the preceding shift (plotted at the 16th and 84th percentiles) on time off. Compliance rates are fitted on the basis of Model 6 in Table 2.

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hygiene compliance on her return to work ($p < .001$ in a simple slope test).

## General Discussion

Industry professional groups, external regulators, and leaders within organizations develop, communicate, and reinforce professional standards to ensure the safe and reliable performance of work and delivery of services. The reality that workers must often pursue multiple and sometimes conflicting goals on the job while facing intense work demands can result in inconsistent compliance with professional standards. Past research has found this to be particularly true in the case of relatively minor deviations from accepted practices (Hofmann & Stetzer, 1996; Reason, 1990).

Although past research has demonstrated that, in general, high work demands are related to decreased compliance with safety guidelines, there has been no research to date suggesting that the impact of work demands may accumulate very quickly—for example, over the course of a typical, 12-hr shift. The current research sought to address this gap in the literature by examining variability in rule compliance within a single work shift. Integrating the existing literature on work demands, multiple goals, and theories of resource depletion, we hypothesized that dealing with demanding work environments should produce immediate declines in routine compliance with professional standards—acts that require executive resources but are often deemed to be of secondary importance in production-oriented work settings (Hypothesis 1). Following our argument that self-regulatory depletion and fatigue underlie the degradation of compliance within a work shift, we further expected that time away from work would help replenish physical and mental resources, thus increasing subsequent compliance (Hypothesis 3). We further proposed several moderators of these effects such as work intensity, recent accumulated hours at work, and recent compliance (Hypotheses 2, 4, 5, and 6).

To test our hypotheses, we examined compliance with hand hygiene guidelines in hospitals. This empirical setting was well-suited to evaluating our hypotheses, because (a) routine compliance in this context is consequential but represents a significant challenge for caregivers (WHO, 2009) and (b) caregivers in health care settings tend to experience acute work demands (Dollard & McTernan, 2011; Houtman & Kompier, 1995). Using 3 years of electronic records on hand hygiene compliance in a population including thousands of health care workers, we provided evidence supporting all of our hypotheses. Specifically, we showed that hand hygiene compliance rates decrease over the course of a normal work shift—an effect that is accentuated when caregivers engage in more intense work.[18] Further, we found that more time off between shifts appears to serve a restorative purpose, as it is associated with greater hand hygiene compliance on a caregiver's subsequent shift. In particular, more time off is associated with greater improvements in compliance rates when caregivers exhibited lower hygiene compliance rates at the end of their previous shift. In addition, we showed that the longer a caregiver worked in the past week, the faster his or her compliance declined over the

[18] It is unlikely that our findings can be simply explained by caregivers engaging in an optimal level of hand hygiene. First, ample evidence has shown that increased compliance is associated with reduced infection rates in health care settings (Boyce & Pittet, 2002; WHO, 2009), suggesting that caregivers are not optimizing their hand hygiene compliance. Second, on the basis of conversations with nurses and according to descriptions of nursing jobs, there is no evidence that the nature of patient care changes across caregiver shifts in a systematic way such that caregivers' hand hygiene needs decrease over time. Also, we did not find that the duration of patient room visits changed significantly over the course of a shift in our data set.

