An Examination of Fatigue in the Construction Industry

Report Presented to
Building Employees Redundancy Trust (BERT)

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Executive Summary

- Work-related fatigue has been identified as an important issue for Australian workplaces. The aim of this research project was to undertake an assessment of fatigue levels in the construction industry and to identify any associations with known risk factors and employee outcomes.

- Together with DJAG, BERT formed an industry committee comprising construction employers and union representatives. This committee developed the questionnaire and identified construction sites to participate in the project. At each construction site, either a BERT staff member or a union representative conducted a short briefing session.

- From August, 2010 to November, 2010, the questionnaire was administered throughout approximately 40 construction sites in South East Queensland to a total of 2000 construction workers. 1285 completed questionnaires were returned, indicating a response rate of 64.25%.

- The Centre for Organisational Psychology at UQ was contracted to undertake an analysis of the data. Descriptive and inferential statistical analyses were conducted and results are provided in Sections 3 to 6 of this report, and in an accompanying electronic spreadsheet – see Appendix A.

- In addition, 186 of these questionnaires were completed by construction workers who participated in a medical health assessment. For these employees, additional questions were asked, relating to their health status (i.e., systolic blood pressure, diastolic blood pressure, weight, height, body mass index, blood glucose, low density lipoprotein, high density lipoprotein). Supplementary analyses on these health indices also were conducted and are presented in Section 7 of the report.

Summary of Results

- Overall, the level of fatigue was found to be slightly below the mid-point (3.72) on the scale from 1 to 7, with a score of 1 denoting a low level of fatigue and a score of 7 indicating a high level of fatigue.

- Construction employees reported feeling most fatigued between 2pm and 4pm each day, and during the month of December. June was the month in which employees felt most rested.

- Older employees and employees with longer industry tenure reported a higher level of fatigue.

- The longer the work hours and commuting hours per day, the higher the level of fatigue.

- Employees who reported a higher level of fatigue, also reported greater overall physical illness (as well as on the subscales of sleep disturbances, headaches, gastrointestinal problems, respiratory problems), poorer overall psychological well-

being (as well as on the subscales of anxiety/depression, social functioning, confidence), less job satisfaction, greater work-life conflict, and a higher number of near misses at work.

- Work hours per day was associated with more anxiety/depression and work-life conflict. Commuting hours per day was associated with more gastrointestinal problems.

- The effect of physical effort on employee outcomes was not mediated by fatigue. Physical effort was associated with a range of employee outcomes (overall physical illness, sleep disturbances, headaches, poorer psychological well-being, anxiety/depression, work-life conflict, near misses at work).

- Fatigue mediated the relationship between work hours per day and several employee outcomes (overall physical illness, sleep disturbances, headaches, respiratory problems, poorer overall psychological well-being). See Figure 1.

- Fatigue also mediated the relationship between commuting hours per day and several employee outcomes (overall physical illness, headaches, poorer overall psychological well-being, anxiety/depression, less confidence and work-life conflict). See Figure 2.

- Approximately one-third (30.2%) of the sample smoked on a daily basis while approximately one-half of the sample had either never smoked (31.1%) or were an ex-smoker (20.9%).

- On average, employees consumed 2.91 standard drinks and smoked 6 cigarettes each day. Alcohol consumption was associated with more physical illness (overall physical illness, sleep disturbances, gastrointestinal problems) and greater odds of having a near miss at work (likelihood of a near miss increased by 130% for a one-unit increase in alcohol consumption). Smoking activity was associated with more physical illness in regards to headaches, gastrointestinal problems, and respiratory problems.

- Of the 186 employees who participated in the medical health assessment, 128 employees provided data on the requested health indices. A large amount of missing data precluded extensive analysis on the range of health outcomes. Correlation analysis for body mass index (BMI) was conducted. This analysis showed that older employees and employees with longer industry tenure had a higher BMI.

- For further breakdowns of the results, please refer to the accompanying excel spreadsheet. A summary of these results is provided in Appendix A.

Section 1 - Introduction

Project Aim

The aim of this project is to undertake an assessment of factors that relate to fatigue, as it applies to the construction industry in Queensland. The Building Employees Redundancy Trust (BERT) and the Department of Justice and Attorney-General (DJAG) developed a questionnaire to measure a range of factors that have been shown to be related to fatigue. It is envisioned that the findings of this project will provide a foundation for improving the capacity of construction employers in Queensland to manage the factors that impact on fatigue and the health outcomes related to fatigue.

Definition of Fatigue

Although fatigue is a concept that has been widely examined in the literature, there is no one clearly ascribed definition of it. This is due largely to the complex nature of fatigue and the fact that it involves a number of psychosocial and behavioural processes (Shen, Barbera & Shapiro, 2006). As a consequence, there are numerous definitions available that vary depending on the origin of the investigation. Shen et al. (2006) suggest that fatigue is "an overwhelming sense of tiredness, lack of energy and a feeling of exhaustion, associated with impaired physical and/or cognitive functioning" (p. 8). This definition was adopted for the purposes of examining fatigue in construction workers.

Previous Research on Fatigue in Construction Workers

While numerous studies have examined fatigue in some form or another, limited research has been conducted with construction worker samples, particularly in Australia (Lingard & Francis, 2004). Studies conducted with broader occupational groups show that fatigue is predictive of injuries and near-miss accidents at work (Gold, Rogacz, Bock, Tosteson, Baum et al., 1992); turnover intentions (De Croon, Sluiter, Blonk, Broersen, & Frings-Dresen, 2004); as well as sickness and absenteeism (Dembe, Erickson, Delbos, & Banks, 2005). Australian studies of construction industry workers has shown that fatigue is a significant contributor towards poor work-life balance (Lingard & Francis, 2004; Townsend, Brown, Bradley, Lingard, & Bailey, 2007). Lingard and Francis also found significant differences in fatigue levels between on site and off site workers, attributed to the longer hours site workers undertook. Studies of broader occupational groups also have shown that the risk of injury or near-misses increases with longer working hours due to the associated fatigue, with the highest risk associated with shifts of 12 hours or longer (Dembe et al., 2005; Folkhard & Lombardi, 2006).

Another study conducted with construction workers found that fatigue had an impact on physical health and symptoms (Chang, Sun, Chuan, & Hsu, 2009). When comparing different worker groups, it was found that scaffolders in particular had the highest physical fatigue levels and reported shorter sleeping hours than the other groups examined (steel fixers, formworkers, electrician/plumbers, and concrete workers). The study also examined smoking and alcohol consumption and found that both smoking and alcohol consumption was quite high among construction workers and may be a contributing factor to poor health outcomes. Both smoking and alcohol consumption was highest among scaffolders, indicating that smoking and consuming alcohol may present a method of relaxation or relieving fatigue.

While many models of fatigue in employees have been developed, perhaps the most relevant to construction workers is the broad occupational model developed by Dembe and colleagues (2004). These researchers found that long work hours and overtime schedules significantly increased the risk for occupational injuries and illnesses through a causal process induced by fatigue or stress. Furthermore, the proposed model hypothesises that long work hours, commuting time and sleep behaviours has an impact on a range of (physical and psychological) health outcomes, near miss accidents at work, and job satisfaction.

Section 2 - Method

Procedure

BERT identified suitable construction organisations and worksites for potential participation in the project. BERT promoted the project and arranged access to employees for questionnaire completion. In addition, the questionnaire was available on-line via the BERT website. Approximately 40 construction sites participated in the project, and a total of 2000 questionnaires were administered.

Project Process

- Questionnaire administration was conducted by BERT from August, 2010 to November, 2010.
- Data entry was conducted by an external provider from September, 2010 to December, 2010.
- Data analysis and report write-up was conducted by the UQ researchers in January, 2010 to February, 2010.

Final Sample

1285 completed questionnaires were returned. The response rate was 64.25%. A description of the sample and its characteristics is provided in the next section.

Questionnaire

The project involved the distribution of an 11-page questionnaire to construction employees in Queensland. The questionnaire was developed by Lauren Cavallaro from Workplace Health and Safety Queensland (DJAG), in consultation with the industry committee. The questionnaire measured a range of demographic characteristics, fatigue-related variables, risk factors, and employee outcomes associated with fatigue.

Demographic Variables

The first section of the survey asked employees for the following demographic information:

Demographic variable	Response categories
Gender	male, female
Age	open-ended response
Relationship status	single, with a partner/married, separated/divorced
Number of children	open-ended response
Ages of children	open-ended response
English as first language	yes, no
Tenure in the construction industry	years
Tenure with current employer	years
Tenure at current worksite	months
Employment status	full-time, part-time, casual, trainee/apprentice, self-employed/subcontractor, labour hire
Work schedule	regular daytime, regular evening, regular night, rotating shift, split shift, on call, irregular schedule, other
Work location	work site, work site but mostly in site office, mostly off site
Supervisor status	yes, no
Job classification	tradesperson, labourer, apprentice, foreman, leading hand, professional, administrative, project/size manager, other manager
Construction classification	manually-coded into site preparation, concreting, bricklaying, roofing, structural steel erection, plumbing, electrical, air conditioning & heating, fire & security system, plastering & ceiling, carpentry, tiling & carpeting, painting & decorating, glazing, landscaping
Project size	small, medium, large, major
Payment type	salary, wages, piece-rates
Site name	open-ended response
Organisation	open-ended response
Principal contractor	open-ended response
Type of work	open-ended response
Work hours	hours
Time leave home, time arrive back home	am, pm
Working longer hours	yes, no
Working shorter hours	yes, no
Number of more hours per day	hours
Number of more hours per week	hours
Commuting time	hours, minutes
Second job	yes, no
Second job in construction industry	yes, no

Fatigue Variables

(a) Fatigue Level
(b) Attitudes toward Fatigue
(c) Variation in Fatigue Levels

(a) Fatigue Level

Level of fatigue was measured using the Fatigue Scale developed by Chalder, Berelowitz, Pawlikowska, Watts, Wessely, Wright, and Wallace (1993). Employees were asked to rate the following11 statements on a scale of 1 (*strongly disagree)* to 7 *(strongly agree)*, in regards to the last 4 weeks. The reliability of the scale was 0.95.

