Factors Causing Train Driver Fatigue: A Systematic Review

Sevty Auliani and Hardianto Iridiastadi
Faculty of Industrial Technology
Bandung Institute of Technology
Bandung, Indonesia
sevtyauliani@gmail.com, hiridias@vt.edu

Abstract

Fatigue is a factor that causes accidents in the railway industry. Understanding the factors that cause fatigue will minimize the risk of accidents. The objective of this study is to investigate the factors that cause fatigue when operating a train base on a literature review. The method of this study is based on the literature published by various sources. Then these reviews are grouped into several factors based on the odds ratio/p-value and concluded which factors influence the level of machinist fatigue. There were 6 articles reviewed. The results of this study indicate that the fatigue of the machinist when operating the locomotive is caused by factors related to the official and non-technical service. These factors are demographics, job characteristics, environment, lifestyle, trips to work, and sleep and rest. However, existing studies do not explain the type of train they studied (passenger train or freight train), especially freight train. This research can be used both for government, companies, and researchers to understand driver fatigue when operating a train so that strategies can be designed to minimize driver fatigue when operating a train.

Keywords
Fatigue, Train Driver, Literature Review.

1. Introduction
The fatigue of train driver while operating the train is one of the factors that can lead to an accident. According to the data from National Transportation Safety Committee (KNKT), in 2016, about 45% of accidents are caused by train drivers. This data corresponds with the American national data which stated that around 11-60% accidents are caused by the fatigue of train driver while operating the train. In addition, Edkins and Pollock (1997) also show that 75% of accidents while driving are caused by fatigue.

In addition to casualties, other impacts that must be accepted by the company include financial losses consisting of delays or cancellations of departures that result in ticket refunds, infrastructure damage, and trauma experienced by victims of the accident. An understanding of what factors affect fatigue can help companies or the government in identifying the causes of fatigue in machinists when operating fatigue so that later a strategy for mitigating accidents caused by fatigue can be determined.

Fatigue is defined as a biological drive for recuperative rest (Williamson et al, 2011). Some researchers have different concepts between sleepiness and fatigue. Philip (2005) concludes that fatigue and sleepiness are not identical. This is because sleepiness cannot explain every important performance aspect related to fatigue. Meanwhile, Williamson et al. (2011) think that sleepiness and fatigue are of one part. This definition is based on the understanding that fatigue can be overcome with sleep or rest. So, it can be said that fatigue is a combination of many types of dimensions, in which the outputs are in a form of physiological, psychological, and behavioural responses. This research uses the definition of Williamson et al. (2011) which said that sleepiness is a part of fatigue.

The fatigue of train driver while operating the train can be caused by many factors, whether it is occupational or non-occupational factors. According to Williamson et al. (2011) in general fatigue (sleepiness) is caused by 3 factors; times awake, time on task, and task-related factor. Times awake is related to the ability of a person to stay alert. The time on task factor is related to the circadian rhythm of the human body to rest at night. Work characteristics or task-related factors are the factors that related to the occupation itself, such as workload and work duration (Williamson et al., 2011)

Di Millia et al., (2011) mentioned in their writing that fatigue can also be caused by factors that are not related to work or rest, such as demographical factors. The variables that are included in the demographical factor are age, gender, socio-economic status, marital status, race, and ethnicity. Those factors indirectly influence fatigue, because the impacts are not felt immediately. Arking (1980) in his research said a person's physical ability will decrease when they reach the age of 45 or older.

The previously discussed factors apply in general cases that happen in general occupations. There is a very limited number of researches that discuss fatigue specifically on train driver, despite that train is one of the most commonly used modes of transportations. A better understanding of factors that influence fatigue will help decrease the risk of accidents. Because of that, this research will discuss what are the factors that can influence the fatigue of train driver while operating the train by using the study of literature. There are 6 articles published between 2017-2021 that will be reviewed in this research. The procedure for collecting articles in this study refers to the systematics rule of review of the University of Edinburgh and several other reviews of literature research. The results of this study are expected to be a reference for researchers or the government in identifying the causes of fatigue in machinists when operating trains so that accident mitigation strategies can be determined and can reduce the risk of fatigue.

1.1 Objectives

The objective of this study is to investigate factors that influence fatigue while driving locomotive through literature review from 2017 until 2021. The results of this study are expected to be useful for companies and the government in determining accident mitigation.

