Strategy Design to Improve Safety on Electronic Manufacturing

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Abstract

Occupational health and safety are a major problem in manufacturing. From 2019 to 2021, there are still accident cases where there is an increase in the incidence of work accidents from 2019 until now, making it necessary to investigate factors that influence accidents to be able to protect workers. This research aims to investigate the many stressors affecting two forms of stress experienced by workers, physical stress and psychological stress, in order to enhance their performance in terms of safety in a hazardous working environment. Using a structural equipment model, this study identified job demand, organizational stress, environmental stress, safety behavior, physical stress, psychological stress, and safety outcome. The study sample of 153 workers who completed questionnaires was developed according to the stressor relationship. Based on the result, recommendations are made to workers on how to reduce the risk of injury or accident.

Keywords
Physical stress, Psychological stress, Safety, Structural equipment model

1. Introduction
Occupational health and safety remain a significant issue for national economies, employers, employees, and society in general. Industrial sectors recording higher than average incidence rates included manufacture, transportation, and construction. The cost of workplace injuries is not only a human one; it also has serious economic implications for employers in uncertain times. The Employment Social Security Administration Agency (BPJS) noted that the number of work accidents in Indonesia was 234,270 in 2021. The number increased by 5.65% from the previous year, which amounted to 221,740. From 2019 to 2021, there are still accident cases where there is an increase in the incidence of work accidents from 2019 until now. One of the losses incurred was that there were 64 pieces of product that fell due to work accidents that occurred and an estimated loss of up to $22,000, as well as medical and recovery costs for work accident victims in one case.

The purpose of this study was to examine the level of significance of the relationship between occupational stressors and injury outcomes, psychological and physical symptoms, and safety behaviors as experienced by manual laborers in the electronic industry who work in a production department. Workers' responses to a questionnaire used in earlier research about reported levels of workplace physical and psychological stressors and physical and psychological symptoms were gathered (Goldenhar et al., 2003).

2. Literature Review

The theoretical model used to guide this research is illustrated in Figure 1. It is a partially mediated model in that it allows for the exogenous stressor and control variables (job demands, organizational factors, environment, and safety behavior) to both directly and indirectly (through physical stress and psychological stress) influence the safety outcomes. The partially-mediated specification was chosen to allow for the possibility that relationships between the exogenous variables and the two outcome variables would exist beyond those accounted for by the physical/psychological stress mediating variables. These relationships would justify and provide support for the inclusion of the paths associated with the direct effects in the partially mediated model.

The first category of external variables is Job-Task Demands. It contains the "traditional" measures of job stress, including job control (one's view of how much discretion they have) and job demands (one's impression of how challenging the job is). Overcompensation, which has been identified as an important concern for women working in non-traditional occupations (Johnson, 1991), is a third indicator in this category. It refers to the perception of having to work at least twice as hard as others (for example, men doing the same job) just to gain respect from coworkers. Finally, this first category also includes using skills and being accountable for other people's safety.

Organizational stressors fall under the second group, which also includes indicators of the workplace's safety climate, accessibility to skills and safety training, job security, and support from coworkers and managers. Recent theoretical and empirical investigations show that the concept of "safety climate," which is sometimes used interchangeably with the word "safety culture," is a multifaceted phenomenon (Clarke, 2000; Guldenmund, 2000).

3. Research Methodology

The model conceptual and research questionnaire was prepared based on the conceptual model that had been carried out in previous studies, namely Goldenhar (2003) and Leung (2012). Where from the conceptual model, the manifest indicators of the six construct variables are described (Figure 1).

