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# Comparison of self-reported alcohol use with the alcohol biomarker phosphatidylethanol among young people in northern Tanzania☆

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ABSTRACT

*Background:* The one-month Time Line Follow Back calendar (TLFB) and the Alcohol Use Disorders Identification Test (AUDIT) are used to collect self-reported alcohol intake data. We compared these instruments with the alcohol biomarker phosphatidylethanol (PEth) among young-people in northern Tanzania.
*Methods:* AUDIT and TLFB were applied in a cross-sectional study of 202 young people (18–24 years), who reported using alcohol during the past year (103 male casual labourers; 99 college students). We assayed whole blood for PEth 16:0/18:1, using liquid chromatography-tandem mass spectrometry.
*Results:* For both self-report methods, alcohol consumption was high, particularly among men (e.g. a median of 54 drinks per month in labourers), and about half of male students (48%) reported hazardous or harmful levels of drinking (AUDIT ≥8). Almost half (49%) of participants were PEth-positive (median concentration 0.03 μmol/L). There were significant positive correlations between reported total alcohol intake and PEth concentration in males (Spearman's correlation $r_s = 0.65$ in college students and $r_s = 0.57$ in casual labourers; $p < 0.001$). Self-reported use in the past month was a sensitive marker of having a positive PEth result (≥0.01 μmol/L) with 89% of those with a PEth positive result reporting alcohol use, and this was similar in all groups. The proportion of those with AUDIT scores ≥8 and AUDIT-C scores ≥6 among those with a high cut-off positive PEth result (≥0.30 μmol/L) ranged between 94 and 100%.
*Conclusion:* TLFB and AUDIT are sensitive measures to detect heavy alcohol use among young-people in northern Tanzania. They can be used to identify young people who may benefit from alcohol-focused interventions.


## 1. Introduction

Excessive alcohol use is a major public health problem, and is associated with an estimated 5% of global mortality and 6% of disability adjusted life year's (DALYs) lost globally (World Health Organisation, 2014). It often begins at a young age (Bellis et al., 2009; Gore et al., 2011; Swahn et al., 2010a, 2010b). According to WHO, 46% of the world's adolescents aged 15–19 years reported having ever used alcohol, and 34% had used it in the last year (World Health Organisation, 2014). In Africa, these estimates were 41% and 29%, respectively (World Health Organisation, 2014). The estimated prevalence of heavy episodic drinking (defined as intake of at least 6 standard alcoholic drinks on one occasion; World Health Organisation, 2014) is higher in adolescents than in adults in general populations (adolescents: 12% globally and 8% in Africa; adults: 8% globally and 6% in Africa; World Health Organisation, 2014).

A recent systematic review showed that alcohol use is also common among young people in eastern Africa, but that few studies used recommended alcohol screening instruments (Francis et al., 2014). Studies to estimate the prevalence of alcohol use and assess the impact of interventions to address hazardous alcohol use in Africa require validated screening tools, based on self-reports. The Alcohol Use Disorders Identification Test (AUDIT), a self-report alcohol screening tool for excessive drinking developed by WHO, has been used in both high and low income countries and

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recommended for use in primary care settings among adults (Chishinga et al., 2011; O'Connell et al., 2004; Saunders et al., 1993). A shorter version of AUDIT, the AUDIT-C that includes the first three questions of AUDIT on alcohol consumption is effective in AUD screening (Bush et al., 1998).

The Time Line Follow Back (TLFB) calendar method that also relies on self-reported information (in terms of quantity and frequency) has been mainly applied in high-income settings (Maisto et al., 1979; Sobell and Sobell, 1978; Sobell et al., 1986).

Expectations from peers and family members influence both the drinking behaviour of adolescents and young adults, and what they report about it; and these are likely to differ from those of adults (Gardner and Steinberg, 2005; Steinberg and Monahan, 2007). Because AUDIT and TLFB have been shown to be useful tools for alcohol screening in young people in some settings (Aertgeerts et al., 2000; Fleming et al., 1991; Sobell et al., 1986), they are potentially useful to inform alcohol interventions among young people in Africa as well; however, they have not yet been validated among such populations. The objective validation of self-reported alcohol consumption tests requires the use of alcohol biomarkers. A range of blood-based biomarkers exists including phosphatidylethanol (PEth), carbohydrate-deficient transferrin (CDT), and gamma-glutamyl transferase (GGT; Conigrave et al., 2002; Golka et al., 2004; Golka and Wiese, 2004). PEth is a direct ethanol metabolite in blood that has a comparatively long half-life, and therefore is able to discriminate between levels of alcohol use during the past one month (Isaksson et al., 2011; Varga et al., 1998; Viel et al., 2012). It has been used among adult populations globally, including in Sub Saharan Africa, to examine self-reported hazardous and harmful alcohol use (Bajunirwe et al., 2014; Hahn et al., 2012a, 2012b). PEth is very specific and sensitive for heavy and chronic alcohol intake, however it is difficult to establish the PEth cut off for heavy alcohol intake due to inter-individual metabolism rates for PEth (Stewart et al., 2010). For this paper, we have utilised the harmonised PEth cut off ($\geq$30 μmol/L) for heavy alcohol use for Swedish population (Helander and Hansson, 2013).