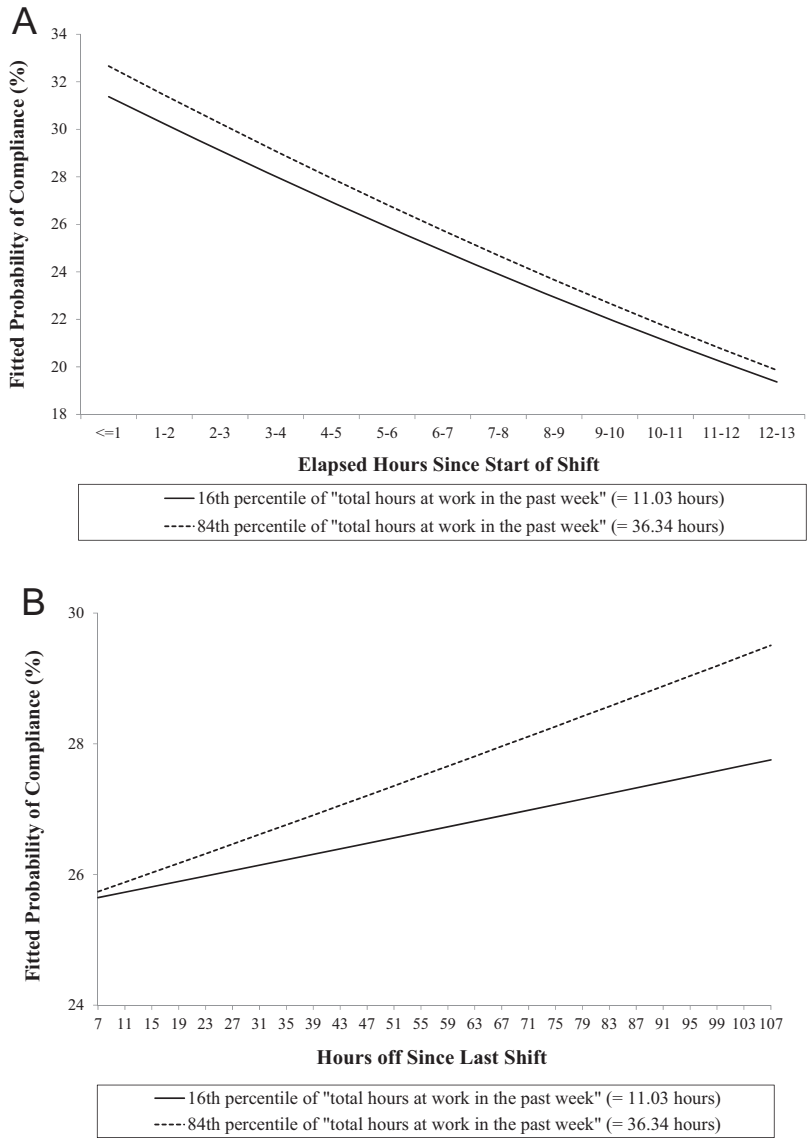



*Figure 4.* Plots of the fitted probability of compliance as a function of the elapsed hours since the start of a caregiver's shift (A: Model 7 in Table 2) and the hours off since a caregiver's previous shift (B: Model 8 in Table 2). Both plots depict the moderating effect of the total hours at work in the past week (plotted at its 16th and 84th percentiles).

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course of a shift and the more his or her compliance improved from more time off between shifts.

## Theoretical Implications

We expect that the effects documented here of accumulated time at work, work intensity, and time off from work are likely relevant to many forms of routine compliance in organizations. Future research exploring the relationship between work demands and compliance in a broader set of contexts (e.g., applying this idea to ethics standards in banking, safe driving behaviors in trucking, or safety standards in manufacturing) would be valuable. However, there may be important boundary conditions. For example, it would be valuable to investigate whether time on and off work also affects compliance with standards that are not part of day-to-day routines (e.g., rules designed for emergencies). Also, it would be useful to learn whether our findings apply to employees for whom work demands increase job satisfaction and intrinsic motivation (e.g., LePine, Podsakoff, & LePine, 2005).

In addition to linking employees' recovery from workplace fatigue to a novel outcome—compliance with professional standards—this article adds to the work recovery literature in a number of additional ways. First, past research on fatigue has compared the outcomes of individuals who engaged in a relaxing activity with those who did not or compared the performance of the same individuals before and after a recovery opportunity (e.g., Fitz &

Sonnentag, 2006; Kühnel, Sonnentag, & Westman, 2009; Westman & Eden, 1997). We, however, explored whether varying levels of time spent away from work (a recovery activity) may have a continuous relationship with improved performance and indeed find evidence consistent with this. In addition, prior research has shown that only depleted individuals can benefit from recovery activities, but it has failed to explore the continuous relationship between levels of depletion and the benefits of recovery activities (e.g., Gailliot et al., 2007; Tice et al., 2007; Tyler & Burns, 2008). We posited and provided initial evidence that the level of depletion—a continuous construct—can influence individuals' recovery experiences. Future research that further explores the continuous (rather than dichotomous) effects of depletion would be valuable, as our research highlights the importance of recognizing that depletion is not a purely dichotomous (e.g., on or off) experience.