1. I have problems with tiredness
2. I need to rest more
3. I feel sleepy or drowsy
4. I have problems starting things
5. I am lacking in energy
6. I have less strength in my muscles
7. I feel weak
8. I have difficulty concentrating
9. I have problems thinking clearly
10. I make slips of the tongue while speaking
11. My memory is worse than usual

(b) Attitudes toward Fatigue

A range of different attitudes toward fatigue was measured with 8 items developed by Workplace Health and Safety Queensland in consultation with the industry committee. Employees were asked to think about how they felt about the construction industry and to rate each statements on a scale from 1 *(strongly disagree)* to 7 *(strongly agree)*. The statements in this scale included:

1. In my opinion, fatigue is a problem in the construction industry
2. Fatigue is a problem for me in my job
3. Fatigue is being managed well in the industry
4. I can manage my own fatigue levels
5. Fatigue contributes to accidents at work
6. I have good understanding and awareness of fatigue
7. Fatigue is well understood as an industry issue
8. Awareness of fatigue has changed over the last 5 years

(c) Variation in Fatigue Levels

Monthly variation in fatigue (due to the weather) was measured with 2 statements. Employees selected as many months as they desired, by crossing a box below the months of the year (January to December).

1. Please indicate the time of year when you feel most fatigued while working because of the weather
2. Please indicate the time of year when you feel most rested while working because of the weather

Daily variation in fatigue was measured with 1 statement. Twelve 2-hour time slots over a 24-hour period were provided as options. Employees selected as many time slots as they desired, by crossing a box below the time slots.

1. Please indicate the time of day when you feel most fatigued while working

Level of sleepiness when most fatigued was assessed with 1 item. Employees responded to the following item, using a scale from 1 *(extremely alert)* to 9 *(extremely sleepy – fighting sleep)*.

1. Please indicate your level of sleepiness when you feel most fatigued while working

Risk Factors

(a) Work hours per day (Monday to Saturday average)
(b) Commuting hours per day
(c) Physical Effort

(a) Work hours per day (Monday to Saturday average)
Employees were asked to report the average number of hours worked for each day of the week (Monday to Sunday), over the past 4 weeks. The average number of hours per day (Monday to Saturday average) was computed by averaging the responses for Monday, Tuesday, Wednesday, Thursday, Friday, and Saturday.

(b) Commuting hours per day
Employees were asked to report the amount of time (in hours and minutes) that they spend travelling to and from work each day. The total commuting hours per day were computed by converting the minutes responses into an hourly value, and summing with the hour values.

(c) Physical Effort
Physical effort was measured with 1 item from Borg (1982). Employees responded to the following question using a rating scale of 0 *(nothing at all)* to 11 *(maximal)*.

1. When you are working a normal shift, how would you rate your level of physical exertion or degree of effort?

Other Variables of Interest

(a) Alcohol Consumption
(b) Smoking Status
(c) Smoking Activity

(a) Alcohol Consumption
Alcohol consumption was measured with the following 2 questions. Employees were provided with the criteria of:
1 standard drink = 1 mid-strength beer (375mL, 3.5% alcohol)
1 shot of spirits
100mL of wine (12.5% alcohol)

1. How many standard alcoholic drinks do you normally consume in one day?
2. How many standard alcoholic drinks do you normally consume in one week?

(b) Smoking Status
Smoking status was measured by asking employees to describe their smoking activity. The response categories included:

1. I smoke on a daily basis
2. I smoke less than once a day
3. I have never smoked on a daily basis
4. I am an ex-smoker

(c) Smoking activity was measured with the following open-ended question.

1. If you smoke, how many cigarettes do you have per day?

Employee Outcomes

(a) Physical Illness
- Sleep disturbances
- Headaches
- Gastrointestinal problems
- Respiratory problems

(b) Psychological Well-being
- Low anxiety/depression
- Social functioning
- Confidence

(c) Job Satisfaction
(d) Work-life Conflict
(e) Near Misses at Work

(a) Physical Illness
Physical illness was measured using a revised and abbreviated (14-item) version of the Physical Health Questionnaire (PHQ: Schat, Kelloway, & Desmaris, 2005) which is a brief self-report scale of a range of somatic symptoms (sleep disturbances, headaches, gastrointestinal problems, and respiratory problems). Employees used a 7-point scale to rate the frequency of these physical symptoms during the last 4 weeks. The response scale was anchored by 1 *(never)* and 7 *(always).*

4 items measured sleep disturbances
1. Have you had difficulty getting to sleep at night?
2. Have you woken up during the night?
3. Have you had nightmares or disturbing dreams?
4. Has your sleep been peaceful and undisturbed (reverse-scored)?

3 items measured headaches
1. Have you experienced headaches?
2. Did you get a headache when there was pressure on you to get things done?
3. Did you get a headache when you were frustrated because things were not going the way they should have or when you were annoyed at someone?

4 items measured gastrointestinal problems
1. Have you suffered from an upset stomach (indigestion)?
2. Did you have to watch that you ate carefully to avoid stomach upsets?

3. Did you feel nauseated ("sick to your stomach")?
4. Were you constipated or did you suffer from diarrhoea?

3 items measured respiratory problems

1. Have you had minor colds (that made you feel uncomfortable but didn't keep you sick in bed or make you miss work)?
2. Have you had respiratory infections more severe than minor colds that 'laid you low' (such as bronchitis, sinusitis)?
3. When you had a bad cold or flu, how long did it typically last?

(b) Psychological Well-being

Psychological well-being was assessed with the 12-item General Health Questionnaire (GHQ: Goldberg, 1972). The GHQ contains three factors, anxiety/depression, social dysfunction, and loss of confidence. In order to maintain consistency with the direction of the overall measure of psychological well-being, the items which measured each of the three factors were scored in such a way that higher scores denoted low anxiety/depression, social functioning, and confidence. Employees used a 7-point scale to rate how they had been feeling over the past 4 weeks. The response scale was anchored by 1 *(never)* and 7 *(always).*The reliability of the overall scale was 0.86.

4 items measured anxiety/depression

1. Felt constantly under strain? (reverse-scored)
2. Lost sleep over worry? (reverse-scored)
3. Felt you couldn't overcome your difficulties? (reverse-scored)
4. Been feeling unhappy or depressed? (reverse-scored)

6 items measured social functioning

1. Felt capable of making decisions about things?
2. Felt able to concentrate?
3. Been able to enjoy your normal day-to-day activities?
4. Felt you play a useful part in things?
5. Been able to face up to problems?
6. Been feeling reasonably happy, all things considered?

2 items measured confidence

1. Been losing confidence in your self? (reverse-scored)
2. Been thinking of yourself as worthless? (reverse-scored)

(c) Job Satisfaction

Job satisfaction was measured with 3 items by Warr (1991). Employees used a 7-point rating scale to indicate how they felt about their current job. The response scale was anchored by 1 *(strongly disagree*) and 7 *(strongly agree)*. The reliability of the scale was 0.94.

1. I enjoy my job
2. I am satisfied with my job
3. I am happy with my job

(d) Work-Life Conflict
Work life conflict was measured with 6 items adapted from Netemeyer, Boles, and McMurrian (1996) and O'Driscoll, Ilgen, and Hildreth (1992). Employees used a 7-point rating scale to evaluate the impact of their job on activities outside of work. The response scale was anchored by 1 *(strongly disagree)* to 7 *(strongly agree)*.

1. My job does not allow me enough time to participate in activities outside of work (O'Driscoll et al., 1992)
2. I have to put off non-work things I would like to do because of my work requirements (O'Driscoll et al., 1992)
3. The demands of my work interfere with my home life (Netemeyer et al., 1996)
4. The amount of time my job takes up makes it difficult to fulfil responsibilities at home (Netemeyer et al., 1996)
5. Things I want to do at home do not get done because of the demands my job puts on me (Netemeyer et al., 1996)
6. My job does not allow me to plan holidays in advance

(e) Near Misses at Work
Near misses at work were measured with 1 open-ended question. Employees wrote the number of near misses they had at work. The following definition of a near miss was provided: "A near miss is an incident that could have resulted in an injury to yourself or someone else, but did not".

1. Over the past 4 weeks, how many near misses did you have at work?

Health Passport Variables

(a) Blood pressure
(b) Height
(c) Weight
(d) Body Mass Index (BMI)
(e) Blood glucose levels
(f) Low density lipoprotein
(g) High density lipoprotein

Section 3 - Sample Characteristics

Individual Characteristics

Gender†

Gender	N	%
Male	1252	97.4
Female	27	2.1
Missing	6	0.5

† Descriptive information on gender is provided in Appendix A.1

Age

N		M	SD	Range
Valid	Missing			
1256	29	35.82	11.90	16-79

Relationship Status†

Relationship Status	N	%
Single	306	23.8
Defacto/married	895	69.6
Separated/divorced	71	5.5
Missing	13	1.0

† Descriptive information on relationship status is provided in Appendix A.1

Number of Children

N		M	SD	Range
Valid	Missing			
1209	76	1.37	1.47	0-12

English as a First Language†

English is First Language	N	%
Yes	1204	93.7
No	61	4.7
Missing	20	1.6

† Descriptive information on English as a first language is provided in Appendix A.1

Tenure

Tenure	N		M	SD	Range
	Valid	Missing			
Construction industry (months)	1258	27	173.47	137.61	1-684
Current organisation (months)	1243	42	41.27	57.28	1-552
Current site (months)	1230	55	5.87	7.59	1-132

Job Characteristics

Employment Status

Employment Status	N	%
Full-time	971	75.6
Part-time	17	1.3
Casual	83	6.5
Trainee/apprentice	79	6.1
Self-employed/subcontractor	81	6.3
Labour hire	42	3.3
Missing	12	0.9

Work Schedule†

Shift Type	N	%
Regular daytime	1236	96.2
Regular evening	1	0.1
Regular night	1	0.1
Rotating	0	0.0
Split	0	0.0
On call	1	0.1
Irregular	12	0.9
Other	2	0.2
Missing	32	2.5

† Descriptive information on work schedule is provided in Appendix A.10

Work Location

Work Location	N	%
On site	1168	90.9
Mostly in site office	91	7.1
Mostly off site	9	0.7
Missing	17	1.3

