D2.1

FitDrive Diary

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.

WP2 – Driver Behaviour / Impairment Causes Alignment

T2.1 – Classification of Professional Driving Roles and Associated Fatigue

D2.1 – FitDrive Diary

Contract number:	953432
Project acronym:	FitDrive
Project title:	Monitoring Devices for Overall Fitness of Drivers
Planned delivery date:	November 2021
Leading partner:	EPDA
Partners contributed:	AIPSS, EFA, ITCL
Document date:	29/11/2021
Version:	1
Subversion:	4
Deliverable type:	Report
Remarks:	
Status:	⦿ PU (Public) ○ PP Restricted to other programme participants (including the Commission Services) ○ Restricted to a group specified by the consortium (including the Commission Services) (please specify the group) ○ Confidential, only for members of the consortium (including the Commission Services

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Document Revision Log

Version	Subversion	Date	Description	Author
0	0	13/11/21	Draft	Sophie Lyons EPDA
1	0	17/11/21	Final First Draft	Kevin Hurley EPDA
1	1	21/11/21	First Review	Carlo Polidori AIPSS
1	2	22/11/21	Second Review	Manuel Picardi EFA
1	3	26/11/21	Process recommendations from reviews, formatting	Kevin Hurley EPDA
1	4	29/11/21	Final review and formatting	Rodrigo Sedano, Marteyn van Gasteren ITCL

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Executive Summary

Deliverable 2.1 aims to understand the roles of the professional driver along with the contributing fatigue factors. This deliverable consisted of a literature review including the classification of professional driving roles and associated fatigue. The review looks at the contributing factors to fatigue in the context of the professional driver. The FitDrive Diary was designed from this research and is designed to capture further information about the factors that cause fatigue and how they compare across different professional driving roles.

This deliverable will help the project partners select test participants to include drivers at various stages and type of fatigue. Fatigue is a major impairment experienced by professional drivers and is therefore important to identify.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

1.Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

2. The Classification of Professional Driving Roles and Associated Fatigue

2.1. Introduction

The following literature review consists of an in-depth evaluation of some of the academic works and reports available regarding professional driving roles and associated fatigue. Undoubtedly, addressing fatigue is imperative not only to the safety of the drivers employed by the transport industry but also to other road users, including vulnerable road users, and pedestrians. Fatigue is estimated to be the cause of approximately 20% of commercial road transport crashes (European Transport Safety Council 2001), and commercial vehicle accidents are a significant contributor to road accidents. A report by the Parliamentary Advisory Council for Transport Safety (2020) found that per distance travelled, vans and light goods vehicles are involved in more deaths of other road users than any other vehicle type, more even than Heavy Goods Vehicles (HGVs).

This review explains what fatigue is according to existing research, and the roles of professional drivers. The many causes of fatigue, how they can impact the driver and the risks associated are also investigated, as well as methods of identifying fatigue, and recommendations on potential interventions that can be undertaken to reduce the risk of fatigue among professional drivers.

2.2. Professional Driving Roles

2.2.1. The roles of a professional driver

There is no universal definition to describe the term 'professional driver'. The Road Safety Authority (RSA) of Ireland (2021) provide a broad definition of a professional driver as someone who earns part or all of their income from driving. Directive 2003/59/EC on the initial qualification and periodic training of drivers of certain road vehicles for the carriage of goods or passengers does not define a 'professional driver' as such but it does set out an appropriate classification of the term as:

> *"... 'drivers', engaged in road transport within the Community, on roads open to the public, using:*
>
> - *vehicles for which a driving licence of category C1, C1+E, C or C+E, as defined in Directive 91/439/EEC, or a driving licence recognised as equivalent, is required,*
> - *vehicles for which a driving licence of category D1, D1+E, D or D+E, as defined in Directive 91/439/EEC, or a driving licence recognised as equivalent, is required."*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

The abovementioned licence category drivers are more commonly known as truck or bus drivers and for the purposes of this review, most of the literature we examined concerned these groups of drivers.

The European Commission for Mobility & Transport (2021) report that the world-wide transport industry work practices include working long hours, lengthy night work, early starting times, working irregular hours and little or poor sleep. The European Commission for Mobility & Transport (2021) also cite Buxton, S. & Hartley, L. (2001) as finding that a great deal of truck drivers will work more than 12 hours per day, of which at least 60% of the time is usually spent driving. A common working week for many owner-drivers may consist of over 70 hours.

Professional driving can include multiple complex activities such as long-distance driving, the loading and unloading of trailers, physical lifting of heavy objects, complicated installations of a range of products both electrical and non-electrical, completing paperwork, interactions with customers, responsibility for the safe transportation of toxic and chemical goods, and inspections and maintenance of vehicles. These additional responsibilities increase the stressors that commercial drivers are exposed to.

According to the Road Safety Authority (RSA) (2021), all professional truck and bus drivers must undergo periodic training with an approved Certificate of Professional Competence (CPC) training organisation in order to obtain their driver CPC card. The Driver CPC programme is compulsory for all EU Member States. Drivers must complete 35 hours of periodic training every 5 years to keep their CPC card and to continue driving as a professional bus or truck driver. The RSA (2021) state that drivers have a responsibility to carry out a walk-around safety check of the vehicle before they drive it in a public place. They must ensure that the vehicle is roadworthy by a visual inspection of the condition of the interior and exterior of the vehicle. This is an efficient way of reducing potential risk to the driver and other road users. The driver must record and report any defects found and appropriate action must be taken before the vehicle is driven (for example, getting a mechanic to repair the defect). Through the Driver CPC programme, drivers are also encouraged to take responsibility towards the environment. Drivers are encouraged to practice eco-driving to reduce environmental damage and improve fuel efficiency for their employer.

2.2.2. Types of drivers

The European Commission for Mobility & Transport (2021) report that certain groups of drivers have a higher risk of being involved in fatigue-related crashes. These groups are young drivers (25 years and younger), professional drivers, long distance drivers, shift workers and drivers with sleeping disorders.

In the context of the professional driver, shift work or shift patterns tend towards irregular work schedules. Rather than working a set working shift, with start and finish times fixed and consistent throughout the week, many professional drivers work times are dependent on when

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

goods need to be delivered. Hege et al (2015) found that 82.7% of drivers reported that their daily schedules were irregular, 63.8% had irregularities in the number of hours they worked from one day to the next, and 32.3% experienced differences in their week-to-week schedule.

Research carried out by Hanowski (2000) explains that Local/short haul (L/SH) truck drivers primarily carry out trips that are 100 miles or less from the vehicle's home base. Long haul truck drivers make trips that are over 500 miles from the vehicle's home base. L/SH operations make up the largest segment of the trucking industry (approximately 90%). This includes light trucks. Hanowski (2000) further explains that the tasks of L/SH drivers are generally more extensive and varied than the task responsibilities of long-haul drivers. The main task for long-haul drivers is driving and they may only make one delivery per trip. In contrast to this, L/SH drivers typically make several deliveries in a single trip. As well as driving, L/SH drivers commonly carry out a variety of different tasks. For example, throughout the day, a L/SH driver may receive the day's driving schedule, load and unload the vehicle, get in and out of the vehicle multiple times, lift and carry heavy objects/packages, engage in customer relations, and perform other miscellaneous tasks. For L/SH drivers, driving is only one factor of their daily work schedule. Hanowski (2000) also found that another difference between L/SH drivers and long-haul truck drivers is that usually L/SH truck drivers start and finish their day's work in the same place every day. This allows them to return home after work and sleep in their own beds at night. In contrast, long-haul truck drivers may be driving on the road for numerous days or weeks at a time. They may have to drive and sleep at irregular times and often sleep in the cab of the truck or a sleeper berth during off-hours.

