

WORKFORCE FATIGUE MODEL AND ITS RELATIONSHIP WITH  
WORKFORCE PRODUCTIVITY

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I dedicate this thesis to my wonderful family. Particularly to my understanding and patient wife, **Mrs. Shohreh Naseripour**, who has put up with these many years of research, and to our precious children **Mr. Mohammad Sajad** and **Miss. Sheida** who are the joy of our lives.

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## ABSTRACT

Earlier studies have shown that attention to ergonomic factors such as suitable work design and planning, appropriate workplace design and facilities, and suitable machine and human design can help to boost workforce productivity, enhance work safety, increase nervous and physical well-being and fulfil job satisfaction. Ergonomic studies can assist managers in planning to reduce fatigue and increase workforce productivity. A review of the models of ergonomics shows that there is a need to conduct further research to gain a more comprehensive fatigue model. This research aims to propose a workforce fatigue model and investigate its relationship with workforce productivity, and the relationships among the variables and mediating variables with the physical and nervous abilities. The main research question is whether there is a significant relationship between the workforce fatigue model and workforce productivity. By adding forgetfulness and retraining as dependent variables and several mediating variables, this model enhances its precision and sensitivity. The service companies in Iran contribute 51.5 % to the economy of the country. From this percentage, the telecommunication service industry holds 12.8%. As a case study, the researcher decided to select a few telecommunication companies, which make up the biggest branches of the telecommunication companies of Iran. To achieve the research objectives, initially interviews were conducted with thirty experts in this area. Answers and responses from the questions about the fatigue model and the degree of its impact on productivity were used to test the performance and validity of the model. The interview results were analysed and the degree of effectiveness of each variable on the conceptual model was measured. Accordingly, a point was assigned to each variable. It was decided to include the main variables and mediating variables with the highest point in the final model. Based on the findings from the interviews, questionnaires were designed and distributed among the eligible study workforce of the companies. Four hundred and fifty respondents were selected as the sample size, among eight hundred workers, from whom information required for the analysis of the model was collected. The survey data collected from the respondents were processed using a Chi-Square Test, Kolmogorov-Smimov Z Test, One Sample T-Test, and Cronbach's alpha. The result showed a strong significant relationship (p-value was less than 5%) between the workforce fatigue model and workforce productivity and this model provides higher efficiency and accuracy in assisting the company managers in their decision making in work planning and design. The findings from the case service companies greatly improve workforce productivity through reducing risks due to fatigue in the work environment.

## ABSTRAK

Kajian awal menunjukkan dengan memberi tumpuan kepada faktor ergonomik didalam perancangan dan rekabentuk kerja, tempat-kerja dan fasiliti, dan rekabentuk mesin dan manusia yang sesuai, dapat meningkatkan produktiviti, keselamatan pekerjaan, keselesaan saraf dan fizikal dan memenuhi kepuasan pekerjaan. Kajian ergonomik juga membantu pengurus merancang pengurangan kelesuan dan meningkat produktiviti kerja. Dari kajian mengenai model ergonomik menunjukkan terdapat keperluan penyelidikan bagi mendapatkan model kelesuan yang lebih komprehensif. Penyelidikan ini bertujuan untuk mencadangkan satu model kelesuan pekerja dan menyiasat hubungannya dengan produktiviti pekerja, dan hubungan antara pembolehubah dan pembolehubah pengantara dengan keupayaan fizikal dan saraf. Persoalan penyelidikan utama adalah samada terdapat hubungan ketara diantara model kelesuan pekerja dan produktiviti. Dengan menambah pembolehubah "lupa" dan "latihan-semula" bersama beberapa pembolehubah pengantara, model baru ini dijangka dapat meningkatkan aspek kejituan dan kepekaan. Syarikat perkhidmatan di Iran menyumbang 51.5% kepada ekonomi negara. Dari peratus ini, industri perkhidmatan Telekomunikasi memegang 12.8%. Sebagai kajian kes, penyelidik membuat keputusan untuk memilih beberapa Syarikat Telekomunikasi perkhidmatan, cawangan syarikat yang terbesar di Iran. Untuk mencapai objektif penyelidikan, temuduga dengan tiga puluh pakar didalam bidang ini telah dilakukan. Jawapan dan maklumbalas dari soalan terhadap model kelesuan yang dibina dan kesan terhadap produktiviti, digunakan untuk menguji prestasi dan kesahan model baru ini. Hasil dari temuduga di analisis dan kesan setiap pembolehubah terhadap model tersebut diukur. Mata diberikan kepada setiap pembolehubah. Pembolehubah dengan mata tertinggi dimasukkan ke dalam model yang dibina. Soalan-kajiselidik direkabentuk dari hasil temuduga dan diedarkan kepada pekerja syarikat yang layak sebagai responden. Empat ratus lima puluh orang telah dipilih sebagai saiz sampel, daripada kalangan lapan ratus pekerja, dari mana maklumat yang diperlukan, dikumpulkan untuk menganalisis model baru itu. Data yang dikumpulkan dari responden, di analisis menggunakan *Chi-Square Test*, *Kolmogorov-Smimov Z Test*, *One Sample T-Test*, dan *Cronbach's alpha*. Keputusan menunjukkan terdapat hubungan ketara yang kuat (nilai  $p$  yang kurang daripada 5%) diantara model kelesuan pekerja dan produktiviti pekerja dan model ini memberikan keputusan yang lebih jitu dan rapi untuk membantu pengurus membuat keputusan rekabentuk dan perancangan. Keputusan dari kajian kes syarikat perkhidmatan juga meningkatkan nilai produktiviti pekerja melalui penurunan risiko yang disebabkan oleh kelesuan di persekitaran kerja.

