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MASTER'S PROGRAM IN PUBLIC POLICY AND GOVERNANCE

«Well-Being And Road Accident Mortality – Is There A Link?»

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ABSTRACT

Road mortality is a global public policy/health challenge. Its abatement has repeatedly been included in the global/local development targets, but has never been achieved as planned, neither at the international nor at the local level. There are a number of traditional factors identified (infrastructure, legislation, enforcement, etc.), which are being addressed by all countries with varying degrees of success. However, it is likely that there are also other factors at play, which are not sufficiently explored/addressed. In this study, we attempted to look into a possible link between subjective well-being (SWB) and road accident deaths using a regression of panel data covering 133 countries during the period from 2010 to 2019. Control variables include a number of factors known to be relevant to road safety, such as per capita GDP, road density, number of motor vehicles, health expenditures, and rule of law. The results do not confirm the traditional "happy drivers are better drivers" belief, but further research will be necessary to better understand the linkages between SWB and more immediate emotions that may affect driving behaviour. In addition to the 'traditional' road safety realm, the findings, albeit negative, could also be useful for the development of intelligent driving assistance systems and driver behaviour models as a vital component of autonomous driving solutions that will largely shape the future of automotive transport and road safety.

Keywords: road accident mortality, subjective well-being, happiness, road safety, driver behaviour, emotional states, driving assistance systems

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ABBREVIATIONS

2SLS	2-stage least squares
AI	Artificial intelligence
B&H	Bosnia and Herzegovina
DALY	Annual Disability Adjusted Life Year
FE	Fixed Effects
FD	First Difference
GDP	Gross domestic product
HI	High income
IRF	International Road Federation
IV	Instrumental variable
LMI	Low and middle income
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares
RE	Random effects
RTA	Road traffic accident
RTC	Road traffic crash
RTD	Road traffic death
SWB	Subjective well-being
UAE	United Arab Emirates
VIF	Variance Inflation Factor
WHO	World Health Organization

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INTRODUCTION

"My dear, here we must run as fast as we can, just to stay in place. And if you wish to go anywhere you must run twice as fast as that."

— Lewis Carroll, Alice in Wonderland

Every day more than 3,000 people die on the roads worldwide as a result of traffic accidents. Road crashes are estimated to be the eighth leading cause of death globally for all age groups and the leading cause of death for children and young people 5–29 years of age. They claim more than 1.35 million lives each year and cause up to 50 million injuries (WHO, 2018). Low-income and middle-income (LMI) countries account for about 85% of the deaths and for 90% of the annual disability adjusted life years (DALYs) lost because of road traffic injury (WHO, 2004).

According to the International Road Assessment Programme (iRAP) estimates, road crashes cost different countries between 2% and 7% of GDP, with a total in excess of $2 trillion a year. For some LMI countries, the economic cost of road injuries and fatalities exceeds the amount of development assistance that they receive.

"Road traffic injuries place a heavy burden, not only on global and national economies but also household finances. Many families, especially in the developing world, are driven deeply into poverty by the loss of breadwinners and the added burden of caring for members disabled by road traffic injuries.

A large proportion of the road crash victims in low-income and middle-income countries are vulnerable road users such as pedestrians and cyclists. They benefit least from policies designed for motorised travel, but bear a disproportionate share of the disadvantages of motorization in terms of injury, pollution and the separation of communities. In low-income and middle-income countries, they account for large portions of road traffic and most road traffic deaths. In high-income countries, car owners and drivers account for a large majority of road users and the majority of road traffic deaths. Nevertheless, even there, pedestrians, cyclists and moped and motorcycle riders have a much higher risk of death per kilometre travelled" (WHO, 2004).

Even though the word 'accident' is traditionally and commonly used for road crashes, traffic injury is largely preventable and predictable; it is a human-made problem amenable to rational analysis and countermeasure.

The UN's Sustainable Development Goals contain two global targets on road safety. SDG Target 3.6 calls to halve the number of global deaths and injuries from road traffic crashes – a global imperative which was extended until 2030 by a UN General

Assembly resolution in 2020 (A/RES/74/299). SDG Target 11.2, on a 2030 timeframe, calls for improving road safety in the provision of access to transport systems and expanding public transport.

Proclaimed through the aforementioned UN General Assembly resolution, the Decade of Action for Road Safety 2021–2030 was launched in October 2021. The Global Plan for the Decade of Action emphasises the importance of a holistic approach to road safety, and calls for continued improvements in the design of cities, roads and vehicles; enhancement of laws and law enforcement; and provision of timely, life-saving emergency care for the injured. The Global Plan also promotes transport policies and road designs that enable safe walking, cycling and public transport, so they can be prioritised as healthy and environmentally sound modes of transport.

"In road traffic, risk is a function of four elements. The first is the exposure – the amount of movement, or travel, within the system by different users or a given population density. The second is the underlying probability of a crash, given a particular exposure. The third is the probability of injury, given a crash. The fourth element is the outcome of injury. Risk can be explained by human error, kinetic energy, tolerance of the human body and post-crash care.

Factors influencing exposure to risk:

- Rapid motorisation
- Demographic factors
- Transport, land use and road network planning
- Increased need for travel
- Choice of less safe forms of travel

Risk factors influencing crash involvement:

- Speed
- Pedestrians and cyclists
- Young drivers and riders
- Alcohol
- Medicinal and recreational drugs
- Driver fatigue
- Hand-held mobile telephones
- Inadequate visibility
- Road-related factors
- Vehicle-related risk factors

Risk factors influencing injury severity:

- Lack of in-vehicle crash protection
- Non-use of crash helmets by two-wheeled vehicle users
- Non-use of seat-belts and child restraints in motor vehicles
- Roadside objects

Risk factors influencing post-crash injury outcome:

- Pre-hospital factors
- Hospital care factors" (WHO, 2004).

But even though the road accident mortality factors seem to be clearly identified and measured, and its abatement has repeatedly been included in the global/local development targets, these targets have rarely been achieved as planned, neither at the international nor at the local level.

It is possible that in addition to the 'conventional' factors, such as infrastructure, legislation, enforcement, etc., which are being addressed by all countries with varying degrees of success, there are also other factors at play which are not sufficiently explored/addressed.

"In addition, progress in reducing road traffic deaths over the last few years varied significantly between different regions and countries of the world. There continues to be a strong association between the risk of a road traffic death and the income level of countries. With an average rate of 27.5 deaths per 100,000 population, the risk is more than three times higher in low-income countries than in high-income countries where the average rate is 8.3 deaths per 100,000 population. The burden of road traffic deaths is disproportionately high among low- and middle-income countries not only in relation to the size of their populations, but also in relation to the number of motor vehicles in circulation. Although only 1% of the world's motor vehicles are in low-income countries, these countries account for 13% of road traffic deaths.

The growing number of deaths in low- and middle-income countries is fuelled by transport that is increasingly motorised. Between 2013 and 2016, no reductions in the number of road traffic deaths were observed in any low-income country, while some reductions were observed in 48 middle- and high-income countries. Overall, the number of deaths increased in 104 countries during this period" (WHO, 2018).

