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Impact of HIV on Cognitive Performance in Professional Drivers

Gouse Hetta., PhD[1,§], **Masson Jane., MA**[1], **Henry Michelle., PhD**[2], **Dreyer Anna., MA**[1], **Robbins Reuben., PhD**[3], **Kew Greg., MBChB, DOH, ACPHM (Occ Med)**[4], **Joska John Andre., MBChB, MMed (Psych), PhD, FCPsych (SA)**[1], **London Leslie, MB ChB, MD, BSc Hons (Epid), DOH, M Med (PH)**[4], **Marcotte Thomas., PhD**[5], **Thomas Kevin GF., PhD**[6]

[1.]HIV Mental Health Research Unit and Neurosciences Institute, Department of Psychiatry and Mental Health, University of Cape Town, Cape Town, South Africa

[2.]Centre for Higher Education Development, University of Cape Town, Cape Town, South Africa

[3.]HIV Center for Clinical and Behavioral Science, New York State Psychiatric Institute and Columbia University, New York, USA

[4.]School of Public Health and Family Medicine, University of Cape Town, Cape Town, South Africa

[5.]HIV Neurobehavioral Research Program, Department of Psychiatry, University of California, San Diego, La Jolla, CA, USA

[6.]ACSENT Laboratory, Department of Psychology, University of Cape Town, Cape Town, South Africa

Abstract

Background: The intellectually demanding modern workplace is often dependent on good cognitive health, yet there is little understanding of how neurocognitive dysfunction related to HIV presents in employed individuals working in high risk vocations like driving. HIV-associated neurocognitive impairment is also associated with poorer long term cognitive, health and employment outcomes.

Setting: This study, set in Cape Town, South Africa, assessed the effects of HIV on neuropsychological test performance in employed male professional drivers.

Method: We administered a neuropsychological test battery spanning seven cognitive domains and obtained behavioral data, anthropometry, and medical biomarkers from three groups of

§ hetta.gouse@uct.ac.za, Tel: +27 21 404 5225.

Author contributions:

All authors contributed to the study conception and design. Material preparation and data collection was done by Hetta Gouse, Jane Masson and Greg Kew. Analysis were performed by Michelle Henry, Anna Dreyer, Kevin Thomas and Hetta Gouse. The first draft of the manuscript was written by Hetta Gouse and Jane Masson. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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The data that support the findings of this study are available from the corresponding author, [HG], upon reasonable request.

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professional drivers (68 men with HIV, 55 men with cardiovascular risk, and 81 controls). We compared the drivers' cognitive profiles, and used multiple regression modelling to investigate whether between-group differences persisted after considering potentially confounding sociodemographic and clinical variables (i.e., income, home language, depression, and Framingham Risk Score).

Results: Relative to other study participants, professional drivers with HIV performed significantly more poorly on tests assessing processing speed (p<.003) and attention and working memory (p=.018). Group membership remained a predictor of cognitive performance after controlling for potential confounders. The cognitive deficits observed in men with HIV were, however, largely characterized as being mild or asymptomatic. Consistent with this characterization, their relatively poor performance on neuropsychological testing did not generalize to self-reported impairment on activities of daily living.

Conclusion: Drivers with HIV may be at risk for poorer long-term health and employment outcomes. Programs that monitor and support their long-term cognitive health are needed.

Keywords

Cognition; Automobile Driving; HIV-associated Neurocognitive Disorders; Occupational Health; Activities of Daily Living; Cardiovascular Disease

INTRODUCTION

Chronic diseases such as HIV, diabetes mellitus type 2, and hypertension are often associated with cognitive dysfunction[1–4]. Such dysfunction may lead to premature socioeconomic inactivity, particularly in professions like vocational driving, in which these medical conditions appear commonly (probably due to vocation-related lifestyle factors such as being away from home for extended periods, poor diet, and sitting for long stretches of time)[5–7]. For professional drivers, cognitive dysfunction also confers an increased safety risk with potentially harsh consequences.

During the Fourth Industrial Revolution[8], rapidly evolving workplaces frequently present complex and intellectually demanding challenges[9]. Task outcomes are often dependent on good mental health, which therefore plays a critical role in the ability to perform work-related duties[10,11]. Nonetheless, there is little understanding of how, for instance, HIV-related cognitive dysfunction might present in actively-employed people and how it might affect current and future work products. Moreover, few guidelines describe how to identify (e.g., via screening instruments) and manage HIV+ employees with symptoms of cognitive impairment[12]. Such guidelines are strikingly absent despite the well-documented neurocognitive effects associated with HIV[13].

HIV-associated neurocognitive impairment (HNCI) or HIV-associated neurocognitive disorder is observed in 15%- 55% of people with HIV (PWH)[14,15] and prevalence rates as high as 70% have been reported in sub-Saharan Africa[16,17]. Dysfunction can range from mild (asymptomatic neurocognitive impairment and mild neurocognitive disorder) to severe (HIV-associated dementia), with effects across the domains of motor functioning, processing speed, attention, language, memory, and executive functioning[2,15,18,19]. Most

people with HNCI who are virally suppressed and on antiretroviral treatment (ART) remain cognitively stable[20]. They also remain in the workplace longer[21–23]. In fact, many people with mild HNCI maintain steady employment[24]. However, the health, medical, and functional consequences of even mild HNCI can be significant, and therefore people who experience the condition are more likely to have difficulty completing work-related activities than those who do not[25–28]. Of pertinence to this paper are studies showing that HNCI can impact driving ability adversely[29–38].