Rohani, Wijeyesekera & Karim (2013) explain that bus drivers play an important role in the transportation of commuting passengers, and highlight that between 1995-2000, buses and coach services were the second most popular form of transport in Europe after cars. There are different types of bus services available such as scheduled city and urban bus services, express bus services, shuttle buses, private buses, tour buses and school buses. The schedules and tasks involved vary with regards to the service being provided (Rohani, *et al.*,2013). Rohani explains that express bus services have less stops, use faster routes than the normal bus service and are usually intended for longer journeys. In contrast, shuttle bus services are usually small buses that make small journeys with a small number of stops, for example, an airport shuttle bus.

Anund, Fors, Ihlström & Kecklund (2018) explain that bus drivers often work split shifts or irregular hours, and their work includes high levels of stress. These factors can result in extreme fatigue and lead to dangerous driving. The study showed that shift-working bus drivers struggle to stay awake while driving.

Similarly, another recent study carried out by Miller, Filtness, Anund, Maynard & Pilkington-Cheney (2020) on London bus drivers found that 20.8% had to fight sleepiness while driving at least 2-3 times a week, as well as 36.6% reporting having had a close call due to fatigue. The

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

study found that the factors involved in causing fatigue were work (working 6 or more days without a day off), lack of sleep and personal factors such as poor health status.

The Road Safety Authority Ireland (RSA) (2008) reports that research has shown that people most likely to have fatigue-related collisions are:

- Night-time workers – particularly after the first night of a shift when the body has not adapted to the change in sleeping pattern.
- Lorry/truck drivers – this work can involve several risk factors such as long periods behind the steering wheel, shift work, physically demanding work and frequently driving during the peak times for fatigue-related collisions. These drivers may also be prone to sleeping disorders such as obstructive sleep apnoea which is mainly seen in males over 50 years old. Additionally, being out on the road all day can make it hard for drivers to maintain a healthy and well-balanced lifestyle. Truck drivers will often eat fast/comfort foods for convenience whilst working. These foods often tend to be high in calories and fats and while they give a quick feeling of fullness, they often do not provide the person with the adequate energy needed and can contribute to obesity and health issues if consumed regularly.
- Men – mainly those aged between 18-24 years old and 50+ years old. Generally young men do not admit to feeling tired and tend to push through and continuing driving while fatigued, while older men are more likely to fall asleep in the afternoon due to changes in the body rhythms.
- Skilled manual workers – Often these workers are required to drive long distances to get to the job, then perform physically demanding tasks over a long period and then drive back home again. This causes distinct problems as tiredness increases throughout the week.

Langan-Fox & Cooper (2011) explain that commercial driving includes a variety of professions such as bus drivers, long-haul drivers and pick up & delivery drivers. Each variety involves driving but they also have different additional tasks and responsibilities. These additional tasks increase the stressors to which the driver is exposed. The demanding work environment leads to driver fatigue and increases the risk of driver error and accidents. Each variant of driving profession has a different impact on the driver.

2.3. What is fatigue and how is it caused?

Engberg, Segerstedt, Waller, Wennberg & Eliasson (2017) state that fatigue lacks a universally accepted definition as it is multidimensional. However, they select one appropriate definition as:

> *"An unpleasant physical, cognitive and emotional symptom described as a tiredness not relieved by common strategies that restore energy. Fatigue varies in duration and intensity, and it reduces, to different degrees, the ability to perform the usual daily activities".*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Fatigue has also concisely been explained as the physical and mental impairment caused by a lack of rest over a period (Road Safety Authority, 2021). A study conducted by Wiegand, Hanowski & McDonald (2009) found that research shows that operational risk factors when assessing driver fatigue are listed as extended work and/or commuting periods, inadequate exercise opportunities, sleep deprivation and sleep disruption, poor diet/nutrition, and unpredictable work schedules. All of these factors contribute to health issues resulting from a sedentary lifestyle, increasing the risk of obesity and as a result, the potential for increased fatigue.

Fatigue is cumulative and increases over time. In the Driver Fatigue and Alertness Study (DFAS) conducted in the US and Canada, there was some evidence of cumulative fatigue across days of driving. In particular, mental fatigue is a gradual and cumulative process and is associated with unwillingness to put in effort, reduced efficiency and alertness and impaired mental performance (Grandjean, 1988 as cited in: Lal & Craig, 2001)

2.4. Factors that can affect fatigue

2.4.1. Gender

A study by Sagberg (1999) found that more males than females were involved in sleep-related driving accidents but that this seems to be largely explained by males driving relatively more than females on roads with high-speed limits. A total of 10% of male drivers and 4% of females admitted having fallen asleep while driving a vehicle during the previous year.

The president of the Women in Trucking Association, Volie (2016) states that in America, male truck drivers have made up approximately 94-96% of the trucking industry for the last 20 years. A study by Sicard (2012) also reports that the truck driving industry is male dominated with over 3 million Americans making a living from truck driving, only 6% of which are female.

According to the World Road Transport Organisation (IRU) (2021) globally, only 2% of truck drivers are women. The IRU (2021) mentions that there has been in a fall in numbers of women truck drivers however there was a rise in Europe regarding the rate of female bus and coach drivers which increased from 10% to 16% of the workforce in the year 2020. The IRU (2020) identify some of the reasons that deter women from the driving profession to be a lack of safe and secure parking areas, tough working conditions and long periods away from home.

According to the U.K National Health Service (2021) overweight middle-aged men are the most prone to obtaining sleeping disorders such as Sleep Apnoea which can cause fatigue.

2.4.2. Age

From the age of 20 people tend to become more alert and energetic in the morning time compared to the evening or night-time according to Randler, Freyth-Weber, Rahafar, Florez Jurardo & Kriegs (2016).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Research carried out by Kent-Braun, Ng, Doyle & Towse (2002) found that as a person gets older, the oxidative capacity in their muscles declines which can cause them to become physically fatigued more quickly than a younger person.

Dr.Mehra (2020) explains that testosterone is a hormone which is produced by the body, mainly in the testicles of men. Testosterone production naturally reduces as men age. Men can experience a variety of symptoms if production reduces more than it should. A sign of low levels of testosterone is feeling tired all the time.

The results of a study carried out in Finland by Summala & Mikkola (1994) showed that crashes involving truck drivers falling asleep at the wheel as a result of fatigue were mainly caused by young adult drivers. This result is interesting considering other research finds that fatigue is more likely to affect older people.

Similar results were reported in a study conducted by the Virginia Tech Transportation Institute (2005), which found that younger drivers were more at risk to fatigue-related crashes. The study postulated that lack of driving experience may be the primary reason younger drivers have fatigue-related crashes.

2.4.3. BMI

BMI (Body Mass Index) is a guide to determine if someone is a healthy weight for their height and is calculated by dividing a person's weight in kilograms by their height in metres squared (NHS 2019). For most adults, a healthy BMI is between 18.5 to 24.9. If a person's BMI is below or above this range, it may indicate that they are underweight or overweight. Being either underweight or overweight can cause a person to feel fatigued. An underweight person may not be getting enough nutrients and the energy they need from food to perform to their fullest, and the low energy levels can leave them feeling drained and fatigued. People who are underweight tend to get less sleep than others and their immune system tends to be weaker, making them vulnerable to disease and infections which in turn may cause fatigue (NHS,2019). An overweight person is carrying around extra weight that may be putting the body under strain and pressure. This can result in the body using up more energy than usual to facilitate basic tasks, leaving the person feeling fatigued or exhausted quicker than normal.

An Italian study carried out by Rosso, Perotto, Feola, Bruno & Caramella (2015) to investigate obesity amongst Italian professional drivers found that 61% of participants where either obese or overweight according to their BMI results.

The results of a study carried out by Wiegand, Hanowski & McDonald (2009) showed that there was a connection between BMI and driver fatigue. The study found that drivers in the obese category were at greater risk of driving with fatigue. The study also found that 53.4% of the drivers that participated were obese, in contrast with an obesity rate among the general US population of 34%. Similarly, another study in the US found 69% of commercial long-haul drivers to be obese in comparison with 31% of the adult working population (Sieber WK, Robinson CF, Birdsey J et al 2014). Furthermore, a 2010 study showed that overweight and obesity amounted

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

to 82% among a sample of professional drivers surveyed in Brazil (Luciane Cesira Cavagioni, Angela Maria Geraldo Pierin 2010).