In this study, we decided to concentrate on the possible effect of subjective well-being (SWB) on road accident mortality. SWB is an important factor whose analysis has recently been coming to the forefront of public policy (Adler & Seligman, 2016). However, it has not been sufficiently explored as a public health factor, in particular in terms of its possible effects on road safety. Better understanding of the potential linkages between SWB/emotions and driving performance is important for both the 'high-level' policy-making (as it may well be the 'missing variable' which prevents from the achievement of the road safety improvement targets) and the practical level of specific measures/improvements. It is also important for the development of the AI-assisted/autonomous driving solutions which will definitely shape the driving/road safety paradigm already in the immediate future. "With the rapid development of intelligent vehicles, the research on driving behaviour analysis and intelligent assistance system design has gradually deepened. Building a driving behaviour prediction model based on emotions can classify the driving violations and predict driving violations within a given period of time. This can not only assist intelligent vehicle decision-making and planning systems to correct the vehicle behaviour trajectory and avoid accidents but also provide new ideas for improving the efficiency and safety of urban traffic" (Wang, 2023).

There is a long-established belief in both everyday life and more academic environments that 'happy drivers are better drivers'; however, this has been challenged in a number of recent studies. This study is confirmatory research since we attempt to find an answer to a very specific question: **Does SWB have a positive effect on decreasing road accident mortality?**

The next section of the thesis includes an overview of the existing literature largely covering three key fields: ‘traditional’ road safety, well-being and its importance for public policy, and effects of human emotions on cognitive processes and risk-taking in the context of human/AI-assisted driving. It is followed by a description of the applied methodology and variables, data sources and explanations, and, lastly, presentation and a brief discussion of the achieved results.

LITERATURE REVIEW

Conventional risk factors

Given the severity and global scale of the road accident mortality problem, reports and other analytical materials of the UN in general and the World Health Organisation in particular are a valuable source of systematised information on the subject.

Key road death/injury risk factors identified in the WHO reports include:

- Driving at speed
- Driving under the influence of alcohol or other psychoactive substances
- Non-use of motorcycle helmets, seat-belts, and child restraint
- Distraction, including the use of mobile phones, leading to impaired driving
- Unsafe vehicles and unsafe road infrastructure can negatively impact safety on the roads
- Inadequate post-crash care
- Inadequate law enforcement of traffic laws (WHO, 2022).

Other variables that influence road traffic accident mortality rates include vehicle and road densities, as well as the availability and effectiveness of public transit and domestic healthcare systems (WHO, 2004).

In addition to the WHO reports, there have been other attempts to analyse combined data on road traffic deaths (RTD). In 2023, Razzaghi et al. reviewed 169 articles covering the situation in different countries of the world. According to the reviewed studies, human factor is the most common RTD risk factor. From the road safety viewpoint, the most important aspects of the human factor include age, gender, education, alcohol consumption, not wearing a helmet (motorcyclists), driving without a driver's licence, and speeding. Also, obesity was reported to be a risk factor for RTDs in the United States and Europe.

Some people also believe that they have no control over the probability of an accident while driving. Such fatalism is more widespread among Hispanic and African populations.

From the epidemiological and causation point of view, there are predisposing, enabling, precipitating, and reinforcing factors in the RTD context (Razzaghi et al., 2023).

The predisposing factors, such as age, gender, marital status, or education, may be essential for causality, but insufficient.

The enabling factors include, for example, income level or access to health services. Some factors in this category are modifiable, and their modification can help to prevent road crashes.

Furthermore, any human, road- or vehicle-related, or environmental factor could play the role of a precipitating factor. For instance, it can be driver distraction, vehicle defects, adverse weather conditions, etc.

The reinforcing factors include high-risk road design, low road safety awareness of road users, high-risk driving behaviour or vehicle defects (Razzaghi et al., 2023).

Speeding is considered as the factor that contributes the most to risk and severity, and, as a consequence, to the mortality related to traffic accidents (Aarts et al., 2006; Elvik et al., 2004). Almost one third of RTDs globally is related to speeding (WHO, 2004).

"The key global patterns are repeated on the regional level, albeit with slight differences. Human related factors (speeding, overtaking, reckless driving, fatigue, drunk driving, drug, seat belt, sleeping, cell phone usage and etc.) are accounted as causes of more than three fourths of road traffic accidents in Africa. In most populated Africa countries like Nigeria, Ethiopia, and Egypt, they account for more than eighty percent of RTAs" (Deme, 2019).

Analysis of a sample of 1,100 Spanish drivers made by Alonso at al. in 2013 revealed that approximately one third of the drivers always or sometimes speed. When asked about the reasons, the drivers reported being in a hurry, unreasonably low (in their view) speed limits, and low probability of being caught. According to this study, the speeding behaviour was conscious in 80% of the cases.

According to Shibata and Fukuda (1993), speed was the most significant risk factor of fatality for both motorcar drivers and motorcyclists in Japan. Its strong effect on fatality was unchanged after adjustment for the other factors, such as driving without a licence, alcohol use, use of seatbelts and helmets.

GDP

Without any doubt, the level of economic development (or per capita GDP) is another important factor in the area of road safety. Obviously, the country's GDP and personal income levels have a direct effect on the road density, the development/technical condition of the road infrastructure, quality and safety of vehicles, etc.

In a remarkable study published in 2000, Van Beeck et al. examined the association between prosperity and traffic accident mortality in 21 industrialised countries in 1962-1990 using WHO mortality and population data, figures on motor vehicle ownership of the International Road Federation (IRF), and OECD country prosperity data. They found a reversal from a positive relation between prosperity and traffic accident mortality in the 1960s to a negative association currently. "At a certain level of prosperity, the growth rate of traffic mobility decelerates and the fatal injury rate continues to decline at a similar rate to earlier phases. In a long-term perspective, the relation between prosperity and traffic accident mortality appears to be non-linear: economic development first leads to a growing number of traffic-related deaths, but later becomes protective. Prosperity growth is not only associated with growing numbers of motor vehicles in the population, but also seems to stimulate adaptation mechanisms, such as improvements in the traffic infrastructure and trauma care".

The non-linear relation between income and RTDs is corroborated by other studies. In particular, an empirical analysis of per capita income and road fatalities across 60 countries over the period from 1972 to 2004 (Law et al., 2011) reveals, in fact, a Kuznets-type curve: the number of road fatalities increases with increasing motorisation in the early stages of economic growth. Eventually, due to advances in technical, policy and political institutions, it declines as per capita income increases. The evidence presented in this study also suggests that lowering corruption levels as well as improvements in medical care and technology helps to reduce road fatalities.

Other 'tangible' factors that may also have an effect on road accident mortality include weather and fuel prices, for example (Burke, 2018; Robertson, 2017; Safaei, 2021).

Culture and national traits

A substantial part of the existing research of road safety determinants is focused on cultural and 'national character' differences between countries.

Given the relative breadth of the concept of culture, its interpretations may differ quite substantially, from certain national traits to law obedience (Golina, 2021), "risk culture" or drivers' education (Camiolo, 2013).

