Stress Detection Techniques in Different Work Domains

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Nurses represent a large portion of shift workers in United States. Nurses often work long hours, have high workload, and usually participate in multitasking, all of which may lead to high stress, turnover, and burnout. The turnover rate among nurses tends to be higher than other healthcare professions. Some studies have analyzed the nursing culture to determine the factors that lead to such high turnover and stress. However, most of the studies have relied on self-reported instruments. While objective metrics to assess stress using physiological measures exist, these methods are rarely used in healthcare. The current study documents the findings from a literature review of stress detection techniques in other work domains (e.g., aviation, transportation). Stress detection techniques are explained, along with potential applications to the healthcare sector.

INTRODUCTION

Mitigating medical errors have been the subject of a large body of work in healthcare human factors. In the United States, preventable medical errors are prevalent and according to one report constitute the third leading cause of death (250,000 deaths annually) (Makary & Daniel, 2016). Of the surgeons surveyed in Shanafelt et al. (2010), 8.9% believed that they had committed at least 1 medical error in the last three months. Out of these surgeons, 70% reported that the medical error was individual and not related to the system, with a further 0.9% reporting that they believed their error resulted in patient's death. The consequences of medical errors are many, including increased length of stay in the hospital, costs, and mortality rates (Cheragi, Manoocheri, Mohammadnejad, & Ehsani, 2013). Many of such errors have been attributed to limitations of attentional resources required in high-multitasking work domains. There is increasing amount of evidence suggesting that such resources may not be available due to a high-stress healthcare working environments. While it is impossible to completely eliminate human error from the workplace, it is possible to develop techniques to support the healthcare personnel by enabling them to manage their stress better or to detect and mitigate sources of stress.

While stress is widespread among variety of providers, nursing has been in the spotlight. Nurses not only work long shifts, they often experience high workload. In addition, studies of nursing culture imply that nurses perceive that asking for help or admitting that they are tired and need a break is a sign of weakness (Apker, 2005; Davidhizar & Shearer, 1999; Steege & Rainbow, 2017). Nurses are often at the sharp end of healthcare systems and are blamed for errors. A study that spanned 29 hospitals over the course of 3 years found that, when medical errors occurred, majority believed that those accidents were the sole responsibility of the nurses (Cook, Hoas, Guttmannova, & Joyner, 2004).

Nurses often feel pressure to accomplish more during their shifts, are faced with increased job complexity, and sometimes lack organizational resources all of which result in additional stress (Apker, 2005) which may lead to increased turnover and decreased job satisfaction (Steege & Rainbow, 2017). To improve working conditions for nurses, it is important to investigate sources of stress to support context-specific mitigation approaches.

Despite many available techniques to detect stress, in nursing, most methods use self-reported measures and are based on subjective accounts (for example the popular Nurse Stress Index (P. E. Harris, 1989)). Broadly stated, the operationalization of stress in healthcare has not been consistent across studies and often intertwined with related constructs of fatigue and burnout (see Table 1 for selected operationalizations of stress in previous research). While objective methods of stress detection and measurement such as physiological metrics have been used in other domains, such methods have not been popular in healthcare. This extended abstract documents the findings from a narrative review of literature on current stress detection techniques in non-healthcare work domains to evaluate their applicability to the nursing domain.

Table 1: Selected Operationalizations of Stress in Nursing

Author	Definition
Keane et al., 1985	Stress defined in terms of burnout- fatigue, frustration, anger, negative self-concepts, lack of enthusiasm, general feeling of hopelessness and entrapment
Foxall et al., 1990	Stress is defined as a nonspecific response of the body to any demand made on it.
Sawatzky, 1996	Stressors are defined as actual objective events or external stimuli that threaten physical or emotional homeostasis.
McCranie et al., 1987	Stress defined in terms of a psychological condition that opposes stress. Resilience- "It is a psychological characteristic that enables one to thrive after being exposed to a traumatic event."
McHugh et al., 2011	Stress defined in terms of burnout: "Burnout is the depletion of one's emotional and physical resources due to work stress." Measured on the nine-item emotional exhaustion subscale of the Maslach Burnout Inventory (27 or higher).
Erlen & Sereika, 1997	Stress occurs when nurses try to reconcile their ideals of patient care with the reality of nursing (Adopted from Jameton 1984).
Mallett, 1991	Burnout is the result of unrecognized and unresolved stress that affects dedicated, hard-working, highly motivated individuals.
R. B. Harris, 1989	Stress is a state that elicits a response and is not conceived as a response
Ganz, 2012	Stress is defined through the construct of Moral distress. Defined as the painful feelings and psychological disequilibrium experienced when a person knows the appropriate or right thing to do in a given