In this study, we compared self-reported alcohol use recorded by the one-month TLFB and AUDIT against PEth among college students and young casual labourers in northern Tanzania. To our knowledge, this is the first study using a specific alcohol biomarker (PEth) to compare self-reported alcohol use among young people in Africa.

## 2. Material and methods

### 2.1. Study populations and procedures

In March and April, 2014, we conducted a cross-sectional study among two groups of young people (college students and casual labourers) in Mwanza city, northern Tanzania. We aimed to enrol participants from these two groups, as they are known to include both modest and hazardous/harmful users of alcohol based on recently completed survey in this area. College students comprised students enrolled in higher learning institutions for diploma or undergraduate training, and young casual labourers were recruited from garages (car workshops). Casual workers from this sector are typical for male casual workers with unstable employment in this geographical setting and can be more easily identified than for example casual workers from temporary building sites. Participants were eligible if they were aged 18–24 years, reported having consumed alcohol in the last year and provided written informed consent. Impartial witnesses documented the consent for Illiterate study participants. None of the participants was under the influence of alcohol at the time of the interview. Ethical approval was received from the Lake Zone Institutional Review Board at the National Institute for Medical Research (NIMR), Mwanza (MR 53/100/155) and the Ethics Committee of the London School of Hygiene and Tropical Medicine (LSHTM ethics ref 7074). Permission was also obtained from heads of colleges and managers of garages.

At two randomly selected colleges, we randomly selected one class in each college and enrolled all volunteering eligible students. We consecutively visited garages in Mwanza city starting with large garages and enrolled all volunteering eligible casual workers until we attained the desired sample size. The study was performed by two lay research assistants who administered the AUDIT questionnaire (Saunders et al., 1993) and one-month TLFB calendar (Sobell et al., 1988), and two medical officers who drew blood samples.

We chose a sample size of 200 young people in total based on the assumption that the true prevalence of alcohol use in the last one month among young people in East Africa is about 28% (Francis et al., 2014), and the intention to determine sensitivities and specificities of self-reported alcohol use against PEth, which is only formed in the presence of ethanol (Helander and Zheng, 2009), with reasonable precision. With a sample of 200 participants, we expected about 46 true positives and 154 true negatives. For a sensitivity of 80% we would expect a 95% confidence interval (CI) ranging from 70.2% to 88.0%; and for a specificity of 95% a 95%CI interval from 88.5 to 98.7%.

### 2.2. Measurement of self-reported alcohol use

Self-reported alcohol use was documented using AUDIT and TLFB. We applied the TLFB method for any alcohol intake in the past one month in combination with an alcohol pictorial display, a list of commonly available types of beverages with their standard drinks equivalents and a brief questionnaire, jointly used to determine the type and actual amount of alcohol consumed as accurately as possible (see Supplementary material, file 1 and 2[1]). In addition, we also asked participants whether they had consumed alcohol in the past 2 and 6 months, respectively. We documented the amount of alcohol intake as standard drinks (1 standard drink being equivalent to 10 g of pure alcohol; World Health Organisation, 2000). We defined an intake of an average of $\geq$6 drinks per day as 'heavy alcohol intake' (World Health Organisation, 2014).

### 2.3. Blood sample collection, processing and laboratory assay for phosphatidylethanol (PEth)

Each study participant was asked to provide 5 mL of venous whole blood collected into EDTA vacutainer tubes. Before blood collection, the veni-pucture site was swabbed twice with clean water and allowed it to dry. Field workers were instructed not to use alcohol for sterilisation. The blood samples were immediately stored in a cool box in the field, and transferred to the NIMR laboratory within 3 h where they were kept at −80 °C.

Samples were shipped in dry ice to the Karolinska Institute and Karolinska University Laboratory (Stockholm, Sweden) for assay of PEth 16:0/18:1, the main PEth homologue in human blood (Helander and Zheng, 2009), using liquid chromatography-tandem mass spectrometry (LC–MS/MS). In the laboratory, samples were stored at −80 °C until taken for LC–MS/MS analysis, using selected ion monitoring (SIM) in negative mode of the deprotonated molecules (Zheng et al., 2011). The lower quantification limit (LLOQ) of the method for measurement of whole blood PEth 16:0/18:1 is 0.01 μmol/L. In Sweden, following a national harmonisation of PEth measurement (Helander and Hansson, 2013), the routinely applied cut-off to indicate "any intake of alcohol" for

[1] Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:10.1016/j.drugalcdep.2015.09.027.

