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The Impact of Shift Work and Long Work Hours on Employers' Health Care Costs

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Objective: To estimate the additional health care costs incurred by two U.S. manufacturing companies due to their policies related to shift work and long work hours. **Methods:** We applied risk ratios from the published literature to data on 2647 workers from Company A and 1346 workers from Company B to estimate the excess cases of several chronic conditions in the worker population due to shift work and long work hours. We estimated the annual health care costs incurred by the companies by applying Medicare cost data. **Results:** Excess annual health care costs related to shift work totaled $1,394,365 and $300,297 for Companies A and B, respectively. Excess annual costs related to long work hours totaled $231,293 and $107,902 for Companies A and B, respectively. **Conclusions:** Excess health care costs related to shift work and long work hours is substantial, but may not be large enough to compel companies to alter their work scheduling policies.

Keywords: employee well-being, health care costs, long work hours, manufacturing, shift work

Approximately 20% of workers in the United States (US) are shift workers, meaning that at least half of their work hours are outside the traditional daytime hours of 8 AM to 6 PM.[1] Numerous studies have shown that shift work disrupts one's circadian rhythm and the internal processes controlled by the rhythm. As a result, shift work is associated with greater risk of chronic health conditions including mental illness, cardiovascular disorders, cancer, gastrointestinal disorders, and obesity, as well as acute conditions, such as pre-term birth.[2–11] Although employers recognize the potential deleterious effects of shift work, they cite a number of arguments in favor of maintaining them, including the nature of the work requiring a 24/7 schedule (eg, public safety), maximization of production capacity in response to consumer demand, and in some cases, employee preference for long shifts to maximize days off and pay.[12,13]

Employers develop and revisit work scheduling policies based on the needs of the companies' stakeholders. Schedules must, therefore, balance operational requirements, costs, safety, employee preferences, and comply with federal and state laws. Currently, company leaders make decisions about work schedules without evidence of the effect of shift work on health care costs, even though the companies ultimately bear the majority of those costs. Our goal was to estimate the additional health care costs incurred by two large manufacturing companies due to their shift work requirements. Specifically, we estimated the additional health care costs associated with shift work (compared to traditional daytime work) and costs associated with 12-hour shifts (compared to 8-hour shifts), which are common in the manufacturing industry. These estimates provide a first look at shift work-related health care costs for employers, and may be considered as employers make decisions about work schedules and wellness benefits.

METHODS

Study Population

We recruited two Fortune 500 manufacturers (Companies A and B), which each contributed data on all hourly workers in two U.S. plants (Plants 1–4). We focused on manufacturing because it is a large industry employing over 12 million workers; shift work and 12-hour shifts are prevalent in the industry; large manufacturers are overwhelming self-insured, meaning that they assume the financial risk for health care costs; and manufacturing leaders may be more highly motivated to reconsider shift work policies in the wake of new evidence on cost than leaders in the public sector, where many shift workers are also employed. Both manufacturers provided employee-level data on age, sex, race, and an indicator of the prevalence of numerous conditions, identified as the highest cost conditions with at least ten percent prevalence among adults in the US, and conditions with the highest personal health spending in the US, for example, diabetes, ischemic heart disease, and low back and neck pain.[14,15] Company A provided us with prevalence data from 2014 to 2017, and Company B provided us with prevalence data from 2016 to 2018. The prevalence was determined through health care claims and identified by the companies' third party vendors. Companies A and B work with different third party vendors, each of which uses a unique proprietary approach to identify incidence of the conditions, so data are not comparable across companies.

Hourly workers employed by Company A, Plants 1 and 2, all work 12-hour shifts that rotate from days to nights. Many, but not all, hourly workers employed by Company B work 12-hour shifts.

Estimates of Excess of Chronic Illness

We used results from a previously published review of meta-analyses that identified the increased risks of the high cost and high prevalence conditions associated with shift work and long work hours.[16] The adjusted risk ratios (RRs) and odds ratios (ORs) for

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This study was supported by the Robert Wood Johnson Foundation (Grant Number 76100).

The authors report no conflicts of interest.

Clinical significance: Shift work and long work hours have negative health consequences. Information about excess cases of chronic conditions among employee populations and excess health care costs incurred by employers may motivate company leaders to invest in health and wellness benefits or refine shift work policies.

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DOI: 10.1097/JOM.0000000000001994

each condition are accessible in the supplemental materials. Using the available adjusted RRs or ORs, and data from the manufacturers, we were able to estimate the rate of each condition for the shift and 12-hour worker populations. The inverse of the risk ratio (or similar calculation for the odds ratio, was used to obtain the estimated rates of the non-shift or non-12-hour working populations. The estimated number of cases for each condition was then compared to the observed number of cases to calculate an excess incidence by condition observed per year, along with 95% confidence limits. Because less research has been conducted on long shifts, we were only able to calculate excess prevalence for a subset of conditions associated with long work hours.

