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Relationship of Work Schedules to Gastrointestinal Diagnoses, Symptoms, and Medication Use in Auto Factory Workers

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Background *Gastrointestinal (GI) complaints are common in shift workers. This study examines the relationship between work schedules and GI symptoms, medications, and diagnoses.*

Methods *In a cross-sectional survey of 343 US auto factory workers, four work schedule variables were examined: assigned shift, number of hours worked, number of night hours, and schedule variability. Multiple regression tested the relationship between GI outcomes and work schedule variables while controlling for covariates.*

Results *The evening shift was associated with more GI symptoms and GI diagnoses. Unexpectedly, more consistent work times were associated with having a GI diagnosis. As schedule variability increased the probability of GI medication use increased in low noise exposure.*

Conclusion *Findings suggest that evening shift and widely varying work start and end times may increase risks for GI disturbances.* Am. J. Ind. Med. 46:586–598, 2004.
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KEY WORDS: shift work; overtime; work hours; work schedule; circadian rhythms; sleep; gastrointestinal diseases; digestive system diseases; work schedule tolerance; workload; occupational diseases; occupational exposure

INTRODUCTION

Shift work is common in industrialized societies. Almost 15% of all American workers work full time on evening, night, rotating, split, or employer-arranged irregular shifts [Bureau of Labor Statistics, 2002]. A negative outcome of these work schedules is the increased risk for health complaints and illnesses as well as accidents and errors. Researchers theorize that shift work disturbs sleep and circadian rhythms and also causes difficulties in arranging time to spend with family and friends [Barton et al., 1995]. These disturbances, in turn, may lead to increased stress and other health problems.

Gastrointestinal (GI) disturbances are one of the most common health complaints reported in shift workers. Vener et al. [1989] theorize that shift work disturbs the timing of GI motility, enzyme availability, and GI acid base balance. GI symptoms could occur theoretically through several mechanisms: imbalances in the aggressive and defensive factors connected with gastric function which weaken the gastric mucosa barrier [Moore et al., 1994]; imbalances in the inflammatory cells and anti-inflammatory cells in the intestine [MacDermott, 1996]; sleep disturbances lead to fatigue and

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activation of the stress response [Spiegel et al., 1999]; sleep disturbances which lead to immune depression allowing proliferation of organisms [Everson and Toth, 2000]. In summary, shift work may lead to GI disturbances through a disorganization of many biological rhythms that are normally ordered and synchronized by the circadian system to take in, digest, and absorb food.

Of nine previous studies that compared shift workers and day workers for GI symptoms, four studies reported more symptoms in shift workers, one study showed a trend for more symptoms, three studies reported mixed results, and one study reported fewer symptoms in shift workers [Thiis-Evensen, 1958; Mott et al., 1965; Koller et al., 1978; Angersbach et al., 1980; Smith et al., 1982; Ottmann et al., 1989; Poole et al., 1992; Jaffe et al., 1996; Zober et al., 1998]. Of eight studies that compared shift workers and day workers for gastric and duodenal ulcers, four studies reported more ulcers in shift workers, one study reported mixed results, and three studies reported no difference [Doll et al., 1951; Thiis-Evensen, 1958; Aanonsen, 1959; Mott et al., 1965; Costa et al., 1981; Segawa et al., 1987; Tuchsen et al., 1994; Zober et al., 1998]. All five studies that looked at other GI diagnoses or grouped all GI diagnoses together reported that the day workers had fewer GI diagnoses [Aanonsen, 1959; Angersbach et al., 1980; Costa et al., 1981, 1990; Koller, 1983]. Two studies that compared shift work groups for GI medication use report contradictory findings [Gordon et al., 1986; Costa et al., 1990]. The types of shift work examined in the majority of the studies were rotating shifts and night work. Two studies examined evening workers. In summary, the majority of the previous findings support an association between shift work and GI disturbances, but more study is needed to further clarify what factors may influence GI outcomes in shift workers.

The above studies did not examine the influence of overtime, which is another common feature of work schedules. Previous studies suggest that overtime is associated with some increased health and safety risks. A meta-analysis by Sparks et al. [1997] found that overtime was associated with a small but significant increase in adverse physical and psychological outcomes. A review by Spurgeon et al. [1997] concluded that the adverse overtime effects were associated with greater than 50 hr of work per week and that little data are available about schedules with less than 50 hr. In 16 of 22 more recently published studies, overtime was associated with poorer perceived general health, increased injury rates, more illnesses, or increased mortality [Bergqvist et al., 1995; Siu and Donald, 1995; Hayashi et al., 1996; Kirkcaldy et al., 1997; Iwasaki et al., 1998; Lowery et al., 1998; Sokejima and Kagamimori, 1998; Tuntiseranee et al., 1998; Fredriksson et al., 1999; Kawakami et al., 1999; Worrall and Cooper, 1999; Kirkcaldy et al., 2000; Simpson and Severson, 2000; Ettner and Grzywacz, 2001; Mizoue et al., 2001; Nylén et al., 2001; Park et al., 2001; Nakanishi et al., 2001a,b; Voss et al., 2001; Liu and Tanaka, 2002; Åkerstedt et al., 2002]. Little is known about the combined influence of overtime and shift work on GI outcomes.