Supervisor Status†

Supervisor Status	N	%
Supervisor	333	25.9
Non-supervisor	934	72.7
Missing	18	1.4

† Descriptive information on supervisor status is provided in Appendix A.1

Job Classification†

Job Classification	N	%
Tradesperson	615	47.9
Labourer	182	14.2
Apprentice	134	10.4
Foreman	78	6.1
Leading hand	112	8.7
Professional	53	4.1
Administrative	13	1.0
Project/site manager	37	2.9
Other manager	22	1.7
Missing	39	3.0

† Descriptive information on job classification is provided in Appendix A.1

Construction Classification

Construction Classification	N	%
Site preparation	63	4.9
Concreting	24	1.9
Bricklaying	26	2.0
Roofing	7	0.5
Structural steel erection	145	11.3
Plumbing	201	15.6
Electrical	120	9.3
Air-conditioning and heating	36	2.8
Fire and security system	56	4.4
Plastering and ceiling	42	3.3
Carpentry	316	24.6
Tiling and carpeting	2	0.2
Painting and decorating	10	0.8
Glazing	4	0.3
Landscaping	6	0.5
Other	162	12.6
Missing	65	5.1

Current Project Size†

Project Size	N	%
Less than $20M	111	8.6
$20 - $100M	252	19.6
$100 - $400 M	385	30.0
More than $400M	427	33.2
Missing	110	8.6

† Descriptive information on project size is provided in Appendix A.1

Payment Type†

Payment Type	N	%
Salary	140	10.9
Wage	1055	82.1
Piece rate	60	4.7
Missing	30	2.3

† Descriptive information on payment type is provided in Appendix A.1

Work Hours

Average Work Hours

Work Hours	N		M	SD	Range
	Valid	Missing			
Week (Mon – Sat)†	1235	50	50.12	7.44	19.73-84.00
Monday	1233	52	9.23	1.30	0-19
Tuesday	1233	52	9.31	1.23	0-18
Wednesday	1234	51	9.28	1.28	0-15
Thursday	1234	51	9.30	1.28	0-18
Friday	1232	53	8.70	1.22	0-18
Saturday	1234	51	4.37	3.18	0-15
Sunday	1232	53	0.15	1.06	0-12.50

†A breakdown of work hours per day and per week (Monday to Saturday) for construction classification, work location, payment type, shift type, work schedule, and job classification is provided in Appendix A.2 and A.3

Change in Hours (compared with 4 years ago)†

Hours Changed	Longer Hours		Shorter Hours	
	N	%	N	%
Yes	603	46.9	228	17.7
No	652	50.7	987	76.8
Missing	30	2.3	70	5.4

† Descriptive information on increase and decrease in hours is provided in Appendix A.1

Increase in Hours (compared with 4 years ago)†

Increased Hours	N		M	SD	Range
	Valid	Missing			
Hours per day	636	649	1.85	1.26	1-5
Hours per week	592	693	20.97	19.60	0-80

†A breakdown of increase in work hours for work location, payment type, work schedule, construction classification, and job classification is provided in Appendix A.8

Commuting Time†

Commuting Direction	N		M	SD	Range
	Valid	Missing			
Minutes to work	1235	50	45.04	29.07	2-240
Minutes from work	1159	126	50.28	31.62	2-210

† A breakdown of commuting time (hours per day) for construction classification, work location, payment type, work schedule, and job classification is provided in Appendix A.4

Second Job†

Second Job	N	%
In construction industry	20	1.5
In other industry	36	2.8
No second job	1209	94.1
Missing	20	1.6

† Descriptive information on second job and second job in construction industry is provided in Appendix A.1

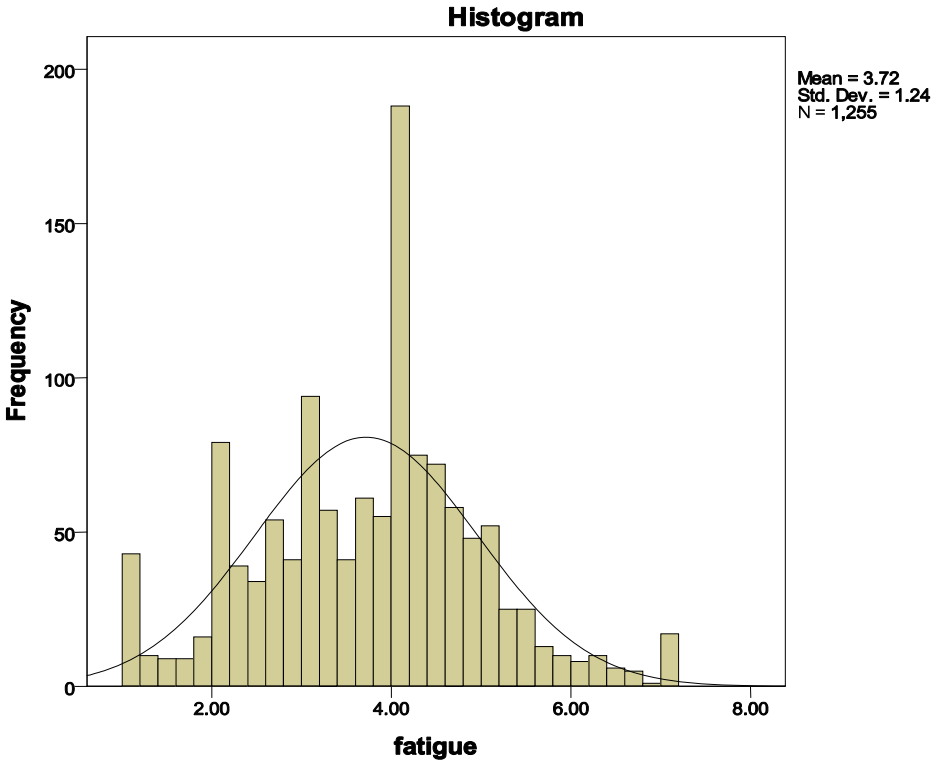
Section 4 - Fatigue

Fatigue Levels†

N		M	SD	Range
Valid	Missing			
1255	30	3.72	1.24	1-7

* likert rating scale of 1 (strongly disagree) to 7 (strongly agree), with midpoint 4 (neutral)

† A breakdown of fatigue levels for relationship status, English as first language, employment status, work location, payment type, work schedule, construction classification, length of work day, supervisory status, job classification, project size, second job, employee outcomes, near misses is provided in Appendix A.6



Fatigue Levels During the Day

Time Most Fatigued	N	%
Midnight – 2am	17	1.3
2am – 4am	20	1.6
4am – 6am	69	5.4
6am – 8am	111	8.6
8am – 10am	62	4.8
10 – Midday	132	10.3
Midday – 2pm	414	32.2
2pm – 4pm	581	45.2
4pm – 6pm	333	25.9
6pm – 8pm	106	8.2
8pm – 10pm	62	4.8
10pm – Midnight	33	2.6
Missing	9	0.5

* respondents could indicate more than one response
** % representative of the percent of total respondents (1278) who indicated each item.

Monthly Variations in Fatigue (due to weather)†

Month Most Fatigued	N	
	Most fatigued	Most rested
January	647	215
February	550	154
March	246	213
April	113	413
May	135	529
June	208	596
July	207	549
August	199	392
September	236	224
October	366	145
November	611	113
December	716	189
Missing	9	9

*respondents could indicate more than one response
† Descriptive information on monthly variations in fatigue is provided in Appendix A.9

Level of Sleepiness When Most Fatigued

N		M	SD	Range
Valid	Missing			
1120	165	5.43	1.66	1-9

* likert rating scale of 1 (extremely alert) to 9 (extremely sleepy), with midpoint 5 (neither alert or sleepy)

Attitudes towards Fatigue

Items	N		M	SD	Range
	Valid	Missing			
Fatigue is a problem in the construction industry	1203	82	4.98	1.45	1-7
Fatigue is a problem for me in my job	1194	91	4.15	1.57	1-7
Fatigue is being managed well in the industry	1178	107	3.32	1.42	1-7
I can manage my own fatigue levels	1195	90	4.75	1.32	1-7
Fatigue contributes to accidents at work	1192	93	5.72	1.34	1-7
I have good understanding and awareness of fatigue	1191	94	5.14	1.28	1-7
Fatigue is well understood as an industry issue	1188	97	3.83	1.68	1-7
Awareness of fatigue has changed over the last 5 years	1183	102	4.30	1.64	1-7

* likert rating scale of 1 (strongly disagree) to 7 (strongly agree), with midpoint 4 (neutral)

Relationship of Fatigue to Sample Characteristics

Sample characteristics measured on a continuous scale

Sample Characteristics	r	p
Age	**.068**	**0.017**
Number of children	-.023	0.430
Tenure in construction industry (months)	**.067**	**0.018**
Tenure with current organisation (months)	.036	0.208
Tenure in current worksite (months)	.041	0.159
Work hours per day (Monday to Saturday average)	**.145**	**<0.001**
Commuting hours per day	**.110**	**<0.001**
Work and commuting hours per day	**.183**	**<0.001**

*significant r-values and corresponding p-values are bolded

The results in this table demonstrate that:

1. Older employees, report more fatigue
2. Number of children is unrelated to fatigue
3. Tenure in the construction industry is associated with greater fatigue
4. Tenure with organisation and worksite is unrelated to fatigue
5. Work hours, commuting hours, and the resulting combination of hours were each significant (and positive) correlates of fatigue

Sample characteristics measured on a categorical scale

The results for the following sample characteristics are provided in Appendix A.6.

- Relationship status
- English as first language
- Employment status
- Work location
- Payment type
- Shift type
- Construction classification
- Length of work day compared to 4 years ago

- Supervisor status
- Job classification
- Project size
- Second job in construction industry
- Employee outcomes (categorised into low and high)
- Near miss at work

Differences in Sample Characteristics as a Function of Fatigue Levels

In this analysis, low and high fatigue groups of employees were compared on sample characteristics. Low and high groups were created using a median split on the fatigue variable. The median score was 3.909 on a scale from 1 to 7. Therefore, employees with fatigue levels ranging from 0 to 3.908 were assigned to the low-fatigue group and employees with fatigue levels ranging from 3.909 to 7 were classified as high-fatigue. A significant t-test indicates a significant difference in the mean values between the two groups.