In people with diabetes and hypertension (both risk factors for cardiovascular disease), relatively subtle and slowly progressive cognitive decrements occur at all ages[1,39]. Diabetes increases the risk of mild cognitive impairment, and in older adults is associated with increased risk of Alzheimer's disease and related dementias[40–43]. In diabetics, mild impairment is observed in motor function, processing speed, memory, and executive function[39,44–49]. Progression of cognitive decline can mirror normal ageing or can occur up to 50% faster than that[43,50,51]. Diabetes can also impact driving performance[52,53]. Hypertension, the leading risk factor for stroke and a well-established risk factor for vascular cognitive impairment, is associated with greater incidence of mild cognitive impairment (mostly in the domains of processing speed and executive function), a relatively steep gradient of age-related cognitive decline, and dementia[1,54–58]. Few studies have investigated the effects of hypertension on driving performance despite relatively high rates of the condition in professional drivers[59]. However, a study of non-professional older drivers suggested that people with hypertension may not experience more driving difficulty, but that they do reduce their frequency of driving compared to healthy peers[60].

In many jurisdictions, fitness to drive is a regulatory requirement for professional drivers. Such fitness is a public health concern: Because those drivers are on the road for extended periods and because of the characteristics of their vehicles (e.g., petrochemical trucks, buses), there is a high risk of third-party harm if they drive unsafely. No previous studies of PWH have used a cohort that was uniformly employed in a reasonably cognitive demanding profession such as driving, or examined the relative risk of impairment in PWH compared to other conditions, such as diabetes and hypertension, with high prevalence in the same profession.

The current study examined, using a sample of actively employed professional drivers, the relative risk of cognitive impairment (and hence potentially reduced driving performance) in men with HIV (MWH) compared to that in men with cardiovascular risk factors (MCVR; diabetes mellitus type 2 and/or hypertension) and in controls. We hypothesised that neuropsychological test performance would be worst among MWH, and that MCVR would also perform more poorly than controls. We also measured, within each clinical group, associations between sociodemographic/clinical risk factors and neuropsychological test performance.

METHOD

Participants

This study is nested within a research program assessing effects of HNCI on driving performance in professional drivers from South Africa. Data were collected between August 2017 and March 2020. Convenience and snowball sampling recruited male professional drivers from occupational and primary healthcare clinics, a mobile-wellness clinic for truckers, an HIV-patient health management company, and social media platforms. The final sample comprised 204 participants (68 MWH, 55 MCVR [32 with hypertension, 23 with diabetes], 81 controls).

Inclusion criteria were: ≥1 year employment as a professional driver; ≥12 hours of professional driving per week; age ≥18 years; English fluency; and a valid South African professional driver's permit. For the two clinical groups, (1) MWH had to have a confirmed prior diagnosis of HIV (we did not exclude MWH who also had cardiovascular risk factors); and (2) MCVR had to have a confirmed prior diagnosis of diabetes and/or hypertension (drivers with both diabetes and hypertension were classified as diabetic), and a HIV-negative status confirmed via ELISA finger prick test. Participants with HIV or hypertension were required to have initiated treatment ≥3 months prior to study enrolment.

Exclusion criteria were: history of non-HIV-related neurological disorder or medical disorder affecting the nervous system (e.g., stroke, epilepsy, or head injury with consequent hospitalization and/or loss of consciousness for ≥30 minutes); presence of an Axis I DSM disorder, excluding major depressive disorder (due to the high prevalence of depressive symptoms in professional drivers and in PWH[61,62]); self-reported history of learning disability; self-reported diagnosis of diabetes mellitus type 1; and current substance abuse or dependence, assessed using the Alcohol Use Disorders Identification Test (AUDIT; cut-off score ≥8)[63], and a five-panel urine toxicology screen for tetrahydrocannabinol (THC), methylenedioxymethamphetamine (MDMA), cocaine, opioids, and amphetamines. Participants who tested positive for THC were only excluded if they had used marijuana within the previous 24 hours.

Additional exclusion criteria for the control group were: self-reported diagnosis of diabetes; self-reported prior prescription for hypertension medication or a blood pressure measure by research staff ≥140/90 mmHg[64]; and HIV-negative status confirmed via ELISA finger prick test on the research day.

Our institution's Human Research Ethics Committee approved this study. Participants provided written informed consent and were compensated the equivalent of US$40.

Measures and Procedure

A psychometric technician administered the study measures. We used standard versions of all tests except the Hopkins Verbal Learning Test-Revised (HVLT-R); in that case, we used a culturally adapted version that combines items from Forms 1 and 4 of the original test[65,66].

Test administrators and scorers were trained, supervised, and monitored by two clinical neuropsychologists (HG, CJM).

Demographic measures—Study-specific questionnaires gathered *demographic information* (e.g., regarding socioeconomic status and occupational history) and enquired about *neuromedical history* (e.g., cognitive changes and neurological symptoms).