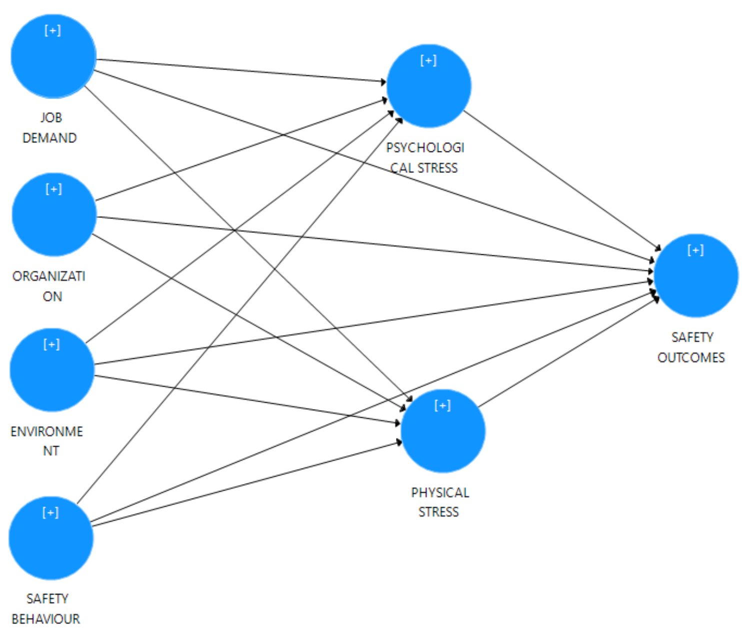

Figure 1 Model Concept

The study sample of 153 workers who completed questionnaires was developed according to the stressor relationship. Participants are production department who work at least 6 months in electronic manufacture prior to administering the questionnaire. The total number of participants are 153 workers. The following is the demographic break down of the participants whose responses were used: 58% females, 42% males. The oldest participant was 25 while the youngest was 19 (Figure 2).

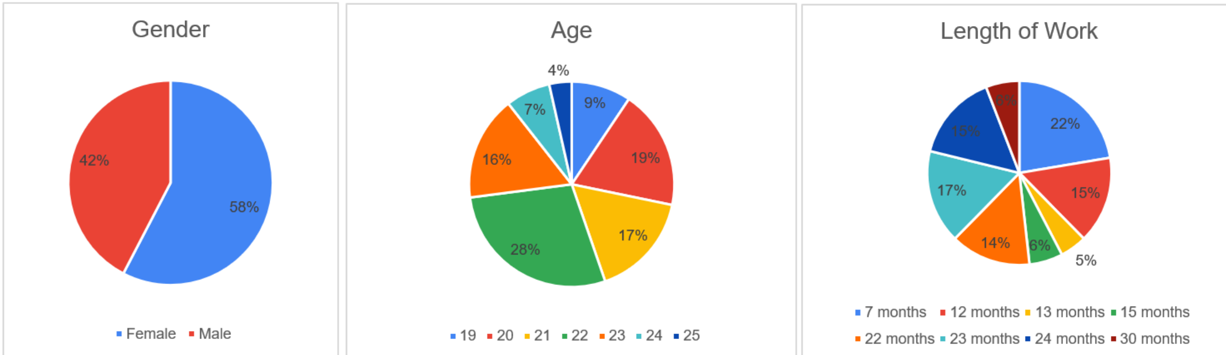

Figure 2. Demography of Respondents

The questionnaires were developed according to the stress-stressor relationship and the scales mentioned earlier. The respondents of this questionnaire were only production department workers and are able to be involved in manufacture accidents. The five points Likert scale were used as a scale agreement which ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaires were given to operator production areas.

4. Results and Discussion

In the composite reliability test, the value for each construct was above the value of 0.7. It can be concluded that each construct is considered reliable for the research measuring instrument. According to Cronbach's alpha reliability test, the overall value for each construct is above 0.7 and is considered reliable. From the whole test, both the validity test and the reliability test, it can be concluded that the conceptual models built are considered valid and reliable as measuring instruments in research. In the AVE calculation for each construct, a value above 0.5 is obtained. so that the construct used as a measuring tool is considered valid in the model's conceptual development (Table 1).