Variable	Low fatigue			High fatigue			t	p
	N	M	SD	N	M	SD		
Age	597	34.95	11.70	600	36.70	11.96	**-2.55**	**0.011**
Number of children	576	1.39	1.53	578	1.34	1.43	0.57	0.567
Tenure in construction industry (months)	595	161.70	130.84	601	184.35	141.81	**-2.87**	**0.004**
Tenure with current organisation (months)	584	36.64	49.80	599	44.81	62.23	**-2.49**	**0.013**
Tenure in current worksite (months)	581	5.69	6.37	591	5.9	7.46	-0.51	0.610
Commuting hours per day	540	1.50	0.93	563	1.64	0.97	**-2.50**	**0.012**
Work hours per day (Mon - Sat average)	593	8.24	1.23	599	8.50	1.24	**-3.62**	**<0.001**
Work and commuting hours per day	529	9.74	1.54	554	10.14	1.55	**-4.30**	**<0.001**

*significant t-values and corresponding p-values are bolded

The results in this table demonstrate that:

1. Employees high on fatigue (compared to employees low on fatigue) are older
2. Employees high on fatigue (compared to employees low on fatigue) have a longer tenure in the construction industry and with their current organisation
3. Employees high on fatigue (compared to employees low on fatigue) spend more time working and commuting to and from work

Differences in Employee Outcomes as a Function of Fatigue Levels

In this analysis, low and high fatigue groups of employees were compared on employee outcomes. Low and high groups were created using a median split on the fatigue variable. The median score was 3.909 on a scale from 1 to 7. Therefore, employees with fatigue levels ranging from 0 to 3.908 were assigned to the low-fatigue group and employees with fatigue levels ranging from 3.909 to 7 were classified as high-fatigue. A significant t-test indicates a significant difference in the mean values between the two groups.

Variable	Low fatigue			High fatigue			t	p
	N	M	SD	N	M	SD		
Sleep disturbances	574	2.90	1.09	587	3.77	1.32	**-12.23**	**<0.001**
Headaches	574	2.33	1.15	586	3.07	1.49	**-9.50**	**<0.001**
Gastrointestinal problems	573	2.08	1.09	583	2.70	1.39	**-8.37**	**<0.001**
Respiratory Problems	563	2.07	1.01	576	2.59	1.24	**-7.70**	**<0.001**
Overall physical illness	574	2.38	0.76	588	3.08	1.02	**-13.30**	**<0.001**
Low anxiety and depression	579	5.16	1.09	590	4.20	1.20	**14.29**	**<0.001**
Social functioning	579	5.48	1.00	592	4.89	0.97	**10.23**	**<0.001**
Confidence	579	5.95	1.23	584	5.13	1.50	**10.19**	**<0.001**
Overall psychological well-being	579	5.45	0.82	592	4.70	0.86	**15.18**	**<0.001**
Job satisfaction	583	5.45	1.25	595	4.83	1.41	**7.99**	**<0.001**
Work-life conflict	575	4.12	1.54	582	5.34	1.22	**-14.93**	**<0.001**
Near miss at work	545	0.50	1.38	539	1.65	3.77	**-6.70**	**<0.001**

*significant t-values and corresponding p-values are bolded

The results in this table demonstrate that:

1. Employees in the high fatigue group report poorer physical health (overall physical illness, sleep disturbances, headaches, gastrointestinal problems, respiratory problems)
2. Employees in the high fatigue group report greater psychological health (higher scores on overall psychological well-being, low anxiety/depression, social functioning, confidence)
3. Employees in the high fatigue group are less satisfied with their jobs, experience greater work-life conflict, and report more near misses at work

Section 5 - Risk Factors and Employee Outcomes

In this section, descriptive data (i.e., means and standard deviations) are provided for (1) risk factors known to be predictive of fatigue and (2) a range of employee outcomes that can be affected by fatigue.

Risk Factors for Fatigue

Risk Factors	N		M	SD	Range
	Valid	Missing			
Work hours per day (Monday to Saturday average)	1235	50	8.37	1.25	3.29-17.58
Commuting hours per day	1153	132	1.56	0.95	.07-7.00
Physical effort[†]	1184	101	5.58	2.33	0-11
Alcohol consumption (standard drinks per day)	1036	249	2.91	3.71	0-40
Smoking activity (cigarettes per day)	1030	255	6.32	11.15	0-120

[†] A breakdown of physical effort for work location, payment type, work schedule, construction classification, and job classification is provided in Appendix A.7

Smoking status	N	%
Daily basis	388	30.2
Less than once a day	37	2.9
Never smoked	400	31.1
Ex-smoker	268	20.9
Missing	192	85.1

Employee Outcomes of Fatigue

Physical Illness

Variable	N		M	SD	Range
	Valid	Missing			
Sleep disturbances	1208	77	3.35	1.29	1-7
Headaches	1205	80	2.70	1.37	1-7
Gastrointestinal problems	1203	82	2.39	1.28	1-7
Respiratory problems	1181	104	2.33	1.16	1-7
Overall physical illness	1210	75	2.74	0.97	1-7

* likert rating scale of 1 (never) to 7 (always), with midpoint 4 (some of the time)

Psychological Well-being

Variable	N		M	SD	Range
	Valid	Missing			
Low anxiety/depression	1215	70	4.68	1.24	1-7
Social functioning	1219	66	5.18	1.03	1-7
Confidence	1208	77	5.54	1.42	1-7
Overall psychological well-being	1219	66	5.07	0.92	2.08-7.00

* likert rating scale of 1 (never) to 7 (always), with midpoint 4 (some of the time)

Job Satisfaction

Variable	N		M	SD	Range
	Valid	Missing			
Job satisfaction	1225	60	5.14	1.37	1-7

* likert rating scale of 1 (strongly disagree) to 7 (strongly agree), with midpoint 4 (neutral)

Work-Life Conflict

Variable	N		M	SD	Range
	Valid	Missing			
Work-life conflict	1199	86	4.73	1.51	1-7

* likert rating scale of 1 (strongly disagree) to 7 (strongly agree), with midpoint 4 (neutral)

Near Misses at Work

Variable	N		M	SD	Range
	Valid	Missing			
Near misses at work	1127	158	1.07	2.85	0-37

Section 6 - Relationships among the Variables

In this section, correlations are provided between fatigue and (1) risk factors known to be predictive of fatigue and (2) a range of employee outcomes that can be affected by fatigue. Correlations among the variables in the proposed fatigue model also are provided.

Correlations

Relationship of Risk Factors to Fatigue

Risk Factors	r	p
Work hours per day (Monday to Saturday average)	**.14**	**<0.001**
Commuting hours per day	**.11**	**<0.001**
Physical effort	.04	0.139
Alcohol consumption (standard drinks per day)	.06	0.055
Smoking activity (cigarettes per day)	-.01	0.729

*significant r-values and corresponding p-values are bolded

The results in this table demonstrate that:

1. Longer working and commuting hours are associated with greater fatigue
2. The positive relationship between alcohol consumption and fatigue was approaching significance

Relationship of Fatigue to Employee Outcomes

Employee Outcomes	r	p
Sleep disturbances	**.42**	**<0.001**
Headaches	**.36**	**<0.001**
Gastrointestinal problems	**.35**	**<0.001**
Respiratory problems	**.29**	**<0.001**
Overall physical illness	**.48**	**<0.001**
Low anxiety/depression	**-.51**	**<0.001**
Social functioning	**-.36**	**<0.001**
Confidence	**-.39**	**<0.001**
Overall psychological well-being	**-.53**	**<0.001**
Job satisfaction	**-.26**	**<0.001**
Work-life conflict	**.50**	**<0.001**
Near misses at work	**.24**	**<0.001**

*significant r-values and corresponding p-values are bolded

The results in this table indicate that:

1. Higher levels of fatigue are associated with more physical illnesses (sleep disturbances, headaches, gastrointestinal problems, respiratory problems)
2. Higher levels of fatigue are associated with poorer overall psychological well-being (lower scores on low anxiety/depression, social functioning, confidence)

3. The more fatigued an employee is, the less satisfied they are with their jobs, the more conflict between work and home life, and the greater the incidence of near misses at work

Table 1. Descriptive Data (Means and Standard Deviations) and Correlations among the Variables in the Proposed Fatigue Model
This table provides the average score (mean) and variation (standard deviation) for each of the variables in the proposed fatigue model. The strength of the relationship between variables is indicated by the correlation values.

Variables	M	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	35.82	11.90	-											
2. Alcohol consumption	2.91	3.71	.088**	-										
3. Smoking activity	6.32	11.15	-.030	.282**	-									
4. Work hours per day	8.37	1.23	.063*	.047	.108**	-								
5. Commuting hrs per day	1.56	0.95	.018	.035	.127**	-.027	-							
6. Physical effort	5.58	2.33	-.127**	.080*	.096**	.036	.074*	-						
7. Fatigue	3.72	1.24	.068*	.060	-.011	.145**	.110**	.043	(.95)					
8. Physical illness	2.73	0.97	-.062*	.101**	.088**	.089**	.105**	.119**	.479**	(.86)				
9. Psychological well-being	5.07	0.92	.098**	-.001	-.025	-.075**	-.082**	-.087**	-.531**	-.560**	(.86)			
10. Job satisfaction	5.14	1.37	.052	-.046	.012	.029	-.019	.000	-.256**	-.191**	.393**	(.96)		
11. Work life conflict	4.73	1.51	.080**	.065*	.025	.379**	.096**	.109**	.495**	.340**	-.383**	-.155**	(.94)	
12. Near misses at work	1.07	2.85	.013	.122**	.113**	.011	.075*	.148**	.236**	.265**	-.233**	-.053	.177**	-

Note. Cronbach's (1951) alpha coefficients for the multi-item variables are in parentheses along the main diagonal, suggesting all scales were considered to have high internal consistency.
*$p < .05$. **$p < .01$.

