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Influence of shift work on cardiovascular disease risk in Southern African long-distance truck drivers: a cross-sectional study

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ABSTRACT

Objectives Cardiovascular disease (CVD) is a major problem globally. Truck drivers have an increased risk of CVD due to a sedentary lifestyle, irregular working hours and behavioural choices. We aimed to get insight into the contribution of night shift work to CVD risk in long-distance truck drivers in South Africa.

Design A cross-sectional study.

Setting Enrolment took place at three South African truck stop locations in two provinces; Bloemfontein (Free State), Pomona Road (Gauteng) and Soweto (Gauteng).

Participants 607 males aged ≥18 years with full-time employment as a long-distance truck driver were included. The criteria for inclusion were willingness and being able to provide informed consent and to complete the study procedures.

Primary and secondary outcome measures Information was collected on sociodemographics, occupational and health characteristics. Physical measurements, an ECG and carotid intima–media thickness (CIMT) measurements were taken. A night shift was defined as working at least 3 hours between 22:00 and 6:00 hours once a week. CVD risk was defined with the Framingham Risk Score (FRS), the Atherosclerotic Cardiovascular Disease (ASCVD) risk algorithm, left ventricular hypertrophy (LVH) and CIMT.

Results In total, 607 truck drivers were included of which 305 (50.2%) worked in day shifts only and 302 (49.8%) worked day and night shifts. There was a high prevalence of CVD risk factors in both groups as 33% were hypertensive, 28% obese and 37% had abnormal lipid levels. Working day and night shifts compared with working only day shifts did not result in differences in FRS, ASCVD risk or LVH. No difference was found in CIMT measurements, except for the maximum bulb thickness which was higher in day shift workers.

Conclusions CVD risk factors are considerably present in male truck drivers in South Africa. CVD risk does not differ between dayshift and day–night shift workers in this cross-sectional analysis.

Strengths and limitations of this study

- This study presents the largest cohort of male truck drivers in Africa.
- Data collection was extensive and included demographics, work and life style-related risk factors for diseases as well as physical measurements.
- Cardiovascular disease (CVD) risk was assessed with CVD risk scores, ECG and carotid intima–media measurements.
- Night shift work was defined in several ways to account for the variation of definitions in literature.
- The influence of night shift work on CVD endpoints was investigated using multivariable regression models.

INTRODUCTION

Cardiovascular disease (CVD) is the number one cause of death and a leading cause of disability globally. An estimated 17.9 million people died of CVD in 2016, representing 31% of all global deaths.[1 2] Over 75% of CVD events occur in low-income and middle-income countries.[3] In South Africa, CVD is responsible for approximately 20% of all deaths, making it the second leading cause of death after HIV/AIDS.[4 5] The cause of CVD is multifactorial and includes behavioural factors such as smoking, physical inactivity, unhealthy dietary patterns and lifestyle related conditions such as high cholesterol, high blood pressure, high body mass index (BMI) and high waist to hip ratio.[6]

Irregular working hours and night shifts are risk factors for CVD. In a large systematic review and meta-analysis published in 2018, which combined the results from 21 cohort and case–control studies with a total of 173 010 unique participants, CVD risk increases with 7.1% for every 5 years of shift work exposure after the first 5 years.[7] A second study shows that shift work in a cocoa processing company in Ghana is associated with risk factors of CVD such as higher BMI and higher cholesterol levels.[8] A possible reason for the increase in CVD risk may be circadian misalignment. Circadian misalignment

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reflects a non-optimal scheduling of behavioural and environmental cycles such as sleep/wake, fasting/feeding, rest/activity, dark/light cycles, with respect to endogenous biological processes governed by the circadian system, such as blood pressure, hormones and inflammation factors.[9]

Truck drivers are a high-risk population for CVD by virtue of their occupation with long working hours, frequent shift work, low physical activity and high levels of sedentary behaviour. There is a high prevalence of risk factors contributing to CVD in truck drivers in South Africa such as smoking, obesity, hypercholesterolaemia, hypertension and abnormal glucose levels.[10 11] This study aims to gain insight into the contribution of night shift work to CVD risk in long-distance truck drivers in South Africa by comparing truck drivers who work day shifts only to truck drivers who work day and night shifts.