One limitation of our data is that we cannot measure individuals' psychological states or perceptions. Although some alternative explanations for our findings can be ruled out (e.g., the potentially demotivating effects of cumulative hand cleansings and changes in the frequency of patient contact), it would be valuable for future research to more directly explore a mechanism responsible for our findings. For example, future research could use the experience-sampling method to measure employees' perceived workload and subjective fatigue at various points in time at work, which could be matched with records of compliance with professional standards.

## Practical Implications

The results of this article point to a previously unexplored and high cost of intrashift workplace fatigue: an increase in deviations from professional guidelines. These deviations pose a threat to the well-being of organizations, employees, and clients (in this case, patients), because such violations can reduce the quality of products produced and services provided as well as create an unsafe work environment. In the context of hand hygiene, our primary model (Model 1 in Table 2) estimated that compliance, on average, decreases over the course of a normal, 12-hr shift by 8.7 percentage points. In a study of Swiss hospitals, Pittet et al. (2000) found that a 1-percentage-point increase in hand sanitation compliance rates reduced the number of infections per 1,000 admitted patients by 3.9. Another study by Scott (2009) estimated that the cost per patient associated with a health care–acquired infection is $20,549. Assuming these estimates applied to our sample, the decrease in hand hygiene compliance that we detected during a typical work shift would contribute to approximately 7,500 unnecessary infections per year at an annual cost of approximately $150 million across the 34 hospitals included in this study with available data on patient admissions.[19] Across all of the 5,723 registered hospitals in the United States, this compliance decrement would be estimated to produce an additional 0.6 million infections per year at an estimated cost of $12.5 billion annually.[20] Considering that 5.82% of health care–acquired infections in hospitals are fatal (Klevens et al., 2007), these estimated additional infections could potentially lead to up to 35,000 unnecessary deaths per year in the United States.

It is also worth noting that even small improvements in compliance with hand hygiene guidelines can be valuable. First, low hand hygiene compliance appears to be a difficult issue to resolve in the health care industry, as numerous interventions for improving hand hygiene among health care professionals have proven ineffective (Gawande, 2004; Whitby et al., 2007). When an important behavior is hard to improve, even a small change can be impressive (Prentice & Miller, 1992). Second, Abelson (1985) suggested that researchers should not underestimate the importance of predictor variables that explain only a small proportion of variance in a one-shot decision context (e.g., a single hand hygiene decision), because these predictor variables can be meaningful in the long run if repeated decisions are involved. Thus, small improvements in compliance can potentially translate into meaningful reductions in health care–associated infections if the enormous number of caregiver–patient interactions that occur on a daily basis across hospitals in the United States (and globally) are taken into account.

Our empirical strategy (multilevel modeling) allows us to identify and partition different sources of variance in the outcome variable of interest here, which is hand hygiene compliance. As mentioned previously in our Analysis Strategy section, the portion of total variance attributable to variability between the 35 hospitals included in our study is quite small (ICC = 0.05)—95% of variability occurs within hospitals, suggesting that many hospitals experience similar levels of compliance and thus our findings are likely quite generalizable. However, given the meaningful variance that remains at the hospital level, future researchers should seek to understand how organizational conditions such as goals, leadership, and monitoring affect compliance behaviors (Staats, Dai, Hofmann, & Milkman, 2014).

Our ICC estimates indicate that 19% of the total variance in compliance in our sample resides between caregivers and 5% resides between hospitals. Thus 74% (i.e., 100% − 19% − 5%) of the total variance in compliance in our sample is attributable to variability within caregivers (including variability between and within shifts). Further, taking into account that 15% of the total variance in our sample can be attributed to differences between shifts, we estimate that 59% (i.e., 74% − 15%) of total variance in compliance resides within shifts. This suggests that the same caregiver's hand hygiene compliance varies dramatically over time, particularly over the course of a single work shift. Thus understanding within-person and within-shift compliance variability is of critical importance. In the present research, we explore multiple factors that can begin to help explain this important variability in compliance over time: accumulated time at work on a shift and time off since an employee's previous shift.