In an effort to generate multiplier values that may be used by manufacturers with similar employee profiles, we performed two additional calculations. We developed standardized morbidity ratios for each condition, which represent the number of observed conditions to expected conditions across both companies. We also calculated excess conditions per 1000 workers, which is the average number of conditions observed minus the predicted number of conditions, divided by the total average number of workers multiplied by 1000.

Estimates of Excess Costs of Chronic Illness

We calculated the estimated annual health care costs associated with the increased prevalence of each condition using Medicare's Diagnostic Cost Groups Hierarchical Condition Categories (DCG-HCC) framework, since Medicare is a commonly used benchmark for health insurance claim payments.[17–19] The DCG-HCC is the ''gold standard'' for premium determination for Medicare Part C risk premiums and includes adaptable models by age, gender, and specific chronic condition which can be used to obtain expected 12-month cost estimates.[17,20,21] This study was determined to be exempt by Northwestern University's Institutional Review Board.

RESULTS

Employee Characteristics

Company A provided data on 2647 hourly workers at Plants 1 and 2, all of whom work 12-hour, rotating shifts (Table 1). Company B provided data on 1346 shift workers at Plants 3 and 4; all shift workers in Plant 3 work 12-hour shifts; 66.2% of workers in Plant 4 work 12-hour shifts. The workers were overwhelmingly male and had a relatively high average number of years of employment with their companies, consistent with national data on the manufacturing workforce.[22,23] Table 1 also shows the percent of hourly workers with the conditions of interest.

Excess Prevalence and Cost

Table 2 shows the excess number of the conditions associated with shift work and long work hours. For example, among Company A's workers, there was an estimated 77.8 additional cases of diabetes due to shift work, leading to an additional $224,919 in related health care claims. Among Company B's workers, there was an estimated 23.1 additional cases of diabetes related to shift work at a cost of $66,782. Estimated excess costs related to shift work across all conditions where data were available totaled $1,394,365 and $300,297 for Companies A and B, respectively. There were fewer estimates available for conditions related to long work hours due the absence of data on increased risk available (Appendix B). Estimated excess costs related to long work hours totaled $231,293 and $107,902, respectively.

Table 3 displays the standardized morbidity ratios and excess conditions per 1000 workers. The largest standardized ratio for shift

TABLE 1. Demographics of Workers and Prevalence of Health Conditions, by Manufacturing Plant

	Company A $N = 2647$		Company B $N = 1346$	
	Plant 1 ($N = 1631$)	**Plant 2 ($N = 1016$)**	**Plant 3 ($N = 360$)**	**Plant 4 ($N = 986$)**
Works 12 Hour Shifts (%)	100%	100%	100%	66.2%
Demographics				
Mean (SD) Age, yrs	39.4 (11.6)	42.8 (10.5)	38.6 (10.5)	43.4 (11.0)
N (%) Male	1381 (84.7%)	839 (82.6%)	335 (93.1%)	891 (90.4%)
White (Not Hispanic or Latino)	77.6%	73.7%	Not Available	Not Available
Black or African American	6.1%	24.7%		
Other	16.4%	1.6%		
Mean (SD) Years of Service	16.0 (12.3)	17.8 (12.2)	10.0 (9.9)	10.8 (9.6)
Prevalence of Health Conditions				
Breast Cancer (among female workers)	0.80%	2.80%	0%	0%
Cardiovascular Disease	6.70%	3.20%	18.60%	16.30%
Colon Cancer	0.10%	0%	0.30%	0.40%
Depression	18.50%	12.20%	10.60%	10.60%
Diabetes	11.20%	19.70%	7.80%	8.20%
Hypertension	43.70%	51.80%	24.70%	26.60%
Ischemic Heart Disease	4.80%	7.00%	3.10%	3.70%
Lung Cancer	0%	0.10%	0%	0.10%
Metabolic Syndrome	35.20%	45.00%	Not available	Not available
Miscarriage (among female workers)	0.80%	0.60%	Not available	Not available
Myocardial Infarction	1.50%	1.50%	Not Available	Not Available
Obesity	65.60%	68.90%	30.30%	31.50%
Occupational Injury	21.00%	8.80%	Not Available	Not Available
Preterm Birth (among female workers)	0.40%	0.60%	16%	0%
Prostate Cancer (among male workers)	0.80%	1.40%	0.60%	0.90%
Reproductive Cancers (among female workers)	0.80%	1.10%	12.00%	2.10%
Skin Cancer	3.40%	4.80%	3.90%	2.90%
Stroke	1.00%	1.10%	0%	0.40%

SD, Standard deviation.
Data are not comparable between across the companies because their third party vendors used different approaches for identifying workers with the conditions.

