

## Abstract

Fatigue due to shiftwork patterns is a silent problem in industries, which is mostly overlooked by employers as well as employees, resulting in occupational injuries. This cross-sectional study, first in a manufacturing plant in Pakistan, was undertaken to evaluate fatigue and its risk to workers employed in rotating shifts by using Fatigue & Risk Indices (FRI) to determine its relationship with occupational injuries. Results shown an average sleep time of 5.8 & 7.9 hours a day in night & day shift-workers, respectively, i.e. significant at  $p < 0.05$ . Job fatigue has significant positive correlation with injury risk ( $r = 0.399$ ) and occupational injury ( $r = 0.160$ ), while, it has negative significant correlation with hours of sleep ( $r = -0.551$ ) at  $p < 0.05$ . Furthermore, hours of sleep has negative significant correlation with occupational injuries ( $r = -0.292$ ). To improve safety of shift-workers and to reduce accidents employers should develop strategic shift schedules, early detection of on the job fatigue, continuous monitoring, shift critical tasks to daytime or at the beginning of shift, provide regular & frequent rest breaks, do systematic accident investigation to determine whether fatigue was a causing factor, trainings to improve sleep are recommended. Where as employee should improve sleep and cooperate with employer.

## Introduction

The modern society has moved towards a 24/7 work schedule. In many industries the shiftwork has become norm to ensure continuity of production and services, making work at nights as common as at daytimes. The shiftwork, especially work at night, and for extended hours causes sleep deprivation and on the job fatigue resulting in minor injuries to serious accidents. For example, some of the most serious accidents in the last three decades have been attributed to the shift worker's fatigue, e.g., nuclear power plant accident at Chernobyl, Three Mile Island, and the oil spill from the Exxon Valdez, all occurred between midnight and 6 am. (Gander et al., 2007).

## Methods and Materials

This cross-sectional study was conducted at a manufacturing plant in Pakistan. Fatigue & Risk Index calculator, a risk assessment tool (Spencer et al., 2006) was used to assess changes in work patterns and to determine whether work pattern can increase levels of fatigue & risk of accident. In this study six-month shiftwork patterns of 184 participants, 84 day shift workers and 100 night shift workers was assessed. Questionnaire was used to collect data of sleep hours & occupational injury accidents.

The Fatigue index consist of shift timing, shift duration, breaks, rest periods, cumulative fatigue and workload.

Fatigue Index  $FI = 100\{1 - (1 - C)(1 - J - T)\}$

Risk Index  $RI = C \times J \times T$

Where, C is the cumulative fatigue component, T is the duty timing component, and J is the job type / breaks component.

Descriptive statistics, one-way analysis of variance (ANOVA) and correlation test were applied, where a p-value < 0.05 was considered significant. Statistical Package for Social Sciences (SPSS) version 24.0 & MS Excel were used to analyze the data.

## Results

Fatigue, risk of accident and occupational injury are significantly positively correlated. Where as fatigue is negatively correlated with hours of sleep that means if hours of sleep reduces than fatigue will increase and eventually increase in risk of injury. Results shown an average sleep time of 5.8 & 7.9 hours a day in night & day shift workers, respectively, significant at  $p < 0.05$ . Night shift fatigue index of 52.08 means half of the workers are likely to feel very tired), Day shift fatigue index of 16.5 therefore means that on average, 3.2 in 20 worker working that pattern are likely to feel very tired.

The details are shown in table 1-2 and figure 1-4.