In conclusion, the findings reported here suggest that demanding work environments can produce negative consequences far more rapidly than prior work exploring the effects of high job demands has recognized (e.g., Bakker & Demerouti, 2007; Demerouti et al., 2001). In other words, a day in the saddle can indeed take its toll, in that immediate and continuous job demands result in a gradual reduction in compliance with professional standards over the

[19] According to statistics provided by Proventix, 442,694 patients are admitted to the hospitals involved in our study per year. Our estimates did not include the one hospital in our data set that was missing information about the annual number of patients admitted.

[20] The total number of patients admitted to the 5,723 registered hospitals in the United States per year is 36,156,245 (AHA Resource Center, 2014).

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course of day. Clearly, future research should investigate how to reduce these harmful effects of work demands on routine compliance.

## References


Abelson, R. P. (1985). A variance explanation paradox: When a little is a lot. *Psychological Bulletin, 97,* 129–133. http://dx.doi.org/10.1037/0033-2909.97.1.129

American Hospital Association Resource Center. (2014). Fast facts on US hospitals. Retrieved August 9, 2014, from http://www.aha.org/research/rc/stat-studies/fast-facts.shtml

Bakker, A. B., & Demerouti, E. (2007). The job demands-resources model: State of the art. *Journal of Managerial Psychology, 22,* 309–328. http://dx.doi.org/10.1108/02683940710733115

Bakker, A. B., Demerouti, E., de Boer, E., & Schaufeli, W. B. (2003). Job demands and job resources as predictors of absence duration and frequency. *Journal of Vocational Behavior, 62,* 341–356. http://dx.doi.org/10.1016/S0001-8791(02)00030-1

Bakker, A. B., Schaufeli, W. B., Sixma, H. J., Bosveld, W., & Van Dierendonck, D. (2000). Patient demands, lack of reciprocity, and burnout: A five-year longitudinal study among general practitioners. *Journal of Organizational Behavior, 21,* 425–441. http://dx.doi.org/10.1002/(SICI)1099-1379(200006)21:4<425::AID-JOB21>3.0.CO;2-#

Barnes, C. M., Schaubroeck, J., Huth, M., & Ghumman, S. (2011). Lack of sleep and unethical conduct. *Organizational Behavior and Human Decision Processes, 115,* 169–180. http://dx.doi.org/10.1016/j.obhdp.2011.01.009

Batt, R. J., & Terwiesch, C. (in press). Waiting patiently: An empirical study of queue abandonment in an emergency department. *Management Science.*

Battisto, D., Pak, R., Vander Wood, M. A., & Pilcher, J. J. (2009). Using a task analysis to describe nursing work in acute care patient environments. *Journal of Nursing Administration, 39,* 537–547. http://dx.doi.org/10.1097/NNA.0b013e3181c1806d

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74,* 1252–1265. http://dx.doi.org/10.1037/0022-3514.74.5.1252

Binnewies, C., Sonnentag, S., & Mojza, E. J. (2010). Recovery during the weekend and fluctuations in weekly job performance: A week-level study examining intra-individual relationships. *Journal of Occupational and Organizational Psychology, 83,* 419–441. http://dx.doi.org/10.1348/096317909X418049

Bliese, P. D., & Hanges, P. J. (2004). Being both too liberal and too conservative: The perils of treating grouped data as though they were independent. *Organizational Research Methods, 7,* 400–417. http://dx.doi.org/10.1177/1094428104268542

Boyce, J. M., & Pittet, D. (2002). Guideline for hand hygiene in health-care settings: Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Morbidity and Mortality Weekly Report, 51* (RR-16). Retrieved from http://www.cdc.gov/mmwr/PDF/rr/rr5116.pdf

Campion, M. A. (1988). Interdisciplinary approaches to job design: A constructive replication with extensions. *Journal of Applied Psychology, 73,* 467–481. http://dx.doi.org/10.1037/0021-9010.73.3.467