Controlling for other risk factors has not been done consistently. Five of the above 17 studies that examined shift work and GI outcomes provided some controls either by the study design or by statistical analysis for risk factors such as age and gender. Noise exposure, which is common in factory work environments, was not controlled in any of these studies. It has been associated with increased GI medication use, more visits to health care providers for GI complaints, and increased risk for ulcers and GI symptoms [Knipschild, 1977; Knipschild and Oudshoorn, 1977; Messing and Reveret, 1983; Johanning, 1991; Babisch et al., 1994]. In summary, previous studies provide little data about the combined influence of shift work and overtime on GI outcomes while controlling for other risk factors. The purpose of this study was to examine the relationship between work schedules (shift work and overtime) and self-reported GI symptoms, GI medication use, and GI diagnoses while controlling statistically for demographic, lifestyle, stress, and noise related factors (see Fig. 1).

METHOD

Design

This study utilized data from a cross-sectional study by Lusk et al. [2002] that examined the relationship between noise exposure and cardiovascular and stress related diseases. Additional work time data were collected post hoc specifically for this study.

Sample

The original study used a convenience sample of 374 workers in one Midwestern United States auto factory that volunteered to participate. Procedures to protect human subjects were followed and all participants gave a written informed consent prior to their participation. Inclusion criteria included employment for 5 years or more at the plant and hourly worker in a skilled or unskilled job category.

The sample for this study consisted of 343 White and Black/African workers who were assigned either permanent day or permanent evening shifts. Work times for day shift were 6:00–14:30 and for evening shift were 14:30–23:00. This study excluded 20 participants because of problems with their work time data (changed work shift or missing time records) and 11 who worked permanent night shift (work times: 22:00–6:00) as the small number was not sufficient to examine this group separately. The night workers were not grouped with the evening workers since night and evening shifts may show different relationships to outcomes.

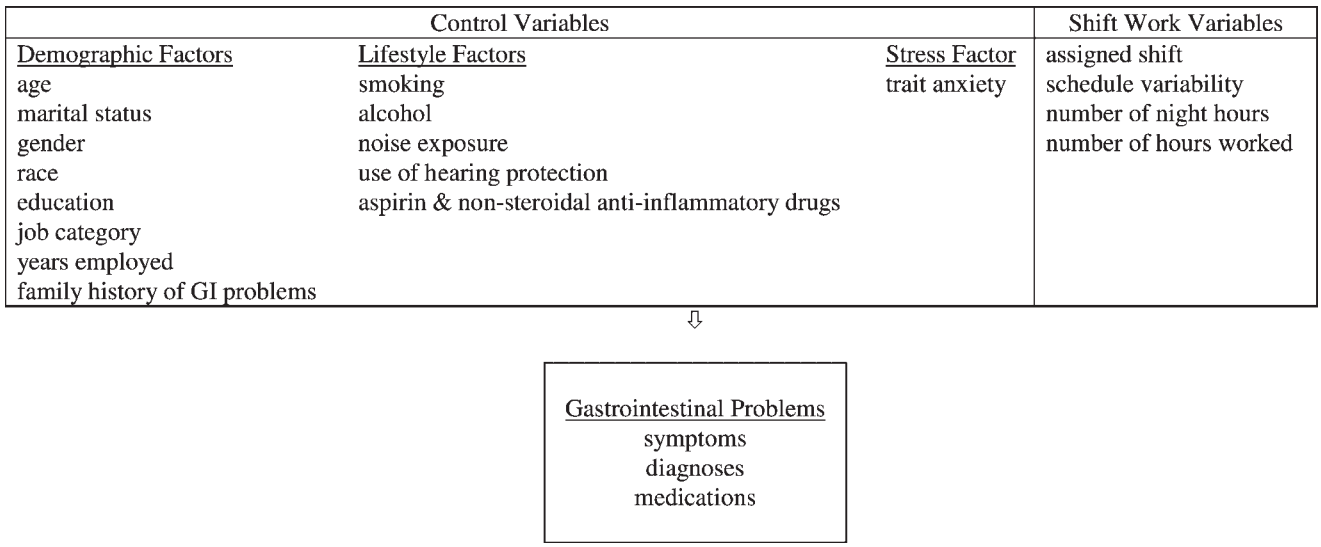

FIGURE 1. Variables in the study.

Measures

In the original study, participants completed a 20-page questionnaire that asked about demographic, lifestyle, and psychosocial factors, health complaints, disease diagnoses, and noise exposure during a scheduled appointment at the beginning of their work shift. Height, weight, and resting blood pressure and pulse measurements were taken. Noise exposure and hearing testing data were obtained from company records. This study used only data related to GI outcomes and risk factors for GI disturbances. The risk factors for GI disturbances, identified from the general GI research literature, included gender, race, smoking, noise exposure, aspirin and non-steroidal anti-inflammatory drug use, family history of GI diagnoses, lower socio-economic status, and stress.