A survey carried out by The European Professional Drivers Association (2018) on long-haul PSV (public service vehicles) and HGV (heavy goods vehicle) drivers in Ireland found a similar trend of increased overweight and obesity among professional drivers in comparison with the general population. The results showed that 92% of professional drivers were overweight or obese compared to 62% of the general population.

2.4.4. Medical Conditions

The NHS (2021) list ten illnesses known to cause fatigue, as follows:

- **Anaemia** which is an iron deficiency. This is a lack of iron in the system which is needed for the transportation of oxygen around the body. A lack of oxygen can result in fatigued cells.
- **Sleep apnoea** which is a closing or narrowing of the throat when a person is sleeping that constantly interrupts sleeping, causing the person to wake up regularly throughout the night and feel exhausted the next day. This condition is commonly found in overweight middle-aged men. The American Sleep Apnoea Association (2021) have reported that an estimated 22 million Americans suffer from this disease, with 80% of moderate and sever cases still undiagnosed. A study carried out by Wiegand, Hanowski & McDonald (2009) mentions that one of the main symptoms of Sleep apnoea is ESD. ESD is a disorder which causes a frequent compulsion to fall asleep at inappropriate times, even when the person has the will to stay awake. The study also mentions that there is extensive research that shows drivers with sleep apnoea are at greater risk of vehicle crashes.
- **An underactive thyroid** meaning you have too little thyroid hormone in your body causing you to feel tired.
- **Coeliac disease**, this is when a person's immune system reacts badly to gluten which in turn can cause fatigue. According to Coeliac UK (2021), in the UK 1 in 100 people have coeliac disease and many have not been diagnosed.
- **Chronic Fatigue Syndrome** is another illness that causes serve and disabling fatigue that goes on for at least 4 months.
- **Diabetes**, one of the main symptoms of diabetes type 1 and 2 is fatigue.
- **Glandular fever** is a common viral infection that causes fatigue. It is mainly common in young adults and can cause long lasting symptoms of fatigue even after the infection is cleared.
- **Depression** can drain a person's energy and effect sleeping patterns causing the person to feel fatigued during the day.
- **Restless legs syndrome** causes disruption to sleep and leads to poor sleep quality.
- **Generalised Anxiety Disorder** (GAD) is a constant uncontrollable feeling of anxiety that can make a person feel worried, irritable and tired.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

The above list is not exhaustive and other medical conditions may also contribute towards fatigue. Medication can sometimes make a person feel tired, such as blood pressure drugs and anti-depressants, Harvard Health (2017). Heart Disease can cause fatigue as it causes the heart to work less efficiently which can result in fluid in the lungs. This can cause a reduction in oxygen to the heart and lungs making a person feel fatigued and experience shortness of breath, Harvard Health (2017). The profession of driving is linked with an amplified risk of cardiovascular disease (Hirata, *et al.*, 2012).

Long COVID - for some people, COVID-19 (popularly known as coronavirus) can cause people to still have symptoms long after the infection has gone. This is called long COVID or post-COVID-19 syndrome. Some common long COVID symptoms are extreme tiredness (fatigue), difficulty sleeping (insomnia), lack of concentration, depression and anxiety. These symptoms can last for months (NHS, 2021).

Other health conditions are linked to fitness to drive such as eyesight, hearing, locomotor disability, epilepsy, other neurological conditions not identified above, renal disorders, and miscellaneous conditions. These conditions may not directly lead to fatigue but are risk factors for the professional driver and it was noted in a report by The International Commission for Driver Testing (2020) that fitness to drive testing regimes differ by country and there is no standard test across the Community to identify medical impairments.

2.4.5. Lifestyle and lifestyle choices

A study carried out in Australia by Ding, Gebel, Phongsavan, Bauman & Mermon (2014) found that long periods of driving was associated with a higher chance of smoking, obesity, lack of sleep, inadequate physical activity and poor physical and mental health in drivers. The study highlights driving as a potential lifestyle risk factor for public health.

Sleep is vital for optimal health. When a person is sleeping their body is repairing and reproducing cells for optimal performance and health. Sleep is also needed for sharpening memories, improving problem solving and decision-making skills. The American Academy of Sleep Medicine and Sleep Research Society (2015) state that regularly sleeping less than 7 hours per night is connected to negative health outcomes, such as weight gain and obesity, diabetes, hypertension, heart disease and stroke, depression, and increased risk of death. Sleeping less than 7 hours per night is also linked with weakened immune system function, increased pain, increased errors, impaired performance and greater risk of accidents (Watson, *et al.*, 2015). Stoohs et al (1995) as cited by Wiegand, Hanowski & McDonald (2009), found that in the United States of America 20% of truck drivers experience regular sleep disturbances.

A lack of physical activity can result in a person feeling fatigued. However, a fatigued person is not likely to be physically active since fatigue negatively impacts a person's motivation and energy levels. This negative loop can enhance itself. Encouragement of physical activity can help break the chain (Engberg, *et al.*, 2017). Sedentary behaviour such as sitting down for long periods of time has also been shown to increase fatigue (Engberg, *et al.*, 2017). A study carried out in

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Canada by Gorczynski, Edmunds & Lowry (2020) found that long haul truck drivers were too stressed, busy or tired to be active, or to learn about physical activity.

Alcohol use may also be a factor that leads to fatigue. The legal limit for professional drivers is 20 milligrams of alcohol per 100mls of blood. Not all EU Member States have the same limits and penalties for drink driving. However, 18 EU Member States apply lower blood alcohol levels for professional drivers (0.2). Harvard Health (2019) explains that alcohol has sedative affects which can make a person feel drowsy but in contrast, alcohol can also disrupt a person's quality and quantity of sleep. Several hours after the drowsy feeling from alcohol the alcohol can then raise the body's level of epinephrine, which is a stress hormone that speeds up the heart rate and usually stimulates the body, which can cause a person to wake up. Harvard Health (2019) goes on to mention that alcohol also relaxes the muscles in the throat. This relaxation can worsen sleep-related breathing issues and contribute to sleep apnoea. Furthermore, alcohol can cause the need to urinate throughout the night, resulting in disrupted sleep.

A recent study conducted by Kagabo, Thiese, Eden, Thatcher, Gonzalez & Okuyemi (2020) mentioned that truck driving is a profession with one of the highest smoking rates, with a study reporting that the occurrence of smoking amongst vehicle operators was 34% compared to 25% in the general working population. The study also mentioned that it has been reported that 51% of long-haul truck drivers' smoke. The study goes on to explain that research shows that tobacco is a stimulant that truck drivers use to keep themselves awake while driving and reduce stress. Furthermore, studies have also shown that cigarette smoking is related to disturbances in sleep. It has been shown that smokers have difficulties falling asleep, have daytime sleepiness and find it hard to maintain good sleep quality (Kagabo, *et al.*, 2020).

2.4.6. Diet

A lack of physical activity and a diet made up of saturated fats, refined sugars and processed food are two key factors behind the poor health status of truck drivers (Gilson, *et al.*, 2017). A healthy diet is vital to a person's overall general health as it supplies people with energy and nutrients needed to fight infection and disease. The World Health Organisation (WHO) (2020) state that an unhealthy diet and a lack of physical activity are the leading risks to a person's health.

The NHS (2019) describe a poor diet to be one that consists of eating large amounts of processed or fast foods that are high in sugar and fat, as well as drinking too much alcohol, eating out at restaurants regularly, eating larger portions than you need, drinking too many sugary drinks and comfort eating. The NHS (2019) also mentions that unhealthy eating habits can often cause obesity which in turn causes fatigue.

