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A Process Model of Shiftwork and Health

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ABSTRACT

The authors developed and tested a process model of adaptation to shiftwork, which hypothesizes that various individual and situational variables influence the development of sleep and social and domestic disturbances. Both types of disturbances trigger various types of coping behavior, leading to several proximal outcomes. The end result is the development of chronic health problems in the form of digestive and cardiovascular symptoms. The model was tested with survey data collected from 2 samples of nurses (*N* = 1,532) in the United Kingdom and was cross-validated against a 3rd sample of industrial workers (*N* = 370). Results indicate support for the model across the 3 samples, although some sample-specific and subgroup effects were found. Results have direct implications for the development of shiftwork theory and interventions.

Shiftwork is becoming increasingly prevalent in contemporary life, affecting 20% to 25% of the employees in manufacturing industries and a growing number in service industries. However, shiftwork, which requires alterations in sleeping and waking hours, is frequently perceived to be detrimental to the health and productivity of workers. This concern has reached societal proportions, as reflected in reports by the U.S. Congress, Office of Technology Assessment (1991) and the British Health and Safety Executive (Waterhouse, Folkard, & Minors, 1992). Such concern appears to be warranted. A substantial body of research exists on the problems individuals may experience from working shifts. These effects range from impairments in health (mental and physical) and sleep (quality and quantity) to disruptions in social and family life (U.S. Congress, Office, of, Technology, & Assessment, 1991 ; Waterhouse et al., 1992).

A major factor in the disruptive influence of shiftwork results from a mismatch between humans' internal biological clocks or circadian rhythms, which are programmed to make individuals diurnal or day active, and environmental time cues (e.g., hours of daylight and darkness). Consequently, shiftworkers are

required to be active when their body rhythms are preparing them for inactivity and sleep and to attempt sleep when their body rhythms are preparing them for activity and wakefulness. Shiftwork researchers generally agree that certain features of shift systems (e.g., fixed or rotating), individual characteristics of shiftworkers (e.g., age and personality type), and differences in jobs or tasks (e.g., workload) can potentially alleviate or exacerbate the disruptive effects of shifting waking and sleeping hours (Waterhouse et al., 1992).

Although the accumulated evidence to date strongly suggests a causal relationship between the experience of shiftwork and the occurrence of health problems, as well as the influence of certain mediating variables on this relationship, researchers have not agreed on the specific processes by which the shiftwork—illness relationship develops. This divergence of opinion has produced several conceptualizations or theoretical models of adaptation to shiftwork, ranging from fairly simple to complex (e.g., Monk, 1988 ; Olsson, Kandolin, & Kauppinen-Toropainen, 1990 ; Rutenfranz, Knauth, & Angersbach, 1981).

Models of Adaptation to Shiftwork

Rutenfranz et al. (1981) proposed one of the first models describing the relationship between shiftwork and health. In this model, stress resulting from the alterations of sleeping and waking hours required by shiftwork directly results in strain or the development of health problems. However, Rutenfranz et al.'s model also hypothesizes that the relationship between the stress of changing schedules and illness is mediated by several variables, such as family situation and personality. For example, a night worker who has an unsupportive spouse and who is also a "lark" (morning oriented) will probably not adjust well to night work; over time, this maladjustment may contribute to the development of health problems, such as sleep disorders and gastrointestinal complaints.

Monk (1988) offered a more complex model, which assumes that the ability to cope with shiftwork is determined by three interrelated domains: biological clock, sleep, and social/domestic. The alteration of sleeping and waking hours causes continual resetting of the body's biological or circadian clock, disruption of sleep, and interference with family and social obligations. However, these domains are also interdependent. For example, changing the hours of sleep (circadian disruption) and caring for a sick child (domestic obligations) can both interfere with the quality and quantity of sleep. Coping attempts simultaneously aimed at these three factors can alleviate adverse outcomes (e.g., illness). Indeed, Monk viewed coping with these three domains as key predictors of successful adaptation to shiftwork.

Finally, Olsson et al. (1990) presented a somewhat different approach by incorporating the concept of appraisal and coping within a general stressor—strain framework. This model extends Rutenfranz et al.'s (1981) stress—strain model by viewing shiftwork as only one of several job-related stressors hypothesized to influence health. Specifically, the Olsson et al. model assumes that occupational (e.g., shiftwork, time pressure) and nonoccupational (e.g., family disruptions) stressors and personal factors (e.g., age, lifestyle) influence the development of illness and that these relationships are also affected by appraisal and coping activities. Shiftworkers are presumed to assess (appraise) the threat (stress) in their environment and their ability to manage it. Coping attempts that are cognitive or passive (e.g., ignore the problem) and behavioral or active (e.g., transfer to the dayshift) are adopted in response to these appraisals; inappropriate responses can lead to strains in the form of mental and physical illness. In this model, perceptions are hypothesized to play a critical role in shiftworkers' adaptation.

Despite the relative abundance of theory specifying the processes hypothesized to affect adaptation to shiftwork, these models have largely served as heuristic frameworks: They were developed from beliefs of the shiftwork research community to guide and generate future research. To date, no direct, systematic empirical tests of these or other shiftwork models have been attempted (Taylor, Briner, & Folkard, 1997). A possible exception to this general statement is the path analysis of a shiftwork model proposed by Barton et al. (1995) . This model hypothesized the processes by which certain features of shift systems (e.g., rotating vs. fixed shifts) lead to disturbed biological rhythms, sleep, and family/social life. Disturbances in these three domains result in acute effects on mood and performance and, eventually, chronic effects on mental and physical health. Certain individual and situational differences and coping

strategies, however, may modify this process, potentially attentuating or aggravating the acute and chronic strains. Although Barton et al. (1995) tested their model using path analysis, they did not report overall model fit statistics or attempt to revise the model based on their initial results.