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**LIST OF SYMBOLS**

FRMS	-	Fatigue Risk Management System
HOS	-	Hours Of Service
IBM	-	International Business Machines
LBP	-	Low Back Pain
MSD	-	Musculoskeletal Disorders
NREM	-	Non-consideration Rapid Eye Movement
REM	-	Rapid Eye Movement
SMS	-	Safety Management Systems
SPSS	-	Statistical Package for Social Science
SIG	-	Significance
SAFE	-	System for Aircrew Fatigue Evaluation
WMSD	-	Work related Musculoskeletal Disorders

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Introduction**

This chapter introduces the problem of interests and outlines the research of objectives. It explains the workforce fatigue model and relationship with workforce productivity. This chapter addresses the existing problems in that context, highlights some research questions, and describes the research scope, and objectives. The outlines of the thesis were finally presented.

#### **1.2 Research Background**

Productivity is the major concern of all the managers in the production and service companies. The lack of a suitable and efficient model for planning and arranging the workforce in relation to workforce fatigue motivates the present researcher to conduct this study (Stephen, 2006). The researcher is determined to eliminate the shortcomings and enhance the research of the previous workforce fatigue models. In addition, this research will provide new knowledge to managers on ergonomics and acquaint them with better and more effective approaches to the improvement of the workforce productivity in the workplace (Bokhorst, *et al.*, 2006). It attempted to review the previous studies, and presented a suitable theoretical

background for a true understanding. Besides, this research facilitated the investigation into the relationship between the variables considered in the research (Yan and Liu, 2001).

A major concern in industry of the developing countries, in particular, is the improvement in the productivity of the workforce and work safety (Battini, *et al.*, 2011). Production and service companies have some features in common such as the inappropriate design of the workplace, unsuitable design of the job, incompatibility between the job structure and the capabilities of the workforce, the difficulties of the work environment, the lack of a suitable relation between humans and machines and finally the improper management programs (Ashraf and Naseen, 2003). These problems cause damage to the workforce in the workplace, and jeopardize his health (Edward and Thomas, 2000; Stephen, 2006). Finally, fatigue can lead to an increase in costs (Bokhorst, *et al.*, 2006). Ergonomics helps the managers of the production and service companies to promote the workforce productivity, health, and safety of the workplace through planning and accurately controlling the production process and services (Jaber and Neumann, 2010). Research shows that lack of attention to ergonomic factors can directly or indirectly affect the performance of the companies and it can make it very hard for the companies to achieve their intended goals (Bokhorst, *et al.*, 2006). Effective plans for ergonomic performance in the system design can establish balance between the capabilities of the workers and the demands of the work (Jaber, *et al.*, 2003).