Clarkson, J. J., Hirt, E. R., Chapman, D. A., & Jia, L. (2011). The impact of illusory fatigue on executive control: Do perceptions of depletion impair working memory capacity? *Social Psychological and Personality Science, 2,* 231–238. http://dx.doi.org/10.1177/1948550610386628

Clarkson, J. J., Hirt, E. R., Jia, L., & Alexander, M. B. (2010). When perception is more than reality: The effects of perceived versus actual resource depletion on self-regulatory behavior. *Journal of Personality and Social Psychology, 98,* 29–46. http://dx.doi.org/10.1037/a0017539

Crawford, E. R., LePine, J. A., & Rich, B. L. (2010). Linking job demands and resources to employee engagement and burnout: A theoretical extension and meta-analytic test. *Journal of Applied Psychology, 95,* 834–848. http://dx.doi.org/10.1037/a0019364

Danziger, S., Levav, J., & Avnaim-Pesso, L. (2011). Extraneous factors in judicial decisions. *PNAS: Proceedings of the National Academy of Sciences, USA, 108,* 6889–6892. http://dx.doi.org/10.1073/pnas.1018033108

DeLucia, P. R., Ott, T. E., & Palmieri, P. A. (2009). Performance in nursing. In F. T. Durso (Ed.), *Reviews of human factors and ergonomics* (Vol. 5, pp. 1–40). Santa Monica, CA: Human Factors and Ergonomics Society.

Demerouti, E., Bakker, A. B., Nachreiner, F., & Schaufeli, W. B. (2001). The job demands-resources model of burnout. *Journal of Applied Psychology, 86,* 499–512. http://dx.doi.org/10.1037/0021-9010.86.3.499

Dollard, M. F., & McTernan, W. (2011). Psychosocial safety climate: A multilevel theory of work stress in the health and community service sector. *Epidemiology and Psychiatric Sciences, 20,* 287–293. http://dx.doi.org/10.1017/S2045796011000588

Erasmus, V., Brouwer, W., van Beeck, E. F., Oenema, A., Daha, T. J., Richardus, J. H., . . . Brug, J. (2009). A qualitative exploration of reasons for poor hand hygiene among hospital workers: Lack of positive role models and of convincing evidence that hand hygiene prevents cross-infection. *Infection Control and Hospital Epidemiology, 30,* 415–419. http://dx.doi.org/10.1086/596773

Ferrara, M., & De Gennaro, L. (2001). How much sleep do we need? *Sleep Medicine Reviews, 5,* 155–179. http://dx.doi.org/10.1053/smrv.2000.0138

Fritz, C., & Sonnentag, S. (2005). Recovery, health, and job performance: Effects of weekend experiences. *Journal of Occupational Health Psychology, 10,* 187–199. http://dx.doi.org/10.1037/1076-8998.10.3.187

Fritz, C., & Sonnentag, S. (2006). Recovery, well-being, and performance-related outcomes: The role of workload and vacation experiences. *Journal of Applied Psychology, 91,* 936–945. http://dx.doi.org/10.1037/0021-9010.91.4.936

Gailliot, M. T., & Baumeister, R. F. (2007). The physiology of willpower: Linking blood glucose to self-control. *Personality and Social Psychology Review, 11,* 303–327. http://dx.doi.org/10.1177/1088868307303030

Gailliot, M. T., Baumeister, R. F., DeWall, C. N., Maner, J. K., Plant, E. A., Tice, D. M., . . . Schmeichel, B. J. (2007). Self-control relies on glucose as a limited energy source: Willpower is more than a metaphor. *Journal of Personality and Social Psychology, 92,* 325–336. http://dx.doi.org/10.1037/0022-3514.92.2.325

Gawande, A. (2004). Notes of a surgeon: On washing hands. *New England Journal of Medicine, 350,* 1283–1286. http://dx.doi.org/10.1056/NEJMp048025

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: A meta-analysis. *Psychological Bulletin, 136,* 495–525. http://dx.doi.org/10.1037/a0019486