Table 1. Descriptive Statistics

Variables	Shift	N	Mean $\pm$ SD	Sig
Hours of Sleep	Day	84	7.94 $\pm$ 0.89	0.000
	Night	100	5.88 $\pm$ 1.27	
Occupational Injury	Day	84	0.43 $\pm$ 0.68	0.000
	Night	100	0.93 $\pm$ 0.96	
Fatigue Index	Day	84	16.50 $\pm$ 5.65	0.000
	Night	100	52.08 $\pm$ 3.67	
Risk Index	Day	84	3.33 $\pm$ 1.40	0.000
	Night	100	4.43 $\pm$ 1.27	

Table 2. Correlations

Correlation Matrix	r	Sig
Fatigue & Risk of Injury	0.399**	P<0.01
Fatigue & Occupational Injury	0.160*	P<0.05
Fatigue & Hours of sleep	-0.551**	P<0.01
Occupational Injury & Hours of Sleep	-0.292**	P<0.01

N=Sample size, Sig=Significant, SD=Standard Deviation, r=Correlations

\*\* . Correlation is significant at the 0.01 level (2-tailed)

\*. Correlation is significant at the 0.05 level (2-tailed)

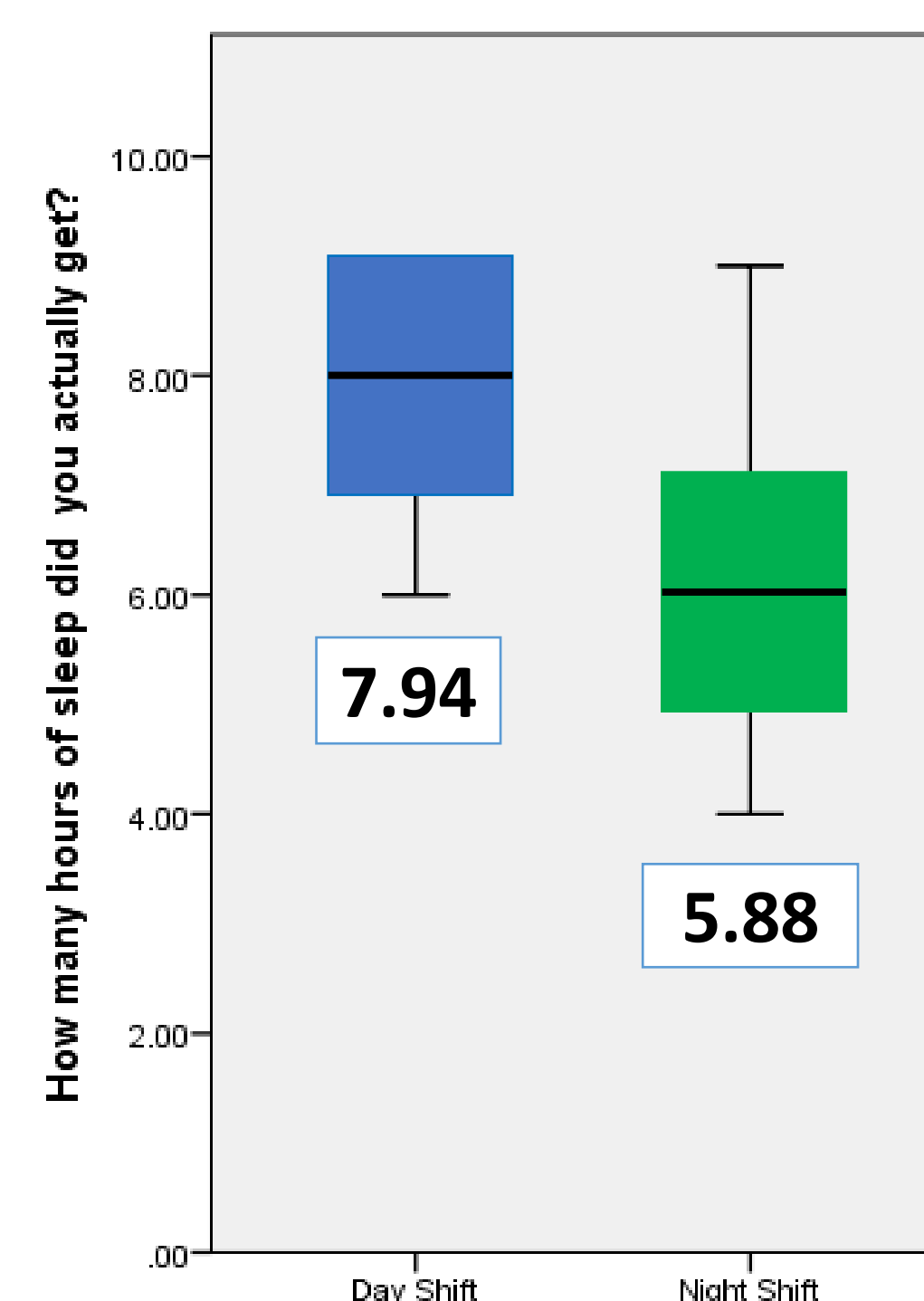


Figure 1. Hours of Sleep Summary

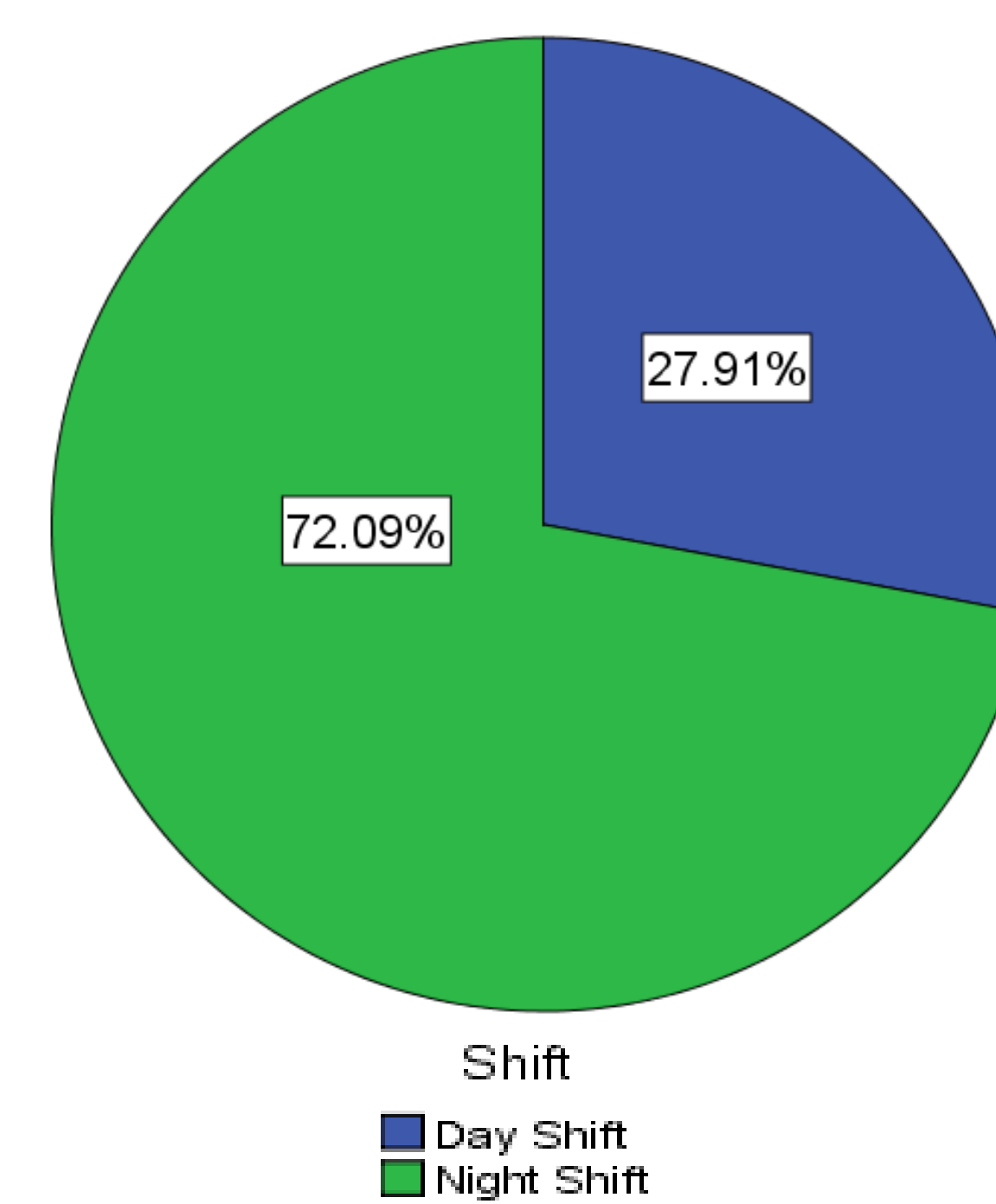


Figure 2. Occupational Injury Summary

*Being fatigued can make you a risk to yourself, your co-workers and the public!*