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TABLE 2. Excess Number of Conditions and Cost Due to Shift Work and Long Work Hours

	Excess Prevalence and Cost Due to Shift Work				Excess Prevalence and Cost Due to Long Work Hours			
	Company A		Company B		Company A		Company B	
CONDITIONS	Excess Number of Conditions (95% CI)	Excess Costs ($) (95% CI)	Excess Number of Conditions (95% CI)	Excess Costs ($) (95% CI)	Excess Number of Conditions (95% CI)	Excess Costs ($) (95% CI)	Excess Number of Conditions (95% CI)	Excess Costs ($) (95% CI)
Breast Cancer	0.1 (0–0.3)	736.9 (0–2210.7)	0 (0–0)	0 (0–0)				
Cardio Vascular Disease	5.8 (3.3–8)	21,889.2 (12,454.2–30,192)	14 (7.9–19.4)	52,836 (29,814.6–73,215.6)	10.6 (3.9–16.2)	40,004.4 ($14,718.6-$61,138.8)	17.9 (6.3–27.8)	67,554.6 ($23,776.2-$104,917.2)
Colon Cancer	0.1 (0–0.1)	736.9 (0–736.9)	0.3 (0–0.6)	2210.7 (0–4421.4)				
Diabetes	77.8 (41.4–108.3)	224,919.8 (119,687.4–313,095.3)	23.1 (12.3–32.1)	66,782.1 (35,559.3–92,801.1)	33.3 (–507–199.4)	96,270.3 (-146,573.7–576,465.4)	6.8 (–102–40.2)	19,658.8 (–29,488.2–116,218.2)
Depression	64.9 (–19–119.2)	131,811.9 (–38,589–242,095.2)	20.3 (–6.2–37.4)	41,229.3 (–12,592.2–75,959.4)	24.1 (5.7–39.6)	48947.1 (11576.7–80427.6)	5.7 (1.2–9.4)	11576.7 (2437.2–19091.4)
Hypertension	31.2 (–75.5–136.9)	52,572 (–127,217.5–230,676.5)	11.2 (–30.1–47.7)	18,872 (–50,718.5–80,374.5)				
Ischemic Heart Disease	18 (12.3–23.7)	67,932 (46,420.2–89,443.8)	5 (3.4–6.5)	18,870 (12,831.6–24,531)	9.7 (8.4–34.8)	36607.8 (31701.6–131335.2)	1.8 (1.5–6.2)	6793.2 (5661–23398.8)
Lung Cancer	0 (0–0.1)	0 (0–736.9)	0 (–0.1–0.1)	0 (-736.9–736.9)				
Myocardial Infarction	1.3 (0.8–1.8)	3420.3 (2104.8–4735.8)						
Metabolic Syndrome	173.5 0.8–283)	501,588.5 (2312.8–818,153)						
Miscarriage	0.1 (0–0.2)	308.4 (0–616.8)			0.2 (0.1–0.2)	616.8 (308.4–616.8)		
Obesity	97.3 (44.6–151.9)	281294.3 (128938.6–439142.9)	36.9 (17.8–54.8)	106,677.9 (51,459.8–158,426.8)				
Occupational Injuries	30 (–2.2–53.6)	125190 (–9180.6–223672.8)						
Preterm Birth	0.1 (0–0.2)	308.4 (0–616.8)	0.3 (0–0.6)	925.2 (0–1850.4)	0.1 (0.1–0.2)	308.4 (308.4–616.8)	0.5 (0.3–0.7)	1542 (925.2–2158.8)
Prostate Cancer	0.6 (0–1.2)	4421.4 (0–8842.8)	0.3 (0–0.6)	2210.7 (0–4421.4)				
Reproductive Cancers	0.1 (–0.3–0.4)	736.9 (–2210.7–2947.6)	0.1 (–0.3–0.4)	736.9 (–2210.7–2947.6)				
Small for Gestational Age	0 (0–0.2)	0 (0–282.8)						
Skin Cancer	–3.4 (–44.1–19.4)	–25054.6 (–324972.9–142958.6)	–1.5 (–18–7.6)	–11,053.5 (–132,642–56,004.4)				
Stroke	0.4 (0.1–0.7)	1552.4 (388.1–2716.7)	0 (0–0.1)	0 (0–388.1)	2.2 (0.9–3.4)	8538.2 (3492.9–13195.4)	0.2 (0.1–0.4)	776.2 (388.1–1552.4)
Total Cost		$1,394,365		$300,297				

CI, Confidence interval.

workers was for metabolic syndrome, suggesting that 59.3% more cases of metabolic syndrome may be found among manufacturing workers who are shift workers. Among manufacturing workers who work shifts, companies may expect an excess of 93.4 cases of metabolic syndrome per 1000 workers.