Most research in this area is, however, focused on the national culture, which may be defined as the collection of norms, beliefs, values, and practices that distinguish the citizens of one country from those of another, and is largely based on Hofstede's cultural dimensions theory. In particular, Van den Berghe et al. (2010) found strong correlation between national culture and road safety performance, which exists even after controlling for the national level of wealth as measured by the gross national income. Further research by Gaygisiz et al. (2009, 2010, 2022) corroborates that cultural values and national personality characteristics must be given proper consideration in the public policy domain, including road safety. Interestingly, Gaygisiz finds that "countries with higher road-traffic accident fatality rates are characterised by higher power distance and uncertainty avoidance as well as embeddedness and emphasis on social hierarchy. Countries with lower road-traffic accident fatality rates are more individualistic, egalitarian, and emphasized autonomy of individuals. Conscientiousness and IQ correlated negatively with road-traffic accident fatalities" (Gaygisiz, 2009).

A cross-cultural comparison of traffic safety attitudes and risk perception in Norway and Ghana found differences between the two nations in terms of risk sensitivity and risk willingness, some of which may be attributed to cultural differences (Lund & Rundmo, 2009). Similar cross-country studies made by these and other authors seem to confirm the validity of the cultural determinants of road safety (Nordfjaern & Rundmo, 2014; Nordfjaern et al., 2014; Solmazer et al., 2016; Özkan et al., 2006; Naevestad et al., 2022).

However, there are also studies which cast doubt on the presumed connection between national culture and certain easily identifiable traits of behaviour, some concluding that "perceptions of national character appear to be unfounded stereotypes that may serve the function of maintaining a national identity" (Terraciano et al., 2005).

Myers et al. (2014) argue the importance of discerning culture as a socially constructed abstract system of meaning, norms, beliefs, and values from concrete behaviours, social relations and properties of specific environments (workplaces, organisational structures, etc.). As regards the social determinants, these can include race, sex, and income, as well as other factors such as religion (Grossetete, 2010; Leonhardt, 2022; Lazo, 2022). In addition to the income level, religion seems to have an impact on values related to safety. For example, being a Catholic country or not seems to be as important as being a wealthy country or not. Being a non-wealthy Catholic country leads to more traffic accidents than being a wealthy Catholic country. Being a wealthy Catholic country, however, does seem to lead to more traffic accidents than being a similar wealthy but non-Catholic country (Melinder, 2007).

Well-being

In this study, we decided to concentrate on the possible effect of subjective well-being (SWB) on road accident mortality. SWB is an important factor whose analysis has recently been coming to the forefront of public policy (Adler, 2016). However, it has not been sufficiently explored as a public health factor, in particular in terms of its possible effects on road safety.

"In 1968, US Senator Robert F Kennedy made a speech that highlighted the deficiencies of using measures of income as indicators of national well-being, stating that the gross national product "measures everything, in short, except that which makes life worthwhile". The speech marked the start of the first wave of the trend towards the use of national indices of well-being as tools for informing and appraising public policy, which implies away from social indicators designed to monitor the state of society as a collective whole, towards an emphasis on measuring individual well-being, and, in particular, individual psychological states. The current, second wave is characterised by a new focus in many countries on consulting citizens directly about their levels of happiness and life satisfaction. Many national and international social surveys now include self-reported measures of respondents' subjective experiences of life" (Austin, 2016).

One of the most widely researched conceptualizations of happiness is subjective wellbeing (SWB). Bradburn (1969) empirically found SWB to be a function of the independent dimensions of positive and negative affectivity. This definition of SWB has since been empirically extended; it encompasses how people evaluate their own lives in terms of both affective (how they feel) and cognitive (what they think) components of wellbeing. Overall, high SWB combines three specific factors: (1) frequent and intense positive affective states, (2) the relative absence of negative emotions, and (3) global life satisfaction (Adler & Seligman, 2016).

"The increasing popularity of subjective well-being in the academic literature is mirrored by the rise of SWB in the policy arena. While many see SWB as a useful addition to existing social indicators, a 'strong' position on SWB has emerged: this strong version holds that SWB provides a summary of how well people's lives are going, and represents, in a single indicator, a reflection of overall, objective welfare" (Austin, 2016).

In a seminal article published in 1995, Ed Diener et al. analysed possible predictors of SWB in 55 countries representing three fourths of the global population. The study based on survey data revealed that high income, individualism, human rights, and societal equality correlated with SWB with strong convergence across surveys; income correlated with SWB even after basic need fulfilment was controlled, and individualism persistently correlated with SWB when other predictors were controlled. Cultural homogeneity, income growth, and income comparison showed either low or inconsistent relations with SWB (Diener et al., 1995).

However, even if there might be a correlation between a country's per capita GDP and the happiness of its people in certain cases, the interplay is not that straightforward (Sen, 1988; Oishi, 2022; Roka, 2019). Therefore, we expect that SWB, or life satisfaction, can play a separate role as a road safety factor.

Emotions

The impact of drivers' emotions on driving performance and safety has only recently gained empirical attention and remains poorly understood. Since internal emotional experiences are often difficult to observe, they have often been neglected from examination in naturalistic driving studies (Cunningham, 2016).

Attention, performance, and judgement are of paramount importance in automobile operation, with even the smallest disturbance potentially having grave repercussions. The road-rage phenomenon (Galovski & Blanchard, 2004) provides one undeniable example of the impact that emotion can have on the safety of the roadways.

Emotions affect many cognitive processes, highly relevant to driving, such as categorisation, goal generation, evaluation and decision-making, focus and attention, motivation and performance, intention, communication and learning (Eyben, 2010).

"Understanding how emotional states influence driving behaviour is crucial for the development of advanced driver assistance systems that improve safety by flexibly adapting to the current state of the driver. However, studies on emotional effects on driving behaviour have revealed heterogeneous results. In terms of causal pathways, there is relative consensus that emotions influence driving behaviour in two ways: directly (e.g., by promoting aggressive driving), or indirectly by altering attentional effects on driving (e.g., by attenuating dual task costs). Emotional effects on driving tend to be highly task-specific and crucially depend on attentional demands involved in the driving task and the emotion-inducing event" (Steinhauser, 2018).

An interesting research was done by Isen and Geva (1987), in which they sought to refine the results of previous studies of positive affect (PA) effects on risk-taking, in particular the finding that persons who are feeling good tend to protect the on-going PA state due to its perceived utility and, therefore, become more risk-averse. Isen and Geva found, however, that PA tends to make people cautious where risk is moderate to high, but relatively risky where the potential loss is low.

In a later article, Isen found additional evidence suggesting positive effects of PA on cognitive processes such as decision-making and problem-solving (Isen, 2001).

Kirkaldy and Furnham (2000) tested the hypotheses that indicators of negative affectivity tend to be positively associated with accidents, while the opposite is true for PA and SWB. Using 3 databases with national statistics gathered from different studies and covering 37 countries, they found certain support for the PA/SWB part of the hypotheses, although admitted that the available data had not allowed them to control for various possible confounding factors like transportation networks, weather effects, etc.

