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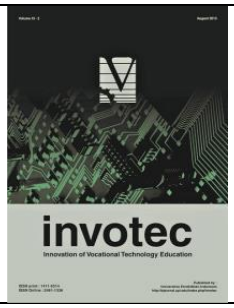

Driving toward wellness: The synergy of stress monitoring in shaping the illness wellness continuum for truck drivers

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ABSTRACT

There are numerous external costs associated with logistics that can potentially have an indirect influence on businesses or society as a whole. The purpose of this research paper is to provide an overview of the external costs related to the health of truck drivers and how it can potentially have a detrimental effect on supply chains. Truck drivers are vital contributors to the logistics and transportation sector and their role has a significant impact on the global economy. However, the demanding nature of their profession often leads them to neglect their own well-being and health, which in turn can have negative consequences for the drivers themselves, their companies, and the overall supply chains. This is a crucial issue that has unfortunately been largely overlooked in the existing literature on logistics and transportation. The objective of this paper is to identify the matter and propose a solution which involves monitoring the stress and fatigue levels of truck drivers in real-time using wearable device sensors and the Internet of Things. The aim is to create awareness within the logistics community and to encourage future research that can help mitigate the issues that may arise due to the presence of unhealthy truck drivers.

1. Introduction

Most individuals and commodities in Indonesia embark on their journeys through the vast network of roads that crisscross the nation. The trucking sector, with its unwavering strength, serves as the very foundation of the tangible goods economy. Nonetheless, the vitality and welfare of this aging labor force hangs precariously in the balance. Recent data reveals that careless drivers often contribute to traffic accidents. Every year, over 1.2 million individuals lose their lives on roads across the globe, making road traffic accidents the primary cause of mortality worldwide (Jelica Davidović et al., 2018). Indonesia is not exempt from this issue, as it faces a significant challenge concerning drivers on the road, particularly truck drivers. The identification of this problem arises due to Indonesia's recent rapid economic growth and urbanization. Consequently, the number of trucks on the road has experienced a substantial increase, with these vehicles primarily utilized for business purposes. As a result, truck drivers often experience fatigue from driving for extensive periods of time (Di Milia 2006; Romo et al., 2014). A disregard for the welfare of truck drivers could potentially impede the smooth operation of supply chains, as these individuals play a vital role in this process. Moreover, such negligence may exacerbate the existing shortage of truck drivers, as the adverse

impact of their work on their personal lives dissuades potential operators of commercial vehicles. When embarking on long journeys, especially during night time, truckers are more susceptible to becoming tired, which can lead to unintentional diversion of attention from the road ahead. This, in turn, results in delayed reaction times, slower responses to hazards, and even instances of falling asleep at the wheel. All these symptoms contribute to a decline in performance and heighten the probability of accidents (Chu et al., 2012). Hence, the occurrence of fatal road accidents remains a critical concern for society.

Previous studies have revealed that the characteristics of drivers significantly influence fatigue-induced truck accidents (Di Milia et al., 2013). The profession of truck driving often entails grueling working circumstances that encompass extensive working hours and demanding schedules (Arnold et al., 1997; Cœugnet et al. 2013), such as nocturnal driving and sporadic breaks, among others. According to the Ministry of Transportation's data (2021), Indonesia has witnessed a 12% occurrence of road traffic accidents in freight transportation, with human factors accounting for 61% of these incidents, which are intricately linked to the drivers' skills and temperament. Given these statistics, it becomes evident that a remedy is required to monitor and assess the state of truck drivers during their journeys. The solution to the problem of accidents in driving is to monitor activities in real time. Miller et al., (2020) said that truck drivers do not do good rest time management, claiming to be in a hurry because they overslept. As an effort to increase awareness of good quality rest, STOPIA (Stress Tracking of Person in Action) comes as a breakthrough or novelty that focuses on monitoring fatigue caused by stress in truck drivers. The solution offered can recognize the fatigue condition of truck drivers in real time by detecting stress fatigue using wearable device sensors and the Internet of Things. STOPIA is expected to reduce the number of traffic accidents that can harm many parties and provide comfort to truck drivers and the industry to be able to work more comfortably and safely.