Anthropometry and medical biomarkers—On the day of the research visit, we collected blood for lipid testing (including total cholesterol, HDL, LDL, and triglycerides), plasma viral load and CD4 count (for MWH), and glycated hemoglobin A1c (for diabetics); measured blood pressure, waist circumference, hip circumference, and weight; and administered a cotinine test (to confirm smoking status) and a five-panel urine toxicology screen. We calculated a Framingham Risk Score (FRS; 10-year cardiovascular risk prediction score informed by the D'Agostino et al, [2008][67] equation) using the calculator available at https://framinghamheartstudy.org/fhs-risk-functions/cardiovascular-disease-10-year-risk/ [68].

Behavioral scales—The *Beck Depression Inventory-II* assessed self-reported severity of depressive symptomatology[69]. The *Patient's Assessment of Own Functioning* (PAOFI) assessed self-reported functioning in the domains of memory, language and communication, use of hands, sensory-perception, and higher-level cognitive and intellectual functions[70]. We used the Woods et al. (2004)[71] guidelines to calculate everyday functional ability. An endorsement of "fairly often" through "almost always" on ≥3 questions within any domain was taken as an indication of self-reported cognitive difficulties.

Neuropsychological assessment—A neuropsychological test battery assessed performance on 16 measures, across seven cognitive domains: *motor function* (indexed by completion time on the Grooved Pegboard Test [GPT] dominant and non-dominant hands); *processing speed* (Trail Making Test Part A [TMT-A], completion time; Color Trails Test [CTT1], completion time; Wechsler Adult Intelligence Scale-Third Edition [WAIS-III] Digit Symbol Coding, total score; WAIS-III Symbol Search, total score); *attention/working memory* (Wechsler Memory Scale-Third Edition [WMS-III] Spatial Span, total score; WAIS-III Digit Span, total score;); *language* (category fluency, total number of animals/total number of fruits and vegetables named in 1 minute); *learning* (HVLT-R, total learning; Brief Visuospatial Memory Test-Revised [BVMT-R], total learning); *memory* (HVLT-R, delayed recall total; BVMT-R, delayed recall total); and *executive functioning* (CTT2, completion time; Wisconsin Card Sorting Test [WCST], total correct).

This battery has demonstrated evidence of psychometric validity in South Africa[72].

Statistical Analyses

We used RStudio (version 1.2.5019), R (version R-4.0.3), and SPSS (version 27.0). The threshold for statistical significance was set at α=.05. Effect size estimates (ESE) were calculated for each analysis. Specifically, we used Cramer's V for chi-square tests and partial eta squared [η_p^2] for ANOVAs. Interpretation of effect sizes followed convention: For

Cramer's V, small effect size ≤ 0.2; medium 0.2 to ≤ 0.6; and large > 0.6; for η_p^2, small <.06; medium .06 to .14; and large ≥.14[73].

First, one-way ANOVAs (for continuous variables) and chi-square tests (for categorical variables) investigated between-group (controls, MWH and MCVR) differences regarding participant sociodemographic and clinical characteristics. Where appropriate, we followed up with post-hoc pairwise comparisons using Tukey's Honestly Significant Difference[74]. The purpose here was to identify potential confounders that would need to be controlled for in subsequent analyses.

Second, we processed the neuropsychological test data. For each outcome variable, the raw score was transformed into a standardized *z*-score (mean [*M*] = 0, standard deviation [*SD*] = 1) using existing regression-based norms[75]. Scores were modified so that lower totals indicated poorer performance on all tests. *Z*-scores were then converted to *T*-scores (*M* = 50, *SD* = 10). An average domain *T*-score was calculated by taking the mean of all *T*-scores within each domain. A global *T*-score was calculated by taking the mean across domain *T*-scores. A global deficit score (GDS) was calculated by, first, converting each *T*-score to a deficit score following these guidelines: $T > 39 = 0$ (normal); $T \geq 35 – 39 = 1$ (mild impairment); $T \geq 30 – 34 = 2$ (mild-to-moderate impairment); $T \geq 25 – 29 = 3$ (moderate impairment); $T \geq 20 – 24 = 4$ (moderate-to-severe impairment); $T < 20 = 5$ (severe impairment). Then, the sum of the deficit scores was divided by the number of tests to compute the overall GDS[76]. Thus, lower *T*-scores and higher GDS scores indicate more severe impairment.

Third, multiple linear regression models assessed the influence group status had on cognitive outcomes after controlling for the potential confounders identified earlier. For each model, the outcome variable was a domain *T*-score, the global *T*-score, or the GDS.

Finally, chi-square tests (initially comparing all three groups, and following up with pairwise comparisons where appropriate) determined between-group differences in proportion of participants classed as showing cognitive impairment on each outcome measure, with the threshold for such impairment set at $z < -1.00$ and at GDS ≥0.5.

RESULTS

Sample Sociodemographic and Clinical Characteristics

Analyses detected significant between-group differences with regard to age and monthly income, but not education (see Table 1). On average, MWH and controls were significantly younger than MCVR (p=.001 and .008, respectively), but controls and MWH were similarly aged (p=.417). MWH had a significantly lower monthly income than MCVR and controls (p=.001 and <.001, respectively), with no significant difference between the latter two groups (p=.566).