Research addressing the impact of affect on various cognitive aspects tends to focus on the effects of global mood rather than those of more specific emotional experiences. In addition, affect-related driving research so far has concentrated on just negative affective states. Literature has simply reported that ''happy drivers are better drivers" (Eyben et al., 2010; Jones & Jonsson, 2005) and produce fewer accidents. However, little research has empirically demonstrated that proposition. Positive affect, for instance, has been shown to lead to an increased reliance on stereotypes and other heuristic processing (Isen, 2000). An 'excessively happy' state may impact driving performance negatively. Taken together, how positive affective states influence driving performance and safety needs to be further validated (Jeon, 2014).

ANALYTICAL FRAMEWORK

The current study was meant to contribute to the general research of possible connections between emotional states of road traffic participants and road safety. However, we made a number of assumptions, predominantly with the purpose of doing a meaningful quantitative research.

First, we narrowed the road safety concept down to just road accident mortality as the most important and easily quantifiable measure (although, as we learned, the counting methodology may differ from one country to another as in some countries, for example, post-accident deaths in healthcare facilities are not included in the road deaths statistics). We also narrowed down the concept of traffic participants to mostly drivers in line with the hard fact that most road accident deaths are caused by drivers.

Furthermore, we narrowed the concept of emotional states to subjective well-being (SWB) and used the happiness scores self-reported by people from different countries. Presumably, this measured 'happiness' covers both the positive and the negative parts of the emotional spectrum depending on the value. Despite its seeming simplicity, this indicator is, in fact, just the tip of the iceberg since it reflects integrally a number of such profound characteristics of a country as income, inequality, social support, freedom, corruption, etc. Therefore, its role for the purposes of this research is twofold: on the one hand, it stands for all those variables that may together create resistance to further progress in the reduction of road accident mortality as a noble and extremely valid sustainable development goal; on the other hand, happiness or well-being as a background or 'deeper' characteristic of the human condition may translate into 'operating' emotions that have very specific and immediate effects on cognitive processes and situational risk-taking, which, in turn, affects driving performance.

Therefore, road accident mortality is our key dependent variable (Y), whereas SWB is our independent variable (X). Since road safety is a function of many important variables, we had to control for them in order to assess the possible link between SWB and mortality. The choice of these explanatory variables was largely governed by the previous long-standing research which identified the most significant road mortality risk factors.

Per capita GDP This is an important variable which may have an effect on both SWB and road mortality, directly and indirectly. Studies (including those mentioned in the previous sections) indicate that income has a substantial effect on happiness, at least until a certain level of prosperity is reached. That said, we have to make a caveat regarding possible inequality since per capita GDP is a country, rather than individual, measure. However, at the country level, it reflects the financial capacity for building and maintaining proper infrastructure, paying for qualified and effective law enforcement and

	healthcare systems, etc. This indicator is also linked to the mix, quality, and technical condition of vehicles on the road.
Road density	This indicator is the most available proxy for the development of road infrastructure. Obviously, the risk of accidents increases with every kilometre of roads built, for purely mathematical reasons, not least for the simple reason that there are more pedestrian crossings.
Number of cars	Similarly to the previous factor, the probability of road crashes increases with motorisation, unless sufficient measures are taken to counterbalance this growth. When the share of cars increases in the traffic mix, so does the risk for other traffic participants, e.g. bicycle, scooter or motorcycle riders.
Health expenditures	This variable is a proxy for the availability/quality of the first aid/post-crash care which is identified among key risk factors.
Rule of law	A proxy for the effectiveness of traffic law enforcement, which is also identified among key road safety factors.
Corruption	Sometimes identified as a road safety factor through indirect mechanisms, such as underinvestment in road safety/infrastructure. However, corruption may also have an effect on SWB, as well as rule of law.

A brief description of the variables used in the model and the sources of relevant data is given in Table 1 below.

H0: There is no link between SWB and road accident mortality

Possible rationale: SWB is so vague that it doesn't translate into more immediate emotions that may affect driving outcomes. And even if it does, other factors play a much more important role so it would be very difficult, if possible at all, to detect the SWB's additional influence from the available 'rough' data.

H1: Higher SWB levels lead to decreased road accident mortality

Presumably, people who report higher levels of SWB are more attentive on the road due to absence of distracting factors such as physical pain, social problems, financial worries, etc. ("happy drivers are better drivers"). They also tend to value more their own lives (as they feel happier and more satisfied with their lives, they have more to lose) and to have more respect for the lives of others. Therefore, we assume that a higher SWB is associated with a higher aversion to risk which is an important factor since a great share of road accident deaths occur as a result of risky behaviour such as speeding or jaywalking.

METHODS AND RESULTS

Since we opted for quantitative research given the availability of quantitative data for a large number of countries and time periods, we use a panel data regression analysis. The dataset includes 133 countries with 10 years (2010-2019) of observations for each country. Certain data manipulations were required due to non-availability of observations for some countries/years (see more detailed information in Table 1).

Using panel data has a number of advantages, including more variability, less collinearity among the variables, more degrees of freedom, and more efficiency (Baltagi, 2005). In particular, this helps to address the potential problem of omitted variables (e.g. time-invariant effects associated with specific countries).

Variables – data sources

Table 1. Data sources

	Variable	Unit of measurement	Source	Stable availability, years	Sample preparation
Road accident mortality	*mortality*	Per 100,000 population	World Bank https://data.worldbank.org/indicator/SH.STA.TRAF.P5	Since 2000	
Subjective well-being	*swb*	Score 0-10	World Happiness Report https://worldhappiness.report/ed/2022/	Since 2010	
Per capita GDP	*loggdppc*	Log of per capita GDP	World Bank https://data.worldbank.org/indicator/NY.GDP.PCAP.CD World Happiness Report https://worldhappiness.report/ed/2022/	Since 1960	
Road density	*rdensity*	km/sq. km	International Road Federation https://irfnet.ch/ CIA https://www.cia.gov/the-world-factbook/field/roadways/country-comparison	Since 2015	First available observations carried backward to fill empty cells. Static values from the CIA database used for several countries for which no IRF time series data were

					available.
Number of cars	*nocars*	Per 1,000 population	International Road Federation https://irfnet.ch/ National statistics, other sources	Since 2015	First available observations carried backward to fill empty cells. Other sources are used (static values) for several countries for which no IRF time series data were available.
Health expenditures	*healthex*	% GDP	World Bank https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS	Since 2000	
Rule of law	*ruleoflaw*	Score 0-1	World Justice Project https://worldjusticeproject.org/rule-of-law-index/	Since 2012	First available observations carried backward to fill empty cells.
Corruption	*corruption*	Score 100-0	Transparency International https://www.transparency.org/en/cpi/2022	Since 2012	First available observations carried backward to fill empty cells. Benchmarked static values for Afghanistan and Belarus.

Variables – summary statistics

The dataset includes 133 countries with 10 years (2010-2019) of observations for each country (N=1330). Key statistical indicators of each variable are shown Table 2 below.