The Present Study

The goal of the present study was to empirically test a theoretical model of adaptation to shiftwork. Our model was adapted from the model proposed by Barton et al. (1995) and heeds the call by Taylor et al. (1997) to develop and test mid-range theories that are narrower and more specific in focus. A mid-range theory, for example, might deal only with a specific type of outcome (e.g., health) or a specific type of occupational group (e.g., nurses). Our (mid-range) model proposes that specific individual (personality and age) and situational (workload) variables negatively influence sleep and family and social life. Disturbed sleep and family and social life provoke coping efforts (approach, avoidance, or both) as the shiftworker attempts to manage or control these disruptions and the stress they produce. If successful, coping efforts may alleviate these problems and terminate the process. If coping is not successful, however, short-term effects (decreased emotional and physical well-being) may develop. If unabated, the short-term outcomes, in turn, may eventually result in certain types of chronic health problems.

Barton et al.'s (1995) model and, consequently, our model were built on the notion that features of the organization and person contribute to the development of disturbed sleep and family and social life, which can lead to both coping attempts and various outcomes. Our model, however, also bears theoretical similarity to Olsson et al.'s (1990) extended stressor—strain model in hypothesizing that both personal and occupational factors result in specific coping efforts. Coping, in turn, leads to several attitudinal and medical strains. However, the precipitating personal and occupational factors may also directly influence the development of strains.

We developed a series of specific hypotheses implied by the linkages in the model:

- *Hypothesis 1:* Older shiftworkers, who are more morning oriented, rigid in their sleeping habits, unable to overcome drowsiness, and report heavier workloads, experience greater sleep and family and social disturbances.

- *Hypothesis 2:* To manage these disturbances, shiftworkers attempt certain coping strategies. The use of engagement (approach or active) strategies aimed at changing the environment may partially reverse or terminate the process (i.e., reciprocal or reverse paths in the model), attenuating or alleviating the sleep and family and social disturbances.

- *Hypothesis 3:* If engagement coping is ineffective or if the shiftworker copes primarily by using disengagement (avoidance or passive) coping, the disturbances may lead to short-term outcomes, such as emotional problems, job dissatisfaction, fatigue, and anxiety (see also Spelten et al., 1993).

- *Hypothesis 4:* The short-term outcomes may eventually culminate in more serious, chronic health effects or strains. Although chronic health problems may take many forms, the most common, persistent health complaint of shiftworkers is digestive problems (Koller, 1983 ; Waterhouse et al., 1992). Research has also suggested a probable connection between shiftwork and cardiovascular disease (e.g., Koller, 1983 ; Knuttson, 1989). Therefore, both digestive and cardiovascular symptoms are hypothesized end-products of unsuccessful adaptation to shiftwork.

To determine its generalizability within and across occupational groups, we tested this model on two large samples of nurses and midwives in England and Wales, one on a permanent nightshift and the other on various types of rotating shifts, and we cross-validated the model against a sample of male industrial workers. The adequacy of the fit of the model and its components was assessed using structural equation modeling.

In summary, on the basis of prior theory and research, we developed a model of adaptation to shiftwork that uses an expanded stressor—strain framework. This model makes specific predictions about the

processes by which shiftwork culminates in acute and chronic strains. The adequacy of these predictions was tested across two samples of shiftworkers and was cross-validated across a third, very different type of sample using confirmatory techniques (structural equation modeling). As such, this study provides one of the strongest confirmatory tests to date of the processes underlying the relationship between adaptation to shiftwork and acute and chronic strains.

Method

Samples and Data Collection

Two independent samples were used to test the hypotheses. One sample consisted of nurses and midwives working in the larger general hospitals of England and Wales (hereinafter referred to as the *nursing sample*); and the other sample consisted of a British group of predominantly male, industrial and service workers from a range of occupations, including air traffic control, the chemical industry, the power industry, the steel industry, the glass industry, the police force, and the post office (hereinafter referred to as the *industrial sample*). Individuals were contacted through their nursing administration for the nursing sample or through their personnel officer for the industrial sample, and were asked to complete a copy of the survey (described below). Participation was entirely voluntary, and the surveys were returned directly by the respondents to the researchers using individual prepaid envelopes.

For the nursing sample, completed questionnaires were returned by 1,532 nurses and midwives out of a total of 4,000 distributed, for a response rate of 42%. The sample spanned 101 different general hospitals throughout the 14 health regions of England and throughout Wales, and therefore can be considered representative of nurses and midwives working in larger hospitals (i.e., greater than 400 beds) in England and Wales. For the industrial sample, 370 questionnaires were returned from a total of 11 different organizations. The number of questionnaires completed within each organization was largely dependent on the willingness of the personnel officer to distribute them and ranged from 9 to 56. It was, however, not possible to calculate the actual response rate because of the incomplete information given by the personnel officers as to the precise number of questionnaires distributed. More detail about the sampling and data collection procedures can be found in Barton et al. (1995) .

Within the nursing sample, 39% worked on permanent nightshift systems, whereas the remainder worked on systems of internal rotation (hereinafter referred to as the *rotating shift subsample*). Internal rotation essentially consisted of a series of morning and afternoon shifts, interspersed with a block of nightshifts either every 6—8 weeks or every few months. The distinguishing feature of these systems was perhaps their high degree of irregularity in shift rostering. In contrast, all of the industrial and service shift systems were regular in nature, rotating between morning, afternoon, and nightshifts on a frequent (2-2-3) basis, or sometimes in blocks of five shifts of the same type. There were no permanent night workers in the industrial sample.