GI outcomes

The dependent variables were self-reported GI symptoms, GI medication use, and GI diagnoses. The original study used questions from the University of Michigan Periodic Health Appraisal Unit Medical History form. Figure 2 lists the items used to assess GI outcomes in the survey.

A GI symptom scale was calculated by summing five items that asked the frequency of symptoms during the previous 6 months: nausea, heartburn or indigestion; abdominal pain; loss of appetite; and diarrhea or constipation. The items were rated on a 3-point scale from ''never'' to ''frequently.'' For this study, the five GI symptom items were viewed as measuring different GI symptoms, which may not necessarily reflect one phenomenon. A special test for reliability called the coefficient theta was calculated for this scale. The coefficient theta maximizes the Cronbach's alpha and is used for scales that are composed of items that do not measure one phenomenon [Carmines and Zeller, 1979]. Using the entire original sample, the coefficient theta for the subscale was 0.66. This was satisfactory since the GI symptom scale was viewed as a measure for the presence and magnitude of the five GI symptoms.

GI medication use was a dichotomous yes/no variable. Participants were assigned a ''yes'' if they listed current use of a prescription medication for a GI problem or checked an item for use of non-prescription medications for upset stomach, diarrhea, or constipation during the previous 6 months.

GI diagnosis was a yes/no variable. Participants indicated on a checklist if they currently had a stomach ulcer, ulcerative colitis, polyps in the colon, or listed another GI diagnosis in the space marked ''other.''

Control variables

Control variables included demographic, lifestyle, noise, and stress factors. Demographic variables were self-reported age, gender, race, marital status, education, job category, and number of years employed. No participant reported a family history of a GI diagnosis. Lifestyle variables were self-reported alcohol use, smoking, and use of aspirin or non-steroidal anti-inflammatory drugs. For alcohol use, one question asked how many servings of beer, wine, and mixed drinks or liquor were consumed per month. For smoking, three questions asked how many cigarettes, cigars, and pipes of tobacco were currently smoked per day. For aspirin or non-steroidal anti-inflammatory drug use, participants were assigned a ''yes'' if they listed a prescription medication that contained these drugs. The data did not include enough information to estimate non-prescription or over the counter use of these drugs.

GI Symptoms	Rate how often you have felt the following in the past 6 months: Never / Sometimes / Frequently Nauseated or sick to your stomach ☐ ☐ ☐ Heartburn or indigestion ☐ ☐ ☐ Abdominal pain ☐ ☐ ☐ Loss of appetite ☐ ☐ ☐ Diarrhea or constipation ☐ ☐ ☐
GI Diagnoses	Medical History Instrument Do you currently have any of the following conditions? ☐ Stomach ulcers ☐ Polyps in colon ☐ Ulcerative colitis ☐ Other
GI Medications	How frequently in the past 6 months have you taken non-prescription medications for the following complaints? Never / Sometimes / Frequently Upset stomach; diarrhea; constipation ☐ ☐ ☐ Please list any prescription medication you currently taking and their purpose: Medication / Purpose 1. _____ _____ 2. _____ _____ 3. _____ _____ 4. _____ _____ 5. _____ _____ 6. _____ _____ 7. _____ _____

FIGURE 2. Survey items to assess gastrointestinal (GI) outcomes.

Stress has been linked with GI problems for over a century, but a clear relationship has not been firmly established. For this study, stress was treated as an independent control variable. Spielberger's trait anxiety scale was used to measure self-reported stress [Spielberger and Krasner, 1988]. For this sample, Cronbach's alpha coefficient for the trait anxiety scale was 0.91.

Noise related data included use of hearing protection, noise exposure, and hearing loss. Three items measuring use of hearing protection asked participants what percentage of the time they estimated wearing hearing protection over the past week, month, and 3 months. Lusk et al. [1995] reported that the items showed acceptable convergent reliability when compared with observations and supervisor reports. Hearing loss data were obtained for each participant from the company's hearing testing records. Noise exposure data were obtained for each participant from the company's noise exposure survey data. A measure of noise exposure was calculated for each participant as a time-weighted average of periodic decibel noise exposure associated with each job category the participant held over the 5-year period prior to participation in the study.

Work schedules

The usual work times for day shift were 6:00–14:30 and for evening shift were 14:30–23:00. Workers usually worked Monday to Friday with every weekend off. Workers were paid time and half for more than 40 hr worked per week and double time for work on Sundays.

The study was conducted during a busy period at the plant when the workers were averaging 55 hr of work per week. As a result of overtime, work occurred on weekends and holidays, and work start and end times changed. Start

times for day shift ranged from 1:00 to 13:00 and end times ranged from 10:00 to 1:00 the next day. Start times for evening shift ranged from 5:00 to 22:00 and end times ranged from 14:00 to 6:00 the next day. The regularity of the work schedules also varied. For example, some day workers consistently clocked in at 1:00 and out at 16:00, whereas other workers showed highly irregular schedule patterns. Since the workers had variable work times as a result of overtime, this study examined actual work start and end time data as well as shift assignment to analyze the relationship between work schedules and the GI outcomes.