Analyses detected significant between-group differences in terms of both home language and medium of schooling instruction. The MWH and control groups both consisted predominantly of Xhosa speakers, whereas the MCVR group consisted predominantly of

Afrikaans speakers. Within each group, approximately 50% of all participants had been schooled in English; however, more than 40% of MWH had been schooled in Xhosa whereas almost 40% of both controls and MCVR had been schooled in Afrikaans.

Although most participants in all groups were employed full-time, significantly more MWH than controls and MCVR were employed part-time.

Regarding the sample's clinical characteristics, most MWH (71%) were virally suppressed (viral load <20 copies/mL) at study enrolment. The median and interquartile range values for relevant variables were: plasma viral load = 0 (0–33) copies mL, CD4 count = 501 (328–674) cells/μl, nadir CD4 count = 270 (103–408) cells/μl. For participants with diabetes mellitus type 2, glycated haemoglobin (NGSP and IFCC) values were 8.3 (6.5–10.7) and 62.5 (46.5–91.2) respectively, with an average glucose (Eag) value of 62.5 (7.6–91.2).

Table 2 illustrates the numerous clinical variables on which analyses detected significant between-group differences. Follow-up pairwise comparisons indicated that, relative to controls and MWH, MCVR had significantly higher (a) risk for cardiovascular disease, as measured by the FRS (all *p*-values *[ps]* <.001); (b) systolic and diastolic blood pressure (*p*s <.05); (c) body mass index (BMI; *p*=.005 and <.001, respectively); (d) triglyceride levels (*p*s=.003); and (e) total cholesterol (*p*=.006 and .009, respectively). MCVR also had a higher hip-waist ratio than controls (*p*=.031), and higher LDL cholesterol than MWH (*p*=.026). All effect sizes were in the low range. Controls and MWH did not differ significantly on any of the measured clinical variables.

Analyses detected no significant between-group differences in the number of participants who met the clinical cut-off for functioning on PAOFI scores. However, there was a significant between-group difference in number of participants who scored above the BDI-II threshold of ≥19 indicating depressive symptomatology (MCVR=18.18%; MWH=11.76%; controls=4.96%).

In summary, there were significant differences between the groups on four sociodemographic variables (age, monthly income, home language, schooling language) and on six clinical variables (BDI-II score, FRS, blood pressure, BMI, hip-waist ratio, cholesterol). Subsequent analyses controlled for these potential confounders. To avoid multicollinearity we used only FRS as an indicator of vascular risk (i.e., we did not include blood pressure, BMI, hip-waist ratio, and cholesterol in subsequent modelling), and we used home language rather than schooling language because home language is positively associated with academic ablility[77].

Cognitive Performance

Table 3 presents within-group descriptive statistics for domain *T*-scores, global *T*-scores, and GDS data. Without controlling for any potential confounders, analyses suggested that (a) MWH performed significantly more poorly than MCVR on all single-domain outcome variables, as well as on the global *T*-score and GDS; (b) MWH performed more poorly than controls on tests assessing processing speed, attention and working memory, language,

memory and executive function, as well as on the global *T*-score and GDS; and (c) MCVR performed significantly better than controls on memory.

Multiple Regression Modelling—Each regression model set out to investigate whether between-group differences in cognitive performance persisted even after considering the total variance accounted for by the potential confounders of income, home language, BDI-II score, and FRS.

After controlling for those potential confounders, group status was significantly associated with test performance in the domains of attention and working memory, learning and memory, and with both measures of overall cognitive performance (see Table 4). More specifically, MWH performed significantly more poorly than MCVR.

Home language was a significant predictor of performance on several different outcome variables. Compared to participants who spoke English as a home language, those who (a) spoke Afrikaans as a home language performed better on tests assessing motor function; (b) spoke Xhosa as a home language performed more poorly on tests assessing processing speed, attention and working memory, learning, and memory, and on the global *T*-score; (c) spoke Shona as a home language performed more poorly on tests assessing processing speed, attention and working memory, memory, and executive functioning, and on the global *T*-score; (d) indicated 'other' as home language performed more poorly on tests assessing language. FRS was a significant predictor for better performance on tests of processing speed and learning. A higher BDI-II score predicted poorer performance on tests of processing speed (see Table 4).

Rates of Cognitive Impairment—Table 5 presents within-group data on the number of participants presenting with cognitive impairment (globally and within each domain), as well as results of between-group comparisons for rates of cognitive impairment. As the Table shows, initial analyses detected significant small to medium sized between-group differences on four different outcome variables with MWH presenting with the highest frequency of impairment. Follow-up pairwise comparisons indicated that (a) significantly more PWH than HC and PCVR presented with impaired performance on tests of processing speed (p=.003 and <.001, respectively) (b) significantly more PWH than PCVR presented with impaired performance on tests of attention and working memory (p=.018), (c) significantly more PWH than HC and PCVR presented with GDS in the impaired range (ps<.001), and (d) with regard to EF, there were no significant between-group differences although there was a trend toward significantly more PWH than HC and PCVR being impaired (ps<.065).