2. Literature Review

2.1 Definition of fatigue

Bridger (2008) defines fatigue as an unpleasant symptom where the body feels exhausted, resulting in a condition that disturbs the abilities and functions of the human body in normal capacity. Meanwhile, according to Pratt (2003), fatigue is a temporary inability, a decreased ability, or a strong reluctance in dealing with situations that are caused by excessive activities that have been done before, be it physical or mental activities. The medical world defines fatigue as a physical phenomenon, in which that phenomenon can be measured and quantified. In practice, fatigue can be measured by heart rate, blood pressure, arm strength, and other objective measurement tools (Di Milia et al, 2011). Besides those tools, fatigue can also be measured by using assignment simulation, such as sustained attention test (SAT), logical reasoning, and numerical aptitude (Rosa, 1991).

Unlike the previous writings which emphasize more on the physical aspect, Brown (1993) defines fatigue as a subjective experience to continue an ongoing work because of a decreased feeling in personal efficiency. This definition by Brown (1993) disregards the physical aspect of humans, only focusing on the human perspective aspect and ignoring the human physical condition. Another opinion on the definition of fatigue came from Williamson et al (2011), who define fatigue as a condition or biological drive for recuperative rest. Compared to other definitions which focused on either the physical aspect or mental aspect only, this definition has the advantage that it covers every aspect of fatigue, including mental and physical aspects.

According to Williamson et al (2011), fatigue can be overcome with sleep or rest. So, it can be said that fatigue is a combination of many types of dimensions, in which the outputs are in a form of physiological, psychological, and behavioural responses. Many researchers agree that sleepiness is a part of fatigue (Anund et al., 2013) because fatigue is a biological drive for rest. But, Philip (2005) concludes that fatigue and sleepiness are not identical. This is because sleepiness cannot explain every important performance aspect related to fatigue

Toomingas et al. (2012) classify fatigue into two big parts, which is physical fatigue and mental fatigue. Physical fatigue is a fatigue that is caused by physical energy expended through activities that require muscle work with the participation of the musculoskeletal, cardiorespiratory, and nervous systems. Physical fatigue is influenced by several important factors such as age, gender, job characteristics, anthropometry and worker fitness. Mental fatigue is a fatigue that is caused by mental activities or tasks, such as attention, memory, decision making, and communication. Mental fatigue usually appears when the activity or task given exceeds the limit of one's capacity.

3. Methods

3.1 Literature search and data management
Articles on this study were obtained from 3 electronic databases, including Science Direct, PubMed, and Google Scholar from January 2017 until December 2021 to identify factors causing fatigue among train drivers. The keyword used in the search engine is fatigue among train drivers. The procedure for collecting articles in this study refers to the systematics rule of review of the University of Edinburgh and several other reviews of literature research. Figure 1 shows the stage of this research.

3.2 Included and excluded criteria
The articles in this study focus on factors that caused train driver fatigue. The data in the article were obtained from experiments and field surveys. The simulator study is not selected in this paper because it does not represent the actual situation. To be qualified, the article had to:
- The object of the study is train drivers.
- Linked with fatigue among train drivers.
- Year of the article publication 2017-2021.
- Data collection through experiments and field surveys.
- Reported factors causing fatigue among train drivers.

3.3 Screening process.
The articles in this article are obtained based on keywords and using advanced features on search engines. Selected papers were re-selected based on title and abstract. The purpose of this stage is to carry out whether the papers per the question to be answered or not. After that, the papers are checked for duplicate papers. Then the selected papers are read in full to determine the appropriate paper.

3.4 Evaluation process
The selected papers were reviewed to determine the factors that affect train driver fatigue based on the significance value. The criteria for the significance value are as follows:
- Strong evidence = odds ratio (OR) >3; P-Value < 0.001
- Reasonable evidence = OR1-3; P-Value < 0.05
- Insufficient evidence = OR <; P-Value >0.05

4. Results

4.1 Literature search and evaluation
2.606 articles were collected from Science Direct (1.695), PubMed (80), and Google Scholar (867). After doing some more shortlisting based on the title and abstract, 47 journals were obtained, of which 16 are from ScienceDirect, 8 from PubMed, and 23 articles from Google Scholar. Then, those journals were reviewed once more. As a result, 2 journals are duplicates and 4 journals are not fully accessible. 45 journals were then reviewed to get the appropriate ones, and in the end, 6 papers are being reviewed. The steps of doing a literature review can be seen in Fig 1.