METHODS

Study design and setting

This analysis is a secondary data analysis of The Trucker Health Survey (THS). The THS was an initiative of the Wits Reproductive Health and HIV Institute, a department of the University of the Witwatersrand and North-Star Alliance (NSA). NSA provided healthcare services to truck drivers through a network of Road side Wellness Centres located at busy truck stops and at border crossings.[12] Methods and characteristics of the THS have been described previously.[13] Enrolment took place between October 2016 and March 2017 in three South African locations in two provinces; Bloemfontein (Free State), Pomona Road (Gauteng) and Soweto (Gauteng). The truck stop in Sowetowas added from January to March 2017 to reach a sufficient number of South African participants. Information was collected during a single visit.

Study population and inclusion criteria

Males aged 18 years and older with full-time employment as a long-distance truck driver were included. The criteria for inclusion were willingness and being able to provide informed consent and to complete the study procedures. All participants with data on shift work available were eligible for this analysis.

Patient and public involvement statement

Patients and the public were not involved in the study design, or in the recruitment to and conduct of the study. Results cannot be disseminated to study participants directly due to insufficient contact information.

Evaluation

Information on sociodemographic (ie, age, education, country of origin, marital status), occupational (ie, time spent working, working night shifts), behavioural (ie, smoking status, physical activity, sleep duration per day) and health (ie, HIV status, diabetes treatment, hypertension treatment) characteristics were collected using validated questionnaires.[14–17] An overview of the survey and all questionnaires that have been used can be found in the previously published methodology paper.[13] The main definition for night shifts was working at least 3 hours once a week between 22:00 and 6:00 hours, the remaining was defined as day shift workers. Night shift truck drivers worked either one night shift a week, two to three night shifts a week or more than four night shifts a week. We used those different cut-offs in a sensitivity analysis to investigate whether an increased number of nights shifts would be associated with increased CVD risk.

CVD risk was defined with four different outcome measures namely the Framingham Risk Score (FRS), the Atherosclerotic Cardiovascular Disease (ASCVD) risk algorithm, left ventricular hypertrophy (LVH) on ECG and carotid intima–media thickness (CIMT).[18 19]

Physical measurements included measurement of blood pressure, waist and hip circumference, height and weight. Blood was collected for measurement of total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein (LDL) cholesterol, triglycerides (TG), random glucose and creatinine. Blood pressure was categorised as normal, prehypertension and hypertension.[20] Cut-off points for glucose and cholesterol were chosen according to international guidelines.[21 22] Estimated glomerular filtration rate was calculated using creatinine levels and presented in stages of chronic kidney disease.[23]

CVD risk according to the FRS was calculated and categorised in low-CVD risk, intermediate-CVD risk and high-CVD risk.[18 24] The ASCVD risk algorithm was calculated for participants between the age of 40–70 according to algorithm guidelines.[19 22]

A standard 12-lead ECG was performed by a trained nurse with a computer-based ECG device (SE-1515 DP12, EDAN)[25] to record heart rate, rhythm and conduction time. LVH was assessed using Cornell's voltage ($RaVL+SV_3$), Cornell's product ((($RaVL+SV_3$)x QRS duration) and Sokolow-Lyon's voltage (SV_1+RV_5). LVH was defined as Cornell's voltage ≥28 mV, Cornell's product >2440 mV. ms or Sokolow-Lyon's voltage ≥35 mV.[26–29] The combined outcome of LVH was deemed positive if one or more criteria indicated LVH.