DISCUSSION

We assessed cognitive performance in professional drivers with and without chronic medical conditions, hypothesizing that men with HIV (MWH) and men with cardiovascular risk factors (MCVR; either hypertension or diabetes) would perform more poorly than matched controls, with PWH performing worst. This hypothesis was partially confirmed: MWH presented with the poorest cognitive outcomes and highest rate of cognitive impairment, but

MCVR did not perform more poorly than controls. Group membership remained a predictor of cognitive performance after controlling for potential confounders (age, monthly income, home language, depressive symptomatology, and cardiovascular risk).

On average, MCVR were older than MWH and controls, and MWH had a significantly lower monthly income than MCVR and controls. This difference in socioeconomic status is likely explained by the fact that a larger proportion of MWH worked part-time rather than full-time. The relevance of this difference for the current study, and one reason why we included monthly income as a predictor in our ultimate regression models, is that higher income may translate into better health care and cognitive health[78,79].

Further regarding sociodemographic characteristics, our sample's language profile reflects cultural aspects of South African society. English was the predominant language of academic instruction, regardless of participants' group assignment or home language. Notably, 84% of MWH had Xhosa as their home language but 54% were schooled in English. Although this suggests that these participants were bilingual to at least some degree, their relative fluency in each language was not measured and we can thus not speculate about effects of language profile on cognitive test performance. Nonetheless, we included home language as a predictor in our ultimate regression models.

Regarding the sample's clinical characteristics, MCVR presented with the highest number of depressive symptoms, but also performed best on cognitive testing. Although major depressive disorder is frequently associated with poorer cognitive performance, milder depressive symptoms in adults with cardiovascular risk factors may not have the same association with cognition[80]. Overall, depression was associated with slower processing speed[81].

Our major analyses indicated that group status was a significant predictor of performance on tests of attention and working memory, learning, and memory, as well as on both measures of overall cognitive functioning (global *T*-score and GDS). As expected, given previous reports of more severe cognitive impairment associated with HIV than with diabetes or hypertension[44,82,83], these between-group differences were driven by MWH performing significantly more poorly than MCVR. Of note is that these between-group differences persisted even after the analyses controlled for potential confounders (i.e., sociodemographic and clinical variables on which previous analyses had detected significant between-group differences). We therefore conclude that in this sample of professional drivers HIV-related factors are sufficient to account for poor cognitive performance. We consider MCVR's marginal and non-significant superior performance over controls, as well as the association of processing speed with higher FRS risk, as potentially spurious results

Although the cognitive performance of the MWH group was poor relative to that of the MCVR group, for the most part the individual test scores of MWH participants were only marginally greater than or within 1 *SD* of the normative mean. Hence, their performance would, broadly speaking, be considered as falling within the range conventionally described as asymptomatic or mild. This categorization is consistent with the fact that MWH PAOFI reports indicated no significant everyday functional impairment.

Although asymptomatic/mildly impaired cognitive performance in professional drivers with HIV may not appear to be immediately concerning, it is important to identify and monitor them because research suggests that (a) MWH with that degree of impairment have a 2- to 6-fold increase in risk for earlier development of symptomatic HIV-associated neurocognitive disorders and for early mortality[28,84], and (b) poorer cognitive performance is associated with lower employment status in older PWH[85]. Drivers could thus benefit, both in terms of health and risk management, from being monitored for HNCI.

A significantly greater proportion of MWH than MCVR presented with cognitive impairment (as defined by a domain *z*-score <−1.00) on tests of processing speed and of attention and working memory. There was also a strong trend toward poorer executive functioning in MWH than MCVR. Furthermore, significantly more MWH (41% of the group) than MCVR and controls met the GDS cut-off for cognitive impairment. These data are consistent with the profile of HIV-associated neurocognitive impairment in the cART era and previously published reports regarding the prevalence of cognitive impairment in MWH[2,16,86].

A noteworthy secondary finding is that home language was a significant predictor of overall cognitive performance (as measured by global *T*-score). Specifically, performance was better among participants with English, rather than Xhosa or Shona, as a home language. This finding can be interpreted in the light of evidence that test-taking proficiency influences neuropsychological test performance[87]. Given there were no significant between-group differences in educational attainment, we suggest that language may serve as a proxy for test-taking proficiency, with Xhosa and Shona speakers being less test-savvy than English speakers. This is an important consideration in clinical settings.

Limitations

We assessed daily functioning using only the PAOFI. Some evidence suggests that self-report is relatively insensitive in identifying impediments to optimal daily functioning, and that more PWH with asymptomatic cognitive impairment may have mild difficulties in daily functioning than is gauged via self-report[27]. Daily functioning could therefore have been assessed more completely. We did not evaluate anxiety or quality of life. Self-reported clinical variables (e.g., time since ART initiation) used in this study may be unreliable. Because so few woman work as professional drivers, we only included men in this study. Substance use other than alcohol was screened for using a urine toxicology screen only. Not all study participants were virally suppressed, but analyses comparing the cognitive test performance of MWH who were virally suppressed and those who were not detected no significant between-group differences.