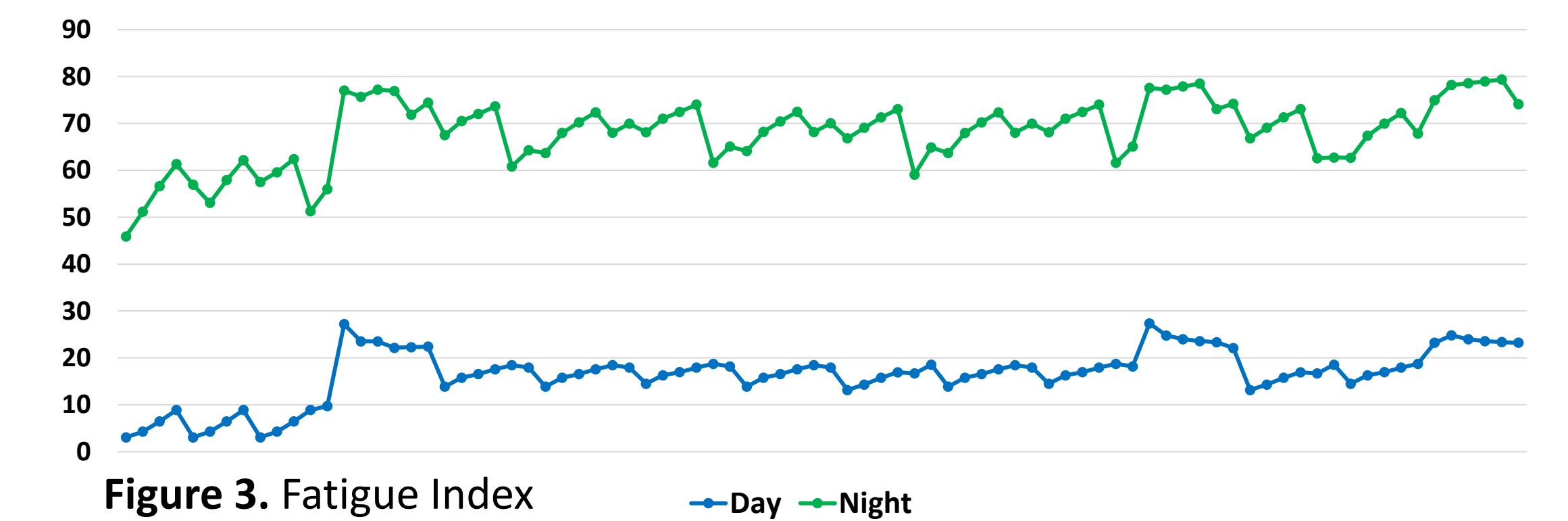


Figure 3. Fatigue Index

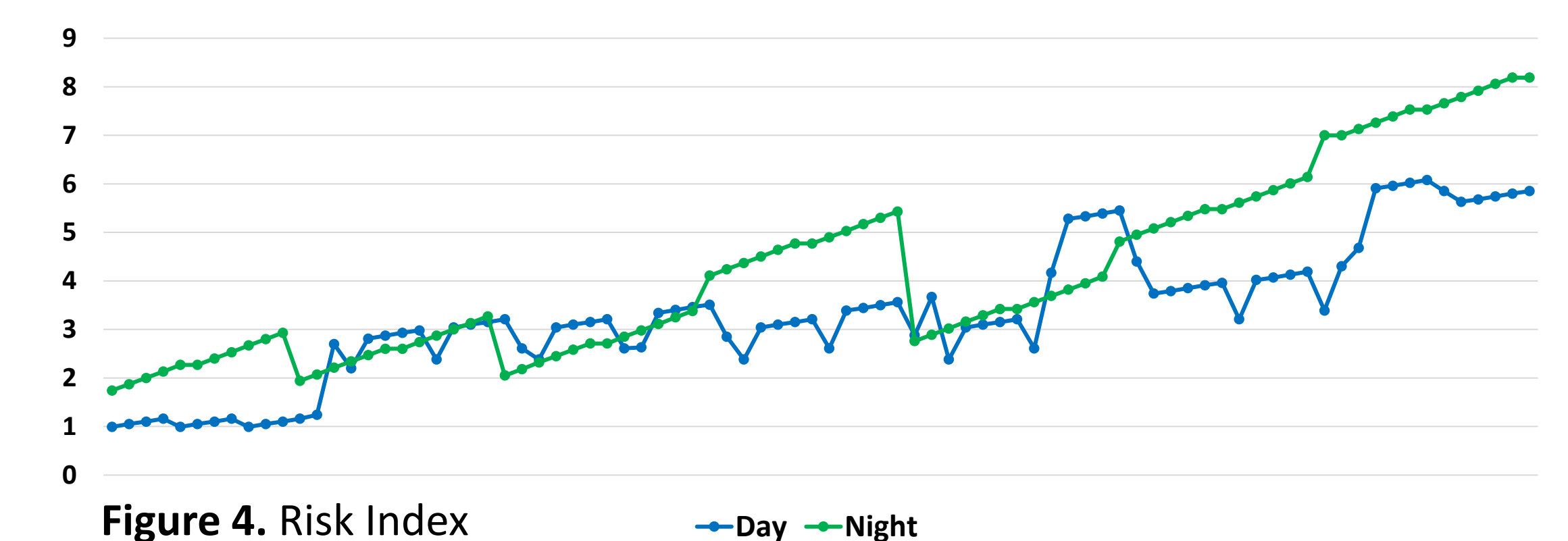
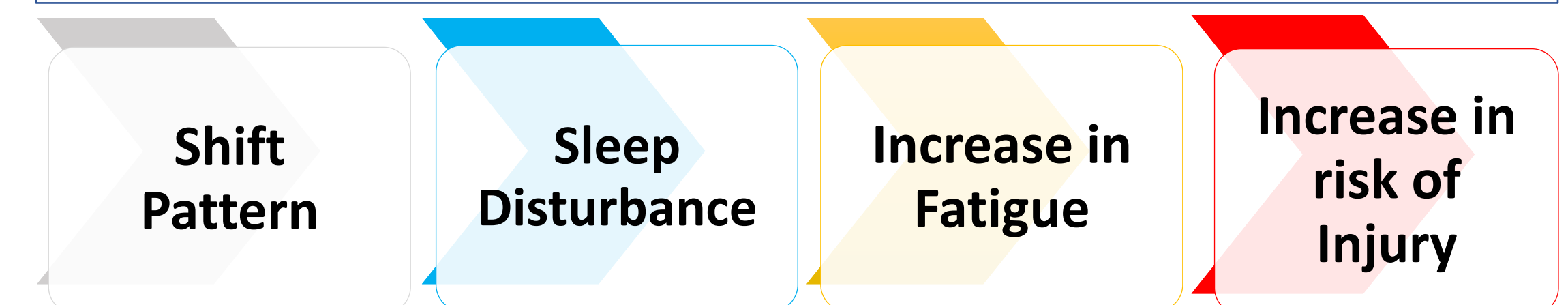


Figure 4. Risk Index

## Conclusions

A fatigued worker is potentially dangerous, not only to himself, but to others as well. Working in night shifts significantly increase the risk of occupational injury due to sleep deprivation & cumulative worker fatigue. Work-related causes of fatigue are largely under the control of the employer and non work-related factors are controlled by individual employees, this put strong responsibilities on both to manage fatigue. Both employers and employees need to be aware of the risks posed by sleep deprivation and on the job fatigue to reduce risk of occupational injuries.