Results of Hierarchical Multiple Regression Analyses

To evaluate the proposed fatigue model, a series of hierarchical multiple regression analyses were conducted. These analyses involved three stages of analysis in order to evaluate the significance of the proposed mediated relationships. The 3-stage mediation procedure as outlined by Baron and Kenny (1986) was followed:

Stage 1: Regressing fatigue on the risk factors
Stage 2: Regressing the employee outcomes on the risk factors
Stage 3: Regressing the employee outcomes on both the risk factors and fatigue

The first requirement for significant mediation is that the risk factors should be significantly related to fatigue (Stage 1). The second requirement is that the risk factors should be significantly related to employee outcomes (Stage 2). The final requirement of mediation is that the effect of the risk factors on employee outcomes should significantly reduce (partial mediation) or disappear (full mediation) when included in the analysis with fatigue (Stage 3).

Stage 1
In Stage 1, fatigue was regressed on the risk factors (work hours, commuting hours, and physical effort) while controlling for the effects of age, alcohol consumption, and smoking activity.

Relationship of Risk Factors to Fatigue

Predictor			
	β	β	β
Step 1			
Age	.062	.052	.057
Alcohol consumption	.062	.061	.059
Smoking activity	-.027	-.055	-.057
R^2	.008		
Step 2			
Work hours per day (Monday to Saturday average)		.139***	.137***
Commuting hours per day		.116***	.114**
ΔR^2		.031***	
Step 3			
Physical effort			.037
ΔR^2			.001

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. The control variables of age, alcohol, and smoking activity were not significantly associated with fatigue (Step 1)
2. Of the risk factors, work hours per day and commuting hours per day were both significant positive predictors of fatigue (Step 2)
3. Physical effort (entered at Step 3) was unrelated to fatigue

Thus, the first requirement for mediation was met for work hours per day and commuting hours per day.

Stages 2 and 3
The following tables provide the results for Stages 2 and 3 of the mediation analyses for each employee outcome:

1. Overall physical illness (including the factors of sleep disturbances, headaches, gastrointestinal problems, and respiratory problems)
2. Overall psychological well-being (including the factors of low anxiety/depression, social functioning, and confidence)
3. Job Satisfaction
4. Work-life conflict
5. Near misses at work

Relationship of Risk Factors and Fatigue to Overall Physical Illness

Predictor				
	β	β	β	β
Step 1				
Age	-.069*	-.075*	-.063*	-.090**
Alcohol consumption	.090**	.090**	.083*	.056
Smoking activity	.060	.039	.033	.060*
R^2	.019***			
Step 2				
Work hours per day (Monday to Saturday average)		.087**	.083**	.019
Commuting hours per day		.100**	.094**	.040
ΔR^2		.017***		
Step 3				
Physical effort			.090**	.073*
ΔR^2			.008**	
Step 4				
Fatigue				.472***
ΔR^2				.214***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. Older employees report less physical illness (Step 1)
2. Employees who consume more alcohol report more physical illness (Step 1)
3. Of the risk factors, work hours per day and commuting hours per day were both significant positive predictors of overall physical illness (Step 2)
4. Physical effort (entered at Step 3) was positively related to overall physical illness
5. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant positive main effect on overall physical illness
6. When fatigue was entered at Step 4, work hours and commuting hours per day no longer predicted overall physical illness. Thus, the second and third requirements of mediation were satisfied for work hours per day (Sobel $z = 4.16$, $p = 0.00003$) and commuting hours per day (Sobel $z = 3.42$, $p = 0.0006$). The effect of these variables on overall physical illness was fully mediated by fatigue.

Relationship of Risk Factors and Fatigue to Sleep Disturbances

Predictor				
	β	β	β	β
Step 1				
Age	.025	.020	.029	.006
Alcohol consumption	.115***	.114***	.110***	.086**
Smoking activity	-.028	-.042	-.046	-.022
R^2	.013			
Step 2				
Work hours per day (Monday to Saturday average)		.071*	.068*	.012
Commuting hours per day		.058	.054	.007
ΔR^2		.008*		
Step 3				
Physical effort			.064*	.049
ΔR^2			.004*	
Step 4				
Fatigue				.411***
ΔR^2				.162***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. Employees who consume more alcohol report more sleep disturbances (Step 1)
2. Of the risk factors, work hours per day was a significant positive predictor of sleep disturbances (Step 2)
3. Physical effort (entered at Step 3) was positively related to sleep disturbances
4. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant positive main effect on sleep disturbances
5. When fatigue was entered at Step 4, work hours per day no longer predicted sleep disturbances. Thus, the second and third requirements of mediation were satisfied for work hours per day. The effect of work hours per day on sleep disturbances was fully mediated by fatigue (Sobel z = 3.98, p = .00006)

Relationship of Risk Factors and Fatigue to Headaches

Predictor				
	β	β	β	β
Step 1				
Age	-.176***	-.183***	-.171***	-.192***
Alcohol consumption	.025	.024	.018	-.003
Smoking activity	.076*	.056	.051	.072*
R^2	.038***			
Step 2				
Work hours per day (Monday to Saturday average)		.106**	.103**	.053
Commuting hours per day		.072*	.066*	.025
ΔR^2		.016**		
Step 3				
Physical effort			.085**	.072*
ΔR^2			.007**	
Step 4				
Fatigue				.360***
ΔR^2				.124***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. Older employees report less headaches (Step 1)
2. Employees who smoke more report more headaches (Step 1)
3. Of the risk factors, work hours per day and commuting hours per day were significant positive predictors of headaches (Step 2)
4. Physical effort (entered at Step 3) was positively related to headaches
5. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant positive main effect on headaches
6. When fatigue was entered at Step 4, work hours and commuting hours per day no longer predicted headaches. Thus, the second and third requirements of mediation were satisfied for work hours per day (Sobel $z = 4.08$, $p = 0.00004$) and commuting hours per day (Sobel $z = 3.37$, $p = 0.0007$). The effect of work hours per day and commuting hours per day on headaches was fully mediated by fatigue.

Relationship of Risk Factors and Fatigue to Gastrointestinal Problems

Predictor				
	β	β	β	β
Step 1				
Age	-.055	-.059	-.052	-.072*
Alcohol consumption	.069*	.070*	.066	.046
Smoking activity	.069*	.051	.048	.068*
R^2	.015**			
Step 2				
Work hours per day (Monday to Saturday average)		.032	.030	-.017
Commuting hours per day		.111**	.107**	.068*
ΔR^2		.013**		
Step 3				
Physical effort			.053	.040
ΔR^2			.003	
Step 4				
Fatigue				.343***
ΔR^2				.113***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. Employees who consume more alcohol report more gastrointestinal problems (Step 1)
2. Employees who smoke more also report more gastrointestinal problems (Step 1)
3. Of the risk factors, commuting hours per day was a significant positive predictor of gastrointestinal problems (Step 2)
4. Physical effort (entered at Step 3) was unrelated to gastrointestinal problems
5. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant positive main effect on gastrointestinal problems
6. When fatigue was entered at Step 4, the effect of commuting hours per day significantly reduced. Thus, the second and third requirements of mediation were satisfied for commuting hours per day. The effect of commuting hours per day on gastrointestinal problems was partially mediated by fatigue (Sobel $z = 4.04$, $p = 0.00005$).

Relationship of Risk Factors and Fatigue to Respiratory Problems

Predictor				
	β	β	β	β
Step 1				
Age	-.074*	-.079*	-.072*	-.088**
Alcohol consumption	.044	.044	.040	.023
Smoking activity	.084*	.072*	.069*	.086*
R^2	.016**			
Step 2				
Work hours per day (Monday to Saturday average)		.067*	.065*	.026
Commuting hours per day		.042	.038	.006
ΔR^2		.006		
Step 3				
Physical effort			.051	.040
ΔR^2			.002	
Step 4				
Fatigue				.286***
ΔR^2				.078***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. Older employees report less respiratory problems (Step 1)
2. Employees who smoke more report more respiratory problems (Step 1)
3. Of the risk factors, work hours per day was a significant positive predictor of respiratory problems (Step 2)
4. Physical effort (entered at Step 3) was unrelated to respiratory problems
5. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant positive main effect on respiratory problems
6. When fatigue was entered at Step 4, work hours per day no longer predicted respiratory problems. Thus, the second and third requirements of mediation were satisfied for work hours per day. The effect of work hours per day on respiratory problems was fully mediated by fatigue (Sobel $z = 3.91$, $p = 0.00009$).

Relationship of Risk Factors and Fatigue to Overall Psychological Well-being

Predictor				
	β	β	β	β
Step 1				
Age	.098**	.104**	.095**	.126***
Alcohol consumption	-.003	-.003	.002	.033
Smoking activity	-.021	-.002	.002	-.029
R^2	.010*			
Step 2				
Work hours per day (Monday to Saturday average)		-.081*	-.078*	-.005
Commuting hours per day		-.085**	-.080*	-.019
ΔR^2		.013**		
Step 3				
Physical effort			-.066*	-.046
ΔR^2			.004*	
Step 4				
Fatigue				-.537***
ΔR^2				.276***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. Older employees report greater overall psychological well-being (Step 1)
2. Of the risk factors, work hours per day and commuting hours per day were significant negative predictors of overall psychological well-being (Step 2)
3. Physical effort (entered at Step 3) was negatively related to overall psychological well-being
4. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant positive main effect on overall psychological well-being
5. When fatigue was entered at Step 4, work hours and commuting hours per day no longer predicted overall psychological well-being. Thus, the second and third requirements of mediation were satisfied for work hours and commuting hours per day. The effect of work hours and commuting hours per day on overall psychological well-being was fully mediated by fatigue (Sobel $z = -4.22$, $p = 0.00002$ for work hours per day, and Sobel $z = -3.44$, $p = 0.0005$ for commuting hours per day).