2. Method

This article was written using the systematic literature review technique and qualitative methodology. Its duration will extend for a span of 10 months, commencing in the month of February and gracefully concluding in November of the year. Focus Group Discussions (FGD) and literature review are the key data collection methods. The author conducted a literature review by searching for online journals available in the Google Scholar database, Emerald, Science Direct, SCOPUS, IEEE, Wiley Online Library, etc. First, the articles obtained were determined by the year of publication, the theory used, the source journal, and others. First of all, the articles obtained were determined by the year of publication, the theory used, the source journal, and others. This article uses descriptive analysis to create a visual representation of the prevailing trends in the existing body of research on how stress impacts truckers, stress control to minimize accidents during distribution. As for the analysis, 20 articles were thoroughly synthesized to find the main sources of information for the research of this article. All articles in this stage had the same input measurements, output metrics, and theoretical adaptations. The following table 1 list the total search criteria and the results.

Table 1. Literature Review Output

Features	Service Quality in Industries	Coherence among Stress and Fatigue in Truckers during Distribution
Research Question	How stressed drivers can become an important aspect for the company?	Is there coherence between Stress and Fatigue in Truckers during Distribution and work performance?
First Screening	22	20
	*The impact of stress and fatigue on truck drivers significantly affects their performance and company operations.	
Second Screening	14	11
	**Stressed drivers hold a pivotal position within the company's framework, their impact surpasses individual well-being, as their performance intricately shapes both company operations and customer contentment. Stressed drivers are more prone to errors, leading to delayed deliveries, compromised service quality, and potential harm to the company's reputation.	

Final Screening	18
	***Following a full-text analysis, the three study contexts are taken into account collectively and either considered as an output or as a mediating or moderator variable. The study highlights the substantial effects of stress and exhaustion on truck drivers, significantly influencing their performance and the overall functioning of the company. Stress disrupts work efficiency by impeding concentration and decision-making abilities, while the effectiveness of drivers directly impacts delivery accuracy and service quality.

3. Results and Discussion

Fatigue or health problems can have serious consequences for both drivers and other vehicle operators on the road. One outcome is the occurrence of fatal crashes involving large trucks. Although fatigue and health problems were previously identified as external costs of logistics that directly affect truck drivers, the potential outcome of accidents and their significant impact on the well-being and health of both drivers and other road users makes it pertinent to this conversation. Although research in this area is lacking in order to achieve this goal, it is valuable to investigate past technological progress that has dealt with comparable problems, as demonstrated in table 2.

Table 2. Comparison of previous studies

TITLE	DISADVANTAGES
Habibi, A. M., Fariqi, M., & Anggriawan, R. 2020. Beware Alat Pendeteksi Kelelahan Berbasis Kecerdasan Buatan dengan Metode Pengolahan Citra untuk Mencegah Kecelakaan Berkendara. Jurnal Penelitian Transportasi Darat, 22(1), 37-46.	This tool is made using artificial intelligence and a camera and is managed through an application on a smartphone. This tool can slow down the speed of the vehicle temporarily. This tool has shortcomings, namely in detecting faces at certain angles.
Farahdina, U., & Pradana, R. L. 2019. GERING: Gelang Monitoring Tingkat Kelelahan Tubuh Berbasis Neural Network Terintegrasi Android Guna Menjaga Kesehatan Jantung. Jurnal Ilmiah Penalaran dan Penelitian Mahasiswa, 3(1), 161-176.	The tool made is used by people with heart disease on the hand and is in the form of a watch. The drawback is that this tool has a sensitive parameter level because it is intended for people with heart disease.