DISCUSSION

Numerous studies have reported on the deleterious effects of shift work and long work hours on the wellbeing of workers.[4,24,25] However, little is known about the related costs incurred by self-insured employers. Our goal was to estimate the excess health care costs incurred by two companies due to their shift work and 12-hour shift policies. We found that excess health care costs related to shift work was substantial, particularly for Company A, which provided data on a larger number of employees and across a larger number of conditions.

However, the excess health care costs identified in this analysis may not be substantial enough to compel companies to alter their shift work policies. For example, companies could accommodate daytime-only shifts by eliminating overnight production, but doing so would likely reduce revenues by half. For large manufacturing plants like those included in this study, revenues could drop by hundreds of millions of dollars per year. Also, companies could build another manufacturing plant to facilitate daytime only shifts; however the cost of building a large new plant can cost upwards of $100 million.[26] Nevertheless, our findings yield other important implications.

First, our results offer new information on the increased risk of shift work and long work hours for workers. While other studies have reported risk ratios associated with shift work and long work hours,[2–11] ours is the first to estimate and report on the number of additional employees who have selected health conditions associated with shift work and long work hours. Seeing these numbers may serve as a "wake up call" for both employers and shift workers, recognizing that many of the conditions included in the analysis lead to reductions in quality of life. Employers may reflect on the potential impact of having a greater number of workers with chronic health conditions. Workers may be less inclined to pursue a job that holds the potential to increase the chance of chronic illness.

Second, although the excess health care cost of shift work may not initially appear substantial enough to warrant a change in shift work policies, it should nevertheless motivate company leaders to make greater investments in prevention and disease management interventions. For example, a company could provide intensive behavioral counseling related to improved nutrition, healthy eating behaviors, and increased physical activity to reduce risk of cardiovascular disease.[27] Additionally, larger employers could incentivize local primary care providers to ensure that patients receive recommended screenings, for example, depression screening and diagnosis, coupled with effective treatment, and appropriate follow-up.[28] Our results also provide direction to employers in terms of which conditions are most costly and therefore good targets for intervention.

Third, costs related to long work hours were difficult to estimate due to the lack of epidemiological research currently available. The available evidence suggests that long work hours compromise worker health, but risk ratios are available for only a limited number of conditions. Our estimates represent an underestimate of the true costs of shift work and long work hours.

There are several limitations to this study. First, the third party vendors used different approaches to identify incidence of the health conditions among the employee populations, therefore the data are not entirely comparable across companies. Second, incidence of the conditions was derived from diagnosis codes in claims across multiple years so that we could accurately more identify all employees with the condition. Our results may overstate the number

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TABLE 3. Standardized Morbidity Ratios and Excess Number of Conditions per 1000 Workers

	Shift Work		Long Work Hours	
	Standardized Morbidity Ratio	Excess Number of Conditions per 1000 Workers	Standardized Morbidity Ratio	Excess Number of Conditions per 1000 Workers
Breast Cancer	1.05	0.3		
Cardio Vascular Disease	1.17	6.9	1.34	10.9
Colon Cancer	1.13	0.1		
Diabetes	1.40	35.0	1.14	15.3
Depression	1.42	29.6	1.12	11.3
Hypertension	1.04	14.7		
Ischemic Heart Disease	1.27	8.0	1.13	4.4
Lung Cancer	1.04	0.0		
Myocardial Infarction	1.13	0.7		
Metabolic Syndrome	1.59	93.4		
Miscarriage	1.10	0.2	1.35	0.7
Obesity	1.10	46.6		
Occupational Injuries	1.33	16.2		
Preterm Birth	1.21	1.1	1.34	1.8
Prostate Cancer	1.05	0.3		
Reproductive Cancers	1.05	0.4		
Small for Gestational Age	1.04	0.1		
Skin Cancer	0.93	−1.8		
Stroke	1.05	0.2	1.32	0.9

of workers with the condition in a given year. Still, these findings related to excess cost are likely underestimates because the third party vendors only supplied data for a limited number of conditions, and our literature review only produced risk ratios for a limited number of conditions,[16] particularly for long work hours. Third, we used Medicare prices for the cost estimates, which likely underestimate the actual costs incurred by companies for the conditions. Finally, cost estimates for occupational injuries and other conditions may not adequately capture the full cost as few workers are affected but large outlier costs may result.

In conclusion, we found that two large US manufacturing companies incurred substantial excess health care related costs due to their shift work and 12-hour shift policies across four plants. The costs are likely underestimates, given the limited data available, particularly regarding the health risk associated with long work hours. Nevertheless, excess health care costs associated with shift work and long work hours may not be substantial enough to warrant major changes in work schedules. However, they should influence employers to make additional investments in interventions to prevent and manage chronic health conditions.

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