**Table 1**
General characteristics among young people included in the study in northern Tanzania, 2014.

| Characteristic<br>Sample size | Categories<br>*N* | Overall<br>202 | Female college students<br>41 | Male college students<br>58 | Male casual labourers<br>103 |
|---|---|---|---|---|---|
| Age | 18–20 years | 36 (17.8) | 4 (9.8) | 2 (3.5) | 30 (29.1) |
| | 21–24 years | 166 (82.2) | 37 (90.2) | 56 (96.6) | 73 (70.9) |
| Religion | Moslem | 36 (17.8) | 8 (19.5) | 5 (8.6) | 23 (22.3) |
| | Catholic | 102 (50.5) | 20 (48.8) | 32 (55.2) | 50 (48.5) |
| | Other Christians | 64 (31.7) | 13 (31.7) | 21 (36.2) | 30 (29.1) |
| Education | Primary and less | 62 (30.7) | 0 (0.0) | 0 (0.0) | 62 (60.2) |
| | Secondary and above | 140 (69.3) | 41 (100.0) | 58 (100.0) | 41 (39.8) |
| Marital status | Single | 64 (31.8) | 9 (22.0) | 19 (33.3) | 36 (35.0) |
| | In relationship | 137 (68.2) | 32 (78.1) | 38 (66.7) | 67 (65.0) |
| Age at alcohol initiation | less than 18 years | 116 (58.0) | 22 (53.7) | 34 (59.7) | 60 (58.8) |
| | 18–24 years | 84 (42.0) | 19 (46.3) | 23 (40.4) | 42 (41.2) |
| Alcohol use in the last 6 months | Yes | 197 (97.5) | 38 (92.7) | 56 (96.6) | 103 (100.0) |
| Alcohol use in the last 2 months | Yes | 158 (78.2) | 30 (73.2) | 44 (75.9) | 84 (81.5) |
| Alcohol use in the last 30 days | Yes | 137 (67.8) | 25 (61.0) | 41 (70.7) | 71 (68.9) |
| Total alcohol intake in a month as reported by TLFB[a] (standard drinks) | Median (IQR) | 25 (13, 76) | 16 (9, 22) | 25 (13, 58) | 54 (16, 146) |
| Average drinking days in a week as reported by the TLFB | None | 65 (32.2) | 16 (39.1) | 17 (29.3) | 32 (31.1) |
| | 1–2 days | 107 (53.0) | 24 (58.5) | 34 (58.6) | 49 (47.6) |
| | Above 2 days | 30 (14.9) | 1 (2.4) | 7 (12.1) | 22 (21.4) |
| Average drinking days in a month as reported by the TLFB | None | 65 (32.2) | 16 (39.1) | 17 (29.3) | 32 (31.1) |
| | 1–10 days | 114 (56.4) | 24 (58.5) | 38 (65.5) | 52 (50.5) |
| | Above 10 days | 23 (11.4) | 1 (2.4) | 3 (5.2) | 19 (18.4) |
| At least 1 heavy episodic intake (≥ 6 standard dinks) as reported by TLFB | Yes | 115 (56.9) | 18 (43.9) | 34 (58.6) | 63 (61.2) |
| Heavy episodic alcohol intake (average of ≥6 standard drinks) as reported by TLFB | Yes | 77 (38.1) | 8 (19.5) | 23 (39.7) | 46 (44.7) |
| AUDIT[b] (10 items) score | Median(IQR) | 8.5 (5.0, 14.0) | 5.0 (3.0–8.0) | 7.0 (5.0, 13.0) | 10.0 (6.0, 16.0) |
| AUDIT | <8 (Low risk drinking) | 95 (47.0) | 30 (73.2) | 30 (51.7) | 35 (34.0) |
| | ≥8 (Risk drinking) | 107 (53.0) | 11 (26.8) | 28 (48.3) | 68 (66.0) |
| AUDIT-C (3 item) score | Median (IQR) | 5.0 (4.0, 8.0) | 4.0 (3.0, 6.0) | 5.0 (4.0, 7.0) | 6.0 (4.0, 9.0) |
| Phosphatidylethanol (PEth) concentration(μmol/L[c] | Median (IQR) | 0.03 (0.00, 0.14) | 0.03 (0.00, 0.07) | 0.03 (0.00, 0.13) | 0.03 (0.00, 0.21) |
| Positive PEth[d] (≥0.01 μmol/L) | Yes | 98 (48.5) | 21 (51.2) | 32 (55.2) | 45 (43.7) |
| PEth cut-off for heavy alcohol intake (≥0.30 μmol/L) | Yes | 25 (12.4) | 2 (4.9) | 7 (12.1) | 16 (15.5) |