The majority of the nurses were female for both the permanent nightshift subsample (94%) and the rotating shift subsample (91%), compared with only 10% of the industrial workers. The large majority of the industrial workers (79%) and permanent nightshift workers (80%) were either married or living with someone, compared with only 58% of the rotating shift nurses. On average, the industrial workers were substantially older than the rotating shift nurses, t (1195) = 21.49, $p < .001$, $\eta^2 = .28$, with a mean age of 40.5 years compared with 29.2 years, but were only slightly older than the permanent nightshift nurses, t (950) = 2.95, $p < .01$, $\eta^2 = .01$, with a mean age of 38.6 years in the permanent nightshift subsample. The difference in ages between rotating and permanent shift nurses was highly significant, t (1413) = 21.13, $p < .001$, $\eta^2 = .24$. Also, the industrial workers had spent substantially more years engaged in shiftwork than the rotating shift nurses, t (1197) = 11.59, $p < .001$, $\eta^2 = .10$, with a mean of 14.4 compared with 9.1 years, but had essentially the same number of years of shiftwork experience in comparison with permanent nightshift nurses, t (928) = 1.725, $p < .10$, $\eta^2 = .003$, with a mean number of years of shiftwork experience of 15.47 years in the permanent nightshift subsample. The difference in number of years of shiftwork experience between rotating and permanent nightshift nurses was also

highly significant, t (1393) = 17.40, $p < .001$, $\eta^2 = .18$.

Measures

The questionnaire used in this research, known as the Standard Shiftwork Index (SSI), consists of previously developed scales and new scales developed specifically for the study of shiftworking samples. The SSI is 24 pages long and takes 30—60 min to complete. Scale development information is provided in Barton et al. (1995) .

For all measures discussed below, the coefficient alphas are indicated separately for the two nursing subsamples and for the industrial sample: α_1 = permanent night nurses; α_2 = rotating nurses; α_3 = industrial sample.

Individual and situational variables.

The Composite Morningness Questionnaire, a 13-item self-report scale developed by Smith, Reilly, and Midkiff (1989) , measures morning or evening orientation (larks vs. owls; $\alpha_1 = .86$, $\alpha_2 = .86$, $\alpha_3 = .84$). The Circadian Type Inventory, developed by Folkard, Monk, and Lobban (1979) , measures two factors, flexibility of sleep habits or flexibility ($\alpha_1 = .74$, $\alpha_2 = .75$, $\alpha_3 = .77$) and the ability to overcome drowsiness or languidity ($\alpha_1 = .80$, $\alpha_2 = .77$, $\alpha_3 = .80$). In the permanent nightshift subsample, subjective workload was assessed with three items: ratings of mental workload, time pressures, and emotional stress ($\alpha_1 = .69$); for the rotating shift subsample and the industrial sample, these same ratings were made separately for the morning, afternoon, and nightshifts, resulting in nine items ($\alpha_2 = .87$, $\alpha_3 = .85$).

Mediator variables.

Overall sleep disturbances were measured with six items in the permanent nightshift subsample ($\alpha_1 = .80$), whereas for the rotating shift subsample and the industrial sample, these same ratings were made separately for the morning, afternoon, and nightshifts and days off, resulting in 24 items ($\alpha_2 = .85$, $\alpha_3 = .89$). Social and domestic disruption was assessed with three items, which asked how the current shift system interferes with leisure time, domestic, and nondomestic activities ($\alpha_1 = .77$, $\alpha_2 = .64$, $\alpha_3 = .65$).

The Coping Questionnaire was developed from the work of Tobin, Holroyd, Reynolds, and Wigal (1984) and measures two forms of coping, each with 16 items. In the industrial sample, a shortened version of this questionnaire was used, with each form of coping being measured by only four items. Engagement coping measures the extent to which a person uses approach or active strategies to cope with stressful events ($\alpha_1 = .65$, $\alpha_2 = .55$, $\alpha_3 = .65$). Disengagement coping measures the extent to which a person uses avoidant or passive strategies to cope with stressful events ($\alpha_1 = .88$, $\alpha_2 = .88$, $\alpha_3 = .78$).

Outcome variables.

Minor psychiatric disturbances (emotional problems) were measured with the General Health Questionnaire (Goldberg, 1972), a 12-item self-report scale ($\alpha_1 = .89$, $\alpha_2 = .87$, $\alpha_3 = .88$). General job satisfaction was measured with a single item taken from Hackman and Oldham's (1975) Job Diagnostic Survey ("Generally speaking, I am very satisfied with this job"). Although an internal consistency reliability estimate could not be obtained for this scale from the present data sets, research suggests that single-item overall job satisfaction items most likely have a reliability approximating .70 (Wanous, Reichers, & Hudy, 1997). Chronic fatigue, or a general tiredness and lack of energy regardless of personal

circumstances, which persists even on rest days and holidays, was measured with 10 items (α_1 = .92, α_2 = .92, α_3 = .91). Seven items from one of the facets of the Cognitive—Somatic Anxiety Questionnaire (Schwartz, Davidson, & Goleman, 1987) were used to measure somatic anxiety (α_1 = .71, α_2 = .71, α_3 = .73). Digestive symptoms were measured with 8 items developed specifically for the SSI (α_1 = .85, α_2 = .84, α_3 = .87). Cardiovascular symptoms were also measured with 8 items developed for the SSI (α_1 = .69, α_2 = .70, α_3 = .79).