Hansez, I., & Chmiel, N. (2010). Safety behavior: Job demands, job resources, and perceived management commitment to safety. *Journal of Occupational Health Psychology, 15,* 267–278. http://dx.doi.org/10.1037/a0019528

Haynes, A. B., Weiser, T. G., Berry, W. R., Lipsitz, S. R., Breizat, A. H. S., Dellinger, E. P., . . . Gawande, A. A. (2009). A surgical safety checklist to reduce morbidity and mortality in a global population. *New England Journal of Medicine, 360,* 491–499. http://dx.doi.org/10.1056/NEJMsa0810119

Hockey, G. R. J. (1993). Cognitive-energetical control mechanisms in the management of work demands and psychological health. In A. D. Baddeley & L. Weiskrantz (Eds.), *Attention, selection, awareness and control: A tribute to Donald Broadbent* (pp. 328–345). Oxford, England: Oxford University Press.

Hockey, G. R. J. (1997). Compensatory control in the regulation of human performance under stress and high workload: A cognitive–energetical


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This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

framework. *Biological Psychology, 45,* 73–93. http://dx.doi.org/10.1016/S0301-0511(96)05223-4

Hofmann, D. A., & Frese, M. (2011). *Errors in organizations*. New York, NY: Routledge.

Hofmann, D. A., & Gavin, M. B. (1998). Centering decisions in hierarchical linear models: Implications for research in organizations. *Journal of Management, 24,* 623–641. http://dx.doi.org/10.1177/014920639802400504

Hofmann, D. A., & Stetzer, A. (1996). A cross-level investigation of factors influencing unsafe behaviors and accidents. *Personnel Psychology, 49,* 307–339. http://dx.doi.org/10.1111/j.1744-6570.1996.tb01802.x

Houtman, I. L., & Kompier, M. A. (1995). Risk factors and occupational risk groups for work stress in the Netherlands. In S. L. Sauter & L. R. Murphy (Eds.), *Organizational risk factors for job stress* (pp. 209–225). Washington, DC: American Psychological Association. http://dx.doi.org/10.1037/10173-013

Hox, J. (2002). *Multilevel analysis: Techniques and application*. Mahwah, NJ: Erlbaum.

Hugonnet, S., & Pittet, D. (2000). Hand hygiene—Beliefs or science? *Clinical Microbiology and Infection, 6,* 348–354. http://dx.doi.org/10.1046/j.1469-0691.2000.00104.x

Inzlicht, M., & Schmeichel, B. J. (2012). What is ego depletion? Toward a mechanistic revision of the resource model of self-control. *Perspectives on Psychological Science, 7,* 450–463. http://dx.doi.org/10.1177/1745691612454134

Job, V., Dweck, C. S., & Walton, G. M. (2010). Ego depletion—Is it all in your head? Implicit theories about willpower affect self-regulation. *Psychological Science, 21,* 1686–1693. http://dx.doi.org/10.1177/0956797610384745

Joint Commission Center for Transforming Healthcare. (2013). Hand hygiene project and the TST [FAQ]. Retrieved August 4, 2013, from http://www.centerfortransforminghealthcare.org/faq.aspx?CategoryId=49#1111

Karasek, R., & Theorell, T. (1990). *Healthy work: Stress productivity and the reconstruction of working life*. New York, NY: Basic Books.

Kc, D. S., & Terwiesch, C. (2009). Impact of workload on service time and patient safety: An econometric analysis of hospital operations. *Management Science, 55,* 1486–1498. http://dx.doi.org/10.1287/mnsc.1090.1037

Klevens, R. M., Edwards, J. R., Richards, C. L., Jr., Horan, T. C., Gaynes, R. P., Pollock, D. A., & Cardo, D. M. (2007). Estimating health care-associated infections and deaths in us hospitals, 2002. *Public Health Reports, 122*(2), 160–166.