Stress monitoring can be accomplished by utilizing various physiological indicators such as heart rate, blood pressure, oxygen saturation, and body temperature. Numerous studies have concentrated on creating systems and algorithms for categorizing and predicting stress based on these indicators. Bhavani et al. proposed an architecture for health monitoring utilizing the Internet of Things (IoT), which integrates sensor data, data analysis, and machine intelligence to continually track and observe the patient's health condition. Talaat et al. examined the existing e-health monitoring system and suggested an algorithm for stress monitoring using wearable sensors. Vavrinsky et al introduced the concept of a telemedicine device for long-term monitoring of individuals in real-life situations, which includes monitoring physiological variables such as heart rate, respiration rate, body temperature, and blood pressure. Sakri et al. conducted a study on stress monitoring based on peripheral physiological indicators obtained from wearable sensors and evaluated the impact of inter-subject and inter-task variability on stress classification. Basjaruddin et al. developed a device that measures stress levels by analyzing vital signs, including heart rate, oxygen saturation, body temperature, and galvanic skin response. As for how stress can affect someone illness wellness continuum can be seen in figure 1 below.

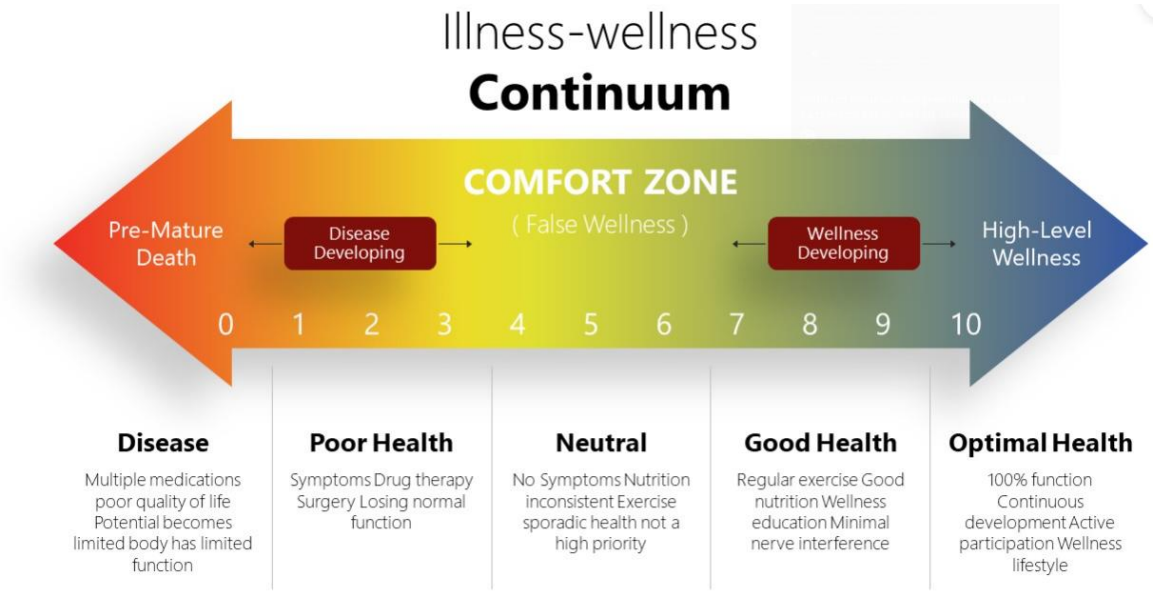


Figure 1. Illness Wellness Continuum Diagram

The concept of the illness wellness continuum pertains to the spectrum of health conditions that individuals can undergo, ranging from illness to wellness. It acknowledges that health is not solely the absence of disease, but rather encompasses mental well-being and overall quality of life. The continuum underscores the notion that health is influenced by a variety of factors, including individual attributes, as well as social, cultural, economic, political, and environmental factors. It proposes that healthcare professionals should prioritize the promotion of wellness and assist patients in progressing towards a heightened state of well-being through awareness, education, and personal development. The continuum also underscores the significance of categorizing illness based on clinical parameters for the purposes of risk stratification, as well as facilitating effective communication among healthcare providers. Furthermore, it posits that chronic and acute diseases are interconnected and that inflammation serves as a common parameter across all diseases. The relationship between monitoring stress and the illness wellness continuum is complex and influenced by various factors. Stress can have both positive and negative effects on health. Short-term stress has been shown to boost the immune system, while chronic stress can suppress the immune system and increase the risk of illness. Stress can affect the illness-wellness continuum by disrupting the body's homeodynamic balance and leading to maladaptive responses and compromised mental and physical health (Agorastos et al., 2021). Chronic stress can have long-term effects on health, especially in older or unhealthy individuals, and can contribute to the development of chronic diseases (Vasudha et al., 2023). Stressors have a major influence on mood, behavior, and health, and the relationship between psychosocial stressors and disease is affected by the nature, number, and persistence of the stressors (Bruce et al., 2006). Additionally, stress symptoms may be affecting health even if they are not recognized, and stress has been linked to a range of physical and mental health issues (Neil et al., 2005). Overall, stress can have a significant impact on the illness-wellness continuum, and managing stress is important for maintaining overall well-being [5].