Analyses

The model was initially developed and tested across the two samples of nurses. The adequacy of the resulting model was subsequently tested in the industrial sample. However, only the final analyses, which incorporate all three samples, are presented here.

Tests of the hypothesized model across the three samples (permanent nightshift nurses, rotating shift nurses, and industrial workers) were performed using LISREL VII (Jöreskog & Sörbom, 1989); maximum likelihood was the loss function used to produce estimates of the population parameters for the structural model. The item covariance matrix was used as input to preserve differences in sample variances. Because of the complexity of the proposed model, we elected to test a path model instead of a full structural model. Measurement error was assessed in the model, however, by setting error terms equal to $(1 - \alpha)\ \sigma\ \hat{}\ 2$ for each variable (Bollen, 1989 , p. 168).

The overall fit of the model to the data was determined by several fit indexes: the goodness-of-fit index (GFI; Tanaka & Huba, 1985), the chi-square goodness-of-fit test (Jöreskog, 1977), the χ^2 / *df* ratio (Jöreskog & Sörbom, 1989 , pp. 43—44), and the root mean square error of approximation (RMSEA; Browne & Cudeck, 1992). The GFI is used to determine the fit of the model for each sample, whereas the chi-square and RMSEA statistics are used to determine the fit of the model across all the samples. The GFI ranges from 0 to 1, with values closer to 1 demonstrating a better fit and values above .90 generally recognized as the minimal level at which one may infer a good model fit. Nonsignificant chi-square values usually indicate a good fit of the model to the data. However, because the chi-square test is sensitive to sample size, chi-square values must be assessed in relation to their degrees of freedom, with a χ^2 / *df* <= 3 generally recognized as indicating a good fit of the model to the data. The RMSEA index assumes an unacceptable fit at values close to .10, a reasonable fit at .06—.08, and a close fit at .05 and less (Browne & Cudeck, 1992).

We used a modified version of traditional path analysis called a *block recursive design.* In most path analyses, the causal relations assumed among dependent variables are completely specified. In our model, however, four groups of dependent variables have no paths specified within groups. In such a model, the error variances are allowed to covary for those variables within blocks (i.e., for those variables for which there are no hypothesized causal relations). The first block was created for sleep and social/domestic disturbances; the second block for engagement and disengagement coping; the third block for overall mental health, chronic fatigue, overall job satisfaction, and somatic anxiety; and the fourth block for digestive and cardiovascular symptoms.

The block recursive design has been thoroughly documented elsewhere (e.g., Blalock, 1985 ; Duncan & Featherman, 1973 ; Goldberger, 1973). This type of model is useful when it is desirable that part of the model remain unanalyzed causally, but some acknowledgment of relationships between the unanalyzed variables is indicated. More specifically, some of the endogenous variables (within blocks or groups) are allowed only to intercorrelate, and therefore no causal assumptions are made between these variables. Because our theoretical interest was focused primarily on the direct and indirect effects between these blocks or groups of variables, not on the relationships between, for example, sleep and social/domestic disturbances or chronic fatigue and overall job satisfaction, the block recursive design is tailored to our research goals.

Results

The proposed model provided a less than adequate fit of the model to the data covariances in the two samples of nurses. Therefore, through an iterative process, the nonrecursive (reciprocal) and a few recursive nonsignificant paths were omitted, and, based on modification indexes and theoretical considerations, a few new paths were added to the model. The resulting model was tested across the two samples of nurses and the industrial sample and was found to provide an acceptable fit to the data in the three samples, χ^2 (156) = 503.94, p <= .001; χ^2 / df = 3.23; RMSEA = .044.

An examination of significant paths within the model that are shared across the three samples yields some insight into the common processes involved in adaptation to shiftwork. Across all samples (see Figures 1 , 2 and 3), higher subjective workload and decreased flexibility of sleep habits were related to the development of sleep disturbances; social and domestic disturbances were influenced only by workload. Hypothesis 1 is only partially supported, however, because the other exogenous variables (age, morningness, and languidity) did not function as anticipated, possibly affected by their moderate intercorrelations. Greater sleep disturbances, in turn, were associated with increased disengagement coping. Because the predicted feedback loop between coping and sleep and nonwork disturbances was not indicated, Hypothesis 2 is only partially supported across the three samples. Disengagement coping was related to increased emotional health problems and fatigue, lending support to Hypothesis 3. Finally, in partial support of Hypothesis 4, increased fatigue and somatic anxiety were associated with the development of digestive and cardiovascular symptoms. A direct effect not specifically hypothesized in the original model also predictably surfaced across the three samples: Greater sleep disturbances were related to increased fatigue.

The individual model statistics are quite adequate for the three samples. The GFIs are .95, .96, and .93 for the permanent nightshift nurses, the rotating shift nurses, and the industrial workers samples, respectively. However, inspection of the path coefficients reveals some interesting differences across the samples.

The two nurses samples (see Figures 1 and 2) have both common and unique path coefficents. In both the permanent nightshift and rotating shift samples, increased languidity, or the inability to overcome drowsiness, was related to increased fatigue. This path, which was not originally predicted, is nonsignificant in the industrial sample. In the nurses samples, there are also rather large, indirect effects of workload on coping (disengagement) and of sleep disturbances on emotional problems, anxiety, and chronic strains (digestive and cardiovascular symptoms) through the mediating variables specified in the model. (These effects are not provided here but can be obtained from Carlla Smith.)