Kouchaki, M., & Smith, I. H. (2014). The morning morality effect: The influence of time of day on unethical behavior. *Psychological Science, 25,* 95–102. http://dx.doi.org/10.1177/0956797613498099

Kühnel, J., Sonnentag, S., & Westman, M. (2009). Does work engagement increase after a short respite? The role of job involvement as a double-edged sword. *Journal of Occupational and Organizational Psychology, 82,* 575–594. http://dx.doi.org/10.1348/096317908X349362

Lepine, J. A., Podsakoff, N. P., & Lepine, M. A. (2005). A meta-analytic test of the challenge stressor–hindrance stressor framework: An explanation for inconsistent relationships among stressors and performance. *Academy of Management Journal, 48,* 764–775. http://dx.doi.org/10.5465/AMJ.2005.18803921

Linder, J. A., Doctor, J. N., Friedberg, M. W., Nieva, H. R., Birks, C., Meeker, D., & Fox, C. (2014). Time of day and the decision to prescribe antibiotics. *JAMA Internal Medicine*. Advance online publication. http://dx.doi.org/10.1001/jamainternmed.2014.5225

Nahrgang, J. D., Morgeson, F. P., & Hofmann, D. A. (2011). Safety at work: A meta-analytic investigation of the link between job demands, job resources, burnout, engagement, and safety outcomes. *Journal of Applied Psychology, 96,* 71–94. http://dx.doi.org/10.1037/a0021484

Page, A. E. (2004). *Keeping patients safe: Transforming the work environment of nurses*. Washington, DC: National Academies Press.

Pittet, D., Hugonnet, S., Harbarth, S., Mourouga, P., Sauvan, V., Touveneau, S., . . . Programme, I. C. (2000). Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *Lancet, 356,* 1307–1312. http://dx.doi.org/10.1016/S0140-6736(00)02814-2

Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interactions in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics, 31,* 437–448. http://dx.doi.org/10.3102/10769986031004437

Prentice, D. A., & Miller, D. T. (1992). When small effects are impressive. *Psychological Bulletin, 112,* 160–164. http://dx.doi.org/10.1037/0033-2909.112.1.160

Raudenbush, S. W., Bryk, A. S., Cheong, A. S., Fai, Y. F., Congdon, R. T., & du Toit, M. (2011). *HLM 7: Hierarchical linear and nonlinear modeling*. Lincolnwood, IL: Scientific.

Reason, J. (1990). *Human error*. Cambridge, United Kingdom: Cambridge University Press.

Reason, J. (1995). Understanding adverse events: Human factors. *Quality in Health Care, 4,* 80–89. http://dx.doi.org/10.1136/qshc.4.2.80

Reason, J., Parker, D., & Lawton, R. (1998). Organizational controls and safety: The varieties of rule-related behaviour. *Journal of Occupational and Organizational Psychology, 71,* 289–304. http://dx.doi.org/10.1111/j.2044-8325.1998.tb00678.x

Rogers, A. E., Hwang, W. T., & Scott, L. D. (2004). The effects of work breaks on staff nurse performance. *Journal of Nursing Administration, 34,* 512–519. http://dx.doi.org/10.1097/00005110-200411000-00007

Schaufeli, W. B., Bakker, A. B., & Van Rhenen, W. (2009). How changes in job demands and resources predict burnout, work engagement, and sickness absenteeism. *Journal of Organizational Behavior, 30,* 893–917. http://dx.doi.org/10.1002/job.595

Schmidt, A. M., & DeShon, R. P. (2007). What to do? The effects of discrepancies, incentives, and time on dynamic goal prioritization. *Journal of Applied Psychology, 92,* 928–941. http://dx.doi.org/10.1037/0021-9010.92.4.928

Scott, R. D., II. (2009). *The direct medical costs of healthcare-associated infections in U.S. hospitals and the benefits of prevention* (Report No. CS200891-A). Retrieved from http://www.cdc.gov/HAI/pdfs/hai/Scott_CostPaper.pdf

See, J. E., Howe, S. R., Warm, J. S., & Dember, W. N. (1995). Meta-analysis of the sensitivity decrement in vigilance. *Psychological Bulletin, 117,* 230–249. http://dx.doi.org/10.1037/0033-2909.117.2.230