Stress can arise from minor incidents, which are mostly harmless, as well as from major incidents, and it can have a direct and long-term impact on an individual's well-being. Consequently, it is essentially unavoidable that the majority of individuals will encounter stress, albeit on an occasional basis (McEwen BS et al., 2011). Depending on the origin of stress and its duration, it can exert both favorable and unfavorable effects on an individual (American Psychological Association, 2013). Truck drivers frequently consume substantial quantities of coffee, which can have detrimental effects on their blood sugar and blood volume. Stress induced by fatigue in average individuals typically manifests as a heart rate within the range of 101-110 beats per minute and a body temperature of 37.5-38°C, along with oxygen levels falling within the range of 80-90% (Farahdina et al., 2019). Insufficient proficiency in truck driving can lead to heightened stress when confronted with time constraints and the demands of loading and unloading cargo (Apostolopoulos et al., 2021;

Beilock, 2003). STOPIA (Stress Tracking of Person in Action) is a breakthrough that focuses on monitoring truck driver stress that can help businesses manage their employees. STOPIA uses a pulse reading system to determine the truck driver's heart rate and blood pressure, in this system a 0.3V 0.72µA pulse oxymeter sensor is used to read the pulse rate per minute. STOPIA also uses a system for reading oxygen levels and body temperature using a MAX30100 0.3V 0.72µA sensor (Z. Zhang et al., 2015). The sensor reading results can be displayed on the user's android as shown in Figure 2 below.