In the permanent nightshift sample (see Figure 1), sleep disturbances were associated with the use of engagement coping, which then was related to increased emotional problems and somatic anxiety. Increased languidity also was associated with the development of social and domestic disturbances. This path is nonsignificant in the rotating shift sample. Contrary to expectations, however, the path between engagement coping and emotional problems is positive in the permanent night nurses, suggesting that higher levels of engagement coping provoked increased emotional problems.

The rotating shift sample (see Figure 2) also has significant paths that are not shared with the permanent nightshift sample: Specifically, in the rotating sample, increased engagement coping and decreased disengagement coping were associated with increased job satisfaction. Comparatively speaking, engagement coping seemed to be a more important mediator variable in the nightshift sample than in the rotating shift sample, whereas job satisfaction played a greater role as a strain in the rotating shift sample than in the permanent nightshift sample.

In the sample of industrial workers (see Figure 3), some sample-specific effects were also found. Greater social and domestic disturbances were related only to increased fatigue, thus demonstrating a weaker mediating role than in the nurses samples. Finally, although the positive relationship between disengagement coping and emotional problems is the strongest in the nurses samples, the positive path

between somatic anxiety and cardiovascular symptoms is the strongest path in the industrial sample.

Because the chronic strains, digestive and cardiovascular symptoms, would be expected to increase with age and exposure to shiftwork, we examined the model fit for workers over 35 years of age in the three samples. The goodness-of-fit statistics and the path coefficents are very similar to those for the full samples. The two exceptions are the paths between somatic anxiety and digestive and cardiovascular symptoms in the industrial sample, which are above .50. (The individual model statistics and path coefficients are not presented here but can be obtained from Carlla Smith.) However, the across-sample statistics, χ^2 (156) = 298.01, p <= .001; χ^2 / df = 1.91; RMSEA = .043, indicate that the model provides an equal or superior fit to the data in the older shiftworkers.

Discussion

The purpose of the present study was to systematically and empirically test a model of adaptation to shiftwork drawn from mid-range theory. Our focus was on those factors in the environment and person that could lead to disturbances in sleeping and social and family life. Such disturbances should provoke the shiftworker to try certain coping strategies, both active and passive, to handle the situation and the stress it produces. If the coping is ineffective in ameliorating the problem, various short-term outcomes, such as emotional ill-health, fatigue, anxiety, and job dissatisfaction, may result. If the process continues over time, chronic health problems in the form of digestive and cardiovascular symptoms may also develop.

The overall model fit statistics suggest that the model provides an acceptable fit to the data in the three samples. Given the difficulty of fitting a complex process model such as this one across multiple data sets, these statistics are even more impressive and provide support for the generalizability of the model across organizations and occupational groups. Across all three samples, the progression of events leading to unsuccessful adaptation is clear. Regardless of type of shift schedule or job, shiftworkers with inflexible sleeping habits and who experienced greater workload incurred increased sleep disturbances. Such disturbances triggered increased use of disengagement (avoidant or passive) coping strategies, which were associated with undesirable short-term outcomes (increased emotional problems and fatigue). These proximal or short-term outcomes, in turn, were associated with the development of chronic strains in the form of digestive complaints and cardiovascular symptoms.

Some sample-specific effects are also interesting. In dealing with sleep and social/family disturbances, the permanent nightshift workers relied on both avoidant (passive) and approach (active) strategies. However, contrary to expectations, both types of coping strategies were related to short-term strains (e.g., increased emotional problems and somatic anxiety). This effect may simply reflect a generalized stress mobilization response in which shiftworkers hastily attempted all types of strategies to cope with their increasing stress. In the rotating shift sample, both types of coping were significant correlates of job satisfaction, such that increased levels of disengagement coping and decreased levels of engagement coping were associated with lower job satisfaction. This result illustrates that job satisfaction may be an important outcome variable in some samples and therefore is worthy of inclusion in future research on adaptation to shiftwork. Finally, in both samples of nurses, the large indirect effects of workload on coping and of sleep disturbances on the short term and chronic strains suggest that workload and sleep disturbances should be targeted for consideration in future shiftwork theory.

The results from both the industrial workers, who were mostly male, and the post hoc analyses of those respondents over age 35 in all three samples reveal the value of investigating demographic subgroups for health effects. Although the model fit the data reasonably well in the industrial sample, the diminished influence of social and domestic disturbances and the increased importance of the chronic strain, cardiovascular symptoms, in relation to the largely female samples of nurses are not surprising. The good fit of the model for shiftworkers over age 35 also underscores the potential cost that adaptation to shiftwork may exact over time (Haider, Kundi, & Koller, 1981).

There are several theoretical implications of this study. First, a relatively strong confirmatory approach

suggests that the strategies shiftworkers use to cope with sleep and nonwork disturbances are determinants of major health complaints. Second, although sleep disturbances have long been acknowledged as a health risk for shiftworkers, our research also emphasizes the central role of personal or nonwork factors in adaptation, at least for groups of (primarily) female shiftworkers. Future theory building (and related empirical studies) should consider both coping efforts and nonwork variables as potential determinants of adaptation to shiftwork. Finally, this study adds to the growing body of empirical research that strongly suggests a causal link between the experience of shiftwork and the development of serious health problems.