Table 1. Validation Result

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
ENVIRONMENT	0.718	0.862	0.759
JOB DEMAND	0.769	0.864	0.679
ORGANIZATION	0.886	0.909	0.590
SAFETY BEHAVIOR	0.790	0.877	0.703
PHYSICAL STRESS	0.835	0.890	0.669
PSYCHOLOGICAL STRESS	0.904	0.928	0.722
SAFETY OUTCOMES	0.911	0.937	0.790

In the Fornell-Lacker criterion test, it is shown that each of the same construct values has a greater value when compared to other construct values. So at this stage, it is concluded that the results of the Fornell-Lacker criterion test for each endogenous and exogenous variable are considered eligible. According to the analysis results in measuring the inner model (structural model), all construct variables are low to moderate. This shows that these variables have a significant impact on safety (Table 2).

Table 2 Fornell-Lacker criterion

	ENVIRONMENT	JOB DEMAND	ORGANIZATION	PHYSICAL STRESS	PSYCHOLOGICAL STRESS	SAFETY BEHAVIOUR	SAFETY OUTCOMES
ENVIRONMENT	0.871						
JOB DEMAND	0.367	0.824					
ORGANIZATION	0.314	0.530	0.768				
PHYSICAL STRESS	-0.380	-0.331	-0.363	0.818			
PSYCHOLOGICAL STRES	-0.302	-0.183	-0.322	0.713	0.849		
SAFETY BEHAVIOUR	-0.443	-0.597	-0.463	0.420	0.410	0.839	
SAFETY OUTCOMES	-0.150	-0.349	-0.321	0.554	0.426	0.392	0.889

The coefficient of determination (R-Square) analysis is an approach to seeing the proportion of variance in endogenous variables that can be predicted from exogenous variables (Ghozali, 2009). Statistically, the value of the coefficient of determination of endogenous variables can be divided into three categories. The first category is the low coefficient of determination with a value of less than 0.25, the moderate coefficient of determination with a value between 0.33 and 0.75, and the high coefficient of determination with a value of more than 0.75 (J. F. Hair et al., 2011). In detail, the analysis of the coefficient of determination for intermediate variables and endogenous variables in the model is shown in the following Table 3.

Table 3. R-square Analysis

	R Square	**R Square Adjusted**	**Remark**
PHYSICAL STRESS	0.250	0.230	Low
PSYCHOLOGICAL STRESS	0.227	0.206	Low
SAFETY OUTCOMES	0.371	0.346	Moderate

According to the analysis results, two construct variables appear to be low. This indicates that the intermediate variables and endogenous variables have a low impact on the calculation results based on the perceptions of operators in the production department.

Bootstrapping test requirements are essential in hypothesis testing performed with Smart PLS software.where the approach is carried out with the Monte Carlo method to produce optimal values. In this process, resampling is carried out to ensure more accurate results. The number of resampling processes used in this stage is 10,000. According to Hair et al. (2011), the amount of T-statistic value that can be accepted in the bootstrapping test must be greater than 1.96, or the amount of P-values cannot be greater than the amount of significance level used. In detail, the results of hypothesis testing are shown in the following Table 4.