SUMMARY AND CONCLUSION

After controlling for potential confounders, between group differences on cognitive performance persisted. A significant percentage of drivers with HIV presented with lower cognitive performance, largely characterised as asymptomatic/mild impairment. Although the level of cognitive impairment in these drivers might be characterised as asymptomatic/mild and did not generalise to activities of daily living, they are at risk for poorer long-term

health and employment outcomes. Hence, programs that monitor and support their long-term cognitive health (e.g., cognitive remediation training) and their mental and physical health (especially as they continue to operate in occupational settings) are recommended. Future studies should directly assess, both cross-sectionally and longitudinally, the impact of cognitive impairment on vocational functioning of PWH, even if it is asymptomatic/mild.

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Table 1

Sample Demographic Variables: Descriptive Statistics and Between-Group Comparisons (N = 204)

Continuous Variables	Controls (*n* = 81) *M* (*SD*)	MWH (*n* = 68) *M* (*SD*)	MCVR (*n* = 55) *M* (*SD*)	*F*	*df*	*p*	ESE [d]
Age (yrs)	40.85 (10.50)	39.58 (9.05)	45.27 (8.14)	5.96	2,201	.003 **	.056
Education (yrs completed)	11.14 (1.27)	11.07 (1.42)	10.85 (1.76)	0.63	2,201	.532	.006
Monthly income (ZAR)	12 959.63 (6 133.22)	7 957.58 (4 736.67) [b]	13 456.60 (6 164.77) [c]	17.28	2,198	< .001 ***	.149
Categorical Variables	*f*(%)	*f*(%)	*f*(%)	χ^2	*df*	*p*	ESE [e]
Home language				70.27	8	< .001 ***	.415
English	15 (18.5%)	2 (2.9%)	15 (27.2%)			-	
Afrikaans	28 (34.6%)	1 (1.5%)	19 (34.5%)			-	
Xhosa	23 (28.4%)	57 (83.8%)	11 (20%)			-	
Shona	10(12.3%)	5 (7.4%)	7 (12.7%)			-	
Other	5 (6.2%)	3 (4.4%)	3 (5.5%)			-	
Schooling language [a]				44.89	8	< .001 ***	.352
English	30 (48.4%)	37 (54.4%)	25 (49%)			-	
Afrikaans	24 (38.7%)	1 (1.5%)	19 (37.3%)			-	
Xhosa	7 (17.9%)	28 (41.2%)	4 (7.8%)			-	
Other	1 (1.6%)	2 (2.9%)	3 (5.9%)			-	
Employment status				12.03	2	.002 **	.243
Full-time	72 (88.9%)	48 (70.6%)	50 (90.9%)			-	
Part-time	9 (11.1%)	20 (29.4%)	5 (9.1%)			-	
Employment type				16.04	2	< .001 ***	.282
Truck driver	64 (79%)	33 (50%)	29 (52.7%)			-	
Not truck driver	17 (21%)	33 (50%)	26 (47.3%)			-	

Note. MWH = men with HIV; MCVR = men with cardiovascular risk; M = mean; SD = standard deviation; ESE = effect size estimate.

[a] Data based on controls *n* = 62 and MCVR *n* = 51 (missing data).

[b] Data based on MWH $n = 66$ (missing data).

[c] Data based on MCVR $n = 53$ (one participant did not disclose their income and the other is missing data).

[d] The effect size here is estimated by the partial eta squared (η_p^2) statistic.

[e] The effect size here is estimated by the Cramer's V statistic.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

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Table 2

Sample Clinical Variables: Descriptive Statistics and Between-Group Comparisons (N = 204)

	Group					
	Controls (*n* = 81)	MWH (*n* = 68)	MCVR (*n* = 55)			
Continuous Variables	***M* (*SD*)**	***M* (*SD*)**	***M* (*SD*)**	***F* (*df*)**	***p***	**ESE**
PAOFI total score	168.99 (27.60)	169.62 (27.81)	165.25 (39.90)	0.34 (2,201)	.715	.003
BDI-II total score	5.85 (6.74)	7.18 (8.41)	7.91 (8.40)	1.21 (2,198)	.301	.01
Framingham Risk Score (%) [a]	7.78 (8.85)	6.15 (6.09)	15.99 (8.77)	21.57 (2,152)	< .001***	.22
Systolic blood pressure	129.15 (14.96)	129.48 (19.34)	137.45 (16.73)	3.85 (2,172)	.023*	.04
Diastolic blood pressure	80.65 (9.70)	83.86 (12.58)	86.66 (13.58)	3.45 (2,172)	.034*	.04
Pulse rate (beats/min)	69.37 (8.59)	71.59 (12.08)	73.70 (11.12)	2.21 (2,172)	.112	.03
Body mass index	28.61 (6.24)	26.50 (5.22)	32.33 (8.24)	11.01 (2,169)	< .001***	.11
Hip-to-Waist Ratio	0.96 (0.12)	0.99 (0.08)	1.00 (0.09)	3.55 (2,192)	.031*	.04
Triglyceride	1.45 (0.78)	1.53 (1.00)	3.11 (4.36)	7.21 (2,157)	.001**	.08
Cholesterol						
High-density lipoprotein (HDL)	1.25 (0.38)	1.37 (0.41)	1.19 (0.43)	2.90 (2,157)	.058	.04
Low-density lipoprotein (LDL)	2.57 (0.89)	2.42 (1.08)	2.92 (0.78)	3.47 (2,152)	.034*	.04
Total	4.51 (0.90)	4.51 (1.16)	5.19 (1.23)	5.97 (2,157)	.003**	.07
Categorical Variables	*f* (%)	*f* (%)	*f* (%)	χ^2 *(df)*	*p*	ESE
PAOFI [b]	10 (12.35)	14 (20.59)	9 (16.36)	1.85 (2)	.395	0.10
BDI-II [c]	4 (4.94)	8 (11.76)	10 (18.18)	6.07 (2)	.048*	0.17