[a] TLFB-Time Line Follow Back Calendar.
[b] AUDIT-Alcohol Use Disorder Identification Test.
[c] Only among those reporting any alcohol use in the last one month by TLFB.
[d] PEth 16:0/18:1 in whole blood.

the last ~1 month is ≥0.05 μmol/L, and ≥0.30 μmol/L to indicate "heavy alcohol intake". These thresholds are based on data from blood donors (Zheng et al., 2011) and drinking experiments (Gnann et al., 2012), and comply with the levels seen in observational studies (Stewart et al., 2010). In our study population, we used as PEth cut-offs the LLOQ (0.01 μmol/L) to indicate "any alcohol intake" and 0.30 μmol/L for "heavy drinking".

### 2.4. Data management and analysis

*2.4.1. Data management.* Data were double-entered onto computers at the data management section of the Mwanza Intervention Trials Unit (MITU) at NIMR Mwanza, using the Open Clinica version 3 software. PEth concentration data were merged with the questionnaire data.

*2.4.2. Main outcomes.* The primary outcomes of interest were (i) the correlation between the reported amount of alcohol use recorded by TLFB calendar and the whole blood PEth concentration, (ii) proportion reporting any use in the last month among those with a positive PEth result (≥0.01 μmol/L) ("sensitivity"), (iii) proportion reporting no alcohol use in the last month among those with a negative PEth result (<0.01 μmol/L) ("specificity"); (iv) proportion reporting heavy alcohol intake (average of >6 drinks per drinking event) in the last month among those with a high cut-off positive PEth result (≥0.30 μmol/L) ("sensitivity") and (v) proportion reporting no heavy alcohol intake in the last month among those with a high cut-off negative PEth result (<0.30 μmol/L) ("specificity"). Secondary outcomes were (i) the correlation between the AUDIT-C scores (the first three AUDIT questions) and whole blood PEth concentration, (ii) proportion of those with AUDIT scores ≥8, AUDIT-C scores ≥6 among those with a high cut-off positive PEth result (≥0.30 μmol/L) ("sensitivity") and (iii) proportion of those with AUDIT scores <8, AUDIT-C scores <6 among those with a high cut-off negative PEth result (<0.30 μmol/L) ("specificity").

*2.4.3. Statistical procedures.* All analyses were conducted using Stata version 13.1. The overall AUDIT score for each participant was calculated and AUDIT scores ≥8 were categorised as

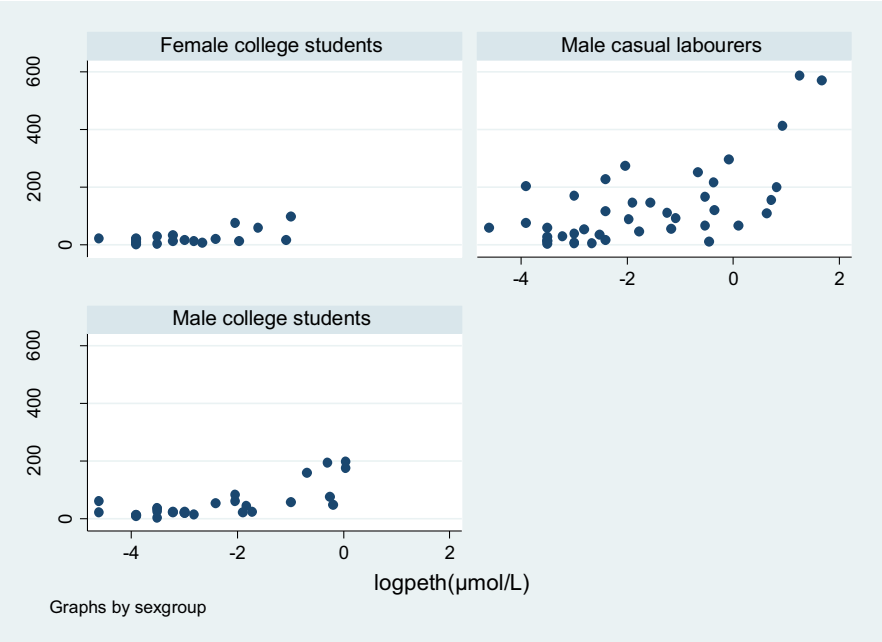


**Fig. 1.** Scatter plot of total reported standard drinks by TLFB and whole blood PEth 16:0/18:1 concentration among male casual labourers, male college students and female college students in northern Tanzania.

hazardous/harmful alcohol use or possible alcohol dependence (Babor et al., 2001). We calculated total AUDIT-C score and the AUDIT-C scores ≥6 were categorised as hazardous/harmful alcohol use or possible alcohol dependence (Kokotailo et al., 2004). The TLFB was used to estimate the total reported amount of alcohol consumed, the mean alcohol intake (standard drinks) for each drinking event, and the prevalence of heavy alcohol intake (average of ≥6 drinks per drinking event; World Health Organisation, 2014) and number of drinking events with heavy intake (≥6 drinks), all reported for the last month.