Earlier studies have shown that attention to ergonomic factors such as suitable work design, appropriate workplace design and facilities, and suitable machine and human design can help to boost workforce productivity, enhance work safety, increase nervous and physical well being and fulfill job satisfaction (Belyavin and Spencer, 2004; Shikdar and Das, 1995). Ergonomic studies can also assist managers in planning to reduce fatigue. Other characteristics of ergonomic studies include machine design, work stations and the related features (Stephen, 2006; Sanders and McCormick, 1992). The main concern is the designing of work systems which can only work when machines and instruments are improved. This designing will be

incomplete and worrying if ergonomic factors are not taken into account (Caruso, *et al.*, 2004; Konz, 1995). Inattention to the principles of ergonomics can impose nervous and physical impacts on the workforce. Noncompliance to the engineering principles of ergonomic factors in the workplace can result in the reduction of workforce productivity and reduced in the quality of service and products (Ayoub, 1990). Considering the fact that the developing countries are not equipped with sufficient developed facilities in production and service, and because of the cheap workforce, the managers prefers to use the human service rather than automation and robotic services (Yan and Liu, 2001). Damages due of physical and nervous fatigue on the workforce can be reduced using the new workforce fatigue models. This can ultimately help to enhance productivity and make industries more favorable (Jaber and Neumann, 2010).

The suitable proposed workforce fatigue model necessarily will be capable to warn individuals of the potential increase of fatigue and consequent risks. Decrease in the rest time can increase the damages due to fatigue (Dawson, *et al.*, 2011). Retraining and awareness can help workforce reduce physical and nervous fatigue due to changes of rest times (Dawson, *et al.*, 2011; Jaber and Neumann, 2010). There have been many studies on the models of workforce fatigue so far. This research which is based on the recommendation given by Jaber and Newman (2010) is designed by introducing a few key variables which are the main concerns and have not being addressed before.

### **1.3 Problem Statement**

The earlier workforce fatigue models had limited input variables: humans and machines (Inman, *et al.*, 2004). Workers in charge of some machines are subject to certain limitations such as the size of the machine compared to the workforce; unemployment time, the length of the line, delivery time, suitable training with detailed particulars for the workforce (Bokhorst, *et al.*, 2006; Kher, *et al.*, 1999).

Lack of attention to ergonomics and the fatigue of the workers due to the improper training given to them and to the companies managers reduce the efficiency of workforce and lower the improvement in the service to the customers (McCreey, *et al.*, 2004). Companies have started improvement in the quality of the products and services (Felan and Fry, 2001). Furthermore, the lack of attention of the managers to reduce the workforce fatigue and the recurrence of stress can lessen companies' productivity (Tekin, 2002). So, it can be said that researchers are made to conduct more research and develop better models because there is inflexibility in the present models of workforce fatigue due to the limitations in the input variables and finally because their fatigue is not accurately measured (Bobrowski and Park, 1993; Hottenstein and Bowman, 1998; Inman, *et al.*, 2004). Other issues arising from the fatigue models include inattention to learning and retraining appropriate to the type of the task in addition to being ignorant to do some of the assigned tasks (Jaber, *et al.*, 2003; Kher, *et al.*, 1999; McCreery and Krajewski, 1999).

The literature review shows that companies managers had not given sufficient attention to the use of the workforce fatigue model and lacked a proper planning recommended by the available fatigue models (Battini, *et al.*, 2011; Ang, 1999; Cheng-Leong, *et al.*, 1999; Easterly and Levine, 2001; Elahrache and Imbeau, 2008; Hursh, *et al.*, 2004; Mcdonald, *et al.*, 2009; Tharmmaphornphilas, *et al.*, 2003). In addition, these studies emphasize that the present workforce fatigue models cannot adequately cover all the ergonomic factors (Dawson, *et al.*, 2011; Battini, *et al.*, 2011).