Note. MWH = men with HIV; MCVR = men with cardiovascular risk; ESE = effect size estimate (in this case, partial eta squared [η_p^2] for continuous variables and Cramer's V for Categorical Variables); PAOFI = Patient Assessment of Own Functioning Inventory; BDI-II = Beck Depression Inventory-II.

[a] Percentage of men at risk of cardiovascular disease, as estimated by Framingham Risk Score.

[b] Data are percentage of men who endorsed "almost always" on three or more questions within any domain.

[c] Data are percentage of participants who scored above the cut-off score of ≥19.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 3

Cognitive Test Performance: Descriptive Statistics and Between-Group Comparisons (N = 204)

Variable	Group				
	Controls (*n* = 81)	MWH (*n* = 68)	MCVR (*n* = 55)	*p*	Partial eta^2
Domain *T*–score					
Motor skills	49.24 (8.27)	46.97 (9.56)	50.25 (9.83)	.120	.021
Processing speed	54.41 (12.21)	45.12 (8.40)	54.95 (9.03)	< .001*** *a*	.163
Attention and working memory	51.76 (8.66)	46.90 (6.13)	53.98 (6.54)	< .001*** *b*	.133
Language	54.92 (10.19)	50.59 (10.60)	56.03 (10.56)	.008** *c*	.047
Learning	51.74 (9.95)	48.90 (8.01)	54.63 (8.42)	.002** *d*	.059
Memory	54.46 (10.29)	50.89 (7.68)	58.26 (9.01)	< .001*** *e*	.090
Executive function	52.51 (10.73)	47.35 (8.29)	53.71 (9.44)	< .001*** *f*	.074
Global *T*–score	52.72 (7.54)	48.10 (5.09)	54.88 (5.74)	< .001*** *g*	.158
GDS	0.29 (0.40)	0.47 (0.36)	0.19 (0.22)	< .001*** *h*	.096

Note. Data presented are means, with standard deviations in parentheses. MWH = men with HIV; MCVR = men with cardiovascular risk; GDS = global deficit score.

a Post-hoc pairwise comparisons: MWH vs MCVR, $p < .001$; MWH vs controls, $p < .001$; MCVR vs controls, $p = .950$.

b Post-hoc pairwise comparisons: MWH vs MCVR, $p < .001$; MWH vs controls, $p < .001$; MCVR vs controls, $p = .196$.

c Post-hoc pairwise comparisons: MWH vs MCVR, $p = .004$; MWH vs controls, $p = .012$; MCVR vs controls, $p = .544$.

d Post-hoc pairwise comparisons: MWH vs MCVR, $p = .001$; MWH vs controls, $p = .132$; MCVR vs controls, $p = .157$.

e Post-hoc pairwise comparisons: MWH vs MCVR, $p < .001$; MWH vs controls, $p = .048$; MCVR vs controls, $p = .048$.

f Post-hoc pairwise comparisons: MWH vs MCVR, $p = .001$; MWH vs controls, $p = .004$; MCVR vs controls, $p = .756$.

g Post-hoc pairwise comparisons: MWH vs MCVR, $p < .001$; MWH vs controls, $p < .001$; MCVR vs controls, $p = .127$.

h Post-hoc pairwise comparisons: MWH vs MCVR, $p < .001$; MWH vs controls, $p = .006$; MCVR vs controls, $p = .191$.

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Table 4

Cognitive Test Performance: Regression Models Predicting Influence of Group Membership After Controlling for Potential Confounders (N = 204)

	Motor Skills				Processing Speed				Attention and Working Memory			
Predictor	β	*SE*	*t*	*p*	β	*SE*	*t*	*p*	β	*SE*	*t*	*p*
Group (vs MWH)												
MCVR	1.39	2.24	0.62	.537	2.67	2.12	1.26	.210	3.82	1.67	2.29	.024*
Controls	−0.29	1.89	−0.15	.880	3.27	1.80	1.82	.071	0.93	1.42	0.66	.513
Home language (vs English)												
Afrikaans	6.76	2.74	2.47	.015*	0.88	2.60	0.34	.736	−0.16	2.04	−0.08	.936
Xhosa	1.19	2.81	0.42	.673	−6.93	2.66	−2.61	.010*	−4.09	2.09	−1.96	.052
Shona	−2.74	3.21	−0.85	.394	−9.86	3.04	−3.24	.002**	−7.37	2.39	−3.08	.002**
Other	−0.92	3.93	−0.23	.816	−6.37	3.73	−1.71	.090	−2.23	2.94	−0.76	.448
Monthly income (ZAR)	0.00	0.00	−0.02	.981	0.00	0.00	0.51	.612	0.00	0.00	1.93	.056
BDI-II (cut-off ≥19)	−0.90	2.50	−0.36	.716	−4.67	2.35	−2.29	.024*	−0.21	1.85	−0.11	.909
FRS (%)	−0.04	0.10	−0.40	.690	0.27	0.10	2.81	.006**	−0.01	0.08	−0.09	.928