We estimated the correlation between different measures of quantity of alcohol consumption and AUDIT-C score with PEth concentrations using the Spearman rank correlation coefficient. We compared the distribution of quantity of alcohol consumption by self-report and PEth concentration using the Wilcoxon rank sum test. We computed sensitivities, specificities, and areas under receiver operating characteristics (AUROC), comparing reported alcohol use by TLFB, AUDIT and AUDIT-C with PEth.

## 3. Results

### 3.1. Characteristics of the population

The study population comprised 202 young people: 103 male casual labourers, 58 male college students and 41 female college students. There were no female casual labourers employed in these garages. The majority (166; 82%) were aged above 20 years. By definition, all participants had consumed alcohol during the last 1 year, but almost all participants (197; 98%) also reported consuming alcohol in the last 6 months and 137 (68%) reported this for the last 1 month. Age at alcohol initiation was below 18 years for most participants (58%). Male casual labourers were more likely to report more total drinks in a month by the TLFB (54 vs 25, $p < 0.001$), and to score ≥8 points in the AUDIT (66% vs 48%, $p = 0.025$) than male college students. Males reported more events with heavy episodic intake than females (Table 1).

### 3.2. Correlation of PEth with reported quantities of alcohol intake

Overall, about half of the participants tested positive (≥0.01 μmol/L) on whole blood PEth (98; 48.5%), with a median concentration of 0.03 μmol/L. Specifically, 21 (51.2%) female college students, 32 (55.2%) male college students and 45(43.7%) male casual labourers tested positive on whole blood PEth. There was a strong positive correlation between the reported quantities of alcohol intake and the PEth concentration among male casual labourers (Spearman correlation coefficient, $r_s = 0.57$; $p < 0.001$; Fig. 1), and male college students (Spearman correlation coefficient, $r_s = 0.65$; $p < 0.001$; Fig. 1), and moderate correlation among female college students (Spearman correlation coefficient, $r_s = 0.45$; $p < 0.001$; Fig. 1). The correlations followed similar patterns for other parameters of alcohol intake such as number of days drinking, number of drinks at each drinking events, and number of events with heavy episodic intake (Table 2). Similarly, there was strong positive correlation between AUDIT-C scores and PEth concentration among male college students (Spearman correlation coefficient, $r_s = 0.58$; $p < 0.001$; Fig. 2) and male casual labourers (Spearman correlation coefficient, $r_s = 0.52$; $p < 0.001$; Fig. 2). In addition, there was strong evidence of an association between median PEth concentration and reported alcohol use (Wilcoxon-rank sum test, $p < 0.001$) in all three study populations.

### 3.3. Performance of self-report against any detectable PEth

Self-reported alcohol use in the past month was a sensitive marker of having a positive PEth result (≥0.01 μmol/L; sensitivity 89%), and was similar in the three population groups. In contrast, self-reported alcohol use in the past month had low specificity against PEth, ranging from 48% among male casual labourers to 62% among female college students (Table 3).

**Table 2**
Correlations of alcohol consumption measured by the one-month TLFB questionnaire and AUDIT-C scores with whole blood PEth 16:0/18:1 concentration (μmol/L) among young people in northern Tanzania.