#### **1.4 Research Questions**

Defining the research questions is the most important step in research (Yin, 2008). Based on the literature research, the independent variables in the proposed workforce fatigue modes include main variables and mediating variables, and the dependent variable is workforce productivity. In order to investigate the relationship

between the main variables and the mediating variables in relation to workforce productivity, the following research questions are derived;

#### **1.4.1 Main Research Questions:**

- (MRQ1) Is there relationship between the workforce fatigue model and workforce productivity?*
- (MRQ2) Is there relationship between physical fatigue and workforce fatigue model?*
- (MRQ3) Is there relationship between nervous fatigue and workforce fatigue model?*
- (MRQ4) Is there relationship between work time and workforce productivity?*
- (MRQ5) Is there relationship between work rhythm and workforce productivity?*
- (MRQ6) Is there relationship between rest time and workforce productivity?*
- (MRQ7) Is there relationship between forgetfulness and workforce productivity?*
- (MRQ8) Is there relationship between retraining and workforce productivity?*

#### **1.4.2 Sub-Research Questions:**

- (SRQ1) Is there relationship between mediating variables (age, gender, education level, experience, work shift) and work time?*
- (SRQ2) Is there relationship between mediating variables (age, gender, education level, experience, work shift) and work rhythm?*

- (SRQ3) Is there relationship between mediating variables (age, gender, education level, experience, work shift) and rest time?*
- (SRQ4) Is there relationship between mediating variables (age, gender, education level, experience, work shift) and forgetfulness?*
- (SRQ5) Is there relationship between mediating variables (age, gender, education level, experience, work shift) and retraining?*

## **1.5 Research Objectives**

This research attempts to improve the accuracy of the earlier studies, on workforce fatigue models, and investigate its effects on the workforce productivity. Considering the points mentioned above on the problems encountered in the earlier workforce fatigue models, the preceding procedures are presented. A comprehensive and more accurate model for planning and making the qualitative policies in production and service companies are introduced. The research objectives are;

- i. To establish the relationship between the workforce fatigue model and workforce productivity.
- ii. To establish the relationships among the variables, and the mediating variables in the workforce fatigue model.
- iii. To validate the workforce fatigue model with the data collected from the case service companies.

## **1.6 Research Scope**

Although many service companies have automated some of their operations and make use of automatic machines for certain services, there are still more tasks that have to be done by human (the workforce), so situations where humans and



machines complement each other are still relevant (Arne, 1994). It is obvious that the informed managers are seeking new approaches to prevent the wastage of workforce and probable damage to their skillful workforce (Madden and Scott, 1999; Valarie, 2000).

Based on what was mentioned above, this research aims to test the proposed workforce fatigue model by collecting and analyzing the necessary data from the selected companies. Although the presented model is a general one, it is capable of being used in manufacturing and service companies (Blach, 2006). Referring to the issues addressed in the previous section, it was mentioned that the share of the service industry in Iran is by 51.7%, indicating higher percentage than that in the production industry for the development of the country's economy. The increase in productivity in the service sector can promote productivity and hence the economy of the country. In service sector especially telecommunication contributes to 12.8% and this has significant role in the economy of Iran (Sobhani, 2008; Gholami, *et al.*, 2004; Calabrese, *et al.*, 2002; Sadjadi, 2010; Arbabisarjou, *et al.*, 2012).

## **1.7 Research Hypothesis**

The development of the existing models of fatigue can be a suitable instrument for scheduling and predicting dangers resulting from fatigue at work. It can also be an important instrument to boost the quality, efficiency, effectiveness, and workforce productivity. When a workforce feels safe and happy at work, he will naturally have a better productivity than other workers who are deprived of suitable work conditions (Dawson, *et al.*, 2011). There have been many studies on the workforce fatigue models so far. This research is based on the recommendation given by Jaber and Newman (2010), which designed and introduced the latest model of workforce fatigue. The models of fatigue which are available now are usually limited to two output variables: human and machines (Bokhorst, *et al.*, 2006). Normally, the level of the workforce is the ratio of the operator to the machine. Here

the workforce is the operator and the assigned task is the machine. These variables are exposed to certain limitations such as the size of the machine, the unemployment times, and the time limitation on delivery of the work, the length of the queue especially in the production workshops and the level of retraining given to the workforce (Kher, *et al.*, 1999; Bokhorst, *et al.*, 2006).

