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Using Bayesian networks to analyze occupational stress caused by work demands: Preventing stress through social support

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ABSTRACT

Occupational stress is a major health hazard and a serious challenge to the effective operation of any company and represents a major problem for both individuals and organizations. Previous researches have shown that high demands (e.g. workload, emotional) combined with low resources (e.g. support, control, rewards) are associated with adverse health (e.g. psychological, physical) and organizational impacts (e.g. reduced job satisfaction, sickness absence). The objective of the present work is to create a model to analyze how social support reduces the occupational stress caused by work demands.

This study used existing Spanish national data on working conditions collected by the Spanish Ministry of Labour and Immigration in 2007, where 11,054 workers were interviewed by questionnaire. A probabilistic model was built using Bayesian networks to explain the relationships between work demands and occupational stress. The model also explains how social support contributes positively to reducing stress levels. The variables studied were intellectually demanding work, overwork, workday, stress, and social support.

The results show the importance of social support and of receiving help from supervisors and co-workers in preventing occupational stress. The study provides a new methodology that explains and quantifies the effects of intellectually demanding work, overwork, and workday in occupational stress. Also, the study quantifies the importance of social support to reduce occupational stress.

1. Introduction

Occupational stress is a major health hazard and a serious challenge to the effective operation of any company and represents a major problem for both individuals and organizations (Noblet and LaMontagne, 2006). On an individual basis, higher levels of stress at work can have a direct impact on the immune system, exacerbating various medical conditions, including depression and anxiety, immune deficiency disorders, headaches, musculoskeletal pain, and cardiovascular disease (Blackmore et al., 2007; Kemeny, 2003; Michie and Williams, 2003; Niedhammer et al., 1998; Paterniti et al., 2002; Piko, 2002; Sapolsky, 2003; Tennant, 2001). On an organizational level, occupational stress affects performance, productivity, absenteeism, and job turn-over and causes lower levels of well-being (Briner and Reynolds, 1999; Michie and Williams, 2003; Vagg et al., 2002).

There are several definitions of stress in the literature. For example Selye (1978, p. 47) defined stress as: "the nonspecific response of the body to any demand, whether it is caused by, or results in, pleasant or unpleasant conditions." McGrath and Altman (1970) defined stress as a "substantial imbalance between demand and response capability, under conditions where failure to meet demand has important (perceived) consequences." Kasl (1978) indicated that stress is "a behavior appearing when environmental demands exceed the individual's capacity to handle them." Lazarus and Folkman (1984) defined stress as "a process of constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands or conflicts appraised as taxing or exceeding one's resources." Although there is no globally accepted definition of stress, there are several important points that characterize stress according to the above definitions, for example response of the body to stress, physical or environmental demands, internal or external demands, and individual capacity exceeded. For this study by integrating all these concepts, we assumed that stress was the response of the body to the demands that exceed the individual's capacity to handle them.

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Many studies have verified that job stressors can result from the job itself (e.g. heavy workloads, low input into decision-making) or from the social and organizational contexts in which the job is performed (e.g. poor social support, interpersonal conflict, poor communication) (Noblet and LaMontagne, 2006). Although stress prevention programs have traditionally focused on the health-related attitudes and actions of individual employees, addressing also the organizational origins of stress at work would most likely lead to more favorable long-term outcomes (Michie and Williams, 2003; Noblet and LaMontagne, 2006). To this aim, all the aforementioned factors should be jointly modeled and analyzed in order to determine their multivariate interactions with occupational stress. The objective of the present research was to perform such an analysis to see how social support reduces the effect that work demands inject on the occupational stress.

Over the past two decades, the conceptual model of job stress that has dominated the literature on occupational health is Karasek and Theorell's Demand-Control-Support model (DCS) (Karasek and Theorell, 1990). In the DCS model, high levels of job stress occurred when the demands of the job did not line up with adequate levels of decision-making authority and social support from supervisors and colleagues. The DCS model has been utilized on several occupational safety problems, such as predicting workplace experience (Snyder et al., 2008) or predicting safety performance (safety compliance and safety participation) (Turner et al., 2012).

In general, previous research has shown that high demands (e.g. workload, emotional) combined with low resources (e.g. social support, control, rewards) were associated with adverse health conditions (e.g. psychological, physical) and had organizational impacts (e.g. reduced job satisfaction, sickness absence) (Dollard et al., 2007).