Eating foods that contain empty calories, meaning they contain little to no nutritional value, is of no benefit to a person other than fulfilling a feeling of hunger for a short amount of time or satisfying a craving. Empty calorie foods often tend to be addictive as they are high in sugar and salt. Examples of these foods are biscuits, cakes, crisps, chocolate, ice cream, butter and energy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

drinks (Kaur, 2019). The Glycemic Index Foundation (2021) explains that carbohydrates are an essential part of our diet as they provide the body and brain with the energy needed to perform efficiently. However, not all carbohydrates are of equal energy value. There are carbohydrates with a high glycemic index (HGI) and carbohydrates with a low glycemix index (LGI). The glycemic index (GI) is a tool used to measure how carbohydrates affect the blood glucose level in the body. HGI foods cause the blood sugar level to spike rapidly and then crash, whereas LGI foods have a slower absorption rate and longer digestion time, allowing for a slow release of glucose into the bloodstream. This prolongs the release of energy to the body and brain. LGI foods are shown to help improve energy levels, maintain weight and are beneficial for health issues such as diabetes. Examples of LGI foods are whole-grain products such as pasta, cereal and bread, as well as fruits. Examples of HGI foods are white bread and potatoes.

A study carried out in Finland found that professional drivers tend to snack. They also eat less fruits and vegetables and more salt and saturated fat than recommended for a healthy diet (Puhkala, *et al.*, 2016).

A study by Balieiro, Rossato, Waterhouse, Paim, Mota, & Crispim, (2014) showed that both daytime and night-time bus drivers had poor diets. However, Night-time workers had a higher risk of being overweight or obese. Night-time workers showed a higher intake of inappropriate foods and lesser intake of vegetables compared to daytime workers.

Recent research has also shown that diets high in snacks and animal proteins among professional drivers leads to more dangerous driving behaviour, compared with diets rich in staple foods and vegetables. The study suggests that fatigue could explain the contrast. (Yan Ge, Shanshan He, Yan Xu, Weina Qu 2021).

2.4.7. Ergonomics and the physical environment

The environment in which professional drivers operate can also increase the risk of fatigue-related accidents. Three common causes of truck driver accidents are the time of day, long hours of work and lack of sleep (Karwowski & Hartley, 2000).

A study carried out by Sagberg (1999) in Norway showed through logistic regression analysis that the following factors made additional substantial and independent contributions to the odds of sleep involvement in an accident: a dry road, high speed limit, high education, and few years of driving experience.

2.4.8. Stress

A study carried out by Useche, S., Cendales, B. and Gomez, V. in 2017 among Columbian bus drivers found that stress-related working conditions (job strain, social support and effort / reward imbalance) may be relevant predictors of risky driving in bus drivers, and that fatigue is the mechanism which links another kind of stress related to working conditions (job strain and low social support) with risky driving.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

2.4.9. Work characteristics – TOD (time of day)

A study carried out in Finland by Summala & Mikkola (1994) showed two distinct peaks in the time of day that car crashes occur. The first occurring between 12am-6am which was caused mainly by drivers 18 years to 20 years old. The second main time for crashes occurred in the late afternoon, primarily by drivers aged 56 years and older. According to the European Commission of Mobility & Transport (2021) in the US, approximately 20% of all accidents and fatalities concerning a long-haul truck happen between midnight and 6am, the peak period of driver fatigue.

Hartley (2000) explains that research shows that the driver's risk is approximately doubled when working between the hours 20.00 and 7.00. In addition, drivers that have worked for 11 hours or more (carrying out driving and non-driving tasks) also have approximately twice the risk of crashing between the hours of 8.00 and 19.00 compared to those who have worked less than 11 hours. For drivers that have worked more than 11 hours, the accident risk is nearly doubled again when driving between the hours of 20.00 and 7.00 compared to driving during the daytime. This research shows that both time of day and length of work have an impact on fatigue and increase the risk of an accident.

Research carried out by Hanowski (2000) indicated that the most important factor affecting fatigue was time-of-day due to circadian rhythm effects. The research showed that fatigue was most dominant during the late evening and at night (midnight to dawn). Similarly, research carried out by Davidovic, Pesic & Antic (2018) found that circadian rhythm, quality and quantity of sleep and work factors all have an impact on driver fatigue.

It has been shown that the time of day influences professional drivers' eating habits, with night-time workers eating less vegetables and more inappropriate foods than day-time workers. Night-time workers were also more likely to be overweight/obese, which in turn can cause fatigue (Balieiro, *et al.*, 2014).

2.5. The effects fatigue can have on a professional driver and the risks involved

Harvard Health (2017) state that fatigue can cause a lack of concentration, trouble remembering things and staying alert. These are three vital tasks that need to be carried out when driving a vehicle and any impairment on them can result in major devastation to both the driver and other road users.

According to the European Commission for Mobility & Transport (2021), fatigue leads to a decline in driving performance, resulting in slower reaction time, reduced steering performance, weakened ability to keep a safe distance between the vehicle in front, and increased tendency to mentally withdraw from the driving task. The European Commission for Mobility & Transport also state that fatigue can cause a reduction in motivation to carry out tasks, the communication

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

and interaction with the surroundings to deteriorate, and can cause one to get irritated faster and react more aggressively towards people and things. The European Commission for Mobility & Transport also found that worldwide survey reports show that over half of all professional drivers drive while feeling fatigued or drowsy at least once a year.

The Road Safety Authority of Ireland (RSA) (2008) state that drivers that are sleep deprived are at risk of falling asleep at the wheel which substantially increases their chances of crashing the vehicle. According to the RSA, approximately 1 in 5 deaths on Irish roads every year are contributed to by driver fatigue. Across Europe at least four thousand people are killed on the roads every year due to driver fatigue. They also state that fatigue-related crashes are 3 times more likely to result in serious injuries and fatalities due to the high impact speeds and the lack of avoiding reactions. These collisions normally occur between either 2am-6am or 3pm to 5pm, as the body rhythm is at a natural low point, causing reaction time to be slower and the driver to be affected by fatigue.

It has been recorded that in 2015 in America 400,000 trucking accidents took place with the main driver impairment being either that they were asleep or fatigued. The second most common cause of trucking accidents was distraction and/or inattention (Wise, *et al.*, 2018). A lack of concentration, alertness and attention have all been described as consequences of fatigue.

Research carried out by Sikander and Anwar (2018) showed that a survey in Canada reported that 20% of fatal collisions were as a result of driver fatigue. The research also showed that in Pakistan, 34% of fatal road accidents were related to fatigue, 20% of fatal road traffic accidents in the US involved a drowsy driver, and in the EU, 20% of commercial transport accidents are connected to fatigue.

Being awake for 17 hours or more has a similar effect on a driver's performance as having a blood alcohol level of 0.5 (Queenstown Government, 2021). Between 2015 and 2019 at least 12% of all fatal road crashes in Queenstown were fatigue-related (Queenstown Government, 2021).

A study in Indonesia carried out by Zuraida & Abbas (2020) showed that road accidents in Indonesia that have a high fatality rate regularly involve intercity buses. Most of these accidents are mainly caused by driver fatigue.

The results of a study in Ontario carried out by Vanlaar, Simpson, Mayhew & Robertson (2008) indicate that relatively unsuccessful measures such as opening a window or turning on the radio are the most popular choices when trying to fight fatigue and the most effective preventive measure - taking a rest - was recorded to be the least popular option for drivers.

2.6. Methods of identifying fatigue in individuals

There is no universally agreed upon method for identifying fatigue in individuals, and the various methods available are divided broadly into subjective measures and objective measures.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Subjective measures include questionnaires such as Multidimensional Assessment of Fatigue, Visual Analogue Scale, the Medical Outcomes Study Short Form 36-item, Functional Assessment of Chronic Illness Therapy Fatigue scale (FACIT-F) and Fatigue Severity Scale.

Fatigue may include a reduction in eye movement, muscle response and brain activity (Wise, *et al.*, 2018) and therefore objective measures such as blink rate and EEG may also be used to detect fatigue. A study by Zhang & Zhang (2010) shows that the detection of percentage time of eye closure can be used to monitor driver fatigue more accurately than nonlinear eye tracking.

The warning signs of tiredness are as follows (Queenstown Government, 2021).