METHOD

A scoping literature review was performed to identify evidence supporting the efficacy of objective stress detection techniques and in particular physiological measures in other work domains. Several databases were searched, including Google Scholar, Scopus, and PubMed. Keywords used include 'Stress, 'Detection,' 'Techniques,' and 'Physiological Measures,' including a combination of these. Additionally, several keywords were used to help refine the search based on work domains.

RESULTS

Usually, studies that analyze stress tend to use a combination of subjective self-reported and physiological measures.

Objective Measures. The findings suggest that cortisol level and heart rate are the most common physiological factors to determine stress among workers. Workers' cortisol levels were measured in domains including military aviation, firefighting, law enforcement, and assembly lines (Meland et al., 2015; Wolkow, Aisbett, Ferguson, Reynolds, & Main, 2016; Strahler & Ziegert, 2015; Wagner, Sahar, Elbaum, Botzer, & Berliner, 2015).

The second most common method to measure stress in work domains is heart rate. Heart rate has been shown to be an indicator of emotional regulations, with higher emotional regulation in an individual pointing to higher heart rate (Appelhans & Luecken, 2006). Additionally, heart rate is modulated by the autonomic nervous system (ANS), which reflects changes in stress levels (Regula et al., 2014). Heart rate has been used to determine stress levels of workers in mining, brick laying, assembly line, deep-sea fishing, and general employment (Varga et al., 2016; Das, 2014; Høye et al., 2016). Another relevant stress detection measure is heart rate variability (HRV), which tends to decrease with increased stress (Myrtek, Weber, Brügner, & Müller, 1996). Heart rate variability has been measured using non-invasive equipment such as chest belts to analyze the ratio of low frequency (LF) to high frequency (HF) variability. Although fluctuations of LF/HF were considered an indicator of stress level, most results indicate that there is no significant relationship between stress level and LF/HF (Regula et al., 2014; Wahlström, Hagberg, Johnson, Svensson, & Rempel, 2002).

Skin conductance measures sweat gland activities, which can also be used to detect stress (Krantz, Glass, & Synder, 1974). Sweat gland activity is measured using electrodes, which correlate with stress levels (Lader, 1967). Skin conductance responses were measured in logarithm (base 10) in most of the studies (Krantz et al., 1974).

Another notable biometric for measuring worker stress is blood pressure. Physical activity can result in blood pressure fluctuation, but so can many other factors. This may be why blood pressure is used in conjunction with other measures for stress, instead of as the primary indicator. Other biometrics for stress include core temperature and skin temperature (Melin et al., 1999).

Subjective Measures. Subjective responses such as perceived stress by the participants, mood, alertness, comfort, and tiredness can be used to determine stress levels (Näswall, Lindfors, & Sverke, 2011). Other techniques used include questionnaires to gauge stress, but the questions can vary from study to study. An example is the Stress Scale used to measure stressful stimuli (Gray-Toft & Anderson, 1981). Stimuli in the work space were found according to the responses given in this questionnaire. This stress scale was the starting scale for other studies, which incorporated certain questions, including 74 items for nurses (Benoliel, McCorkle, Georgiadou, Denton, & Spitzer, 1990) and 32 for aviation (Ahmadi & Alireza, 2007). Similarly, intellectual reactions to stressful environments can be identified through responses provided to questionnaires (Folkman, Lazarous, Moore, & Stambrook, 1988). The Short Form-36 healthy survey Version 2 is an example of the last questionnaire, which measures health status based on factors such as physical and social activities (Esther et al., 2007).

Combination of subjective and objective methods to measure stress is also popular. In the study of Hall et al. (2004) and of Schubert et al. (2009), HRV was calculated in addition to giving questionnaire to participants. Measuring HRV along with the blood pressure is also a reliable tool to determine stress level (Hjortskov et al., 2004).

In conclusion, while physiological metrics have been operationalized for stress detection and measurement in domains such as aviation, military, and transportation, the application of such methods in nursing has been limited and is warranted.

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