CIMT was measured in 217 (42.9%) participants, dependent on the availability of a sonographer. A Siemens Acuson p500 ultrasound (Siemens Healthcare, South Africa) with a ≥7 mHz linear probe was used. Measurements of the near wall and the far wall of the common carotid artery (CCA) were taken at three standardised angles each side using the Meijer's Arc.[30] At bulb level, the far wall was measured at the best visible angle at both sides. The images were analysed off-line in batch with the semi-automatically Artery Measurement System software (Chalmers University, Götenburg, Sweden). The mean of the mean CCA intima–media thickness (CCA-IMT) and the max of the mean CCA-IMT were calculated by averaging the near and far wall measurements across the three angles on both sides. Mean-max bulb IMT was calculated using bilateral measurements of the bulb far wall. A mean

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CCA-IMT of >1.0 mm at any of the measured angles was considered a carotid plaque.[31 32]

Statistical analysis

Analyses were done using SPSS V.25.0 (SPSS). A p≤0.05 was considered to be statistically significant. Categorical variables were represented as counts with percentages. All continuous outcomes were non-normally distributed and summarised using median with IQR. Non-normally distributed data were transformed using the Box-Cox technique combined with a goodness-of-fit test using normal, lognormal and exponential distributions. To test how cardiovascular measures differed between day and night shift workers a χ^2 test was used for categorical outcomes and a Mann-Whitney-U test was used for continuous outcomes. Next, regression analysis was used to assess the influence of shift work on FRS, ASCVD risk, mean CCA-IMT and LVH while adjusting for confounders. Variables considered as confounders were age, country of origin, education level and relationship status.[33] We did not adjust for known CVD risk factors as outcomes represent the cumulative effect of CVD risk factors. Variables were included in multivariable analysis if the p value was ≤0.20 in univariable analysis. Age was added to the multivariable model independent of the p value in univariable analysis. FRS, ASCVD and mean CCA-IMT were log transformed to meet criteria for normal distribution.

In a sensitivity analysis, above describedanalyses were repeated using different cut-off points for night shift work, namely 0–1 night shift a week, 2–3 night shifts a week or 4 or more night shifts a week. Finally, all analyses were repeated including only truck drivers who had been working as a truck driver for more than 10 years (n=229 out of 607).

RESULTS

In total, 614 male truck drivers completed the survey, of which 607 (99%) had data on shift work available. Nearly half (n=305, 50.2%) worked in day shifts only and 302 drivers (49.8%) worked both day and night shifts (table 1).

There were no drivers who only worked night shifts. The median age was 37 (IQR: 31–42) years. The majority of the drivers were from Zimbabwe (62.5%), followed by South Africa (20.2%). The drivers had worked for a median duration of 9 (IQR: 5–14) years as a truck driver. There was a high prevalence of CVD risk factors in both groups as 28% of participants were obese, 33% hypertensive and >35% had abnormal LDL and TG levels. No significant differences were seen between the groups for most of the CVD risk factors. The day-night shift group had a higher activity score (p=0.02), higher neck circumference (p<0.01) and a lower waist to hip ratio (p=0.03) than the participants who worked day shifts only.

Shift work was borderline associated with a difference in FRS (p=0.05) as continuous outcome, but there was no difference between the groups when categorised in low, intermediate and high risk (p=0.57). Shift work was not associated with ASCVD risk score (p=0.94), LVH occurrence (all p >0.20) or CIMT, except for max bulb IMT, which was higher in day shift workers compared with day–night shift workers (p<0.01) (table 2).

Following multivariable regression analysis shift work was not associated with any of the cardiovascular outcomes. Factors associated with higher FRS and ASCVD were increasing age (p<0.01 for both), having finished primary school or less (p=0.01 and p<0.01, respectively) and a stable relationship (p<0.01 for both). An increase in age (p<0.01) was associated with an increase in mean CCA-IMT. A stable relationship was positively associated with LVH (p<0.01) (online supplemental appendix 1).

Repeating the analysis using different definitions for night shift work resulted in the same findings(online supplemental appendices 2 and 3). Limiting the analysis to truck drivers who had been working as a truck driver for more than 10 years (n=229) did also not show a difference in CVD outcomes between day and day–night shift workers (online supplemental appendix 4).