- yawning
- noticing your eyes closing for a moment or going out of focus
- blinking more than usual
- feeling drowsy, tired or exhausted
- having trouble keeping your head up
- forgetting the previous few minutes of driving
- starting to 'see' things
- droning and humming in ears
- general tiredness
- stiffness and cramps
- aches and pains
- daydreaming
- experiencing slower reaction times
- changing speed without reason
- fumbling for gear changes
- drifting in the lane or over lane lines.

Some of these warning signs can be measured objectively. Simulated driving scenarios can measure participant signals such as yawning, eye movement / closure, fumbling for gear changes and lane drift.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

3. Conclusions

In conclusion, the research carried out for this literature review shows that amongst professional drivers, insufficient sleep, poor health status, working conditions and negative psychological states may all have an impact on driver performance, driver fatigue and increased risk of accident.

There are numerous factors that play a role in the onset and cause of driver fatigue. Each professional driver is a unique individual with different factors affecting their levels of fatigue (for example, if they are a smoker, their age and BMI). The type of work being carried out (for example, long-haul trucking driving, local short haul driving and public transportation) also have unique factors that may lead to fatigue (for example, workload, numerous responsibilities, public interactions, working hours and split shifts).

The research available also shows that there are different types of driving roles which may have their own work-related conditions that impact on fatigue, for example bus-drivers dealing with the public are more likely to display emotional fatigue. We have broadly categorised the different driving roles and their associated fatigue as follows:

Driver Category	**Nature of Work**	**Potential Fatigue Impact**
Local Multi Drop Driver	Physical, Stressful	Physical & Emotional Fatigue
National Driver	Monotonous	Mental Fatigue
International Driver	Monotonous	Mental Fatigue
National Coach Driver	Monotonous, Stressful	Mental Fatigue
Scheduled Bus Driver	Stressful	Emotional Fatigue

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

4. Recommendations

Studies suggest that professional driver fatigue is a huge problem across the globe. The effects of driver fatigue are detrimental to the lives of the professional drivers and other road users. Research shows that a large portion of professional drivers do not lead a healthy lifestyle and are at risk of several health complications. The work-related conditions of the professional transportation industry, such as long working hours, strict time constraints, high levels of workload and poor resting periods, all play a role in causing or exacerbating poor driver health and driver fatigue. The conditions of the truck driving industry such as social isolation, excess fatigue, and stress, facilitate truck drivers' substance use of tobacco which in turn causes sleep impairments among other health defects. These results validate the need of lifestyle-intervention programs for these professional drivers.

Several recommendations are suggested based on the research that was undertaken.

- Encourage individuals to obtain adequate sleep durations and educate them on the importance of adequate sleep for their own health, and the safety of others.
- Educate professional drivers on the dangers of driving while fatigued and the factors that can cause fatigue (for example, obesity, diet, alcohol).
- Educate drivers on the warning signs of fatigue and how to prevent it.
- Efforts to identify professional drivers with Sleep Apnoea or other sleeping disorders is essential as treatment would reduce health risks such as cardiovascular disease, hypertension, and diabetes as well as reducing the risk of fatigue on the roads.
- All professional drivers should be educated on the importance of a balanced, healthy diet and on how to make healthier food choices.
- Professional drivers, such as truck drivers should be encouraged to primarily choose LGI foods instead of HGI foods as part of their daily carbohydrate intake. This will help maximise energy levels and reduce the risk of driver fatigue on the roads.
- Other healthy practices for eating should be followed:

- Don't overeat. Portion control meals.
- Take time to eat. Don't rush meals in between other tasks. This will give the body time to send signals to the brain letting it know it has had enough food to function properly.
- Cut down on snacking. Unhealthy snacking can increase hunger. Choose small healthy snacks such as a piece of fruit.
- Avoid emotional eating. Binge eating is unhealthy and using it to relieve sadness, stress or anxiety can be detrimental to a person's health. Healthier alternatives should be used to address emotions.
- Chose LGI foods instead of HGI foods for longer lasting energy.

- Encourage drivers to reduce and if possible quit smoking. This will aid in their overall health status and levels of fatigue.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

There is a need for a change in the transportation industry's lack of wellbeing for employees with regards to workload, working hours and stress levels. All of these factors play a huge role in the contribution to professional driver fatigue. Irregular work schedules are common within the transport industry, and it is within the remit of employers to plan more structured work timetables and provide a reasonable workload. If positive changes were made in these aspects, then driver burnout and fatigue levels would be reduced.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

5. Further Research

The existing literature we examined provided valuable insight into fatigue risks among subsets of drivers, such as bus drivers, long-haul drivers, and others. These studies investigated the nature and prevalence of fatigue among these driver subsets. We did not discover any study comparing fatigue risks among these subsets.

To account for this, we have designed a survey to better understand how the different types of driving roles may impact some of the identified fatigue risk factors. The factors chosen were:

Diet: dietary habits may vary among the different driver groups, for example long haul drivers may be more prone to snacking than other groups.

Age: different driving groups may display variations in age distribution. In addition, age would be expected to play a role in certain other criteria such as BMI and sleeping habits and this will be investigated.

Medication: medication may lead to fatigue and this factor will be investigated.

Sleep: research found that different groups of drivers may have different sleeping habits, for example the L/SH driver sleeping in their own bed at night. This question will help determine the sleeping habits for the various groups of drivers.

Irregular shift-times and work patterns: scheduled bus drivers (inter-city) often work split shifts, as do international drivers. National drivers often begin shifts at differing times during the day. This question is included to assist categorise these roles and whether shift-work can impact other fatigue-related risks.

Physical activity: this question will determine whether there is any difference in the physical activity levels between the driver groups. We expect local multi drop drivers to have a greater level of physical activity while at work due to the nature of the role.

The diary will be distributed to twenty drivers in each of the five driver groups in the Republic of Ireland. The scope of the survey is limited to a relatively small group to meet the aims of the FitDrive project. However, the survey could be used as the basis for more wide-ranging research across the Community in the future.

Participants will be selected from companies the European Professional Driver Association have knowledge of and employ the types of drivers we are seeking to survey. This includes local transport companies, international transport companies, coach operators and national semi-state transport companies.

Each driver will complete the diary for fourteen days. Instructions on how to complete the diary are provided but there will also be telephone contact from the European Professional Drivers Association to ensure the diary is being completed by the driver on a regular basis and to offer support should any questions require further explanation. Each driver will be distributed with

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

two diaries – one to keep at home and one to keep in their vehicle, to ensure the driver has daily access to the diary.

Ethical considerations are particularly relevant for the question regarding medication. It is expected some respondents may not be comfortable providing this information and the diary instructions explain that this question should only be answered where the respondent feels comfortable in giving a response. The diary also includes a section explaining the purpose of the survey, how the results will be used and seeking consent from the respondent. Examples of the diary pages are included in Annex I – FitDrive Driver Diary.

At the end of the fourteen-day period, the diary will be collected. The home diary and vehicle diary will be collated, and each respondent will be allocated a numerical indicator. The data will be entered into a spreadsheet for each numeric indicator. The data will then undergo quantitative analysis and these results will be presented to the FitDrive project group.

The results of this survey may indicate if certain categories of drivers are more at risk of experiencing fatigue-causing factors than others.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

6. References

Anund, A., Fors, C., Ihlström, J. and Kecklund, G. (2018). An on-road study of sleepiness in split shifts among city bus drivers. *Accident Analysis & Prevention*, 114, pp.71-76.

Balieiro, L., Rossato, L., Waterhouse, J., Paim, S., Mota, M. and Crispim, C. (2014). Nutritional status and eating habits of bus drivers during the day and night. *Chronobiology International*, 31(10), pp.1123-1129.

Cavagioni, L. and Pierin, A., (2010). Hypertension and obesity among professional drivers who work transporting loads. *Acta Paul Enferm*, 23(4), pp.455-460.

Coeliac UK. (2021). Is it coeliac disease? [online] Available at: <https://www.coeliac.org.uk/galleries/28/> [Accessed 12 October 2021].