Relationship of Risk Factors and Fatigue to Low Anxiety/Depression

Predictor				
	β	β	β	β
Step 1				
Age	.022	.031	.018	.047
Alcohol consumption	-.003	-.003	.004	.033
Smoking activity	-.032	-.008	-.002	-.031
R^2	.002			
Step 2				
Work hours per day (Monday to Saturday average)		-.130***	-.126***	-.057*
Commuting hours per day		-.089**	-.083**	-.026
ΔR^2		.024***		
Step 3				
Physical effort			-.093**	-.074**
ΔR^2			.008**	
Step 4				
Fatigue				-.501***
ΔR^2				.241***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. Of the risk factors, work hours per day and commuting hours per day were significant negative predictors of low anxiety/depression (Step 2)
2. Physical effort (entered at Step 3) was negatively related to low anxiety/depression
3. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant negative main effect on low anxiety/depression
4. When fatigue was entered at Step 4, commuting hours per day no longer predicted low anxiety/depression, and the effect of work hours per day significantly reduced. Thus, the second and third requirements of mediation were satisfied for work hours and commuting hours per day. The effect of commuting hours per day on low anxiety/depression was fully mediated by fatigue (Sobel z = -4.14, p = 0.00003). And the effect of work hours per day on low anxiety/depression was partially mediated by fatigue (Sobel z = -3.40, p = 0.0007).

Relationship of Risk Factors and Fatigue to Social Functioning

Predictor				
	β	β	β	β
Step 1				
Age	.133***	.135***	.130***	.152***
Alcohol consumption	.003	.003	.006	.028
Smoking activity	.018	.027	.029	.007
R^2	.018**			
Step 2				
Work hours per day (Monday to Saturday average)		-.034	-.032	.019
Commuting hours per day		-.042	-.039	.004
ΔR^2		.033		
Step 3				
Physical effort			-.037	-.023
ΔR^2			.001	
Step 4				
Fatigue				-.377***
ΔR^2				.137***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. Older employees report greater social functioning (Step 1)
2. No risk factors were significantly related to social functioning (Step 2)
3. Physical effort (entered at Step 3) was unrelated to social functioning
4. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant negative main effect on social functioning
5. When fatigue was entered at Step 4, it was significantly related to social functioning. Thus, the second and third requirements of mediation were not satisfied for the risk factors. Work hours per day, commuting hours per day and physical effort were not related to social functioning.

Relationship of Risk Factors and Fatigue to Confidence

Predictor				
	β	β	β	β
Step 1				
Age	.046	.048	.047	.069*
Alcohol consumption	-.039	-.039	-.039	-.015
Smoking activity	-.052	-.040	-.039	-.062*
R^2	.007			
Step 2				
Work hours per day (Monday to Saturday average)		-.016	-.016	.038
Commuting hours per day		-.079*	-.078*	-.033
ΔR^2		.006*		
Step 3				
Physical effort			-.013	.002
ΔR^2			.000	
Step 4				
Fatigue				-.395***
ΔR^2				.149***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. Of the risk factors, commuting hours per day was a significant negative predictor of confidence (Step 2)
2. Physical effort (entered at Step 3) was unrelated to confidence
3. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant negative main effect on confidence
4. When fatigue was entered at Step 4, commuting hours per day no longer predicted confidence. Thus, the second and third requirements of mediation were satisfied for commuting hours per day. The effect of commuting hours per day on confidence was fully mediated by fatigue (Sobel z = -3.34, p = 0.0008).

Relationship of Risk Factors and Fatigue to Job Satisfaction

Predictor				
	β	β	β	β
Step 1				
Age	.059	.058	.060	.075*
Alcohol consumption	-.060	-.060	-.061	-.045
Smoking activity	.030	.032	.031	.016
R^2	.006			
Step 2				
Work hours per day (Monday to Saturday average)		.012	.011	.048
Commuting hours per day		-.021	-.022	.008
ΔR^2		.001		
Step 3				
Physical effort			.011	.020
ΔR^2			.000	
Step 4				
Fatigue				-.266***
ΔR^2				.068***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. No risk factors were associated with job satisfaction (Step 2)
2. Physical effort (entered at Step 3) was unrelated to job satisfaction
3. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant negative main effect on job satisfaction
4. When fatigue was entered at Step 4, it was related to job satisfaction. Thus, the second and third requirements of mediation were not satisfied for the risk factors. Work hours per day, commuting hours per day, and physical effort were not related to job satisfaction.

Relationship of Risk Factors and Fatigue to Work-Life Conflict

Predictor				
	β	β	β	β
Step 1				
Age	.076*	.054	.067*	.042
Alcohol consumption	.055	.053	.046	-.019
Smoking activity	.011	-.038	-.044	.020
R^2	.010*			
Step 2				
Work hours per day (Monday to Saturday average)		.369***	.365***	.304***
Commuting hours per day		.105**	.098**	.048
ΔR^2		.142***		
Step 3				
Physical effort			.096**	.079**
ΔR^2			.009**	
Step 4				
Fatigue				.440***
ΔR^2				.186***

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this table demonstrate that:

1. Older employees report more work-life conflict (Step 1)
2. Of the risk factors, work hours per day and commuting hours per day were significant positive predictors of work-life conflict (Step 2)
3. Physical effort (entered at Step 3) was positively related to work-life conflict
4. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue exerted a significant positive main effect on work-life conflict
5. When fatigue was entered at Step 4, commuting hours per day no longer predicted work-life conflict. The effect of work hours per day significantly reduced. Thus, the second and third requirements of mediation were satisfied for work hours per day and commuting hours per day. The effect of commuting hours per day on work-life conflict was fully mediated by fatigue (Sobel $z = 3.44$, $p = 0.0005$). The effect of work hours per day on work-life conflict was partially mediated by fatigue (Sobel $z = 4.20$, $p = 0.00003$).

Relationship of Risk Factors and Fatigue to Near Misses at Work

Predictor								
	Wald χ^2	Odds Ratio	Wald χ^2	Odds Ratio	Wald χ^2	Odds Ratio	Wald χ^2	Odds Ratio
Step 1								
Age	0.04	1.02	0.05	1.02	0.64	1.08	0.11	1.03
Alcohol consumption	8.25**	1.31	8.22**	1.31	7.99**	1.31	5.49*	1.28
Smoking activity	1.92	1.13	1.66	1.12	0.63	1.07	2.72	1.17
-2 Log likelihood		731.37						
Nagelkerke R^2		0.03						
Model χ^2		14.81**						
Step 2								
Work hours per day (Monday - Saturday average)			0.26	0.95	0.37	0.94	6.06*	0.77
Commuting hours per day			2.47	1.15	1.43	1.12	0.14	1.04
Δ -2 Log likelihood				2.75				
Δ Nagelkerke R^2				0.01				
Step χ^2				2.75				
Step 3								
Physical effort					27.68***	1.64	25.68***	1.69
Δ -2 Log likelihood						28.84		
Δ Nagelkerke R^2						0.06		
Step χ^2						28.84***		
Step 4								
Fatigue							64.06***	2.63
Δ -2 Log likelihood								80.99
Δ Nagelkerke R^2								0.08
Step χ^2								80.99***

*$p < .05$. **$p < .01$. ***$p < .001$.
Wald chi-square values denote the significance of the variable as a predictor.
Odds ratios greater than 1 reflect the increase in odds of the outcome (a near miss), with a one-unit increase in the predictor. For example, an odds ratio of 6 means that the likelihood of a near miss increases by 600% (6 people may suffer a near miss for every 1 person that does not)
Odds ratios less than one reflect the decrease in odds of that outcome (a near miss), with a one-unit increase in the predictor. For example, an odds ratio of 0.2 means that the likelihood of a near miss decreases by 80% (1 person may suffer a near miss for every 5 people that do not)

The results in this table demonstrate that:

1. Alcohol consumption increases the odds of a near miss at work by 130% (Step 1)
2. Neither work hours per day or commuting hours per day were associated with a greater likelihood of a near miss at work (Step 2)
3. Physical effort (entered at Step 3) was related to a 164% increase in the odds of a near miss at work (Step 3)
4. After accounting for the effects of the control variables and risk factors (Steps 1 to 3), fatigue was a significant contributor to the odds of a near miss at work (263%)
5. When fatigue was entered at Step 4, physical effort maintained a strong odds ratio on near miss at work. Thus, the second and third requirements of mediation were not satisfied for any risk factor. The effect of work hours per day, commuting hours per day, and physical effort on near misses at work was not mediated by fatigue.

Figure 1. The mediating role of fatigue on the relationship between work hours per day and employee outcomes. Please note that the control variables (age, alcohol consumption, and smoking activity) are not included in this figure.