Clock-in and clock-out work times and assigned shift data were obtained from the company's payroll records for the 28-day period prior to participation in the study. This study focused on the following features of the work schedules: assigned shift (day or evening); number of night hours worked between midnight and 5:00 a.m.; total number of hours worked; and schedule variability. These shift work variables were assessed for the 7-day and the 28-day periods before participants answered the questionnaires. The clock-in and clock-out data were used to calculate the number of work hours, number of night hours, and schedule variability (see Table I). Schedule variability was calculated based on three approaches: the standard deviation (SD) of clock-in time or clock-out time; sum of difference (absolute value) in clock times between each adjacent pairs of work days (in the number of minutes minus 30 min for minor variation); and the SD of the number of hours worked per day. Based on the three approaches, 10 measures of schedule variability were tested. These measures of schedule variability were highly correlated, with Pearson correlation coefficients between 0.85 and 0.97. The measure of schedule variability, which showed the strongest relationship to the GI outcomes in the multiple regression models, was the sum of the differences in clock time between adjacent pairs of workdays and, therefore, the one used in the results reported here. The sum of differences in clock time included three measures: (1) sum of differences in clock-in time; (2) sum of differences in clock-out time; and (3) sum of differences in clock-in and clock-out times combined. Since the data were skewed to the right, the data were transformed as listed in Table I to normalize the distribution for the subsequent analysis.

Data Analysis

Data analysis included multiple regression (for GI symptoms) and logistic regression (for GI diagnosis and GI medication use) to test for a relationship with shift work variables while statistically controlling for demographic, lifestyle, noise, and anxiety variables. The modeling process initially explored the relationships between GI outcomes and the other risk factors listed in Figure 1. A base model was developed that included any significant control variables. The shift work variables were then added one by one to the base model to determine any significant relationships between shift work and the dependent variable while controlling statistically for the other risk factors.

Quadratic terms were used to test for significant curved relationships between continuous covariates and GI variables. Interaction terms tested whether any pairs of the independent variables showed a significant variation in the relationship of one variable with GI outcomes across levels of the other independent variable. The significance level was set at 0.05 for the main effects and at 0.01 for the interaction and quadratic terms to partially control for multiple inferences.

To identify outliers or influential cases for each regression model, the process described by Bollen and Jackman [1985] was used. No influential cases were identified for the results reported here.

RESULTS

Sample

The study included 343 participants. Tables II and III present the characteristics of the sample. The sample was

TABLE I. Calculations Used for the Shift Variables

Variable name	Calculation	Transformation	
		7-day period	28-day period
Number of work hours	$\sum_{i=1}^{n}$ (clock-out$_i$ − clock-in$_i$)	—	—
Number of night hours	$\sum_{i=1}^{n}$ (work-hours$_i$ 00:00 am to 5:00 am)	log	Square root
Sum clock-in variability (minutes)	$\sum_{i=1}^{n}$ for adjacent pairs of work days ((abs(clock-in$_i$ − clock-in$_j$)) − 30 min) where $< 0 = 0$	log	log
Sum clock-out variability (minutes)	$\sum_{i=1}^{n}$ for adjacent pairs of work days ((abs(clock-out$_i$ − clock-out$_j$)) − 30 min) where $< 0 = 0$	Square root	Square root
Sum clock-in + out variability (minutes)	$\sum_{i=1}^{n}$ (clock-in variability$_i$ + clock-out variability$_i$)	Square root	Square root

TABLE II. Univariate Statistics for Lifestyle, Trait Anxiety, and Work Schedule Variables: Workers From One US Auto Factory

	n	M	Standard deviation (SD)	Range
Number smoking products per day	343	7.9	13.9	0–60
Number alcohol drinks per month	322	12.8	24.9	0–212
Spielberger's trait anxiety scale	340	37.3	8.8	20–70
Time hearing protection used in required area (%)	226	47.9	45.0	0–100
Total hours worked 28-day period	343	220.9	47.2	95–341
Hours worked at night 28-day period	343	16	22.8	0–113.7
Clock-in variability 28-day period (minutes)	343	200	371.2	0–3,448
Clock-out variability 28-day period (minutes)	343	495	448.3	0–3,239
Clock-in and -out variability 28-day period (minutes)	343	695	694	0–6,687

predominately White men. Their ages ranged from 31 to 64 years old with a mean of 46 years (SD = 6.2). Approximately 70% were married and had one or more children. Slightly over half had more than a high school education, and 74% worked in an unskilled job category. The mean number of years employed was 23 years with only seven workers employed between 5 and 10 years.