Sonnentag, S., Binnewies, C., & Mojza, E. J. (2008). "Did you have a nice evening?" A day-level study on recovery experiences, sleep, and affect. *Journal of Applied Psychology, 93,* 674–684. http://dx.doi.org/10.1037/0021-9010.93.3.674

Sonnentag, S., Kuttler, I., & Fritz, C. (2010). Job stressors, emotional exhaustion, and need for recovery: A multi-source study on the benefits of psychological detachment. *Journal of Vocational Behavior, 76,* 355–365. http://dx.doi.org/10.1016/j.jvb.2009.06.005

Staats, B. R., Dai, H., Hofmann, D. A., & Milkman, K. L. (2014). *Process compliance and electronic monitoring: Empirical evidence from hand hygiene in healthcare* [Working paper]. Chapel Hill: University of North Carolina at Chapel Hill.

Staats, B. R., & Gino, F. (2012). Specialization and variety in repetitive tasks: Evidence from a Japanese bank. *Management Science, 58,* 1141–1159. http://dx.doi.org/10.1287/mnsc.1110.1482

Steed, C., Kelly, J. W., Blackhurst, D., Boeker, S., Diller, T., Alper, P., & Larson, E. (2011). Hospital hand hygiene opportunities: Where and when (HOW2)? The HOW2 benchmark study. *American Journal of Infection Control, 39,* 19–26. http://dx.doi.org/10.1016/j.ajic.2010.10.007

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This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Stimpfel, A. W., & Aiken, L. H. (2013). Hospital staff nurses' shift length associated with safety and quality of care. *Journal of Nursing Care Quality, 28,* 122–129. http://dx.doi.org/10.1097/NCQ.0b013e3182725f09

Stimpfel, A. W., Sloane, D. M., & Aiken, L. H. (2012). The longer the shifts for hospital nurses, the higher the levels of burnout and patient dissatisfaction. *Health Affairs, 31,* 2501–2509. http://dx.doi.org/10.1377/hlthaff.2011.1377

Tice, D. M., Baumeister, R. F., Shmueli, D., & Muraven, M. (2007). Restoring the self: Positive affect helps improve self-regulation following ego depletion. *Journal of Experimental Social Psychology, 43,* 379–384. http://dx.doi.org/10.1016/j.jesp.2006.05.007

Trougakos, J. P., Beal, D. J., Green, S. G., & Weiss, H. M. (2008). Making the break count: An episodic examination of recovery activities, emotional experiences, and positive affective displays. *Academy of Management Journal, 51,* 131–146. http://dx.doi.org/10.5465/AMJ.2008.30764063

Turner, N., Chmiel, N., Hershcovis, M. S., & Walls, M. (2010). Life on the line: Job demands, perceived co-worker support for safety, and hazardous work events. *Journal of Occupational Health Psychology, 15,* 482–493. http://dx.doi.org/10.1037/a0021004

Tyler, J. M., & Burns, K. C. (2008). After depletion: The replenishment of the self's regulatory resources. *Self and Identity, 7,* 305–321. http://dx.doi.org/10.1080/15298860701799997

Welsh, D. T., & Ordóñez, L. D. (2014). The dark side of consecutive high performance goals: Linking goal setting, depletion, and unethical behavior. *Organizational Behavior and Human Decision Processes, 123,* 79–89. http://dx.doi.org/10.1016/j.obhdp.2013.07.006

Westman, M., & Eden, D. (1997). Effects of a respite from work on burnout: Vacation relief and fade-out. *Journal of Applied Psychology, 82,* 516–527. http://dx.doi.org/10.1037/0021-9010.82.4.516

Whitby, M., Pessoa-Silva, C. L., McLaws, M., Allegranzi, B., Sax, H., Larson, E., . . . Pittet, D. (2007). Behavioural considerations for hand hygiene practices: The basic building blocks. *Journal of Hospital Infection, 65,* 1–8. http://dx.doi.org/10.1016/j.jhin.2006.09.026*

World Health Organization. (2009). *WHO guidelines on hand hygiene in healthcare*. Geneva, Switzerland: World Health Organization Press.

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