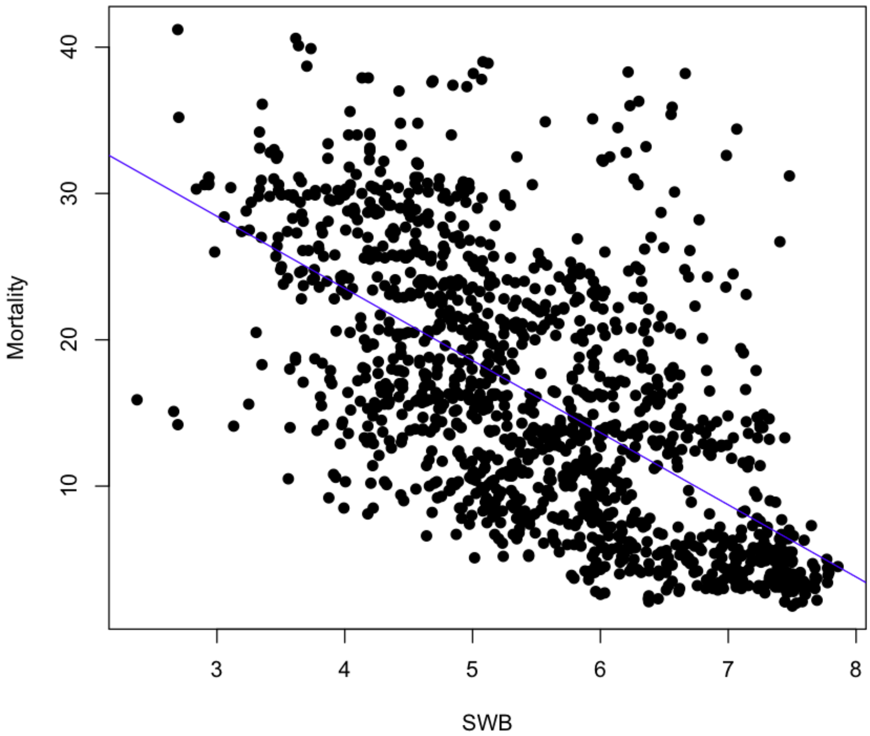
Table 2. Summary statistics of variables

Variable	Mean	Standard deviation	Min	Max
mortality	16.073	8.959	1.8	41.2
swb	5.508	1.128	2.375	7.858
loggdppc	9.435	1.141	5.527	11.664
rdensity	0.805	1.599	0.01	13.41
nocars	262.079	238.897	1.87	900.52
healthex	6.630	2.592	1,926	20.413
ruleoflaw	0.566	0.146	0.275	0.899
corruption	44.868	19.334	8	92

Results

A *mortality-swb* scatterplot (Figure 1) built for the entire dataset with a regression line for these two variables looks very promising for the support of H1, i.e. better road safety associated with higher levels of SWB. However, we also see a large number of outliers on both sides of the line representing both "high SWB-high mortality" and "low SWB-low mortality" situations.

Figure 1. Mortality and SWB, 2010-2019



The correlation matrix for all variables (Table 2) is a useful initial step for assessing the interplay between them and potential risks of endogeneity. We see, indeed, that there is strong correlation between our key independent variables *swb* and *loggdppc*, which is in line with the conceptualisation of *swb*, common sense, and earlier research findings discussed in the previous sections. There is even stronger correlation between *corruption* and *ruleoflaw* indicating a potential multicollinearity risk.

Table 3. Correlation matrix

	mortality	swb	loggdppc	rdensity	nocars	healthex	ruleoflaw	corruption
mortality	1.000							
swb	-0.621	1.000						
loggdppc	-0.751	0.780	1.000					
rdensity	-0.392	0.286	0.386	1.000				
nocars	-0.716	0.678	0.803	0.297	1.000			
healthex	-0.361	0.395	0.356	0.094	0.561	1.000		
ruleoflaw	-0.671	0.680	0.762	0.373	0.814	0.511	1.000	
corruption	-0.622	0.676	0.734	0.396	0.763	0.505	0.939	1.000

The multicollinearity risk is further corroborated by the VIF calculation (Table 4).

Table 4. VIF values (with and without corruption)

swb	loggdppc	rdensity	nocars	healthex	ruleoflaw
2.73	4.57	1.22	4.51	1.60	3.59

swb	loggdppc	rdensity	nocars	healthex	ruleoflaw	corruption
2.77	4.57	1.25	4.54	1.62	10.58	8.98

Given the above reasoning, we excluded *corruption* from our models. The initial idea of using this variable was to capture the possible effect of inefficient governance on road accident mortality; however, its extremely high correlation with *ruleoflaw* suggests that it can be dropped without reducing too much the accuracy of the model.

We started with a pooled OLS regression (Table 5) in order to assess the general situation with the variables and possible endogeneity problems. Stepwise addition of explanatory variables revealed that the link between *mortality* and *swb* is not statistically significant and much weaker than the link between *mortality* and *loggdppc*, with the latter being strongly statistically significant. We also see that the addition of *loggdppc* affects quite dramatically the size, the sign, and the statistical significance of *healthex*.

Table 5. Regression (pooled OLS) results – all data

Intercept	43.235*** (0.961)	41.361*** (0.937)	31.672*** (0.938)	30.944 *** (0.999)	33.316*** (1.145)	56.222*** (2.123)
SWB	-4.931*** (0.171)	-4.399*** (0.171)	-1.775*** (0.195)	-1.789*** (0.195)	-1.555*** (0.202)	-0.327 (0.223)
Road density		1.308*** (0.121)	-0.987*** (0.106)	-0.966*** (0.106)	-0.864*** (0.108)	-0.663*** (0.105)
Number of cars			-0.019*** (0.001)	-0.020*** (0.001)	-0.017*** (0.001)	-0.010*** (0.001)
Health expenditures				0.157* (0.075)	0.199** (0.075)	-0.006 (0.075)
Rule of law					-8.500*** (2.040)	-4.525* (1.988)
Log GDP per capita						-3.161*** (0.286)
Adjusted R2	0.385	0.435	0.573	0.574	0.579	0.614
Balanced panel: n = 133, T = 10, N = 1330 Standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05						

Since we have 10-year time series for specific countries, it would be reasonable to assume that there might be unobservable time-invariant country-specific effects. Therefore, we decided to try a fixed-effect (FE) regression, also with stepwise addition of variables (Table 6). One possible alternative to the FE model could be the random effects (RE) model, which gives a wider pooling, but the choice was decided by the Hausman test. Stepwise addition of variables in the FE model, as in the pooled OLS case, confirmed the general strong effect of *loggdppc*, as well as waning and not statistically significant connection between *swb* and *mortality*.