Comparison of Day and Evening Shift Work Groups

The number of day shift participants was 225, and 118 were on permanent evenings. Table III displays the characteristics of these groups. The mean age of the day group was 47 years and the evening group was 45 years. The day group had a significantly smaller proportion of women, African/Americans, and single workers as compared with the evening group. The shift groups did not differ on Karasek's job content subscales [Karasek, 1985] for skill discretion, decision authority, or psychological workload. Day shift had a significantly higher mean number of years employed as compared with the evening group. Evening shift had slightly higher mean noise exposure as compared the day group. Over the 28-day period, the mean number of night hours for evening shift was twice that of the day shift. Evening shift also had a higher mean number of hours worked and 18% more variability in their clock-in and out times over the 28-day period as compared with the day shift. Examining bivariate relationships between work schedule variables and control variables, alcohol use and clock-in variability over

TABLE III. Characteristics by Shift Group (N = 343): Workers From One US Auto Factory

Characteristics	Day (n = 225)	Evening (n = 118)	Statistical results
Age (M, SD)	47.0 (5.7)	45.2 (7.0)	$t = 2.3$; df = 198; $P = 0.018$
Gender (n, %)			
Male	199 (88%)	93 (79%)	$\chi^2 = 5.67$, $P = 0.02$
Race (n, %)			
White	206 (92%)	80 (68%)	$\chi^2 = 31.53$, $P < 0.001$
Black/African	19 (8%)	38 (32%)	
Married—yes (n, %)	180 (80%)	71 (60%)	$\chi^2 = 15.51$, $P < 0.001$
Noise exposure at work 5-year period (M, SD)	85.3 (2.2)	85.7 (1.6)	$t = -1.9$; df = 298; $P = 0.06$
Years employed (M, SD)	24.7 (5.9)	20 (6.7)	$t = 6.2$; df = 212; $P < 0.001$
Number of hours worked 28-day period (M, SD)	217 (45.1)	229 (50.0)	$t = -2.4$; df = 341; $P = 0.02$
Number of night hours 28-day period (M, SD)	2.1 (1.6)	5.6 (2.4)	$t = -14.7$; df = 171.7; $P < 0.001$
Clock-in and -out variability 28-day period (M, SD)	21.9 (11.3)	26.7 (12.3)	$t = -3.6$; df 341; $P < 0.001$
Gastrointestinal (GI) symptom scale (M, SD)	2.01 (1.5)	2.52 (1.8)	$t = -2.65$; df 204.7; $P < 0.01$
GI diagnosis—yes (n, %)	10 (4.4%)	13 (11%)	$\chi^2 = 5.35$, $P = 0.02$
GI medication use—yes (n, %)	72 (32%)	47 (39.8%)	ns

Concerning *t*-test results when the Levine test of equality of variance between groups was significant, the *t*-statistic for "equal variance not assumed" was used. This test results in reduced degrees of freedom.

the 28-day period showed a small positive correlation ($r = 0.12$; $P = 0.032$; $n = 322$).

GI Symptom Scale

For this sample, the scores on the GI symptom scale ranged from 0 to 7 with a mean of 2.18 (SD = 1.61). The base multiple regression model for the GI symptom scale included significant control variables for age, gender, trait anxiety, and two interactions: (1) smoking and noise; and (2) age and noise. After controlling these, evening shift was associated with 0.41 more symptoms ($P = 0.02$). The addition of shift to the base model increased the explained variance by 1.1% to an adjusted R^2 of 15.7% (see Table IV). To examine trends in the participants without a diagnosis, the regression model was rerun excluding participants with a GI diagnosis. The unstandardized beta coefficient for shift was 0.28 and the *P*-value was 0.118 ($n = 311$).

The total number of hours worked, number of night hours worked, schedule variability, and an interaction of shift by work hours were not significant. A lowess line [Cleveland, 1979] fitted on a partial residual plot of night hours during the 28-day period showed a pattern of constant GI symptoms up to 30 hr, but increasing GI symptoms after 30 hr of night work. Several spline (+) functions [Smith, 1979] were tested, but none were significant.

GI Diagnosis

Twenty-three participants (6.7%) reported a GI diagnoses. Of the control variables in the bivariate analyzes, only trait anxiety showed a significant difference between those with and without a GI diagnosis; participants with a GI diagnosis had a higher mean trait anxiety score. For GI diagnosis, statistical modeling with logistic regression was limited to trait anxiety and shift work variables due to the small number of participants who reported a diagnosis. While controlling for trait anxiety, assigned shift and schedule variability were significant (see Table V). Evening shift was associated with a three-fold increase in the odds of a GI diagnosis. Clock-out variability and the combined clock-in and clock-out variability were significantly associated with a *decreased* odds for a GI diagnosis. For example, when the sum of clock-in and clock-out variability over the 28-day period totaled 20 hr (approximating the 80th percentile), the odds for a GI diagnosis decreased by 87%. The model max-rescaled R^2 was 13.7%. The other work schedule measures were not significant.