DISCUSSION

Our study provides insight into the role of shift work on CVD risk in truck drivers in South Africa and possibly sub-Saharan Africa. We did not find an association between shift work and CVD risk according to the FRS strata, the ASCVD risk score, LVH and CIMT.

Our results are in line with recent studies done in cohorts of hospital workers. A study including female hospital employees showed that shiftwork was not directly linked to CVD risk.[34] Another study on healthcare workers employed in hospitals found no difference in metabolic risk factors between day and night shift workers.[35] Similar results were seen in a Finnish cohort study with a 20-year follow-up period as no association between shift work and cardiovascular morbidity was observed.[36]

However, other studies did find an increased CVD risk for night shift workers. In a systematic review and meta-analysis, shift work for more than 5 years had a positive and significant dose–response relationship on CVD risk. Shift work less than 5 years did not have a relation with CVD risk.[7] Another study, also a systematic review and meta-analysis, demonstrated that an increase in shift work of 5 years was associated with a five percent increase in the risk of CVD.[37] A third single site study with nearly 2000 participants showed that in male petrochemical plant workers, exposure to night shift work for over 20 years leads to a significant higher risk of getting hypertension.[38] Our study lacked data on intension and duration of night shifts so a dose–response relationship could not be investigated. Second, the group of truck drivers in our dataset who worked longer than 20 years was too small to do additional analysis.

Our findings on the abundance of CVD risk factors are in line with other studies that showed that CVD risk factors are notably present in truck drivers.[39 40] In the

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Table 1 Characteristics of the study population

	Participants (n=607)	Day shifts (n=305)	Day–night shifts (n=302)
Age (years), median (IQR)	37 (31–42)	37 (32–43)	36 (30–42)
Country of origin, n	605	303	302
Zimbabwe, n (%)	378 (62.5)	188 (62.0)	190 (62.9)
South Africa, n (%)	122 (20.2)	60 (19.8)	62 (20.5)
Zambia, n (%)	45 (7.4)	24 (7.9)	21 (7.0)
Other, n (%)	60 (9.9)	31 (10.2)	29 (9.6)
Working as driver (years), median (IQR)	9 (5–14)	9 (5–14)	8 (5–14)
Time spent working per month (days), median (IQR)	20 (15-24)	20 (18–24)	20 (15–24)
Time sleeping/day (hours), median (IQR)	8 (6–9)	8 (6–9)	7.5 (6–9)
Education level, n	585	287	298
Primary school or less, n (%)	51 (8.7)	32 (11.1)	19 (6.4)
Secondary school, n (%)	322 (55.0)	150 (52.3)	172 (57.7)
Matrix/college/university, n (%)	212 (36.2)	105 (36.6)	107 (35.9)
Marital status, n	607	305	302
Stable relationship, n (%)	545 (89.8)	278 (91.1)	267 (88.4)
No relationship, n (%)	62 (10.2)	27 (8.9)	35 (11.6)
HIV positive, n (%)	54 (8.9)	24 (7.9)	30 (9.9)
Weekly leisure activity score, median (IQR)	17 (0–27)	17 (0–19)	17 (0–31)
Body mass index (kg/m^2), n	597	298	299
Body mass index <30 kg/cm^2, n (%)	428 (71.7)	220 (73.8)	208 (69.6)
Body mass index ≥30 kg/cm^2, n (%)	169 (28.3)	78 (26.2)	91 (30.4)
Waist to hip ratio, median (IQR)	0.86 (0.81–0.91)	0.87 (0.82–0.92)	0.85 (0.80–0.91)
Neck circumference (cm), median (IQR)	37 (36–39)	37 (35–39)	38 (36–40)
Smoking ever in life, n (%)	90 (14.9)	47 (15.6)	43 (14.2)
Family history for CVD, n (%)	32 (5.3)	14 (4.7)	18 (6.0)
Heart rate (bpm), median (IQR)	75 (66–83)	75 (68–83)	75 (65–83)
Blood pressure classification, n	594	297	297
Normal, n (%)	100 (16.8)	43 (14.5)	57 (19.2)
Prehypertension*, n (%)	297 (50.0)	159 (53.5)	138 (46.5)
Hypertension† or Tx, n (%)	197 (33.2)	95 (32.0)	102 (34.3)
Serum glucose, n	457	234	223
≥7.8 mmol/L or Tx, n (%)	38 (8.3)	18 (7.7)	20 (9.0)
<7.8 mmol/L, n (%)	419 (91.7)	216 (92.3)	203 (91.0)
Serum creatinine	586	296	290
≥110 mmol/L, n (%)	102 (17.4)	58 (19.6)	44 (15.2)
<110 mmol/L, n (%)	484 (82.6)	238 (80.4)	246 (84.8)
eGFR‡	586	296	290
≥90 mL/min/1.73 m^2, n (%)	440 (75.1)	212 (71.6)	228 (78.6)
60–90 mL/min/1.73 m^2, n (%)	139 (23.7)	80 (27.0)	59 (20.3)
<60 mL/min/1.73 m^2, n (%)	7 (1.2)	4 (1.4)	3 (1.1)
Total cholesterol	587	296	291
≥5.17 mmol/L, n (%)	140 (23.9)	77 (26.0)	63 (21.6)
<5.17 mmol/L, n (%)	447 (76.1)	219 (74.0)	228 (78.4)
HDL cholesterol	587	296	291