4.2 Factors causing driver's fatigue while operating locomotive
The collected articles consist of many types of data collection methods. Five articles are using questionnaire as their data collection method, and 1 article is using field experiment (Hardianto, 2021). Fan and Smith (2017) did a 2-phase research. The first phase is a large-scale survey that involves not only train driver, but every entity that is involved in train operation. This first research aims to find out the relationship between workload and fatigue level. The second phase studies how can workload influence fatigue by measuring driver's performance.

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│  Potentially relevant studies screened │
│     Science Direct = 1.659 articles    │
│        Pubmed = 80 articles            │
│        Scholar = 867 articles          │
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│           2.606 articles               │
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│    After abstract and tittle screening │
│     Science Direct = 16  articles      │
│        Pubmed = 8 articles             │
│        Scholar = 23 articles           │
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│     6 studies investigating factors    │
│    causing fatigue among train driver  │
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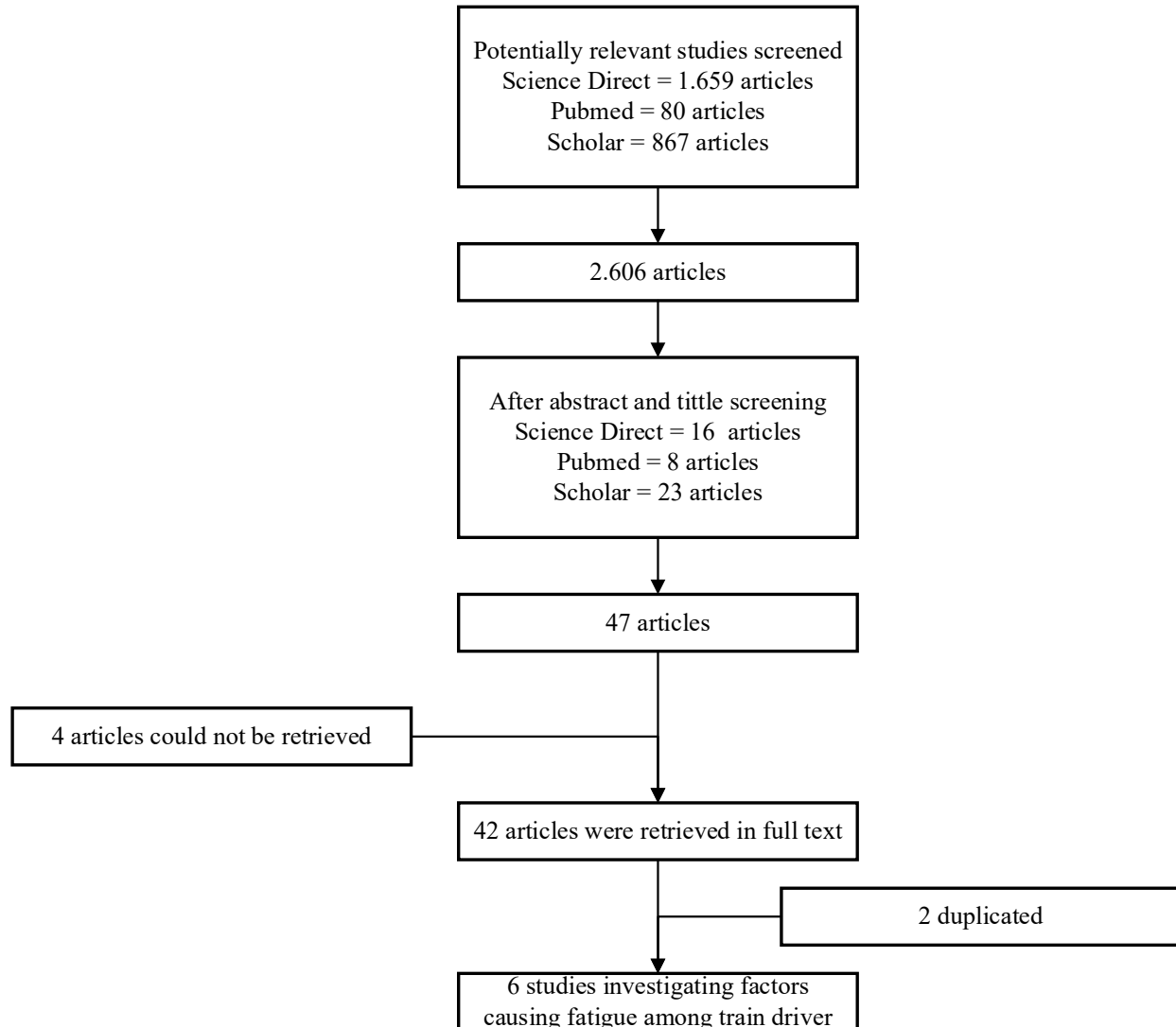
Figure 1. Stage of systematic literature review