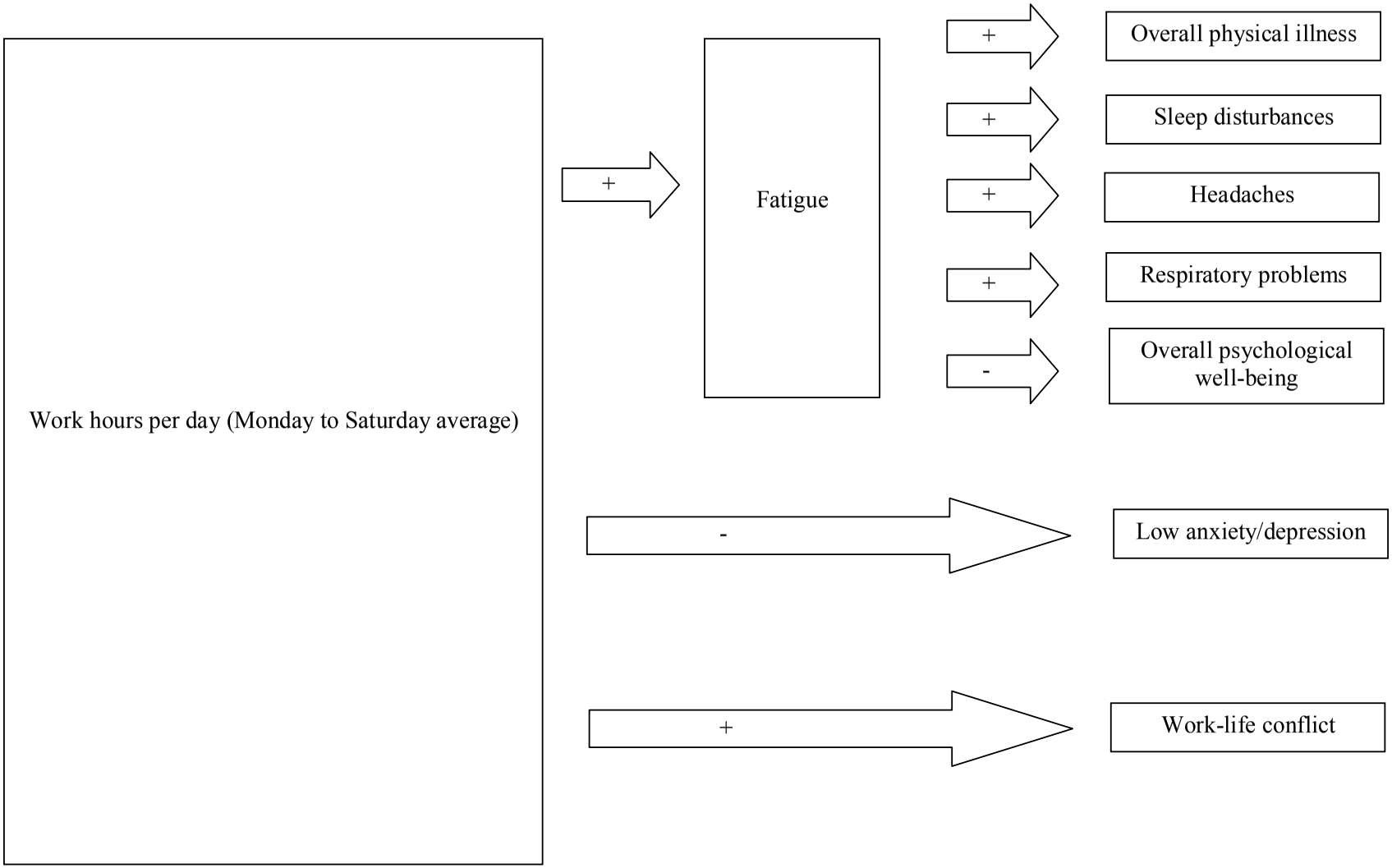


Figure 2. The mediating role of fatigue on the relationship between commuting hours per day and employee outcomes. Please note that the control variables (age, alcohol consumption, and smoking activity) are not included in this figure.

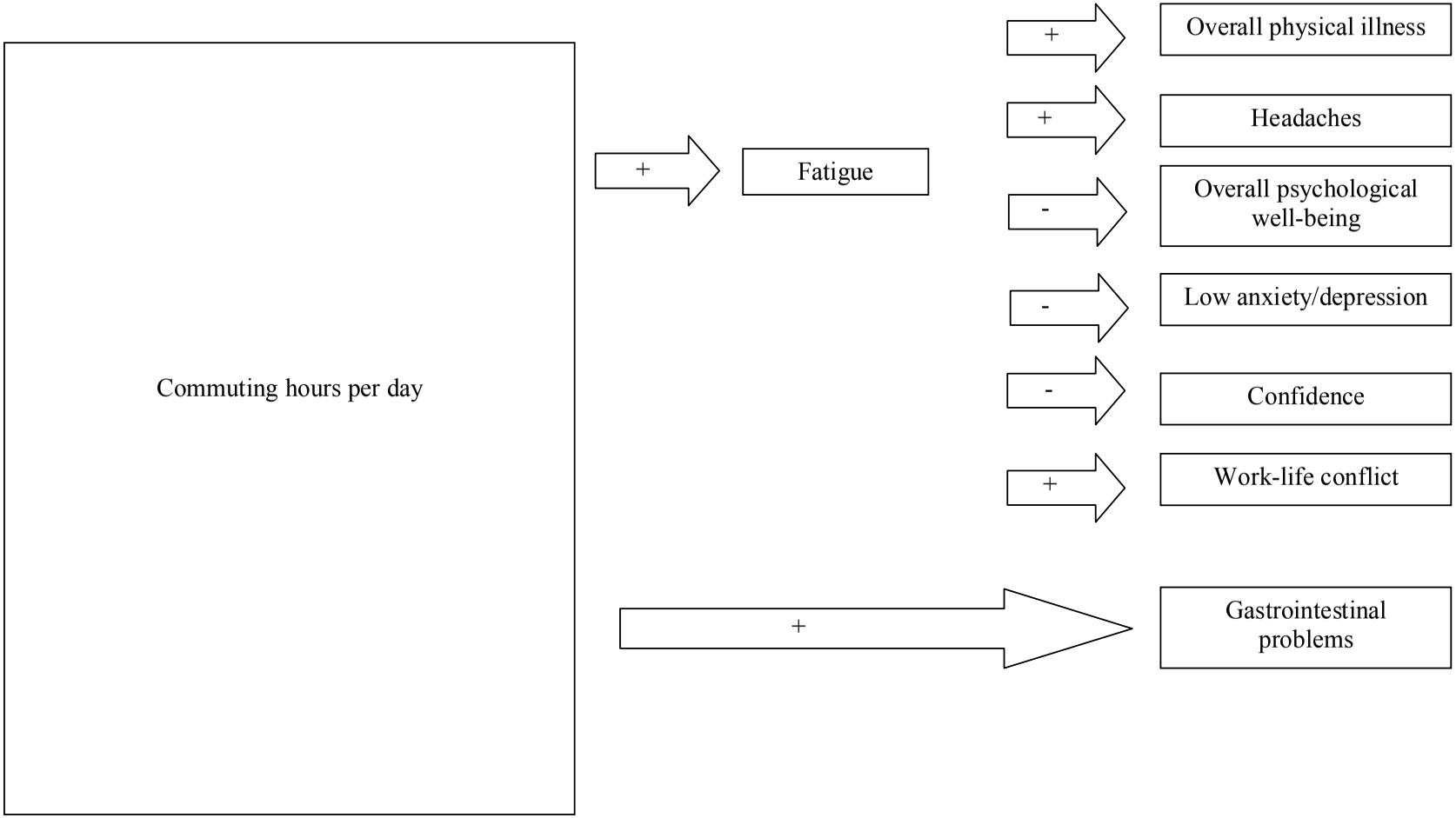
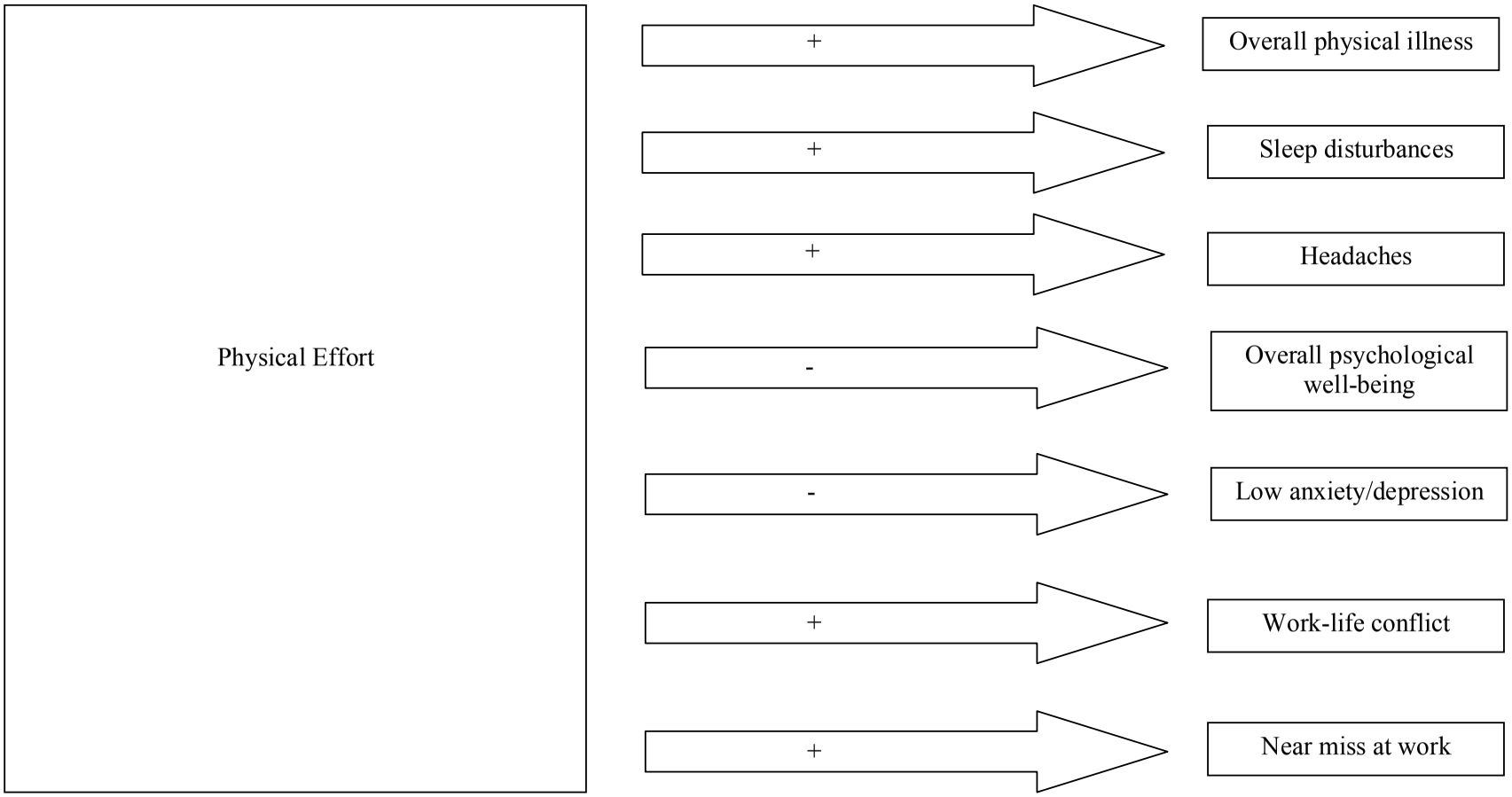


Figure 3. The effect of physical effort on employee outcomes. Please note that the control variables (age, alcohol consumption, and smoking activity) are not included in this figure.



Section 7 - Health Passport Data

Of the construction workers who were asked to provide health passport data, 186 employees returned a questionnaire. 128 employees provided such data on at least one of the following health indices.