## Recommendations

The fatigue risk management system is a comprehensive approach to manage workers fatigue. However, following are the major recommendations to improve sleep and to manage fatigue:

**Employer should do followings:**

- Sleep opportunity** by sensible scheduling, making sure schedules provide employees with enough time off to get the sleep they need, napping opportunities if possible, limit extended shifts
- Track actual sleep** determining whether employees actually got the sleep they needed, use pocket sleep cards
- Check Fatigue Related Symptoms** key idea is early detection of on the job fatigue, use checklists, encourage self reporting and continuous monitoring
- Proactive Strategies** like improved lightings, ensure work in pairs, shift critical tasks to daytime or at the beginning of the shift if possible, provide regular and frequent rest breaks and training programs to improve sleep quality
- Investigation of accidents** systematically to determine whether fatigue was a causing factor to accident, and if so, how to avoid a recurrence of incidents in future

**Employees** avoid using sleeping pills, caffeine, alcohol or large meals before going to sleep, make sure your family members are aware and take care of your sleep, ensure dark & quiet place to sleep, switch off mobile phones, and cooperate with employer.

## Contact

Abdullah Malik  
College of Earth & Environmental Sciences  
University of the Punjab, Lahore, Pakistan  
abdullah1582@gmail.com  
+92 313 572 1111



## References

- Extended Unusual Work Shifts. (n.d.). Retrieved May 1, 2020, from [https://www.osha.gov/OshDoc/data\\_Hurricane\\_Facts/faq\\_longhours.html](https://www.osha.gov/OshDoc/data_Hurricane_Facts/faq_longhours.html)
- Folkard, S., Lombardi, D. A., & Tucker, P. T. (2005). Shiftwork: Safety, sleepiness and sleep. In *Industrial Health* (Vol. 43, Issue 1, pp. 20-23). <https://doi.org/10.2486/indhealth.43.20>
- Institution of Occupational Safety and Health. (2006). The effects of shift work on health. [www.iosh.co.uk/shiftworkhealth](http://www.iosh.co.uk/shiftworkhealth)
- Pasupathy, K. S., & Barker, L. M. (2012). Impact of fatigue on performance in registered nurses: data mining and implications for practice. *Journal of Healthcare Quality: Official Publication of the National Association for Healthcare Quality*, 34(5), 22-30. <https://doi.org/10.1111/j.1945-1474.2011.00157.x>
- RR318 - Effect of shift schedule on offshore shiftworkers... (n.d.). Retrieved February 22, 2020, from <https://www.hse.gov.uk/research/rrhtm/rr318.htm>
- Sadeghniaat-Haghighi, K., Yazdi, Z., Jahanihashemi, H., & Aminian, O. (2011). The effect of bright light on sleepiness among rapid-rotating 12-hour shift workers. *Scandinavian Journal of Work, Environment and Health*, 37(1), 77-79. <https://doi.org/10.5271/sjweh.3086>
- Spencer, M. B., Robertson, K. a., & Folkard, S. (2006). The development of a fatigue / risk index for shiftworkers Prepared by QinetiQ Centre for Human Sciences The development of a fatigue / risk index for shiftworkers. HSE Books.
- Yazdi, Z., & Sadeghniaat-Haghighi, K. (2015). Fatigue management in the workplace. *Industrial Psychiatry Journal*, 24(1), 12. <https://doi.org/10.4103/0972-6748.160915>