Huang et al. (2019) and Irdiastadi (2021) did an experiment to find out the fatigue level of train drivers by conducting a field study. The data collection was done by following the train company's schedule so it does not interfere with the company's operational activities. There is a difference between those 2 journals regarding the work shift of the train driver's being researched. Huang et al. (2019) did their research on 3 work shifts, while Irdiastadi (2021) only researched 2 work shifts, morning and night. Huang et al. (2019) use a physiological approach based on heart rate availability. Meanwhile, Irdiastadi (2021) uses an approach based on the eye movement and fatigue level rating (Observed Rated Sleepiness).

Some of the previously collected articles show that fatigue can be caused by work-related factors as well as demographical factors. The factors that are proven to be not significant enough (P-Value>0.05) in influencing fatigue factors while operating the train are gender, fumes, length of shift, timing of shift, effort, sleep factor, and other activities. The factors that are significantly influencing fatigue are age, personality, lifestyle, job support and control, noise and vibration, shift work, and overtime work. Workload is the factor that influences fatigue the most. The list of those factors can be seen in table 1.

Many researchers argue that work shift influence the fatigue level of train driver, although the impact is not as big (Fan & Smith, 2017; Fan & Smith, 2019; Huang et. al., 2019; Iridiastadi, 2021). Two researchers said that the factor that most significantly influences train drivers' fatigue while operating the train is workload (Fan & Smith, 2017; Fan & Smith, 2019). There are two articles that stated that job support and control, over time, noise, and vibration, are statistically significant enough, followed by factors related to individual characteristics such as lifestyle and personality which also have a quite significant influence. Factors like gender, fumes, length of shift, and other activities are only supported by a single journal (Fan and Smith, 2019), and also are not significant enough in influencing fatigue. Figure 2. Represents the grouping of factors that influenced fatigue.

Table 1. Factors causing train driver's fatigue

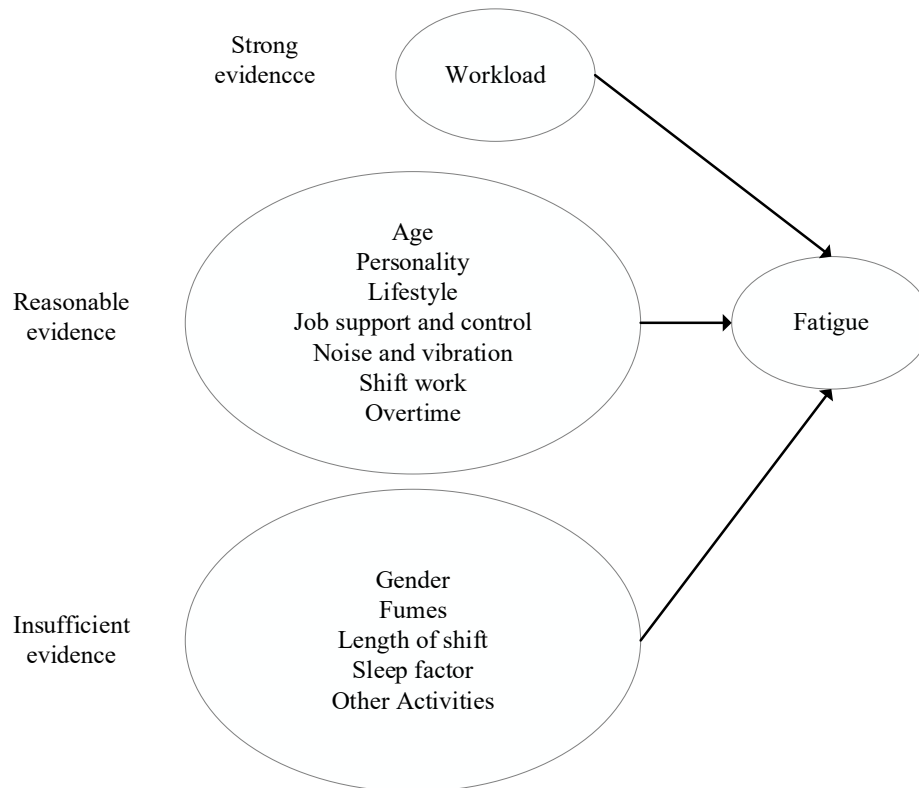| Factors	Strong evidence	Reasonable evidence	Insufficient evidence	Reference
Age		v		Fan and Smith (2017)
Gender			v	Fan and Smith (2017)
Personality		v		Fan and Smith (2017), Fan and Smith (2019)
Lifestyle		v		Fan and Smith (2017), Fan and Smith (2019)
Workload	v			Fan and Smith (2017), Fan and Smith (2019)
Job support and control		v		Fan and Smith (2017), Fan and Smith (2019)
Noise and vibration		v		Fan and Smith (2017), Fan and Smith (2019)
Fumes			v	Fan and Smith (2017), Fan and Smith (2019)
Shift work		v		Fan and Smith (2017), Fan and Smith (2019), Iridiastadi (2021), Huang et al. (2019)
Length of shift			v	Fan and Smith (2019)
Overtime work		v		Fan and Smith (2019)
Sleep factor			v	Fan and Smith (2019)
Other activities			v	Fan and Smith (2019)