Table 6. Regression (fixed effects) results – all data

SWB	-0.129 (0.116)	-0.130 (0.117)	-0.053 (0.117)	-0.056 (0.116)	-0.054 (0.116)	0.239 (0.126
Road density		-0.034 (0.622)	2.605** (0.821)	2.635** (0.819)	2.609** (0.819)	2.596** (0.809)
Number of cars			-0.01744*** (0.003585)	-0.01735*** (0.003576)	-0.01732*** (0.003574)	-0.015*** (0.003544)
Health expenditures				-0.188** (0.067562)	-0.185** (0.067542)	-0.149* (0.067012)
Rule of law					-3.711 (2.448)	-2.135 (2.433)
Log GDP per capita						-1.130*** (0.203)
Adjusted R2	-0.110	-0.111	-0.090	-0.084	-0.083	-0.056
Balanced panel: n = 133, T = 10, N = 1330 Standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05						

As discussed in the previous sections and confirmed by the WHO reports, the road safety situation, both in general and in terms of road accident mortality patterns, is different in different countries of the world, mostly due to income differences, but also because of a number of other factors, such as level of development, structure of the vehicle mix on the roads, motorisation rates, demographic trends, etc. Therefore, it might be an interesting idea to split the dataset in two parts – high-income (HI) and low- and middle-income (LMI) countries in accordance with the World Bank (2023) classification.

The *mortality-swb* scatterplots for these groups (Figures 3 and 4 below) indicate that there are indeed certain differences between them. In particular, the HI group expectedly has lower road mortality levels (albeit with a number of outliers) with a visible concentration of data points in the bottom right corner ("high SWB – low mortality"). In the LMI countries, the road mortality is much higher, with a large number of data points way above the 15 deaths/100,000 people level. In addition, the bottom right corner of the LMI group scatterplot is almost empty, and even though there are countries with high SWB levels in this group, the road mortality in such countries also seems to be high.

Figure 3. Mortality and SWB in high-income (HI) countries, 2010-2019

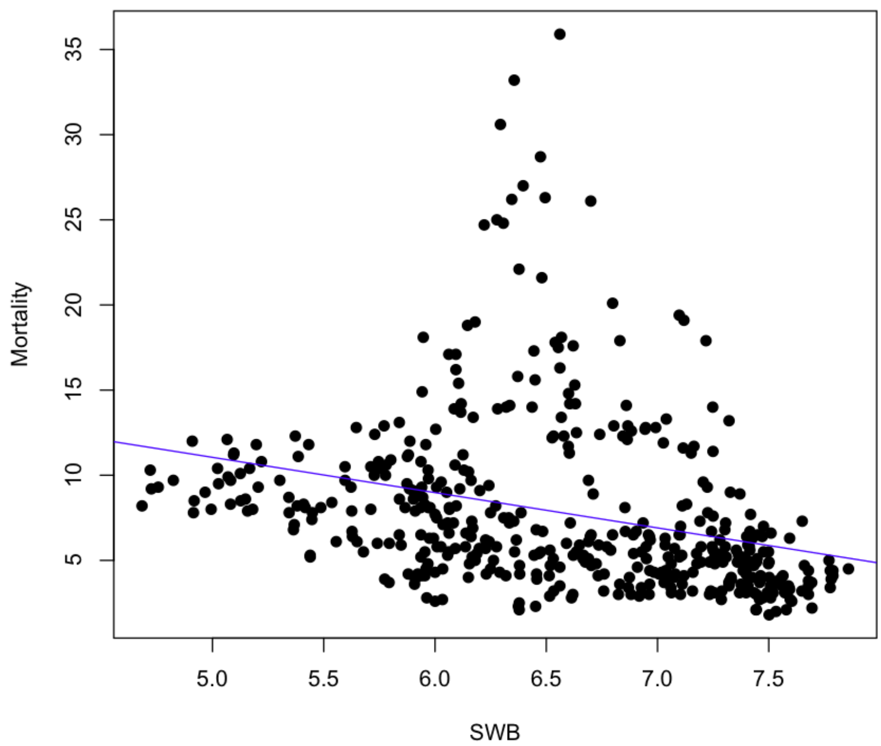
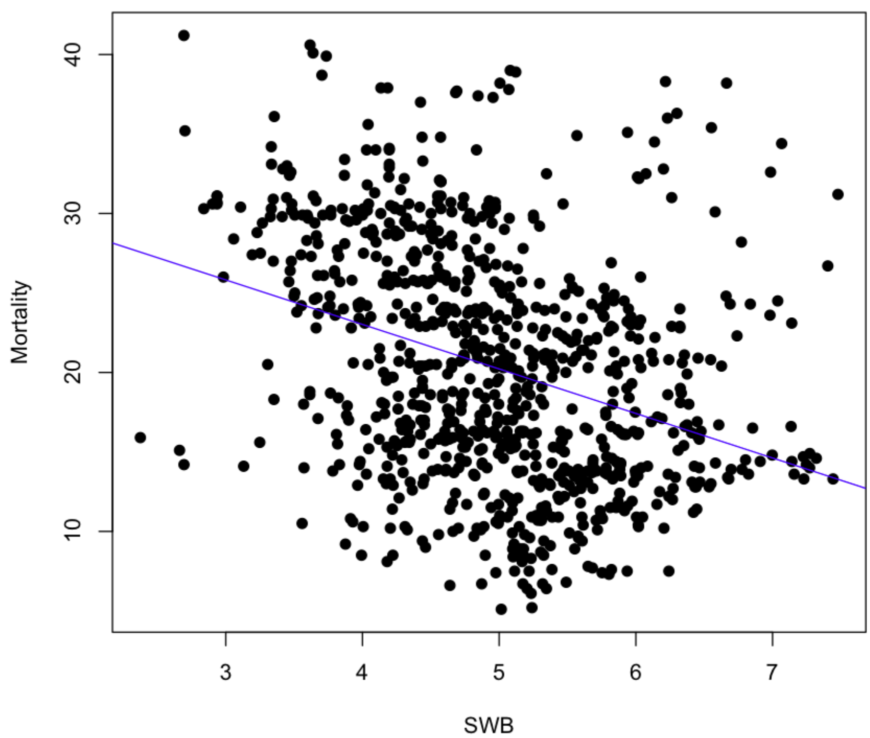


Figure 4. Mortality and SWB in low- and middle-income (LMI) countries, 2010-2019



The results of the two separate pooled OLS regressions for these groups (Tables 7 and 8 below) are quite similar, though, to the general pooled OLS for the entire dataset (Table 5 above). The *swb* coefficient changes its size quite substantially and loses statistical significance in both cases once *loggdppc* is added. However, *healthex* is not affected in the HI group regression as much as in the general regression for the entire dataset. In addition, *loggdppc* in the HI group appears with a positive coefficient and is statistically significant.

Table 7. Regression (pooled OLS) results - HI countries

Intercept	21.416*** (2.048)	22.890*** (1.947)	25.952*** (1.772)	25.096*** (1.739)	28.084*** (1.611)	10.631 (5.703)
SWB	-2.073*** (0.310)	-2.123*** (0.294)	-1.578*** (0.269)	-1.097*** (0.281)	0.612* (0.310)	-0.022 (0.366)
Road density		-0.656*** (0.089)	-0.778*** (0.081)	-0.808*** (0.079)	-0.694*** (0.073)	-0.796*** (0.079)
Number of cars			-0.012*** (0.00114)	-0.009*** (0.00125)	-0.005*** (0.00121)	-0.006*** (0.00124)
Health expenditures				-0.450*** (0.094)	-0.371*** (0.086)	-0.302*** (0.087)
Rule of law					-23.573*** (2.429)	-24.265*** (2.414)
Log GDP per capita						2.096** (0.286)
Adjusted R2	0.088	0.184	0.343	0.373	0.482	0.493
Balanced panel: n = 45, T = 10, N = 450 Standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05						

In the LMI group (Table 8), *healthex* reacts much stronger to the addition of *loggdppc* losing both its size and significance, whereas *ruleoflaw* becomes much stronger and statistically significant once *loggdppc* is added.