Davidović, J., Pešić, D. and Antić, B. (2018). Professional drivers' fatigue as a problem of the modern era. *Transportation Research Part F: Traffic Psychology and Behaviour*, 55, pp.199-209.

Ding, D., Gebel, K., Phongsavan, P., Bauman, A. and Merom, D. (2014). Driving: A Road to Unhealthy Lifestyles and Poor Health Outcomes. *PLoS ONE*, 9(6), p.e94602.

Engberg, I., Segerstedt, J., Waller, G., Wennberg, P. and Eliasson, M. (2017). Fatigue in the general population- associations to age, sex, socioeconomic status, physical activity, sitting time and self-rated health: the northern Sweden MONICA study 2014. *BMC Public Health*, 17(1).

European Professional Drivers Association. (2018). *2018 Report on the Health Survey of long-haul PSV and HGV drivers*. [online] Available at: <https://epda.ie/health-epda/> [Accessed 8 October 2021].

European Professional Drivers Association. (2020). *Health - epda - European Professional Drivers Association*. [online] Available at: <https://epda.ie/health-epda/> [Accessed 3 November 2021].

European Transport Safety Council. (2001). The role of driver fatigue in commercial road transport crashes. [online] Available at: <https://etsc.eu/wp-content/uploads/The-role-of-driver-fatigue-in-commercial-road-transport-crashes.pdf> [Accessed 23 November 2021]

Ge, Y., He, S., Xu, Y. and Qu, W. (2021). Effects of dietary patterns on driving behaviours among professional truck drivers: the mediating effect of fatigue. *Occupational and Environmental Medicine*, 78(9), pp.669-675.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Gilson, N., Pavey, T., Wright, O., Vandelanotte, C., Duncan, M., Gomersall, S., Trost, S. and Brown, W. (2017). The impact of an m-Health financial incentives program on the physical activity and diet of Australian truck drivers. *BMC Public Health*, 17(1).
Glycemic Index Foundation (2021). [online] Available at: <https://www.gisymbol.com/low-gi-explained/> [Accessed 22 October 2021].

Gorczynski, P., Edmunds, S. and Lowry, R. (2020). Enhancing physical activity knowledge exchange strategies for Canadian long-haul truck drivers. *International Journal of Workplace Health Management*, 13(2), pp.139-152.

Hanowski, R., (2000). The Impact of Local/Short Haul Operations on Driver Fatigue. *Virginia Polytechnic Institute and State University*, pp.1-100.

Hartley, L.R. (2000). Fatigue and Driving. *International encyclopedia of ergonomics and human factors*. (3 vols). Boca Raton, Flor.: CRC/Taylor & Francis, p.446-448.

Harvard Health. (2017). *Tired of being fatigued - Harvard Health*. [online] Available at: <https://www.health.harvard.edu/staying-healthy/tired-of-being-fatigued#:~:text=%22Everyone%20gets%20tired%20sometimes%2C%20and%20your%20endurance%20may,ways.%20You%20may%20have%20less%20energy%20to%20exercise.> [Accessed 14 October 2021].

Harvard Health. (2019). *Alcohol and fatigue - Harvard Health*. [online] Available at: <https://www.health.harvard.edu/mind-and-mood/alcohol-and-fatigue> [Accessed 10 November 2021].

Hege, Adam et al. "Surveying the Impact of Work Hours and Schedules on Commercial Motor Vehicle Driver Sleep." *Safety and health at work* vol. 6,2 (2015): 104-13. doi:10.1016/j.shaw.2015.02.001

Hirata, R., Sampaio, L., Leitão Filho, F., Braghiroli, A., Balbi, B., Romano, S., Insalaco, G. and Oliveira, L., (2012). General Characteristics and Risk Factors of Cardiovascular Disease among Interstate Bus Drivers. *The Scientific World Journal*, 2012, pp.1-7.

Hse.ie. (2019). [online] Available at: https://www.hse.ie/eng/about/who/healthwellbeing/our-priority-programmes/heal/heal-docs/food%20pyramid%20professional%20version.pdf [Accessed 17 Oct. 2021].

IRU.org. (2020). *IRU report forecasts alarming jump in driver shortage in Europe*. [online] Available at: <https://www.iru.org/news-resources/newsroom/iru-report-forecasts-alarming-jump-driver-shortage-europe> [Accessed 3 November 2021].

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

IRU.org. (2021). *New IRU survey shows driver shortages to soar in 2021*. [online] Available at: <https://www.iru.org/news-resources/newsroom/new-iru-survey-shows-driver-shortages-soar-2021> [Accessed 7 November 2021].

Jamroz, K. and Smolarek, L., (2013). Driver Fatigue and Road Safety on Poland's National Roads. *International Journal of Occupational Safety and Ergonomics*, 19(2), pp.297-309.
Kagabo, R., Thiese, M., Eden, E., Thatcher, A., Gonzalez, M. and Okuyemi, K., (2020). Truck Drivers' Cigarette Smoking and Preferred Smoking Cessation Methods. *Substance Abuse: Research and Treatment*, 14, p.117822182094926.

Kaur, P. (2019). *Importance of Balanced Diet in a Healthy Lifestyle*. [online] Narayana Health Care. Available at: <https://www.narayanahealth.org/blog/importance-of-balanced-diet-for-a-healthy-lifestyle/> [Accessed 21 October 2021].

Kent-Braun, J., Ng, A., Doyle, J. and Towse, T. (2002). Human skeletal muscle responses vary with age and gender during fatigue due to incremental isometric exercise. *Journal of Applied Physiology*, 93(5), pp.1813-1823.

Langan-Fox, J. and Cooper, C. (2011). *Handbook of stress in the occupations*. Cheltenham: Edward Elgar, p.435.

Luciane Cesira Cavagioni, Angela Maria Geraldo Pierin, Hypertension and obesity among professional drivers who work transporting loads. Acta Paul Enferm. 2010; 23(4): 455-460

Mackie, R. and Miller, J. (1978). *Effects of hours of service, regularity of schedules, and cargo loading on truck and bus driver fatigue*. Washington, D.C.: The Dept., p.5.

Matthews, G. and Desmond, P. (2002). Task-induced fatigue states and simulated driving performance. *The Quarterly Journal of Experimental Psychology Section A*, 55(2), pp.659-686.

Mehra, M., (2020). *Men's Health: 6 Causes of Fatigue and How to Prevent Them*. [online] NDTV Food. Available at: <https://food.ndtv.com/health/mens-health-6-causes-of-fatigue-and-how-to-prevent-them-1650831> [Accessed 10 November 2021].

Miller, K., Filtness, A., Anund, A., Maynard, S. and Pilkington-Cheney, F. (2020). Contributory factors to sleepiness amongst London bus drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, 73, pp.415-424.

Mobility and transport - European Commission. (2021). *Fatigue - Mobility and transport – European Commission*. [online] Available at:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

<https://ec.europa.eu/transport/road_safety/specialist/knowledge/fatique_en> [Accessed 4 October 2021].

National Institute of General Medical Science. (2021). *Circadian Rhythms*. [online] Available at: <https://nigms.nih.gov/education/fact-sheets/Pages/Circadian-Rhythms.aspx> [Accessed 14 October 2021].

NHS.uk. (2019). *What is the body mass index (BMI)?*. [online] Available at: <https://www.nhs.uk/common-health-questions/lifestyle/what-is-the-body-mass-index-bmi/> [Accessed 27 October 2021].

NHS.uk. (2021). 10 medical reasons for feeling tired. [online] Available at: <https://www.nhs.uk/live-well/sleep-and-tiredness/10-medical-reasons-for-feeling-tired/> [Accessed 12 October 2021].

Parliamentary Advisory Council for Transport Safety. (2020). What kills most on the roads? [online]. Available at <https://www.pacts.org.uk/wp-content/uploads/PACTS-What-kills-most-on-the-roads-Report-15.0.pdf> [Accessed 23 November 2021]

Puhkala, J., Kukkonen-Harjula, K., Aittasalo, M., Mansikkamäki, K., Partinen, M., Hublin, C., Kärmeniemi, P., Sallinen, M., Olkkonen, S., Tokola, K., Ojala, A., Nygård, C. and Fogelholm, M. (2016). Lifestyle counseling in overweight truck and bus drivers - Effects on dietary patterns and physical activity. *Preventive Medicine Reports*, 4, pp.435-440.