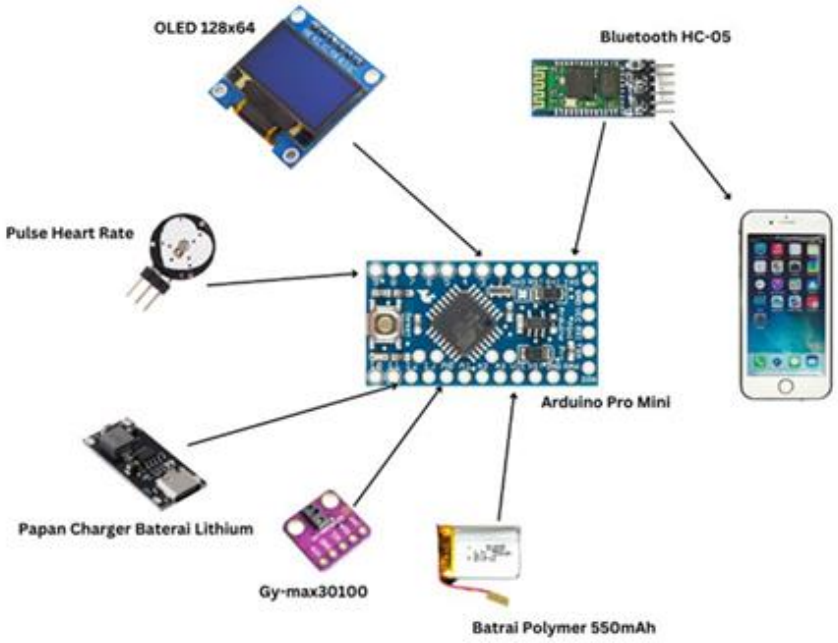


Figure 2. STOPIA Concept

Body monitoring in STOPIA is obtained from heart rate, blood volume pressure, temperature and oxygen levels. Heart rate is the pounding caused by the heart pumping blood throughout the body. The normal heart rate in humans ranges from 60-100 beats per minute, the human heart rate decreases between 10 and 30 beats per minute during sleep. A person's heart rate can be known through the pulse. Pulse rate is one of the physiological variables of the body that describes the body in a static or dynamic state. Blood pressure is the result of the pumping activity of the heart that takes place in contraction and relaxation. Normal adult blood pressure ranges between 120 mmHg systole and 80 mmHg diastole (Yusen et al., 2015). Blood pressure monitoring needs to be done to determine the condition of hypertension, hypotension and become a measure of stress in truck drivers while driving. Therefore, pulse rate is used as one of the indicators used to determine a person's fatigue level (Azizah et al., 2005). Wearable on STOPIA uses sensors that detect heart rate, blood volume pressure, and oxygen levels and temperature in the body. the data is obtained using sensors mounted on the wrist like a clock. To be able to use wearable system technology, the PKM team uses sensors consisting of Arduino mini pro for microcontroller as sensor support, Keyes XD-58C or PULSE HEART SENSOR which functions as a heart rate sensor (IC) and blood pressure, MAXIM GY-MAX30100 as a pulse oximeter detecting oxygen levels as well as body temperature, Bluetooth as a link from the device to android, and OLED as an indicator on the device (Wan J et al., 2017).

The sensors are integrated through an android or truck driver's device, the results of reading data on body temperature, pulse rate, and O2 levels in the blood can be received by the arduino mini pro then sent a microcontroller input signal to the android regarding body temperature data, pulse rate, and O2 levels. Processing sensor reading data to classify truck driver stress levels using Neural Network. Sensor readings will be identified by colour indicators in the application. The colour indicator is divided into 3 colours namely green, yellow and red. For the green colour case the truck driver is still in good shape and not yet exhausted. The yellow case indicates that the truck driver is getting sleepy and STOPIA will give a warning to stop every 3 minutes with a warning duration of 30

seconds. In the case of red, STOPIA will give an emergency alarm for 5 minutes, and if the alarm is not stopped by the 3rd minute, STOPIA will automatically warn the industry operator about the condition of their truck driver and also give an emergency call to the local authorities (police, hospital, etc.) if the alarm has lasted for 5 minutes.

During the 5-month manufacturing period. The prototype has been successfully worked on by 100% both from the start of the needs analysis stage to testing and troubleshooting. The prototype in the form of a truck driver stress monitoring system and android application product is currently in the finalisation stage for prototype launch. The resulting product specifications are as follows:

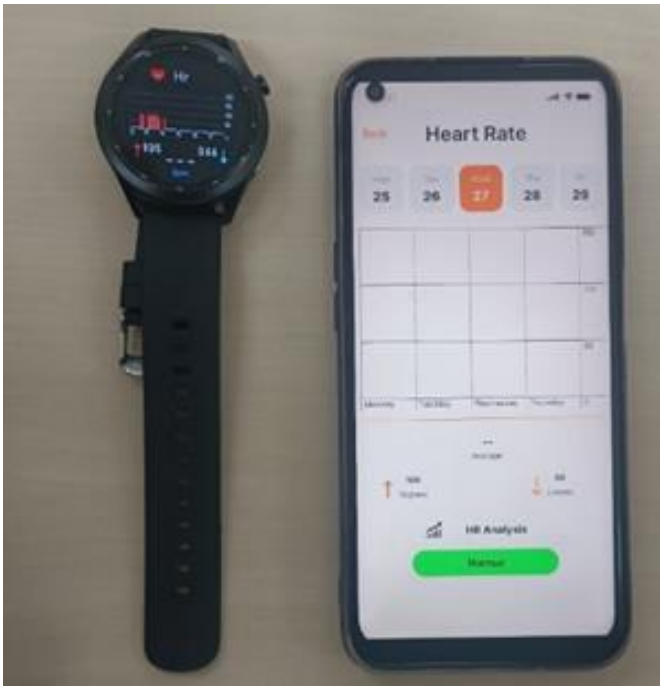


Figure 3. Prototype of STOPIA

a) Physical Product Specifications

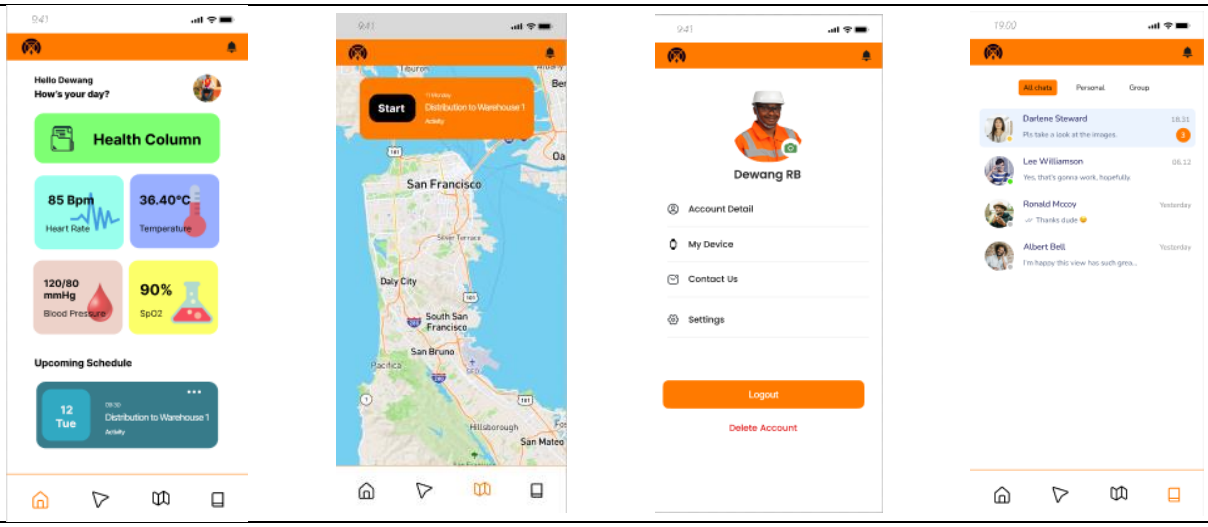
The clock prototype is made based on the STOPIA hardware system design, the following are the physical product specifications

1. Connectivity – Bluetooth 4.2 BR/EDR BLE and WiFi 4 2.4GHz 802.11 b/g/n
2. Display – 1.3-inch circular touchscreen LCD with 240×240 resolution (Model GC9A01)
3. USB – Micro USB
4. Sensor
   - 3-axis BMA423 accelerator, pedometer
   - QMC5883L 3-axis magnetometer, compass
   - Gy-Max 30100
   - MLX90614
5. Programming and debugging Via USB-C port using T-U2T USB to serial dongle
6. Misc -Reset button, Boot button, 2x user buttons, DS323M RTC, vibration motor
7. Power Supply
   - 5V/1A power input via USB Type-C port
   - 2-pin JST connector for the battery
   - Battery charging and discharging protection chip (MCP73831)

b) Application Product Specifications

The android application product consists of 4 main views, namely Load Screen, which is the initial display when opening the application, Home Screen, which is the display for entering user accounts, Menu Screen, which is a menu display consisting of the option "Status" to start monitoring truck driver stress, "Tracker" contains a real time record of truck driver activity, "Contact" this feature is a message feature to contact related parties, and "Account" to manage android application user information.

Table 3. Application of STOPIA



(a) (b) (c) (d)

4. Conclusion

The matter pertaining to the health and well-being of truck drivers has been extensively examined in the medical literature. However, there has been a dearth of research on this subject in the realm of business. The trucking industry and its drivers possess the capability to undertake measures to mitigate this issue. Nonetheless, it is imperative for businesses and researchers to allocate significant attention and resources towards addressing this deficiency. This is due to the fact that inefficiencies in the trucking sector can have adverse effects on firms, customers, and the overall economy. STOPIA offers a resolution in the form of a fatigue monitoring system for truck drivers, which employs sensors to measure pulse rate, blood pressure, body temperature, and oxygen levels. Said data is subsequently transmitted to the industry, with the purpose of notifying drivers in the event of drowsiness or stress. The key advantage of this technology lies in its real-time capability to identify bodily conditions and relay notifications to the industry, thereby facilitating enhanced truck driver management and mitigating the likelihood of accidents and the resultant insurance expenses.

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