| Measure of alcohol consumption | Median (interquartile range) | Spearman correlation with PEth value | *p* Value |
|---|---|---|---|
| Overall (*n* = 137) | | | |
| PEth (μmol/L) | 0.03 (0.00, 0.14) | | |
| TLFB variables | | | |
| Total alcohol intake as reported by TLFB (standard drinks) | 25 (13.0, 76.0) | 0.55 | <0.001 |
| Drinking days in month (days) | 5 (3, 8) | 0.48 | <0.001 |
| Drinking days in a week (days) | 1 (1, 2) | 0.48 | <0.001 |
| Total drinks in occasion (standard drinks) | 6.5 (4.0, 10.7) | 0.56 | <0.001 |
| Episodes of heavy episodic use (≥6 drinks) | 3 (1, 7) | 0.51 | <0.001 |
| AUDIT variable | | | |
| AUDIT-C scores | 6 (4,9) | 0.48 | <0.001 |
| Female college students (*n* = 25) | | | |
| PEth (μmol/L) | 0.03 (0.00, 0.07) | | |
| TLFB variables | | | |
| Total alcohol intake as reported by TLFB (standard drinks) | 16 (9.0, 22.0) | 0.45 | 0.02 |
| Drinking days in month (days) | 3 (2, 6) | 0.34 | 0.09 |
| Drinking days in a week (days) | 1 (1, 2) | 0.35 | 0.09 |
| Total drinks in occasion (standard drinks) | 4.5 (3.3, 6.0) | 0.49 | 0.01 |
| Episodes of heavy episodic use (≥6 drinks) | 1 (0, 3) | 0.48 | 0.02 |
| AUDIT variable | | | |
| AUDIT-C scores | 5 (3, 7) | 0.29 | 0.152 |
| Male college students (*n* = 41) | | | |
| PEth (μmol/L) | 0.03 (0.00, 0.13) | | |
| TLFB variables | | | |
| Total alcohol intake as reported by TLFB (standard drinks) | 25 (13.0, 58.0) | 0.65 | <0.001 |
| Drinking days in month (days) | 4 (3, 6) | 0.54 | <0.001 |
| Drinking days in a week (days) | 2 (1, 3) | 0.54 | <0.001 |
| Total drinks in occasion (standard drinks) | 6.3 (4.0, 9.0) | 0.68 | <0.001 |
| Episodes of heavy episodic use (≥6 drinks) | 3 (1, 5) | 0.64 | <0.001 |
| AUDIT variable | | | |
| AUDIT-C scores | 6 (4, 8) | 0.58 | <0.001 |
| Male casual labourers (*n* = 71) | | | |
| PEth (μmol/L) | 0.03 (0.00, 0.21) | | |
| TLFB variables | | | |
| Total alcohol intake as reported by TLFB (standard drinks) | 54 (16.0, 146.0) | 0.57 | <0.001 |
| Drinking days in month (days) | 6 (3, 12) | 0.53 | <0.001 |
| Drinking days in a week (days) | 1 (1, 2) | 0.53 | <0.001 |
| Total drinks in occasion (standard drinks) | 8.5 (4.0, 12.0) | 0.58 | <0.001 |
| Episodes of heavy episodic use (≥6 drinks) | 4 (2, 10) | 0.53 | <0.001 |
| AUDIT variable | | | |
| AUDIT-C scores | 8 (5, 10) | 0.52 | <0.001 |

### *3.4. Performance of self-reported heavy alcohol intake against high levels of PEth*

The sensitivity of self-reported heavy alcohol use (average of ≥6 standard drinks per drinking event) when compared with the PEth cut-off for heavy use (≥0.30 μmol/L) was high, ranging from 92 to 100% across groups. The specificity ranged from 64 to 85%. Sensitivity was highest among male college students (sensitivity 100%) and specificity was highest among female college students (specificity 85%) (Table 3). Using the AUDIT-C cut-off of ≥6 points for hazardous drinking in order to detect heavy drinking (PEth ≥0.30 μmol/L), sensitivity ranged between 96 and 100%. Specificity ranged between 53 and 74%, was highest in female college students (74%) and lowest among male casual labourers (specificity 52%) (Table 4). The sensitivity of the standard AUDIT cut-off (≥8) for hazardous drinking in order to detect heavy drinking (PEth ≥0.30 μmol/L) ranged between 94 and 100% and the specificity between 67 and 95%. The highest AUROC (0.96) was observed with AUDIT-C and AUDIT, in the groups of female college students and male college students respectively (Table 4).

## 4. Discussion

To our knowledge, this is the first study to compare the TLFB calendar and AUDIT tools against the ethanol metabolite and specific alcohol biomarker PEth among young people in sub Saharan Africa. The results suggest that both the one-month-TLFB calendar, AUDIT-C and AUDIT are sensitive measures to detect heavy alcohol use, but have fairly low sensitivity to detect moderate use (an average of <6 drinks) of alcohol, especially among young women.

Our findings show that the TLFB calendar is a valid tool for reporting alcohol intake among young people, as has also been reported from high income countries for various groups of young people including college students (Sobell et al., 1996, 1988, 1986). In our study we used the TLFB calendar together with an additional tool to describe each drinking event and determine more precisely the kind and amount of alcohol consumed at each drinking event (see Supplementary material, files S1 and S2[2]). This strategy

[2] Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:10.1016/j.drugalcdep.2015.09.027.