Health index	N		Range
	Valid	Missing	
Systolic blood pressure	25	103	110-156
Diastolic blood pressure	24	104	60-102
Weight (in kg)	127	1	54-161
Height (in cm)	125	3	120-200
Body mass index (provided)	6	122	13.00-34.20
Body mass index (calculated)	124	4	16.80-49.69
Blood glucose	4	124	5.09-6.01
Low density lipoprotein	5	123	1.10-3.80
High density lipoprotein	3	125	1.35-3.90

Provided = provided by employees
Calculated = manually calculated with weight and height data based on the following formula: weight in kilograms divided by the square of the height in metres (kg/m^2)

Given the large amount of missing data, inferential statistical analyses could only be conducted for BMI (calculated).

Relationship of BMI to Sample Characteristics

Sample Characteristics	r	p
Age	**.29**	**0.001**
Number of children	.07	0.425
Tenure in construction industry (months)	**.23**	**0.010**
Tenure with current organisation (months)	.02	0.847
Tenure in current worksite (months)	-.01	0.913
Work hours per day (Monday to Saturday average)	-.00	0.995
Commuting hours per day	-.02	0.810
Work and commuting hours per day	-.02	0.846

*significant r-values and corresponding p-values are bolded

The results in this table indicate that:

1. Older employees have a higher BMI
2. Number of children is unrelated to BMI
3. Employees who have a longer industry tenure have a higher BMI
4. Organisation and worksite tenure are unrelated to BMI
5. Work hours per day and commuting hours per day, and the combination thereof are unrelated to BMI

Relationship of BMI to Fatigue and Employee Outcomes

Employee Outcomes	r	p
Fatigue	.05	0.589
Sleep disturbances	.01	0.899
Headaches	.04	0.704
Gastrointestinal problems	.07	0.425
Respiratory problems	.03	0.756
Overall physical illness	.05	0.570
Low anxiety/depression	.07	0.412
Social functioning	-.00	0.995
Confidence	.15	0.107
Overall psychological well-being	.05	0.552
Job satisfaction	-.14	0.121
Work life conflict	-.01	0.940
Near miss at work	-.04	0.688

The results in this table show that:

1. BMI was not related to any employee outcome. For this reason, regression analysis was not conducted.

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Appendix A - Supplementary Analyses

Additional results are provided in the accompanying excel spreadsheet. This spreadsheet contains 10 worksheets and a summary of the results in each worksheet follows:

A.1 General Demographics

The majority of the sample was:

- male (97.4%)
- partnered/married (69.6%)
- non-supervisory (72.7%)
- working in carpentry (24.6%)
- working either in large (30.0%) or major (33.2%) projects
- did not have a second job (94.1%)
- if they did have a second job, it was in the construction industry (64.3%)
- received wages as the payment type (82.1%)
- had English as a first language (93.7%)
- 46.9% worked longer hours per day compared to 4 years ago
- 50.7% did not work longer hours per day compared to 4 years ago
- 17.7% worked shorter hours per day compared to 4 years ago
- 76.8% did not work shorter hours per day compared to 4 years ago
- employed as a tradesperson (47.9%)

A.2 Work Hours per day

For employees who have one job (in the construction industry), the average work hours per day (Monday to Saturday average) was 8.4 hours.

Employees who worked significantly longer hours per day than the average included:

- Site preparation (9.3 hours)
- Concreting (9.0 hours)
- Carpentry (9.0 hours)
- Salaried workers (9.1 hours)
- Foreman (9.1 hours)
- Project/site manager (9.1 hours)
- Other manager (9.7 hours)

Employees who worked significantly fewer hours per day than the average included:

- Bricklaying (7.7 hours)
- Structural steel erection (8.0 hours)
- Plumbing (7.8 hours)
- Electrical (7.7 hours)
- Air-conditioning and heating (7.7 hours)
- Fire and security system (7.6 hours)
- Plastering and ceiling (8.0 hours)
- Employees who receive wages (8.3 hours)
- Tradespersons (8.2 hours)
- Apprentices (7.8 hours)
- Administrative (7.2 hours)

A.3 Work Hours per week

For employees who have one job (in the construction industry), the average work hours per week (Monday to Saturday average) was 50.1 hours.

Employees who worked significantly longer hours per week than the average included:

- Site preparation (55.9 hours)
- Concreting (54.0 hours)
- Carpentry (53.8 hours)
- Salaried workers (54.2 hours)
- Labourer (51.2 hours)
- Foreman (54.4 hours)
- Professional (52.7 hours)
- Project/site manager (54.4 hours)
- Other manager (58.1 hours)

Employees who worked significantly fewer hours per week than the average included:

- Bricklaying (46.1 hours)
- Structural steel erection (47.1 hours)
- Plumbing (46.5 hours)
- Electrical (46.3 hours)
- Air-conditioning and heating (46.2 hours)
- Fire and security system (45.6 hours)
- Plastering and ceiling (48.2 hours)
- Landscaping (42.3 hours)
- Employees who receive wages (49.5 hours)
- Tradespersons (49.0 hours)
- Apprentices (46.8 hours)
- Administrative (41.4 hours)

A.4 Commuting Time (hours per day)

For employees who have one job (in the construction industry), the average commuting time (hours per day) was 1.6 hours.

Employees who commuted significantly longer hours per day included:

- Bricklaying (2.5 hours)
- Air-conditioning and heating (2.0 hours)

Employees who commuted significantly fewer hours per day included:

- Plumbing (1.3 hours)
- Electrical (1.4 hours)
- On-site (office) employees (1.3 hours)
- Professionals (1.3 hours)

A.5 Work & Commuting Time (hours per day)

For employees who have one job (in the construction industry), the average work and commuting time (hours per day) was 9.9 hours.

Employees who worked and commuted significantly longer hours included:

- Site preparation (10.7 hours)
- Concreting (11.2 hours)
- Carpentry (10.5 hours)
- Salaried employees (10.6 hours)
- Employees on irregular shift (11 hours)
- Foreman (10.6 hours)
- Project/site manager (10.7 hours)
- Other manager (11.4 hours)

Employees who worked and commuted significantly fewer hours included:

- Structural steel erection (9.8 hours)
- Plumbing (9.1 hours)
- Electrical (9.1 hours)
- Fire and security system (9.4 hours)
- Employees who receive wages (9.8 hours)
- Tradespersons (9.8 hours)
- Apprentices (9.4 hours)
- Administrative (8.3 hours)

A.6 Fatigue

For the overall sample of employees, the average level of fatigue was 3.72 on a scale from 1 (strongly disagree) to 7 (strongly agree).

Employees who reported significantly more fatigue included:

- Employees working longer hours per day (4.0)
- Employees not working shorter hours per day (3.8)
- Employees who report higher physical illness (4.1)
- Employees who report lower psychological well-being (4.3)
- Employees who report low job satisfaction (4.1)
- Employees who report experiencing a near miss at work (4.4)

Employees who reported significantly less fatigue included:

- Structural steel erection (3.4)
- Employees not working longer hours per day (3.5)
- Employees working shorter hours per day (3.4)
- Employees who report lower physical illness (3.3)
- Employees who report high psychological well-being (3.3)
- Employees who report high job satisfaction (3.5)
- Employees who report not experiencing a near miss at work (3.4)

A.7 Physical Effort

For the overall sample of employees, the average level of physical effort was 5.58 on a scale from 1 (nothing at all) to 11 (maximal).

Employees who reported significantly more physical effort included:

- On-site employees (5.7)
- Employees who receive wages (5.8)
- Concreting (7.5)
- Bricklaying (7.5)
- Structural steel erection (6.7)
- Plastering and ceiling (6.5)
- Carpentry (6.1)

Employees who reported significantly less physical effort included:

- On-site (office) employees (4.0)
- Off-site (head office) employees (3.6)
- Salaried employees (4.3)
- Site preparation (3.7)
- Plumbing (5.1)
- Electrical (5.2)
- Air-conditioning and heating (4.9)
- Professionals (4.2)
- Administrative (3.2)
- Project/site manager (3.8)
- Other manager (4.3)

A.8 Increase in Work hours

For the employees who reported an increase in work hours per week compared to 4 years ago, the average increase in work hours per week was 21 hours.

No employees reported a significantly higher number of hours per week than the average.

Employees who reported a lower number of hours than the average included:

- Plumbing (16.2 hours)
- Air-conditioning and heating (12.8 hours)
- Plastering and ceiling (12.5 hours)
- Tradespersons (18.5 hours)

A.9 Monthly Variations in Fatigue

More than half of the sample (55.7%) reported that they felt most fatigued during the month of December.

A.10 Work Schedule

The vast majority of employees were employed on a regular daytime shift.

Appendix B - Glossary of Terms

Correlation Analyses

A correlation analysis is a method used to measure the degree of association between two variables. A positive correlation value indicates that where there is an increase in one variable, the other variable also increases. In contrast, a negative correlation value indicates that were there is an increase in one variable, the other variable decreases. It is important to note that correlations are sensitive to sample size such that a certain correlation value is more statistically significant for larger sample sizes compared to smaller sample sizes.

Test of significance: Independent groups t-test Analysis and related terms

The independent groups t-test analysis is a statistical method which evaluates whether there is a statistically significant difference between the sample mean of one group (i.e., the mean of the group of low fatigue employees) and the sample mean of another independent group (i.e., the mean of the group of high fatigue employees). A statistically significant difference means that the difference is unlikely to have occurred by chance (i.e., a highly improbable result). Statistical significance is evaluated through the computation of a *t*-value. A *t*-value (degrees of freedom) is calculated from the independent one-sample t-test, which is then compared to a probability distribution of other *t* values in order to obtain a probability or *p*-value.

Probability (*p*-value)

In statistical hypothesis testing, the *p*-value is the probability of obtaining a result at least as extreme as a given data point. Thus, the *p*-value reflects the statistical significance of the difference between the department and organisation mean, whereby smaller *p*-values indicate that the difference is more statistically significant. In the current analysis, statistically significant *p*-values are those that are equal to or less than .05, which means that the probability of obtaining that particular mean difference (and associated, computed t-value) is equal to or less than 5%. Smaller *p*-values include .01 and .001 which equate to a probability value of 1% or .1%, respectively.