Table 8. Regression (pooled OLS) results - LMI countries

Intercept	34.223*** (1.338)	34.331*** (1.323)	30.924*** (1.258)	28.348*** (1.401)	28.073*** (1.961)	51.597*** (3.043)
SWB	-2.802*** (0.265)	-2.668*** (0.263)	-1.341*** (0.268)	-1.251*** (0.267)	-1.2496*** (0.266)	-0.032 (0.285)
Road density		-2.389*** (0.522)	-2.308*** (0.483)	-2.003*** (0.485)	-2.020*** (0.493)	-1.829*** (0.469)
Number of cars			-0.026*** (0.002197)	-0.0297*** (0.002319)	-0.0299*** (0.0025)	-0.012*** (0.00299)
Health expenditures				0.414*** (0.103)	0.412*** (0.103)	0.122 (0.103)
Rule of law					0.645 (3.209)	7.974* (3.139)
Log GDP per capita						-3.847*** (0.394)
Adjusted R2	0.112	0.132	0.255	0.26785	0.26704	0.339
Balanced panel: n = 88, T = 10, N = 880 Standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05						

Repeating the FE regression for the HI and LMI groups (Tables 9 and 10) further confirms the lack of statistically significant association between *swb* and *mortality*, only this time, unlike in the pooled OLS case, *swb* is not significant in any of the iterations in both HI and LMI groups. In both groups, *loggdppc* appears with a negative statistically significant coefficient; however, its absolute valued is twice as large in the HI case. Both *rdensity* and *nocars* in the HI case and *healthex* in the LMI case lose their statistical significance after the addition of *loggdppc*.

Table 9. Regression (fixed effects) results - HI countries

SWB	-0.246 (0.224)	-0.210 (0.228)	0.068 (0.241)	0.012 (0.2422)	0.011 (0.2424)	0.102 (0.2417)
Road density		0.466 (0.528)	2.537** (0.821)	2.413** (0.822)	2.381** (0.826)	1.630 (0.853)
Number of cars			-0.012** (0.0038)	-0.0115** (0.003873)	-0.0114** (0.003857)	-0.006 (0.0041)
Health expenditures				-0.20983 (0.123)	-0.20984 (0.1232)	-0.234 (0.122)
Rule of law					-1.346 (3.044)	-1.391 (3.011)
Log GDP per capita						-1.946** (0.631)
Adjusted R2	-0.108	-0.109	-0.082	-0.078	-0.0798	-0.057
Balanced panel: n = 45, T = 10, N = 450 Standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05						

Table 10. Regression (fixed effects) results - LMI countries

SWB	-0.106 (0.13927)	-0.118 (0.13902)	-0.093 (0.13712)	-0.089 (0.13674)	-0.086 (0.13651)	0.203 (0.151)
Road density		-4.784* (2.127)	-2.264 (2.159)	-2.091 (2.154)	-2.115 (2.150)	-1.220 (2.139)
Number of cars			-0.0316*** (0.006427)	-0.0322*** (0.006415)	-0.0334*** (0.006431)	-0.030*** (0.006405)
Health expenditures				-0.190* (0.0815)	-0.186* (0.0814)	-0.149 (0.0810)
Rule of law					-6.716 (3.460)	-4.291 (3.472)
Log GDP per capita						-0.981*** (0.233)
Adjusted R2	-0.110	-0.104	-0.073	-0.067	-0.063	-0.041
Balanced panel: n = 88, T = 10, N = 880 Standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05						

In addition to the above methods, we tried 2SLS, including with a prior FD transformation. The first attempt was with freedom as a potential IV candidate based on the common sense assumption that freedom (Human Freedom Index) should be connected with *swb*, but it should have no direct effect on *mortality*. However, the first stage regression did not confirm any statistically significant link between freedom and *swb*.

The second attempt was to use unemployment (World Bank data) as an IV after FD transformation of the entire dataset with a further split into HI and LMI groups. Despite successful first stage results, the second stage gave statistically significant positive coefficients for *swb*, for which we couldn't find any common sense explanation, except for, perhaps, a possible direct connection between unemployment and *mortality*, in which case unemployment is not suitable as an IV.

DISCUSSION

This study was an attempt to check whether there is really a link between emotional states and road safety, for which a number of assumptions were made, predominantly with the purpose of doing meaningful quantitative research.

First, we narrowed the road safety concept down to just road accident mortality as the most important and easily quantifiable measure (although, as we learned, the counting methodology may differ from one country to another as in some countries, for example, post-accident deaths in healthcare facilities are not included in the road deaths statistics). We also narrowed down the concept of traffic participants to mostly drivers in line with the hard fact that most road accident deaths are caused by drivers.

Furthermore, we narrowed the concept of emotional states to subjective well-being and used the happiness scores self-reported by people from different countries. Presumably, this measured 'happiness' covers both the positive and the negative parts of the emotional spectrum depending on the value. Despite its seeming simplicity, this indicator is, in fact, just a tip of an iceberg since it reflects integrally a number of such profound characteristics of a country as income, inequality, social support, freedom, corruption, etc. Therefore, its role for the purposes of this research is twofold: on the one hand, it stands for all those variables that may together create resistance to further progress in the reduction of road accident mortality as a noble and extremely valid sustainable development goal; on the other hand, happiness or well-being as a background or 'deeper' characteristic of the human condition may translate into 'operating' emotions that have very specific and immediate effects on cognitive processes and situational risk-taking, which, in turn, affects driving performance.

The choice of the other variables was largely governed by the previous long-standing research which identified the biggest road mortality risk factors. Despite this, we could not prove a statistically significant relation between SWB and road traffic mortality, even after splitting the original dataset into two income groups and applying FE regressions in order to address the apparent endogeneity problem. (Both 2SLS attempts were also unsuccessful; however, this option should not be ruled out in the future provided that a suitable IV can be found.) It is quite likely that such relation does not exist, contrary to the assumption that well-being as a deeper and more permanent state of mind may manifest itself at the level of more transient emotions, which, in turn, may affect the behaviour and capabilities of road traffic participants.

Other problems may include data quality and, more specifically, data measurement/collection errors. Many countries have inadequate information systems on road traffic injury, including multiple and often conflicting data sources; non-standardisation of data; inappropriate use of indicators; definitional issues related to traffic deaths and injuries; and underreporting (WHO, 2004). In LMI countries, there is a lack of systematic enforcement to collect data on RTDs. In Ukraine, in particular, substantial differences are observed between road accident data reported by the traffic police and the relevant statistics from other official sources, which may be due to serious deficiencies in the road accident data collection system or purposeful statistical data manipulations with a view to ‘meeting’ international obligations (Holovkin, 2022).