Queensland Government, (2021). Driving tired. *Department of Transport and Main Roads*. Available at: https://www.tmr.qld.gov.au/Safety/Driver-guide/Driving-safely/Driving-tired.aspx [Accessed October 5, 2021].

Randler, C., Freyth-Weber, K., Rahafar, A., Florez Jurado, A. and Kriegs, J. (2016). Morningness-eveningness in a large sample of German adolescents and adults. *Heliyon*, 2(11), p.e00200.

Road Safety Authority. (2008). Driver fatigue - RSA.IE. [online] Available at: https://www.rsa.ie/Documents/Road%20Safety/Driver%20Fatigue/Driver_Fatigue_FA.pdf [Accessed October 7, 2021].

Road Safety Authority. (2021). *RSA.ie - Commercial drivers*. [online] Available at: <https://rsa.ie/en/RSA/Licensed-Drivers/Safe-driving/Commercial-drivers/> [Accessed 4 October 2021].

Rohani, M., Wijeyesekera, D. and Karim, A. (2013). Bus Operation, Quality Service and The Role of Bus Provider and Driver. *Procedia Engineering*, 53, pp.167-178.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Rosso, G., Perotto, M., Feola, M., Bruno, G. and Caramella, M., (2015). Investigating obesity among professional drivers: The high-risk professional driver study. *American Journal of Industrial Medicine*, 58(2), pp.212-219.

Sicard, S. (2012) Female Truck Drivers: Negotiating Identity in a Male Dominated Environment, *McNair Scholars Journal*, 16(1), pp.49-46.

Sieber, W., Robinson, C., Birdsey, J., Chen, G., Hitchcock, E., Lincoln, J., Nakata, A. and Sweeney, M. (2014). Obesity and other risk factors: The National Survey of U.S. Long-Haul Truck Driver Health and Injury. *American Journal of Industrial Medicine*, 57(6), pp.615-626.

Sikander, G. and Anwar, S. (2018). Driver Fatigue Detection Systems: A Review. [online] Ieeexplore.ieee.org. Available at: <https://ieeexplore.ieee.org/abstract/document/8482470> [Accessed 12 October 2021].

Sleepapnea.org. (2021). *Sleep Apnea Information for Clinicians - www.sleepapnea.org*. [online] Available at: <https://www.sleepapnea.org/learn/sleep-apnea-information-clinicians/> [Accessed 3 November 2021].

Stevenson, M., Elkington, J., Sharwood, L., Meuleners, L., Ivers, R., Boufous, S., Williamson, A., Haworth, N., Quinlan, M., Grunstein, R., Norton, R. and Wong, K. (2013). The Role of Sleepiness, Sleep Disorders, and the Work Environment on Heavy-Vehicle Crashes in 2 Australian States. *American Journal of Epidemiology*, 179(5), pp.594-601.

Summala, H. and Mikkola, T. (1994). Fatal Accidents among Car and Truck Drivers: Effects of Fatigue, Age, and Alcohol Consumption. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 36(2), pp.315-326.

Taylor, A. and Dorn, L. (2006). Stress, Fatigue, Health, And Risk Of Road Traffic Accidents Among Professional Drivers: The Contribution of Physical Inactivity. *Annual Review of Public Health*, 27(1), pp.371-391.

Englund, L., O'Neill, D.J., Pisarek, W., Ryan, M., Wagner, T., on behalf of Medical Fitness to Drive Subgroup of the CIECA Topical Group on Fitness to Drive. 2020. CIECA Report Medical Fitness to Drive. CIECA, Brussels.

Useche, S., Cendales, B. and Gomez, V. (2017). Measuring Fatigue and its Associations with Job Stress, Health and Traffic Accidents in Professional Drivers: The Case of BRT Operators. *EC Neurology* 4.4, pp.103-118.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Vanlaar, W., Simpson, H., Mayhew, D. and Robertson, R. (2008). Fatigued and drowsy driving: A survey of attitudes, opinions and behaviors. *Journal of Safety Research*, 39(3), pp.303-309.

Virginia Tech Transportation Institute. The Prevalence of Driver Fatigue in an Urban Driving Environment: Results from the 100-Car Naturalistic Driving Study. 2005 International Conference on Fatigue Management in Transportation. Available at: <https://www.researchgate.net/publication/329070560_The_prevalence_of_driver_fatigue_in_an_urban_driving_environment_Results_from_the_100-Car_Naturalistic_Driving_Study.>

Volie, E. (2016). *Truck Drivers Are Mostly Male, and Here's Why*. [online] Trucks.com. Available at: <https://www.trucks.com/2016/07/21/truck-drivers-mostly-male/> [Accessed 16 October 2021].

Watson, N., Badr, M., Belenky, G., Bliwise, D., Buxton, O., Buysse, D., Dinges, D., Gangwisch, J., Grandner, M., Kushida, C., Malhotra, R., Martin, J., Patel, S., Quan, S. and Tasali, E. (2015). Recommended Amount of Sleep for a Healthy Adult: A Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society. *SLEEP*.

Wiegand, D., Hanowski, R. and McDonald, S. (2009). Commercial Motor Vehicle Health and Fatigue Study. *The National Surface Transportation Safety Centre for Excellence*, [online] pp.1-41. Available at: <https://scholar.lib.vt.edu/VTTI/reports/Health_and_Fatigue_021109.pdf>.

Wise, J., Heaton, K. and Patrician, P. (2018). Fatigue in Long-Haul Truck Drivers: A Concept Analysis. *Workplace Health & Safety*, 67(2), pp.68-77.

Wylie et al., (1996); Mitler et al., (1997). Commercial Motor Vehicle Driver Fatigue and Alertness Study: Project Report

Zhang, Z. and Zhang, J. (2010). A new real-time eye tracking based on nonlinear unscented Kalman filter for monitoring driver fatigue. *Journal of Control Theory and Applications*, 8(2), pp.181-188.

Zuraida, R. and Abbas, B. (2020). The Factors Influencing Fatigue Related to the Accident of Intercity Bus Drivers in Indonesia. *International Journal of Technology*, 11(2), p.342.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Annex I – FitDrive Driver Diary

Fit Drive

Driver Diary

EPDA EUROPEAN PROFESSIONAL DRIVERS ASSOCIATION

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Introduction

About FitDrive

FitDrive is an EU grant funded project to develop and test devices to detect driver impairment. The aim of the project is to reduce the risk of accidents and improve road safety. This will be achieved by the FitDrive device and associated software, which, when installed in a vehicle, can be used to notify the driver or other necessary parties when the driver is suffering from an impairment that could impact their driving ability and / or road safety.

Who we are

The FitDrive consortium consists of ten partners based across a number of countries. A full listing of these companies is provided at the back of this book. This book is designed, distributed and collected by the European Professional Drivers Association (EPDA). The EPDA is an association of professional drivers established to represent the interest of professional drivers. The EPDA mission statement is a simple and concise one which is "to develop and support a professional driving culture", issues that we care about are the issues that drivers care about.

The purpose of this diary

Part of the FitDrive project is to understand the role of the professional driver and how this can impact fatigue. The EPDA manages this element of the project and we have developed this diary in order to gather data on the various types of driving roles (international, national, regional, local) and how each of these could lead to fatigue and other wellness related issues. It is important to understand the role of the professional driver so that the FitDrive devices can accurately determine whether or not a driver is impaired.

Why your answers are important to us

Those of us in the industry are well aware of the challenges facing the modern professional driver. We are an industry with an ageing population, unsocial working hours, faced with daily stresses that impact our health. The aim of the EPDA is to raise the profile of the driver and this can be done by presenting the challenges faced by drivers to relevant stakeholders.