Continued

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Table 1 Continued

	Participants (n=607)	Day shifts (n=305)	Day–night shifts (n=302)
≤1.04 mmol/L, n (%)	151 (25.7)	79 (26.7)	72 (24.7)
>1.04 mmol/L, n (%)	436 (74.3)	217 (73.3)	219 (75.3)
LDL cholesterol	587	296	291
≥3.0 mmol/L, n (%)	217 (37.0)	113 (38.2)	104 (35.7)
<3.0 mmol/L, n (%)	370 (63.0)	183 (61.8)	187 (64.3)
Triglycerides	587	296	291
≥1.7 mmol/L, n (%)	211 (35.9)	116 (39.2)	95 (32.6)
<1.7 mmol/L, n (%)	376 (64.1)	180 (60.8)	196 (67.4)

*Systolic blood pressure >120 mm Hg and/or diastolic blood pressure >80 mm Hg.
†Systolic blood pressure >140 mm Hg and/or diastolic blood pressure >90 mm Hg.
‡Calculated using: 186 × (creatinine/88.4)$^{-1.154}$ x (age)$^{-0.203}$ × (0.742 if female) × (1.210 if black African).
bpm, beats per minute; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate; HDL, high-density lipoprotein; LDL, low-density lipoprotein; Tx, on medication.

South African Demographic and Health Survey including almost 14 000 participants with a mean age of 38.5 years, the overall prevalence of hypertension was 30% and the prevalence of obesity was 20%.[41] In apopulation study in the northern part of South Africa, including 3641 participants (64% males, median age <30 years), 30% of the men had hypertension, 5% were obese and up to 20% had disturbances in lipid levels.[42]

In our population the mean age was 37.6 years. Hypertension occurred in 33% of the participants, and 28% were obese. In our study up to 37% of the participants had abnormal lipid levels. To summarise, it seems that in

Table 2 Cardiovascular risk assessments between dayshift only and day-night shift drivers