Figure 2. Mapping of factor causing train driver's fatigue

4.3 Train driver's effort to stay alert

Cheng et al. (2019) in their research studies on how train driver overcome their fatigue while operating the train. The model used is based on the model that was developed by Dorrian et al. (2016). The result shows that 21% of drivers are not able to overcome their fatigue. Furthermore, the drivers that are single (not married) and those who have minimal work experience are more susceptible to fatigue.

5. Discussion

Fatigue is one of the most prominent factors of accidents in the railway sector. This research shows that fatigue can be caused by many factors, be it work-related or non-work-related factors. Workload is one of the work-related factors and has a quite significant impact that can influence fatigue. This shows that despite operating the train does not require a large number of activities, it still requires quite a lot of mental energy.

Non-work-related factors such as age, personality, and lifestyle are quite significant in influencing fatigue while operating the train. Those factors are indirectly influencing fatigue, considering that human performances are decreasing as they grow older (Di Milia et al., 2011). Besides, lifestyle choice such as drinking alcohol and fitness level can influence how someone copes with fatigue.

There are so many factors being discussed that can influence train driver's fatigue. Despite that, these factors are still limited to work, environmental, and demographical aspects. Other factors such as the trip to the workplace, the rest area comfort, or the locomotive cabin comfort need to be researched more on how it's influenced with fatigue level in the workplace. Furthermore, the journals reviewed in this article are limited only to a certain type of trains, such as high-speed rails or other local trains. Other types of trains such as freight trains need more research on how can it affect fatigue level, considering freight trains in some countries have different characteristics. For example, in Indonesia, where the freight train does not have a fixed schedule for work shift or work duration. This research aims to help researchers to be able to study more on the other factors that contribute to fatigue In addition, this research is also expected to be used as a reference in determining strategies for mitigating accidents caused by fatigue.

6. Conclusion

Fatigue is one of the factors that cause accidents when operating a train. Factors that significantly affect the occurrence of fatigue was workload. Further research is needed on other factors that influence accidents, such as the effect of service duration, travel to work, and the type of train.

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Biographies

Sevty Auliani earned her bachelor's degree in Industrial Engineering from University of Jenderal Achmad Yani, Indonesia. Her master's degree was obtained from Bandung Institute of Technology (ITB), Indonesia. She is a doctoral student in Bandung Institute of Technology, majoring in Industrial Engineering and Management. Her research Interest include transportational ergonomics, and cognitive ergonomics. She is a lecture in University of Buana Perjuangan Karawang, Indonesia.

Hardianto Iridiastadi earned his bachelor's degree in Industrial Engineering (IE) from Institut Teknologi Bandung (ITB), Indonesia. His master's and doctoral degree were obtained from Louisiana State University and Virginia Polytechnic Institute and State University, respectively. He is currently an Associate Professor within the Faculty of Industrial Technology at ITB. His research interests include occupational ergonomics, design of patient handling assistive device, and fatigue/workload in the transportation sector. He is a certified professional ergonomist (CPE), and was the President of the Indonesian Ergonomics Society. He has published a book entitled "Introduction to Ergonomics" (in Indonesian), a reference for undergraduate IE students.