How your data will be used

Any personal data collected by the EPDA is confidential and will not be shared with any of the partners in the FitDrive consortium, the EU funding & tenders team, or any third party unless required to do so by law. Personal data is defined as any information that could identify you. For more information on how your data will be used, please see our data protection notice at the back of this book.

Your personal data may be used by employees of the EPDA for the purpose of completing this survey. In this regard, our employees may contact you to clarify one of your answers, or to remind you to complete certain sections of this book.

Your answers to this survey will be kept anonymous and only provided in aggregate format to the FitDrive consortium and the EU. The results of this survey may be published in scientific journals, websites, newspapers and other media.

Please consent to your answers being used in the manner described above by signing here:

Signature _____ Date [ ]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Diary Instructions

Many thanks for joining the FIT Drive research group. Filling out the Lifestyle diary is a very important part of the project as it will contribute significantly to the quality of the research. Professional Drivers across Europe will benefit immensely from your effort.

Keeping a diary is easy. It may help to keep this diary in you cab or in your work bag, so you can access it every working day. It may be easier to keep a second copy at home so you can record you time off activities. You can then combine all together.

A) Work and rest

This section of the diary is designed to gather information about your working times and sleeping patterns, as well as details of any medication you may be taking. The information is important as shift patterns, sleep cycles and medications can contribute to fatigue. Remember, your answers will be kept confidential but if you do not feel comfortable writing down details of any medication you take, just leave this section blank.

1. Write the time you got up at today
2. Write the time you went to sleep at the previous night
3. Tick yes or no whether you woke up during your sleep and write the length of time you were awake. You can write in your best guess if you are unsure of the exact time. If your sleep was disturbed a few times during your sleep, write in the total time you were awake during your rest.
4. The duration of your sleep will be the length of time between when you woke up and you went to sleep last night, less any periods you were awake.
5. Write in when you arrive at work, rather than the time you begin working.
6. Write in the time you leave work, rather than the time you finish driving.
7. This section is for international drivers only and scheduled bus drivers who work split shifts.
8. Tick yes or no whether you took any medication today. If you took any medication, please list the names of these in the box.

B) Diet and exercise

This section of the diary is to record information on your daily food and exercise routines. This information will be used to determine whether there is any pattern between eating habits and exercise, and shift working times, or difficulty in sleeping.

9. Tick yes or no if you had breakfast and write in the time you ate. Place a tick beside the breakfast size which best represents your meal. The examples provided are for an indication only so don't worry about the type of food you ate. Just use your best guess to match with the size in the image.
10. Similarly, tick yes or no whether you had lunch and write in the time. Like breakfast, the images provided are an example only so choose the image that best fits the size of your lunch.
11. The same process for the above should be completer for your dinner.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

12. Tick the number of pieces of fruit you ate today. Leave blank if you did not eat fruit.
13. Tick the number of other snacks you ate today and write in which types. Other snacks would include items like yoghurts, crackers, crisps and sweets.
14. Physical exercise is any period of activity at work, e.g. loading or unloading, carrying boxes upstairs. Please write the amount of time under work: duration and any exercise outside work (e.g. a walk or time in the gym) in the appropriate section. If you keep a count of your daily steps, please enter the number in the box indicated
15. Tick yes or no whether you consumed any alcohol today and write in the number of units. One unit is a small glass of wine (9 glasses per bottle of wine), a half pint of beer, or a standard pub measure of spirits.

C) How you feel today

Rate how you feel today about your food, work, rest and exercise. The red face at the end means you are very unhappy with this part of your day, and the green face at the beginning means you are very happy with it. Please circle the face that best fits your mood about this part of your day.

Please be as accurate with your answers as possible. This information will be used to ensure that the project delivers a benefit for professional drivers.

If you have any questions or are unsure how to fill any section of the diary, please call your EPDA representative. Their contact details are as follows:

EPDA representative	
Phone Number	
Email	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 953432

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Personal Details

Please select the type of professional driving role that describes your work

- ☐ National Driver
- ☐ Local Multi Drop Driver
- ☐ International Driver
- ☐ National Coach Driver
- ☐ Scheduled Bus Driver

Name	
Date of birth	
Gender	
Nationality	
Country of Employment	
Weight	
Height	
Waist Size	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

DAY 1

A Work, rest & medication

1. Rising Time

2. Bed-Time

3. Did you wake during your sleeping time? Yes No

For how long

4. Duration of Sleep

5. Start of Shift 6. End of Shift

7. International Drivers & Scheduled Bus Drivers

Start of 1st Shift End of 1st Shift

Start of 2nd Shift End of 2nd Shift

8. Did you take any medication today? Yes No

If so, list

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

B Diet and exercice

9. Did you have a **Breakfast** Yes ☐ No ☐ Time: ☐

 Small ☐  Medium ☐  Large ☐

10. Did you have a **Lunch** Yes ☐ No ☐ Time: ☐

 Small ☐  Medium ☐  Large ☐

11. Did you have a **Dinner** Yes ☐ No ☐ Time: ☐

 Small ☐  Medium ☐  Large ☐

12. How many pieces of fruit did you eat today? 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more ☐

13. How many other snacks did you eat today? 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more ☐

List snacks here ☐

14. Did you engage in any physical exercise today? Yes ☐ No ☐

During Work: Duration hr: mins: Outside work: Duration hr: mins:

Steps ☐

15. Did you consume any alcohol today? Yes ☐ No ☐

If so, please list number of units here: ☐

C Please rate how you feel today about:

Food 

Work 

Rest 

Exercise 

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Data Protection Notice

For full details of our Data Protection Policy – please visit www.epda.ie/dataprotection

For any queries relating to the data collected from you, please contact Kevin Hurley, Data Protection Officer, EPDA, Unit 5 Glasnevin Business Centre, Ballyboggan Road, Dublin 11, Ireland, Telephone 01 8600 444. Email: **dataprotection@epda.ie**

Purpose of the data

This diary has been developed in order to gather data on the various types of driving roles (local, national international, multi-drop, heavy lifting, trunking etc.) and how each of these could lead to fatigue and other wellness related issues. It is important to understand the role of the professional driver so that the FitDrive devices can accurately determine whether or not a driver is impaired. For further information on the FitDrive project, please visit **www.epda.ie/fitdrive**.

Where your data may be shared

Your answers to the work related and wellness questions in this diary will be aggregated with other users' data and this aggregated data ("the results") will be shared with the partners of the FitDrive project. The results are required in order to design the FitDrive device to improve road safety. Personal data will be retained only by the EPDA and only for the purpose of verifying the information collected.

'personal data' means any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person;

Safeguards in place governing the transfer of personal data

No personal information will be transferred and therefore we have determined no safeguards are necessary for the transfer of the results to the other partners in the FitDrive project.

Fair & transparent processing

The data provided in this diary will be kept for the length of the FritDrive project (42 months) and a further 2 years beyond this date. The results will be shared with the partner organisations of the FitDrive project. The partners of the FitDrive project are:

Fundacion Instituto Tecnologico de Castilla y Leon. Spain
Associazione Italiana Dei Professionisti Per La Sicurezza Stradale. Italy
Mäelardalens Höegskola. Sweden
Advantic Sistemas Y Servicios SI. Spain
Universita Degli Studi Di Roma La Sapienza. Italy
Europaische Fahrlehrer Assoziation. Germany
Securetec Detektions-Systeme Ag. Germany
Eliocity. France
European Professional Drivers Association. Ireland
Aselsan Elektronik Sanayi Ve Ticaret Anonim Sirketi. Turkey

You may request at any time, to access the data we hold pertaining to you, rectify any of your data we hold, or request us to erase this data, or restrict processing of this data. For further details on your rights concerning data to be accessed, rectified, erased, or processing restricted, please visit our data protection policy at **www.epda.ie/data-proection** or contact Kevin Hurley as above.

Where you are unsatisfied with our handling of your data, you may lodge a complaint with the Data Protection Commissioner who can be contacted in the ROI at 1890 252 231 or 057 868 4800 and its website is **www.dataprotection.ie**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 953432.
The content of this deliverable does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).