	Participants (n=607)	Day shifts (n=305)	Day–night shifts (n=302)	P value
Framingham Risk Score				
10-year Framingham risk percentage, n	585	295	290	0.05
10-year Framingham risk percentage, median (IQR)	3.21 (1.66–5.99)	3.52 (1.95–6.23)	2.98 (1.47–5.56)	
Low risk (<10%), n (%)	518 (88.5%)	265 (89.8%)	253 (87.2%)	
Intermediate risk (10%–20%), n (%)	52 (9.0%)	24 (8.1%)	28 (9.7%)	
High risk (>20%), n (%)	15 (2.5%)	6 (2.0%)	9 (3.1%)	
ASCVD risk score				
10-year ASCVD risk percentage, n	215	111	104	0.94
10-year ASCVD risk percentage, median (IQR)	5.13 (3.62–7.20)	5.16 (3.64–6.66)	5.12 (3.57–7.63)	
Low risk (<5%), n (%)	103 (47.9)	54 (48.6%)	49 (47.1%)	
Intermediate risk (5%–20%), n (%)	107 (49.8%)	55 (49.5%)	52 (50.0%)	
High risk (≥20%), n (%)	5 (2.3%)	2 (1.8%)	3 (2.9%)	
Cornell LVH				
LVH based on criteria >2.8 mV, n (%)	555	14 (4.9%)	9 (3.3%)	0.33
LVH based on product >244 mVms, n (%)	547	18 (6.5%)	11 (4.1%)	0.21
Solokow-Lyon LVH				
LVH based on criteria >3.5 mV, n (%)	581	92 (31.7%)	94 (32.3%)	0.88
LVH combined, n (%)	582	105 (36.1%)	104 (35.7%)	0.93
CIMT				
Mean CCA IMT (mm), median (IQR)	217	0.54 (0.50–0.70)	0.52 (0.49–0.59)	0.10
Max CCA IMT (mm), median (IQR)	217	0.62 (0.57–0.70)	0.60 (0.55–0.66)	0.12
Max bulb IMT (mm), median (IQR)	216	0.70 (0.60–0.86)	0.61 (0.51–0.75)	0.01
Carotid plaque, n (%)	216	5 (4.1%)	4 (4.3%)	0.93

ASCVD, arteriosclerotic cardiovascular disease; CCA, common carotid artery; CIMT, carotid intima–media thickness; IMT, intima–media thickness; LVH, left ventricular hypertrophy.

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our study there is a comparable percentage of hypertension, but increased percentage of obesity and abnormal cholesterol levels compared with the general population.

Some limitations need to be mentioned. The first relates to our definition of night shifts, as only 3 hours of work between 10pm and 6am classified someone as a night shift worker. To account for this, we did additional sensitivity analyses using different cut-offs for the number of nights worked in a week. Unfortunately, we did not have information on the exact number of hours worked per night nor did we have information on the time a driver had been involved in shiftwork. This limits our analysis on the dose–response relationship between shiftwork and CVD risk.

Another limitation is potential bias due to the healthy worker effect. Workers who are relatively fitter might do night shifts more often and will continue to do night shifts for a longer period of time. More unhealthy workers might possibly switch to day shifts only or to a different job. Although CVD risk factors did not differ between day and night shift workers there might be unmeasured risk factors leading to an underestimation of the influence of night shift work on CVD risk.

The combined LVH outcome may result in an overestimation of the number of participants without also conducting cardiac echocardiography which is considered the gold-standard measure. CIMT data were only available for 43% of the participants. This limits the power, but as CIMT scans were omitted randomly and the number of missing scans was evenly divided over the groups, we do not expect that this would result in a bias.

A major strength of this study is the size of the study with 607 truck drivers, of whom half were working day–night shifts. This is the largest cohort of male truck drivers in South Africa, and to the best of our knowledge, the largest in Africa. Our data represent the situation in the general truck driver community in South Africa and beyond as drivers from several African countries were included at public truck stops. Another strength is that we defined CVD risk in complementary ways using four different outcome measures namely FRS, ASCVD, LVH on ECG and CIMT in combination with the wide variety of physical measurements.

CONCLUSION

CVD risk factors are abundantly present in male long-haul truck drivers in South Africa. CVD risk does not differ between day shift and day–night shift workers in this cross-sectional analysis. Nevertheless, the high prevalence of CVD risk factors in this male cohort necessitates further investigation to develop and implement strategies to reduce CVD risk.

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Contributors Guarantor: AV. Designed the study: MD, AV, FV and DEG. Acquisition of data: STL-E, FV and AV. Analysed the data and interpreted results: MD, KS, STL-E, AEF and AV. Wrote the initial draft: MD and FV. All authors critically reviewed and approved of the final draft.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The study was approved by the Research Ethics Committee of the University of the Witwatersrand (reference number M160760). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

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