These results also have practical implications for intervening in the adaptation process. Our data clearly indicate that interventions for shiftworkers should focus on ameliorating sleep and nonwork disturbances and the ineffective coping efforts they trigger. One option is to provide guidance or counseling on sleep hygiene and general lifestyle management. The inappropriate application of avoidant coping by shiftworkers is also a particularly important area to target for individual or group counseling or therapy. High subjective workload, a variable that we specified to occur early in the causal chain, can be addressed by the organization through job or task redesign. Because we found some effects that seemed to be specific to certain types of workers or shift systems, any interventions should be selected only after considering the demographic composition and shift schedules of the shiftworkers in question. For example, the results for older (35+ years) workers suggest that they are potentially a high-risk group that may benefit from frequent health monitoring.

The most important limitation of this research is that we had access only to cross-sectional, self-report data. Although reliance on such data may have contributed to common method variance, prior research (Howard, 1994 ; Spector, 1987 , 1994) has suggested that method variance is not an invariant characteristic of self-report methods, particularly when complex effects are investigated. Harrington (1978) argued that workers' perceptions of their health status may be more important than "objective" health measures: Several studies have found relationships between short- and long-term adaptation to shiftwork and perceived well-being or emotional disorders (e.g., Bohle & Tilley, 1989 ; Costa, Apostoli, D'Andrea, & Gaffuri, 1981).

The constructs examined in our model obviously do not exist independently of other, potentially important constructs. If other constructs had been incorporated into the model, our conclusions may have changed significantly. For example, we did not examine the effects of various organizational factors, such as the location and type of hospital or industrial site, which varied widely across the three samples. Specifically, nurses employed in urban, specialty hospitals (e.g., children's hospitals) may view their jobs quite differently than nurses working in rural, general care hospitals. Likewise, shiftworkers in the air traffic control industry may respond very differently to their jobs than those in the steel industry. We could not examine unconfounded gender effects within the three samples because the nurses were overwhelmingly female and the industrial workers were almost totally male. We were also unable to measure the participants' preferences for shiftwork or their current shift. We assume, however, that "local" differences were minimized because of the size and heterogeneity of the samples.

Other limitations should be mentioned. First, the marginal reliability of some variables, such as social and domestic disturbances and the single-item satisfaction variable, may have limited our results. Also, we could have controlled measurement error more precisely by testing a full structural model instead of a path model. Second, although the statistical constraints on our model (i.e., the block recursive design) prevented us from investigating interactive effects, such effects are not only possible but probable. For example, the relationship between social and domestic disturbances and coping may be stronger for younger shiftworkers who are also experiencing a heavy workload (i.e., overtime). Third, because we inferred causality through statistical analyses and not repeated measurements, longitudinal research is needed to establish the causal relationships implied by our model. Finally, models other than the one tested in this study may provide equal or superior fit (MacCallum, Wegener, Vchino, & Fabrigan, 1993). We hasten to add, however, that the fit of our model to three different samples is quite acceptable, despite these several limitations.

In summary, we conducted a systematic, empirical examination of a model of the factors that affect

adaptation to shiftwork. As a confirmatory effort toward building a theoretical base for future shiftwork theory, research, and application, this study demonstrated the variety and complexity of the constructs and processes involved in such an adaptation.

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Figure 1. Path model of the effects of shiftwork on health for permanent nightshift nurses. Significant causal paths included ($p < .05$). AGE = age of respondent; MORN = morningness; SWL = subjective workload; FLEX = flexibility; LANG = languidity; SLEEP = sleep disturbances; SOC = social and domestic disturbances; ECOPE = engagement coping; DCOPE = disengagement coping; EMOT = emotional problems; FAT = chronic fatigue; SAT = overall job satisfaction; SANX = somatic anxiety; DIGEST = digestive symptoms; CARDIO = cardiovascular symptoms. The disturbances or error terms within blocks are omitted here because of space constraints but can be obtained from Carlla S. Smith.