GI Medication Use

The number of participants who reported GI medication use was 119. The base logistic regression model for GI medication use included significant associations with trait anxiety and an interaction of hearing protection use and noise. The interaction indicated that with hearing protection use at 100%, as noise increased the probability of GI medication use increased. With no hearing protection use, as noise increased the probability of GI medication use decreased slightly. After controlling for these, an interaction of noise exposure and schedule variability was significant. Clock-out variability and combined clock-in and -out variability over the 7-day period were significant. The model parameters for clock-out variability are presented in Table VI. Assuming noise at 81 dBA, a 4-hr increase in clock-out variability over the 7-day period (or 15.5 units) increased the odds for GI

TABLE IV. Multiple Regression Model Predicting GI Symptom Scale (n = 334): Workers From One US Auto Factory

ANOVA	SS	df	MS	*F*	*P*
Regression	152.607	8	19.076	8.749	<0.001
Residual	708.615	325	2.180		
	β	SE β	*P*	95% CI for β	
Constant	−19.6209	10.752	0.069	−40.772	1.530
Age	0.0655	0.032	0.042	0.003	0.128
Gender	0.4702	0.230	0.042	0.018	0.923
Smoking	−0.4928	0.147	0.001	−0.781	−0.204
Noise exposure	0.2098	0.116	0.072	−0.019	0.439
Interaction: age by noise	0.0527	0.009	<0.001	−0.031	−0.004
Interaction: smoking by noise	−0.0176	0.007	0.010	0.021	0.140
Trait anxiety	0.0807	0.030	0.008	0.034	0.071
Shift	0.4064	0.175	0.021	0.062	0.750
R^2	0.177				
Adjusted R^2	0.157				

Interaction terms centered at age 31, noise exposure 81dBA, no smoking.

TABLE V. Logistic Regression Model Predicting GI Diagnosis (n = 340): Workers From One US Auto Factory

Max-rescaled R^2	Model R^2	−2 log L	df	*P*		
0.137	0.0534	18.659	3	<0.001		
Variable	Odds ratio	β	SE β	*P*	95% CI for odds ratio	
Constant		−4.0146	1.0976	<0.001		
Trait anxiety	1.055	0.0534	0.0241	0.027	1.0062	1.1058
Shift	3.296	1.1927	0.4568	0.009	1.3463	8.0677
Clock-in and -out variability 28-day period	0.943	−0.0585	0.0225	0.009	0.9025	0.9858

medication use by 30. The lowest probability of GI medication use was associated with no schedule variability, low noise and hearing protection use at 100%. At low noise as schedule variability increased, the probability of GI medication increased. In high noise, the opposite pattern occurred: as schedule variability increased, GI medication probability decreased. The addition of the interaction of clock-out time variability and noise increased the variance explained from the base model max-rescaled R^2 of 9.7 to 16.1%. When the model was rerun excluding participants with a GI diagnosis, the unstandardized beta coefficient for the interaction term was −0.0388 and the *P*-value was 0.005 (n = 205), which is similar to the model with the full sample.

After controlling for trait anxiety and an interaction of hearing protection use and noise, hours worked approached significance ($P = 0.09$). Over the 28-day period, 40 extra hours of work (or an additional 10 hr per week) increased the odds for GI medication use by 23%. The addition of hours worked to the base model increased the max-rescaled R^2 to 11.3% or by 1.6%. When the model was rerun excluding participants with a GI diagnosis, 40 extra hours of work over the 28-day period increased the odds for GI medication use by 18% (odds ratio 1.0042; $P = 0.18$; n = 205). The other work schedule measures were not significant.

DISCUSSION

This is one of the first studies to examine the way shift work and overtime combine to influence health outcomes. The study explored the influence of work schedules on GI outcomes in a sample of auto factory workers and statistically controlled for several demographic, lifestyle, noise, and stress-related factors that have been associated with increased the risk for GI disturbances. A new method using actual work start and end times enabled us to examined four features of the work schedules: assigned shift, day or evening; number of hours worked; number of night hours; and schedule variability. We found associations between these work schedule characteristics and GI outcomes and imply no causal direction since the study used a cross-sectional design.

Comparison Between Day and Evening Workers

Evening shift was associated with a slightly higher GI symptom scale score and a three-fold increase in the odds for a worker having a GI diagnosis. Medication use was not significantly different between shifts. Previous studies to specifically examine permanent evening shift workers were

TABLE VI. Logistic Regression Model Predicting GI Medication Use (n = 221): Workers From One US Auto Factory

Max-rescaled R^2	Model R^2	−2 log L	df	*P*		
0.1607	0.1183	27.823	6	<0.001		
Variable	Odds ratio	β	SE β	*P*	95% CI for odds ratio	
Hearing protection (HP) use	0.9753	−0.025	0.0105	0.017	0.9554	0.9956
Noise	2.2021	0.7894	0.197	<0.001	1.4968	3.2397
Trait anxiety	1.0448	0.0438	0.0172	0.01	1.0102	1.0806
Interaction: HP use by noise	1.0054	0.0054	0.002	0.007	1.0015	1.0093
Clock-out variability 7-day period	1.2473	0.221	0.0683	0.001	1.0910	1.4260
Interaction: clock-out variability by noise	0.9595	−0.0414	0.0131	0.002	0.9352	0.9844
Constant		−67.9158	16.4682	<0.001		

Noise centered at 81 dBA, hearing protection use at 100%, and clock-out variability at 1.

by Smith et al. [1982] and Mott et al. [1965]. Comparing their day and evening shift results, Smith reported that appetite was poorer for evening shift, but blood in the stool was higher in female day workers and there was no difference in constipation or gas pain in male workers or abdominal tightness in female workers. Mott reported more ulcers in evening workers as compared with day workers. In the current study, it is not certain that evening shift alone was the significant factor, since the evening workers also had more schedule variability and more night hours than day shift. Given that evening shift had more schedule variability and more night hours, these findings are in consistent with most previous studies that report more GI symptoms and GI diagnoses in workers on rotating shifts or night work.