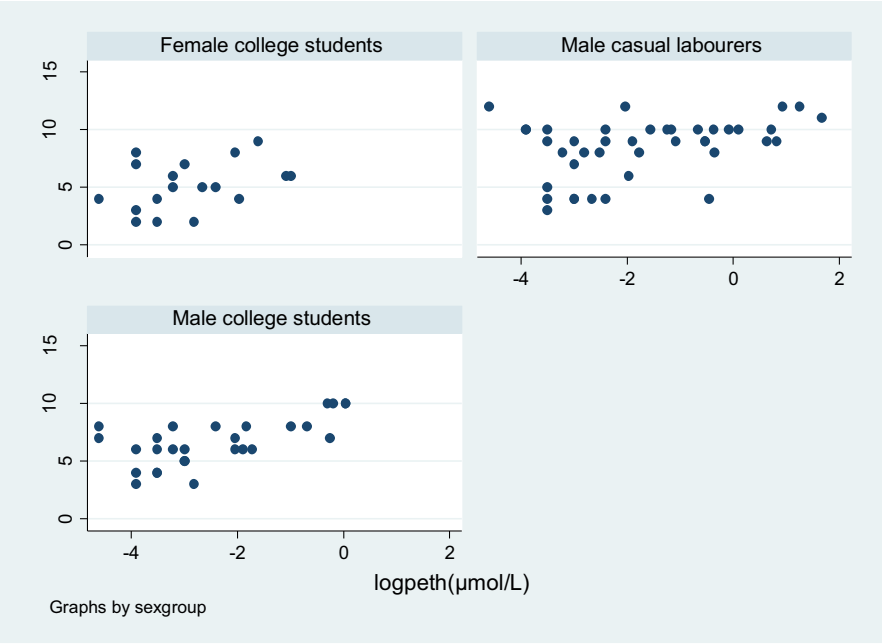


**Fig. 2.** Scatter plot of total AUDIT-C score and whole blood PEth 16:0/18:1 concentration among male casual labourers, male college students and female college students in northern Tanzania.

**Table 3**
The distribution of self-reported alcohol use by the one-month TLFB and whole blood PEth 16:0/18:1 results among young people in northern Tanzania.

| | Reported alcohol use | | PEth status | |
|---|---|---|---|---|
| | | | Positive (%) | Negative (%) |
| PEth (≥0.01 µmol/L) | | | | |
| Overall (*n* = 202) | Any drink | Yes | 87 (88.8)[b] | 50 (48.1) |
| | | No | 11 (11.2) | 54 (51.9)[c] |
| Female college students (*n* = 41) | Any drink | Yes | 18 (85.7) | 7 (35.0) |
| | | No | 3 (14.3) | 13 (65.0) |
| Male college students (*n* = 58) | Any drink | Yes | 28 (87.5) | 13 (50.0) |
| | | No | 4 (12.5) | 13 (50.0) |
| Male casual labourers (*n* = 103) | Any drink | Yes | 41 (91.1) | 30 (51.7) |
| | | No | 8 (8.9) | 28 (48.3) |
| PEth (>0.30 µmol/L) | | | Yes | No |
| Overall (*n* = 202) | Heavy alcohol intake[a] | Yes | 24 (96.0) | 53 (29.9) |
| | | No | 1 (4.0) | 124 (70.1) |
| Female college students (*n* = 41) | Heavy alcohol intake | Yes | 2 (100.0) | 6 (15.4) |
| | | No | 0 (0.0) | 33 (84.1) |
| Male college students (*n* = 58) | Heavy alcohol intake | Yes | 7 (100.0) | 16 (31.4) |
| | | No | 0 (0.0) | 35 (68.6) |
| Male casual labourers (*n* = 103) | Heavy alcohol intake | Yes | 15 (93.8) | 31 (35.6) |
| | | No | 1 (6.2) | 56 (64.4) |

[a] Heavy alcohol intake (average of ≥6 drinks per event).
[b] Sensitivity.
[c] Specificity

facilitated the documentation of the number of standard drinks consumed, an information that is often not readily available for some alcoholic products such as sachets.

The level of correct self-reporting of high alcohol use among young people in our study was similar to reports from young drug users in the US (Jain et al., 2014). However it stood in contrast to studies conducted in Uganda in adults receiving HIV care and treatment among whom under-reporting was high when compared with PEth (Bajunirwe et al., 2014; Hahn et al., 2012a). The underreporting in the Ugandan study might be attributed to the population characteristics and desirability bias. Our study was carried out in a casual setting with no anticipated favourable or unfavourable consequences, whilst in the Ugandan study patients may have feared that reported alcohol consumption would negatively affect their HIV treatment (Bajunirwe et al., 2014; Hahn et al., 2012a; Jain et al., 2014). It is worth noting that in another study conducted among HIV patients in Uganda, the prevalence of self-reported alcohol use increased when patients were made aware of a potential assessment with alcohol biomarkers (Hahn et al., 2012b). This suggests that the routine use of alcohol biomarkers even in subsets of a study population, if feasible and affordable, may improve self-reports.