Other well-known work stress theories, like the Job Demand-Resource (JD-R) model (Bakker and Demerouti, 2007), highlight the interaction between demands and resources; these theories establish the concept that job demands may not be so damaging if sufficient job resources are provided (De Jonge and Dormann, 2006). Recent investigations proposed that this interaction really depended on the organizational context and extended the Job Demands-Resources (JD-R) framework to include the model of Psychosocial Safety Climate (PSC), The PSC embodies four elements: Management commitment, management priority, organizational communication, and organizational participation (Dollard and Bakker, 2010; Idris et al., 2012). It has been shown that PSC is indirectly related to psychosocial hazard effects through its relationship with both job demands and job resources (Dollard and Bakker, 2010; Dollard et al., 2012; Idris et al., 2012; Law et al., 2011).

In the present work we focused upon the potential risk of high demands on occupational stress and the protective or moderator effect of social support to various factors. In the literature there are several studies that have widely demonstrated that social support ameliorates the impact of occupational stress; specifically, the relationship between stressors and strain is stronger for individuals with low levels of support (Beehr et al., 1990; Bromet et al., 1992; Frese, 1999; Johnson et al., 1989; LaRocco et al., 1980; Viswesvaran et al., 1999). For example, recent research by Dollard et al. (2012) proposed that the positive relationship between emotional job demands and distress were moderated by emotional job resources. An example of emotional job resources provided by Dollard et al. (2012) included that an employee should receive emotion support from colleagues and supervisors when needed.

The above research was based on traditional statistical analyses, such as regression models, analysis of variance (ANOVA), and hierarchical linear models. However, when all the variables considered in the study are categorical – as in the present study, based on survey data – modern data-mining techniques, such as Bayesian Networks (BNs), become more appropriate for some problems, since they allow to directly model the relationships among all the variables into a joint probabilistic model (see Castillo et al., 1997a for details). In particular, in the present study, BNs were applied to jointly model the inter-relationships among social support, job demands, and stress in order to determine how social support reduced the job stress caused by work demands. The model has been validated using the receiver-operating characteristic curve (Fawcett, 2006) and has been compared with standard logistic regression models.

BNs are increasingly popular data-mining techniques being used with categorical data (e.g. survey databases) (Martín et al., 2009), since they provide a visual appealing and statistically sound methodology to automatically build a joint probabilistic model for these problems which encodes all the relevant dependencies among the variables. Thus, BN models offer a sound data-driven reasoning technique, which allows estimating the value (probability) of any target variable given any set of conditioning variables. This is a clear advantage of BNs with respect to other standard alternatives (e.g. regression), which can fit a particular model for a given set of conditioning variables, considering some assumptions on the underlying distributions. Since BN models work directly with the joint distribution of the categorical variables, they do not need extra assumptions and, therefore, are more appropriate for this type of problem.

BNs have been used in several knowledge areas, such us medicine (Antal et al., 2004), ecology and natural resources management (Borsuk et al., 2004; Dlamini, 2010; McCann et al., 2006), geology (Rivas et al., 2007), life cycle engineering (Zhu and Deshmukh, 2003), software engineering (Fenton et al., 2007), and reliability (Langseth and Portinale, 2007).

Also, BNs are being applied in different research related to safety and health. For instance, Zhou et al. (2008) proposed a BN model to establish a probabilistic relational network looking at causal factors, including safety climate factors and personal experience factors, which exert influences on human safety behavior. In a primary study the authors found that safety behavior was more sensitive to safety climate factors including management commitments and workmate's influences and less sensitive to personal experience factors such as work experience and education experience. The study also indicated using a simple strategy did not result in the obtainment of a higher safety behavior goal. A joint strategy of simultaneously controlling multiple factors proved more effective. Further analysis indicated that the effectiveness of a joint strategy did not necessarily coincide with the combination of the most effective simple strategies. In this particular study the combination of safety climate factors (i.e. safety management systems and procedures, employee's involvement) and personal experience factors (i.e. work experience) achieved the higher results on safety behavior. Martín et al. (2009) used BNs to analyze self-reported workplace accidents caused by falls from a height. The BNs enabled the researchers to identify the circumstances that had the greatest bearing on workplace accidents, such as the adoption of incorrect work postures, the duration of tasks, and a worker's inadequate knowledge of safety regulations. For these authors, BNs represented a statistical tool of huge potential in investigating the causes of accidents in the workplace. BNs enabled the researchers to establish the dependency relationships between the different causes of accidents. The combined use of surveys and BNs enabled the authors to establish hypotheses more in keeping with reality compared to conventional techniques. The researchers found that categorical variables (i.e. worker inexperience, incorrect posture, risk perceived by the worker) were difficult to incorporate in conventional statistical techniques, but these variables can be easily analyzed using BNs. For example, Martín et al. (2009) found by comparing workers according to their experience that workers who had received specific training had a heightened perception of potential