In any case, our results do not confirm the traditional and ‘common sense’ belief that ‘happy drivers are better drivers’ (in particular, because they see utility in their positive state of mind and, therefore, are more risk-averse and conservative in their driving behaviour as they have more to lose). This finding goes well with some previous research suggesting that elevated emotional states are not necessarily good for optimal and safe driving. However, more substantial research will be needed to better understand possible linkages between such deep/background emotional states as overall well-being and more immediate emotions experienced by road traffic participants.

Albeit negative, our findings can still contribute to the progress in the relatively new, but rapidly advancing sphere of AI-assisted/autonomous driving which depends a lot on having proper driver’s behaviour models and will largely shape the future of automotive transport and road safety, as well as in the traditional road safety sphere where they can serve as an input to more high-level policy making, mostly in the form of understanding that the recent lack of progress in the reduction of road accident mortality may be due to other than purely technical/mechanical/hard factors, such as condition of the road infrastructure, age of the vehicle fleet or severity of traffic law enforcement.

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APPENDIX 1. R CODE

```
#Load packages
library(foreign)
library(plm)
library(car)
library(AER)
library(collapse)

#Load data
mortall <- Road_Mortality_and_SWB_2010_2019_Filled
morthi <- High_income
mortlmi <- Low_and_middle_income

#Declare our data to be a panel data set
mortall.p <- pdata.frame(mortall, index=c("country","year"))
morthi.p <- pdata.frame(morthi, index=c("country","year"))
mortlmi.p <- pdata.frame(mortlmi, index=c("country","year"))


# Build scatter plots with regression lines
x<-(mortall$swb)
y<-(mortall$mortality)
reg <- lm(mortality~swb, data=mortall)
plot(x, y, xlab = "SWB", ylab = "Mortality", pch = 19)
abline(reg,col='blue')

x<-(morthi$swb)
y<-(morthi$mortality)
reg <- lm(mortality~swb, data=morthi)
plot(x, y, xlab = "SWB", ylab = "Mortality", pch = 19)
abline(reg,col='blue')

x<-(mortlmi$swb)
y<-(mortlmi$mortality)
reg <- lm(mortality~swb, data=mortlmi)
plot(x, y, xlab = "SWB", ylab = "Mortality", pch = 19)
abline(reg,col='blue')

#Check correlations
data <- mortall[ , c("mortality", "swb", "loggdppc", "rdensity", "nocars", "healthex",
"ruleoflaw", "corruption", "freedom", "unemployment")]
cor(data)

#Check summary statistics
colMeans(data)
colMins(data)
sapply(data, sd, na.rm = TRUE)
```

```
#Run a panel model
#Pooling - all
pooledall1 <- plm(mortality~swb,data=mortall.p,model="pooling")
summary(pooledall1)
pooledall2 <- plm(mortality~swb+rdensity,data=mortall.p,model="pooling")
summary(pooledall2)
pooledall3 <- plm(mortality~swb+rdensity+nocars,data=mortall.p,model="pooling")
summary(pooledall3)
pooledall4 <-
plm(mortality~swb++rdensity+nocars+healthex,data=mortall.p,model="pooling")
summary(pooledall4)
pooledall5 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw,data=mortall.p,model="pooling")
summary(pooledall5)
pooledall6 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw+loggdppc,data=mortall.p,model="
pooling")
summary(pooledall6)

#Check VIFs
vif(pooledall6)

#Pooling - high-income countries
pooledhi1 <- plm(mortality~swb,data=morthi.p,model="pooling")
summary(pooledhi1)
pooledhi2 <- plm(mortality~swb+rdensity,data=morthi.p,model="pooling")
summary(pooledhi2)
pooledhi3 <- plm(mortality~swb+rdensity+nocars,data=morthi.p,model="pooling")
summary(pooledhi3)
pooledhi4 <-
plm(mortality~swb++rdensity+nocars+healthex,data=morthi.p,model="pooling")
summary(pooledhi4)
pooledhi5 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw,data=morthi.p,model="pooling")
summary(pooledhi5)
pooledhi6 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw+loggdppc,data=morthi.p,model="p
ooling")
summary(pooledhi6)

#Pooling - low- and middle-income countries
pooledlmi1 <- plm(mortality~swb,data=mortlmi.p,model="pooling")
summary(pooledlmi1)
pooledlmi2 <- plm(mortality~swb+rdensity,data=mortlmi.p,model="pooling")
summary(pooledlmi2)
pooledlmi3 <- plm(mortality~swb+rdensity+nocars,data=mortlmi.p,model="pooling")
summary(pooledlmi3)
pooledlmi4 <-
plm(mortality~swb++rdensity+nocars+healthex,data=mortlmi.p,model="pooling")
summary(pooledlmi4)
```

```
pooledlmi5 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw,data=mortlmi.p,model="pooling")
summary(pooledlmi5)
pooledlmi6 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw+loggdppc,data=mortlmi.p,model="
pooling")
summary(pooledlmi6)


#Run a panel model
#fixed effects / within - all
fixedall1 <- plm(mortality~swb,data=mortall.p,model="within")
summary(fixedall1)
fixedall2 <- plm(mortality~swb+rdensity,data=mortall.p,model="within")
summary(fixedall2)
fixedall3 <- plm(mortality~swb+rdensity+nocars,data=mortall.p,model="within")
summary(fixedall3)
fixedall4 <- plm(mortality~swb++rdensity+nocars+healthex,data=mortall.p,model="within")
summary(fixedall4)
fixedall5 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw,data=mortall.p,model="within")
summary(fixedall5)
fixedall6 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw+loggdppc,data=mortall.p,model="
within")
summary(fixedall6)


#Fixed effects / within - high-income countries
fixedhi1 <- plm(mortality~swb,data=morthi.p,model="within")
summary(fixedhi1)
fixedhi2 <- plm(mortality~swb+rdensity,data=morthi.p,model="within")
summary(fixedhi2)
fixedhi3 <- plm(mortality~swb+rdensity+nocars,data=morthi.p,model="within")
summary(fixedhi3)
fixedhi4 <- plm(mortality~swb++rdensity+nocars+healthex,data=morthi.p,model="within")
summary(fixedhi4)
fixedhi5 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw,data=morthi.p,model="within")
summary(fixedhi5)
fixedhi6 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw+loggdppc,data=morthi.p,model="
within")
summary(fixedhi6)

#Fixed effects / within - low- and middle-income countries
fixedlmi1 <- plm(mortality~swb,data=mortlmi.p,model="within")
summary(fixedlmi1)
fixedlmi2 <- plm(mortality~swb+rdensity,data=mortlmi.p,model="within")
summary(fixedlmi2)
fixedlmi3 <- plm(mortality~swb+rdensity+nocars,data=mortlmi.p,model="within")
```

```
summary(fixedlmi3)
fixedlmi4 <-
plm(mortality~swb++rdensity+nocars+healthex,data=mortlmi.p,model="within")
summary(fixedlmi4)
fixedlmi5 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw,data=mortlmi.p,model="within")
summary(fixedlmi5)
fixedlmi6 <-
plm(mortality~swb+rdensity+nocars+healthex+ruleoflaw+loggdppc,data=mortlmi.p,model="
within")
summary(fixedlmi6)
```