AUDIT-C and AUDIT showed very high sensitivities for heavy drinking against PEth in all three study groups, and reasonable specificity. This suggests that AUDIT and AUDIT-C may be valid tools for detecting heavy drinking in young people in sub-Saharan Africa, when using either the WHO recommended AUDIT and AUDIT-C cut-offs for risky drinking (Babor et al., 2001; Kokotailo et al., 2004). AUDIT-C showed strong correlation with PEth concentration in the

**Table 4**
Risky drinking by AUDIT-C score ≥6 and AUDIT score ≥8 vs whole blood PEth 16:0/18:1 ≥ 0.30 μmol/L in northern Tanzania.

| Populations | Risky drinking by AUDITs | | PEth (≥0.30 μmol/L) | | AUROC[a] (95%CI) |
|---|---|---|---|---|---|
| | | Positive | Negative | | |
| Overall (*n* = 202) | Risky drinking by AUDIT-C | Yes | 24 (96.0)[b] | 72 (40.7) | 0.89 (0.83–0.92) |
| | | No | 1 (4.0) | 105 (59.3)[c] | |
| Female college students (*n* = 41) | Risky drinking by AUDIT-C | Yes | 2 (100.0) | 10 (25.6) | 0.78 (0.62–0.89) |
| | | No | 0 (0.0) | 29 (74.4) | |
| Male college students (*n* = 58) | Risky drinking by AUDIT-C | Yes | 7 (100.0) | 21 (41.2) | 0.96 (0.88–1.00) |
| | | No | 0 (0.0) | 30 (58.8) | |
| Male casual labourers (*n* = 103) | Risky drinking by AUDIT-C | Yes | 15 (93.8) | 41 (47.1) | 0.86 (0.77–0.92) |
| | | No | 1 (6.2) | 46 (52.9) | |
| Overall (*n* = 202) | Risky drinking by AUDIT | Yes | 25 (100.0) | 82 (46.3) | 0.89 (0.84–0.93) |
| | | No | 0 (0.0) | 95 (53.7) | |
| Female college students (*n* = 41) | Risky drinking by AUDIT | Yes | 2 (100.0) | 9 (23.1) | 0.96 (0.83–0.99) |
| | | No | 0 (0.0) | 30 (76.9) | |
| Male college students (*n* = 58) | Risky drinking by AUDIT | Yes | 7 (100.0) | 21 (41.2) | 0.93 (0.83–0.98) |
| | | No | 0 (0.0) | 30 (58.8) | |
| Male casual labourers (*n* = 103) | Risky drinking by AUDIT | Yes | 16 (100.0) | 52 (59.8) | 0.84 (0.76–0.91) |
| | | No | 0 (0.0) | 35 (40.2) | |

[a] Area under receiver operating characteristic.
[b] Sensitivity.
[c] Specificity.

blood, which is similar to what was observed among binge drinkers young people in the US (Piano et al., 2015).

Our findings need to be interpreted in light of the following potential limitations. Whilst PEth is specific in detecting the intake of ethanol, the test is mainly an indicator of prolonged excessive alcohol use and therefore moderate occasional use, or intake that occurred several weeks ago, could result in undetectable PEth levels (the half-life for PEth in blood is about 4–5 days), and this may lead to an underestimation of light to moderate drinking. PEth also shows high inter-individual variation in its metabolism rates (Viel et al., 2012). The PEth cut off level for heavy use applied has been established for the Swedish population (Helander and Hansson, 2013). When we explored alternative PEth cut offs levels (e.g. ≥0.40 μmol/L), we obtained similar results, and this did not improve sensitivity or specificity. Whilst AUDIT questions refer to a reporting period of one year and PEth detects recent alcohol intake, we think that individuals reporting heavy alcohol intake using AUDIT could be expected to show high levels of PEth also at present. However, we accept that there may be individuals with reported risky drinking behaviour according to AUDIT who may have become abstinent and would therefore not be expected to show high PEth test results. Lastly, in our study young people came from two selected groups and were recruited in a casual environment, and therefore our findings may not necessarily be representative for other populations of young people, for example those being screened in the context of legal issues or in anticipation of a medical treatment. The one-month TLFB tool allows assessment of current alcohol consumption, whilst AUDIT-C and AUDIT assesses consumption, but also suspected dependence and other effects of harmful use. Generally, AUDIT-C and AUDIT are easier to administer and can be completed faster than the one-month-TLFB tool, but not provide accurate estimates of actual consumption.

In conclusion, our findings indicate that the one-month-TLFB calendar and AUDIT-C and AUDIT are valid tools particularly to detect heavy alcohol use among young people in northern Tanzania, and possibly elsewhere in East Africa.

## Author's contribution

JF, HG and HW developed the study design, with contributions from JC, SK and AH. JF, HG, and SK oversaw study implementation and data collection. JF and HW performed data analysis, with contributions from HG. All authors took part in the interpretation of the data. JF, HW and HG drafted the article, and all authors provided critical revisions of the article for important intellectual content.

JF is the guarantor of the paper.

## Conflict of interest statement

None.

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.drugalcdep.2015.09.027.

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