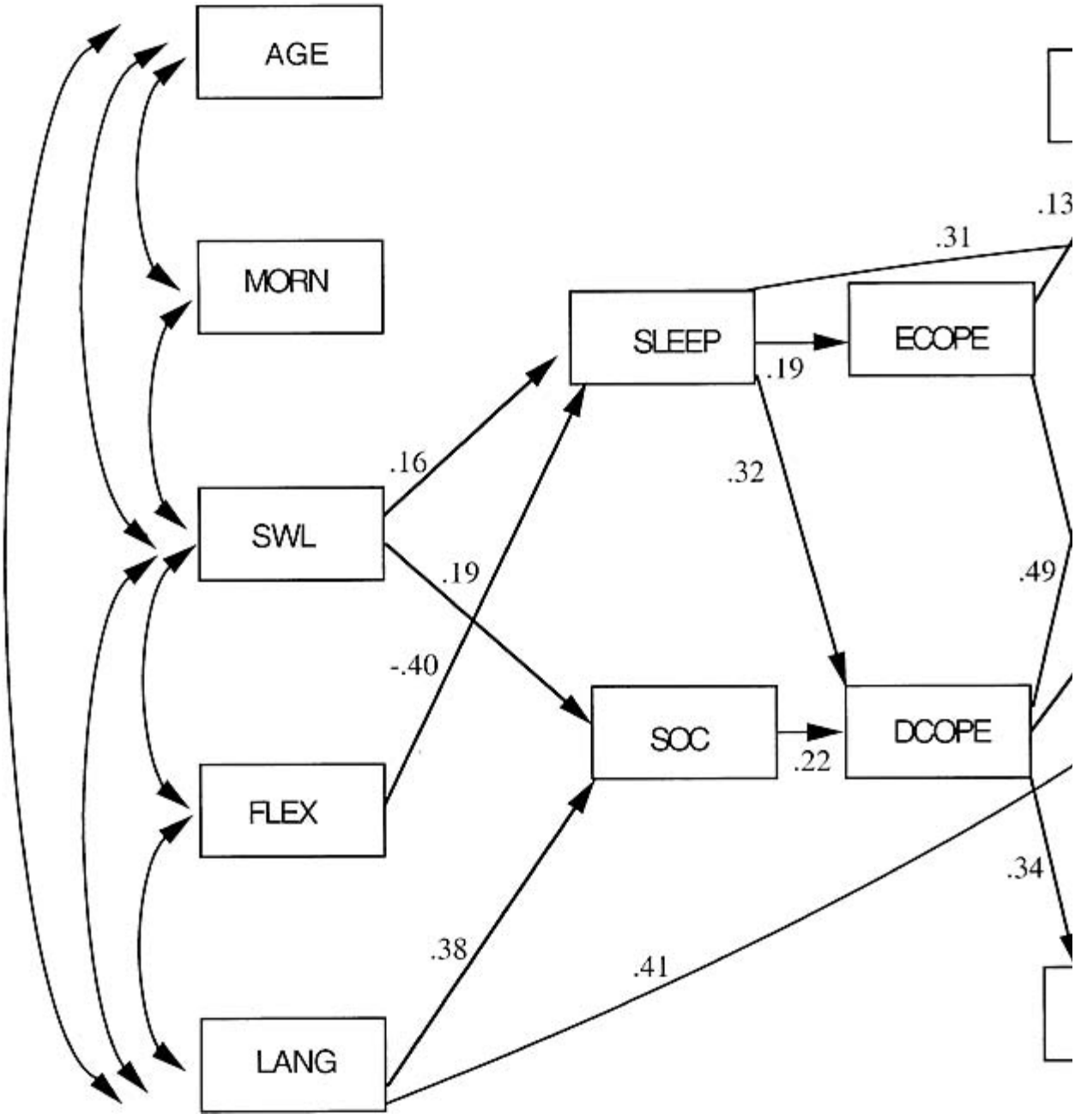


Figure 2. Path model of the effects of shiftwork on health for rotating shift nurses. Significant causal paths included ($p < .05$). AGE = age of respondent; MORN = morningness; SWL = subjective workload; FLEX = flexibility; LANG = languidity; SLEEP = sleep disturbances; SOC = social and domestic disturbances; ECOPE = engagement coping; DCOPE = disengagement coping; EMOT = emotional problems; FAT = chronic fatigue; SAT = overall job satisfaction; SANX = somatic anxiety; DIGEST = digestive symptoms; CARDIO = cardiovascular symptoms. The disturbances or error terms within blocks are omitted here because of space constraints but can be obtained from Carlla S. Smith.