Table 4. Path Analysis

	T Statistics	**P Values**	**Remark**
ENVIRONMENT -> PHYSICAL STRESS	**2.788**	**0.006**	**Accepted**
ENVIRONMENT -> PSYCHOLOGICAL STRESS	**2.669**	**0.008**	**Accepted**
ENVIRONMENT -> SAFETY OUTCOMES	1.442	0.151	Rejected
JOB DEMAND -> PHYSICAL STRESS	0.186	0.853	Rejected
JOB DEMAND -> PSYCHOLOGICAL STRESS	**2.190**	**0.030**	**Accepted**
JOB DEMAND -> SAFETY OUTCOMES	1.154	0.250	Rejected
ORGANIZATION -> PHYSICAL STRESS	**2.071**	**0.040**	**Accepted**
ORGANIZATION -> PSYCHOLOGICAL STRESS	**2.369**	**0.019**	**Accepted**
ORGANIZATION -> SAFETY OUTCOMES	0.602	0.548	Rejected
PHYSICAL STRESS -> SAFETY OUTCOMES	**4.401**	**0.000**	**Accepted**
PSYCHOLOGICAL STRESS -> SAFETY OUTCOMES	0.505	0.615	Rejected
SAFETY BEHAVIOR -> PHYSICAL STRESS	**2.383**	**0.018**	**Accepted**
SAFETY BEHAVIOR -> PSYCHOLOGICAL STRESS	**4.624**	**0.000**	**Accepted**
SAFETY BEHAVIOR -> SAFETY OUTCOMES	1.674	0.096	Rejected

From the Table, 5 hypotheses are accepted out of the 14 that were built. where the accepted hypotheses have different T-statistic values. Then further tests are carried out to see the direct and mediating effects of exogenous variables, as in the following table

Table 5. Indirect Effect

	T Statistics	P Values	Remark
ENVIRONMENT -> PHYSICAL STRESS -> SAFETY OUTCOMES	**2.168**	**0.032**	**Accepted**
JOB DEMAND -> PHYSICAL STRESS -> SAFETY OUTCOMES	0.181	0.856	Rejected
ORGANIZATION -> PHYSICAL STRESS -> SAFETY OUTCOMES	1.901	0.059	Rejected
SAFETY BEHAVIOR -> PHYSICAL STRESS -> SAFETY OUTCOMES	**1.989**	**0.048**	**Accepted**
ENVIRONMENT -> PSYCHOLOGICAL STRESS -> SAFETY OUTCOMES	0.416	0.678	Rejected
JOB DEMAND -> PSYCHOLOGICAL STRESS -> SAFETY OUTCOMES	0.486	0.628	Rejected
ORGANIZATION -> PSYCHOLOGICAL STRESS -> SAFETY OUTCOMES	0.438	0.662	Rejected
SAFETY BEHAVIOR -> PSYCHOLOGICAL STRESS -> SAFETY OUTCOMES	0.538	0.592	Rejected

In the indirect effect, there are 2 accepted hypotheses out of the 8 hypotheses built. where the accepted hypothesis has a different R square value. The accepted hypothesis is that there is an influence of the environment, job demand, organization, safety behavior, and physical stress variables on safety outcomes in the electronics manufacturing industry. As well as the indirect effect, there is a relationship in the environment that affects physical stress and has an impact on safety outcomes. And safety behavior affects physical stress and has an impact on safety outcomes. Based on the accepted hypothesis, there are several strategy recommendations, namely, first in the environment variable, rearranging the machine layout so that movement and handling become small. In terms of job demand variables, it is recommended to review and evaluate working hours and job allocation to workers regularly. In terms of organization, it is recommended to improve the relationship between workers and superiors. And in the safety behavior variable, it is recommended to review the guidelines for routine maintenance of personal protective equipment to avoid a decrease in safety behavior and to develop safety policies and practices (a safety program) in the organization.

6. Conclusion

In the current study, three regression models were developed to explore the relationships between the three dependent variables i.e., physical stress, psychological stress, and safety outcome and various sets of independent variables. R square values were obtained to explain the percentage of variance in the three dependent variables. The R square value of Model 3 is comparatively low and moderate. This result reveals that, besides the two types of stress identified in the present study, there may be other independent variables that predict safety incident e.g., environment, the job demand and culture of the organization, the individual safety behaviors of coworker, etc. Based on the accepted hypothesis, there are several strategy recommendations, rearranging the machine layout so that movement and handling become small, review and evaluate working hours and job allocation to workers regularly, improve the relationship between workers and superiors, review the guidelines for routine maintenance of personal protective equipment to avoid a decrease in safety behavior and to develop safety policies and practices (a safety program) in the organization.

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