Previous studies have presented a model in which the items were taken into consideration and tested included the variables of the length of work time on any work shift, the physical ability of the workers in carrying loads, the appropriate use of the muscles in doing jobs, the average amount of a worker's tolerance to the work pressures, the workforce fatigue at the beginning of the work in different work cycles, the workforce fatigue in terms of physical and nervous aspects at the end of the job in any work cycle and the length of the worker's rest during a certain period of work (Jaber and Neumann, 2010). Reviewing from the literature, this research aims to prove the following basic hypothesis:

- H<sub>0</sub>:** There is no significant relationship between the workforce fatigue model and the productivity of the workforce.
- H<sub>1</sub>:** There is a significant relationship between the workforce fatigue model and the productivity of the workforce.

## **1.8 Research Contribution**

The ergonomic and its relationship with productivity is a subject that has involved the managers for a long time and there have been many studies on the analysis of the ergonomic performance and optimization in the workplace (Battini, *et al.*, 2011). The workforce fatigue models in the workplace which were previously introduced are used to increase the knowledge of the companies and the employers

and to set a fixed model for work times and rest times of the workers (Dawson, *et al.*, 2011). However, these models are not sufficiently effective because these models vary in the main variables and do not pay attention to all of the variables effective in the workforce fatigue and the workforce productivity (Khalid and Daniel, 2008; Gander, *et al.*, 2011).

Studies on the ergonomic factors and workforce productivity continued with the investigations into the degree of the worker's physical ability in carrying loads (Battini, *et al.*, 2011). In fact, these factors were conducted to predict the worker's physical capacity and to set balance between the worker's ability and the work volume (Jaber and Neumann, 2010; Gander, *et al.*, 2011). Using other factors which affect workforce fatigue, the present research aims to enhance the previous models of workforce fatigue, and investigate the effect of fatigue on the productivity of the workforce. The enhanced model developed to improve of the earlier models of workforce fatigue and productivity, and it will also assist the companies managers in their decision making in work planning and design (Jaber and Neumann, 2010; Battini, *et al.*, 2011).

The literature on the workforce fatigue model indicates that in the previous studies, the focuses are on the variables affecting the physical fatigue and nervous fatigue of the workforce. Research shows that, despite the sensitivity to the variables affecting nervous fatigue in the previous models, there was no specific attention to these variables in the earlier versions (Gander, *et al.*, 2011; Dawson, *et al.*, 2011). Therefore, in the present research based on the results derived from the literature review and the conclusions drawn from the interviews with the experts, it was decided to include in the model of workforce fatigue, three main variables affecting the physical fatigue, two main variables affecting the nervous fatigue of the workforce, and five mediating variables (gender, age, education level, experience, work shift). In fact, with the expansion of the fatigue models, this research has managed to introduce a workforce fatigue model and greatly contribute to raising the sensitivity and precision of predicting the effect of workforce fatigue in the present models (Jaber and Neumann, 2010).

## **1.9 Outline of Thesis**

This thesis has been organized into six chapters. In this chapter a general overview of the thesis is given. This chapter presents the statement of the problem, the research objectives, the research questions, the research hypothesis, the contribution of the research, the scope of the study reputational outline of the thesis. The second chapter deals with the literature review on the title of the research and a review on the previous studies. This chapter discusses the previous fatigue models and the gaps which existed in them. Then the theoretical model is presented. Chapter Three discusses the details of the research methodology, the conceptual models, the research questions, and the instrument of the research. Furthermore, it elaborated on the method of data collection, reliability, and validity of the research. Chapter Four presents the analysis of the data and discussion on the research questions and the research hypothesis. Chapter Five depicts the result of the research and the experiments done, and presents the discussion on the findings. The final chapter presents the conclusions and it also offers some recommendations for future studies.

## **1.10 Summary**

A concise review of the previous studies has shown that improved representation of a workforce fatigue model encompassing the variables that effect on the productivity of workforce seems required. In this chapter, requirement to such a workforce fatigue model has been considered as a problem in service and manufacturing companies. The researcher has developed research hypothesis that need to be tested. The main questions and sub-questions of research have been developed to achieve the research objectives. To collect data and test the workforce fatigue model and the relationship between workforce fatigue model and the productivity of workforce, some service companies were selected as case studies. In next chapter, based on previous studies, the researcher strives to detect the variables that have not already been used in the workforce fatigue models.

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