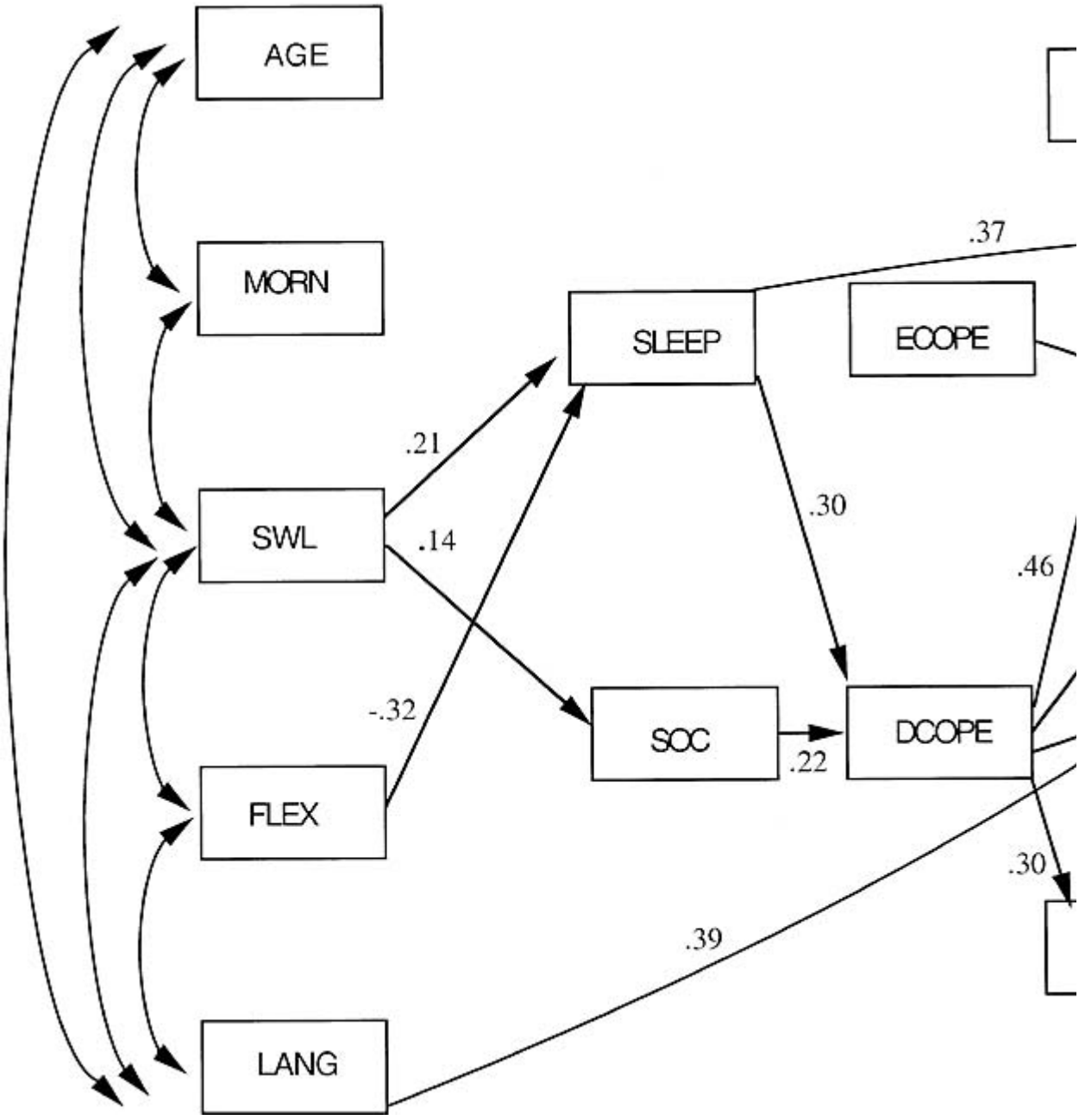
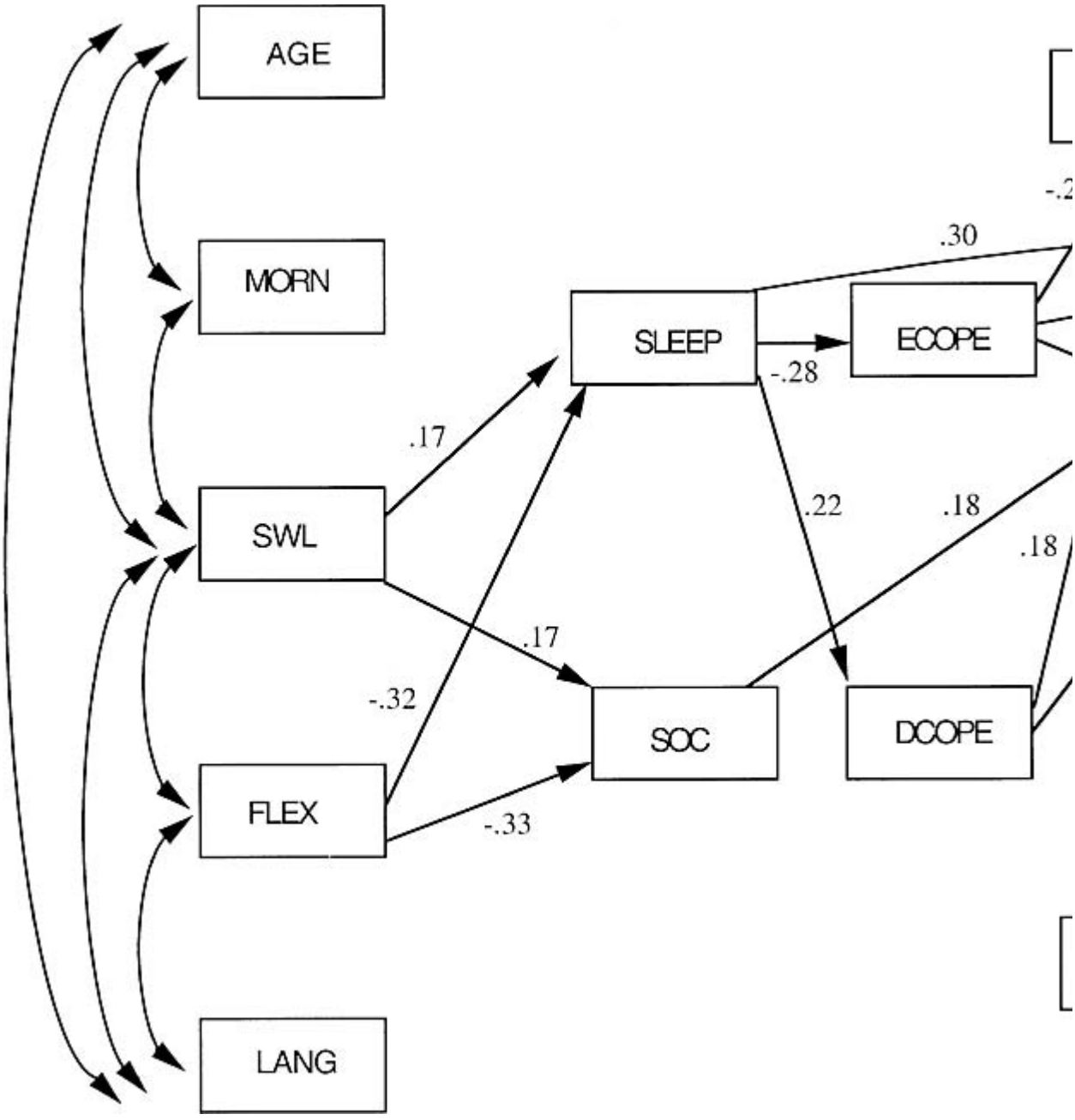


Figure 3. Path model of the effects of shiftwork on health for industrial workers. Significant causal paths included ($p < .05$). AGE = age of respondent; MORN = morningness; SWL = subjective workload; FLEX = flexibility; LANG = languidity; SLEEP = sleep disturbances; SOC = social and domestic disturbances; ECOPE = engagement coping; DCOPE = disengagement coping; EMOT = emotional problems; FAT = chronic fatigue; SAT = overall job satisfaction; SANX = somatic anxiety; DIGEST = digestive symptoms; CARDIO = cardiovascular symptoms. The disturbances or error terms within blocks are omitted here because of space constraints but can be obtained from Carlla S. Smith.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