	Language				Learning				Memory			
Predictor	β	*SE*	*t*	*p*	β	*SE*	*t*	*p*	β	*SE*	*t*	*p*
Group (vs MWH)												
MCVR	4.44	2.68	1.66	.100	5.13	2.21	2.32	.022*	4.81	2.23	2.16	.032*
Controls	2.83	2.27	1.25	.214	1.92	1.87	1.03	.307	2.30	1.88	1.22	.224
Home language (vs English)												
Afrikaans	−0.75	3.28	−0.23	.819	−2.57	2.71	−0.95	.344	−0.65	2.72	−0.24	.812
Xhosa	−2.49	3.35	−0.74	.459	−7.17	2.77	−2.59	.011*	−6.67	2.78	−2.39	.018*
Shona	−6.03	3.84	−1.57	.118	−5.86	3.17	−1.85	.067	−7.02	3.19	−2.20	.029*
Other	−9.41	4.71	−2.00	.048*	−7.01	3.89	−1.80	.074	−7.69	3.91	−1.97	.051
Monthly income (ZAR)	0.00	0.00	1.00	.318	0.00	0.00	−0.43	.670	−5.07	0.00	−0.36	.718
BDI-II (cut-off ≥19)	0.70	2.97	0.24	.813	−1.08	2.45	−0.44	.660	2.60	2.46	0.11	.916
FRS (%)	−0.08	0.12	−0.63	.531	−0.20	0.10	−1.98	.050*	−0.18	0.10	−1.81	.072

Predictor	Executive Function				Global Deficit Score				Global *T*−Score			
	β	*SE*	*t*	*p*	β	*SE*	*t*	*p*	β	*SE*	*t*	*p*
Group (vs MWH)												
MCVR	1.10	2.25	0.49	.624	−1.45	0.40	−2.26	.024*	3.62	1.50	2.42	.017*
Controls	1.64	1.90	0.86	.392	−0.84	0.50	−1.68	.093	1.76	1.27	1.39	.166
Home language (vs English)												
Afrikaans	−0.58	2.75	−0.21	.834	−0.42	0.91	−0.46	.648	0.43	1.83	0.23	.816
Xhosa	−5.70	2.81	−2.03	.045*	−0.11	0.81	−0.14	.891	−4.08	1.87	−2.18	.031*
Shona	−8.14	3.22	−2.53	.013*	1.37	0.87	1.57	.116	−5.28	2.14	−2.47	.015*
Other	−2.32	3.95	−0.59	.558	0.64	1.04	0.62	.538	−4.77	2.63	−1.82	.078
Monthly income (ZAR)	0.00	0.00	0.43	.665	0.00	0.00	−0.87	.386	7.53	0.00	0.80	.424
BDI-II (cut-off ≥19)	0.69	2.49	0.28	.783	0.57	0.62	0.91	.361	−1.07	1.66	−0.65	.520
FRS (%)	0.11	0.10	1.09	.278	0.00	0.00	0.04	.969	0.00	0.07	0.12	.902

Note. MWH = men with HIV; MCVR = men with cardiovascular risk; BDI-II = Beck Depression Inventory-II; FRS (%) = Framingham Risk Score 10-year cardiovascular disease risk percentage.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 5

Rates of Cognitive Impairment: Between-Group Differences (N = 204)

Variable	Group			χ^2	*p*	ESE
	Controls (*n* = 81)	MWH (*n* = 68)	MCVR (*n* = 55)			
Cognitive domain *T*−score						
Motor skills	11 (13.6%)	14 (20.6%)	9 (16.4%)	1.31	.519	.08
Processing speed	9 (11.1%)	22 (32.4%)	2 (3.6%)	21.03	< .001***	.32
Attention and working memory	7 (8.6%)	11 (16.2%)	1 (1.8%)	7.49	.024*	.19
Verbal fluency	5 (6.2%)	7 (10.3%)	5 (9.1%)	0.88	.645	.07
Learning	8 (9.9%)	9 (13.2%)	3 (5.5%)	2.08	.353	.10
Memory	8 (9.9%)	7 (10.3%)	3 (5.5%)	1.07	.586	.07
Executive function	7 (8.6%)	14 (20.6%)	4 (7.3%)	6.64	.036*	.18
Global *T*−score	2 (2.5%)	2 (2.9%)	0 (0)	*a*	.565	.09
GDS	15 (18.5%)	28 (41.2%)	8 (14.5%)	14.51	< .001***	.27

Note. Data presented are raw frequencies (percentages) of participants who presented with cognitive impairment (for individual cognitive domains, $z < -1.00$; for GDS, score ≥ 0.05). For each between-group comparison, degrees of freedom were 2. MWH = men with HIV; MCVR = men with cardiovascular risk; ESE = effect size estimate (in this case, Cramer's *V*); GDS = global deficit score.

[a] Fisher's Exact Test performed.

* $p < .05$.

** $p < .01$

*** $p < .001$.