The interaction of assigned shift and overtime were not significant in this study indicating that working long hours did not influence these GI outcomes differently for the workers on day as compared with evening shift. In contrast, a previous laboratory study by Rosa et al. [1998] reported that four 12-hr night shifts per week were associated with higher upper extremity muscle fatigue as compared to five 8-hr days and four 12-hr days. Also, Trinkoff and Storr [1998] reported that, as compared with day shift, nurses working extended night or extended rotating shifts were at increased risk for alcohol use and that extended night shifts increased the risk for smoking. These two studies compared day shift with night or rotating shifts whereas the current study examined evening shift. Evening, night, and rotating shifts may differ in the way they influence outcomes. The combined influence of long work hours and different types of shift work schedules on health outcomes is an area for further study.

Schedule Variability

The interaction of schedule variability by noise exposure in the medication use model indicates that after controlling for noise exposure, as schedule variability increased, the probability of medication use increased. For example, a 4-hr increase in clock-out variability over the previous week increased the odds for medication use by 30. In high noise exposure as schedule variability increased, the probability of medication use decreased. The effects associated with higher noise exposure may be due to the survivor effect and hearing loss. Two stressors, high noise exposure and schedule variability, may select out workers not able to tolerate the conditions so that the group remaining are the ''survivors.'' Hearing loss from exposure to high noise levels may also explain some of the effects associated with this interaction. Consistent with theories concerning effects of noise exposure and shift work, low noise exposure and low schedule variability were associated with low medication use.

The finding that the participants with a diagnosis had less schedule variability in this study was not expected. For example, 20 hr of schedule variability over the 4-week study period was associated in a 87% drop in the odds for a GI diagnosis. The majority of previous studies reported that the shift schedules with the most variability were associated with more GI diagnoses. Five of these studies reflect diagnoses that occurred in samples followed overtime using retrospective or longitudinal designs [Thiis-Evensen, 1958; Aanonsen, 1959; Angersbach et al., 1980; Costa et al., 1981; Tuchsen et al., 1994]. Cross-sectional designs, as used in the present study, are limited to diagnoses reported at one time point. Also, several of the previous studies used a combination of medical record data, interview, and questionnaire, which would increase the probability of detecting any diagnoses that occurred over time. In addition, the methods used to measure schedule variability between this study and other studies might have resulted in differing results. Thus, differences in study methods may account for the disagreement between the current study findings and most previous studies examining GI diagnoses.

Another explanation for the finding is that once a person is diagnosed with GI disorder and recognizes their compromised health state, they may change their lifestyle to reduce the symptoms. If increased schedule variability leads to more symptoms, one could expect workers with a diagnosis to manipulate their schedules to decrease the schedule variability to help reduce their symptoms. The actual ability of the workers in this sample to manipulate their schedules was not known. However, given that all but seven participants worked at the plant 10 years or more, manipulation of the work schedules or selection bias might have occurred.

Early Morning Start Times

Previous studies reported that early morning start times were associated with more problems with alertness, sleep, fatigue, accidents, and errors [Rosa et al., 1996; Kecklund et al., 1997]. The current study did not find a significant relationship between early morning start times in the day shift workers and GI symptoms, diagnosis, or medication use. One explanation is selection bias since all but seven participants were employed 10 years or more at the plant. The day shift group may consist of persons who were able to tolerate early morning start times and irregular work schedules. Persons who had problems might have left the work setting voluntarily or involuntarily, or may have remained on evening shift and not sought a transfer to day shift after accruing seniority.

Night Hours and Total Hours Worked

The number of night hours worked showed a trend toward increased GI symptoms as the number of night hours increased, but was not significant. This sample of workers might not have had a broad enough distribution of night hours to adequately test for this relationship since few workers had a substantial number of night hours. On the other hand, the

data for total number of hours worked showed an adequate distribution to test for a relationship: normal bell-shaped distribution with a range from 95 to 341 hr over the 28-day period. But total number of hours worked showed only a modest positive relationship with GI medication use, and no relationship with GI symptoms or diagnosis. The higher pay rates for more than 40 hr per week and work on Sundays may have represented a positive incentive and reduced the adverse effect of overtime on these GI outcomes.

Few studies have examined the way pay rates influence the relationship between overtime and health outcomes. Siu and Donald [1995] reported that men who received no payment for overtime reported more health complaints when compared with men who received payment. Van der Hulst and Geurts [2001] compared groups of Dutch postal workers based on whether they worked overtime or not and their level of rewards, low or high. Low rewards were associated with increased risks for adverse psychological health, but over time itself did not show an increased risk. Data were not available in this study to examine the influence of pay rates. The way pay rates influence the relationship between work schedules and health outcomes is an area for further study.

Findings from the current study suggest that time of work (day vs. evening) and the consistency of the schedule may have a greater influence on these GI outcomes than over time. Previous research and theory concerning gastric and intestinal circadian rhythms provide some support for this interpretation [Tarquini et al., 1986; Vener et al., 1989; Larsen et al., 1994; Moore et al., 1994]. Evening shift phase delays the timing of sleep (go to bed later and get up later), which can change the relationship between the external light/dark cycle cues and circadian system. These changes, in turn, could lead to dissociation or desynchronization of biological rhythms, which could lead to GI symptoms by disturbing biological rhythms that are normally ordered and synchronized to digest and absorb food. Evening shift also can isolate the workers from family and friends since the majority of population works or goes to school during the day and has evening hours for socializing. The disruption of social and family life can lead to stress and other adverse health outcomes. The way evening shift influences health outcomes is an area for further study.

Implications for Occupational Health Practice

The current study, as well as previous studies, suggests that noise, increased work schedule variability, and perhaps also evening shift may have adverse effects on GI function. The findings suggest implications for occupational health practice. Surveillance programs could be established to identify workers with problems early and provide counseling on measures to promote adjustment to shift work and use of hearing protection (HP) to protect against noise. Workers with family history of GI problems should be targeted for special counseling and follow-up since previous studies have shown some associated increased risk. Educational programs could be developed to inform workers what signs and symptoms might indicate health problems, and what measures they could take to reduce the health effects. When overtime work is needed, the previous work hours could be considered when planning the extended work hours.

Limitations

Selection bias was possible since all but seven participants worked at the plant for one decade or longer and, as a result, the sample could be a group of ''survivors.'' Data concerning any workers who might have dropped out of the work setting because of problems with the work schedules or other reasons were not available for the analysis, a common problem with cross-sectional study designs.

The data lacked adequate information about history of shift work in the day sample or history of night work, rotating shifts or a recent change from day shift in the evening sample. As a result, it was not possible to control for shift work history in the analysis. Previous studies have found some residual negative effect on GI outcomes even after workers move to day shift [Thiis-Evensen, 1958; Aanonsen, 1959; Koller et al., 1978; Angersbach et al., 1980]. If some participants in the day sample had a history of shift work and some residual adverse effect, the day shift might have shown more GI disturbances than a day group with no shift work history. This would have reduced the differences seen between day and evening shifts.

Another limitation was some time mismatch between study measures. Participants were asked to recall the frequency of GI symptoms and over the counter medications during the past 6 months. Diagnoses and prescription medications were assessed at the time they answered the questionnaire. Noise exposure was an average over 5 years because of the important accumulative effects that occur over time. The clock-in and -out work times were from the 28-day period before the participants answered the questionnaire. In the analysis, all measures were treated the same, for example, the relationship between the 28 days of work schedule data and GI symptoms across 6 months were tested. Recent GI symptoms probably would influence a participant's response on a questionnaire more strongly than symptoms that occurred 6 months before. However in future studies, it would be desirable that the time reference for GI symptoms, medication use, and diagnosis to more closely match the work schedule time period.

Summary

Shift work is associated with increased health and safety risks and affects a large proportion of the population, 15% of

all American workers. Overtime is also common in the United States and has itself been associated with increase increased health and safety risks. The way shift work and overtime interact and influence outcomes has rarely been examined in detail. Of the various types of shift work schedules, little data are available examining the way evening shift influences health outcomes. This study examined the relationships between GI outcomes and four characteristics of work schedules, evening versus day shifts, number of hours worked, number of night hours, and schedule variability. A new method tested the relationship of the four work schedule characteristics that was based on actual clock-in and clock-out times. This method is recommended for future studies. Work sites with work time data in electronic files would increase the feasibility of use. Future studies could consider extending the definition of night hours past 5:00 a.m. if workers continue working past that time (a rare event in this sample).

The strongest relationship with the GI outcomes was schedule variability and evening shifts. As the subjects worked at the one plant for many years and could be considered a group of ''survivors,'' any positive findings are particularly noteworthy. Whether evening shift alone had the adverse effect on GI symptoms is not clear since evening schedules also had more schedule variability, night hours, and slightly more total hours worked as compared with day shift. To date, very few studies have examined evening workers. The way evening shift influences GI and other health outcomes is an area for further study. It is also noteworthy that persons with a GI diagnosis had less schedule variability. This apparent contradictory finding might reflect lifestyle changes that workers make to adjust to a diagnosis and manage their symptoms. Less variable work times may help reduce GI symptoms. If future studies also support these findings, a practical recommendation would be to schedule overtime so that the work times are not highly variable.

Many research questions remain about the complex relationships between the timing of work, the length of work, and schedule variability, and the way these influence health and safety in various occupational settings. The large number of workers exposed to shift work and overtime will benefit from research findings that identify difficult scheduling patterns so that these can be modified or avoided.

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