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# Hydration Status in Nigeria: A Cross-Sectional Study

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**Abstract:** Most literatures on daily water intake are focused on developed countries and to our knowledge; there is limited information on the hydration status of Nigerians. Our objective was to describe daily water intake (DWI) among Nigerian students, develop a model for the prediction of students' DWI and examine the association between DWI and four predictor variables. Data on DWI for 150 students aged 18-26 years were collected through a survey conducted at Kwara State University in February, 2013 together with information on their age, weight, gender and awareness of dieticians' recommendation. Our results indicates that students' DWI varies by gender with male students drinking more than their female counterparts; although, the awareness rate is higher in females than males. We found that nearly half of participants (44%) drank less than 2.7 L of water/day, 25% between 2.7 and 3.7 L/day and 31% reported drinking more than 3.7 L of water/day. Results also revealed that students' DWI decline with age but increases with weight and one-in-two of the students are unaware of the dangers of poor hydration. Arguably, this study is the first description of DWI among Nigerian students and fills the gap in the literature by developing two models for the prediction of students' DWI. In light of the significance of the knowledge and awareness of Dieticians' recommendation on DWI (as evidence in this study) and the low awareness rate existing among the students; nutrition and health promotion program on the benefits of adequate DWI by schools and health organizations is extremely important. This has the potential of improving the health of students.

**Key words:** Awareness, daily water intake, hydration, students, Nigeria

## INTRODUCTION

Water is essential for life, makes up about 55-65% of the human body weight and has important physiological role in virtually every organ system in the body. Adequate intake of water is essential for optimal health and performance (physical and mental); because every living cell in human body (blood 83%, muscles 75%, brain 74% and bones 10%) depends on it for nourishment, elimination of waste, insulation, cooling and provision of a moist environment for ear, nose and throat tissues (Andersson, 2008). The human body water needs are obtained from two sources: food and beverages. The European Food Safety Authority (EFSA) (EFSA, 2010) reports that about 20-30% of the total water consumed by human comes from food and about 70-80% from beverages (all types, not just plain water). We refer readers to Food Standards Agency McCance and Widdowson (2002) for a comprehensive description of the average water contents of different kinds of non-alcoholic beverages and foods.

Lack of water can lead to dehydration, this occurs when there is no balance between water lost and water consumed. The symptoms of acute dehydration vary with the degree of water deficit (Greenleaf, 1986) but signs and symptoms of mild dehydration (1-2% decrease in body mass (Kavrouras, 2010) are neither specific nor sensitive, but may include thirst, tiredness, reduced alertness and lower levels of concentration (Szinnai *et al*., 2005; Kolasa *et al*., 2009). When dehydration exceeds about 2% of body weight, physical work capacity is diminished as reported by Cheuvront *et al*. (2009), Institute of Medicine (IOM) (2004).

There have been a number of reviews in literature about the negative effect of poor hydration practice. For instance, Kleiner (1999) list light-headedness, dizziness, headaches and tiredness as some of the symptoms of mild dehydration; reduced alertness and ability to concentrate was described in Rogers *et al*. (2001); D'Anci *et al*. (2006) as another effect of poor hydration. More so, Szinnai *et al*. (2005); Gopinathan *et al*. (1988) reported that dehydration can adversely influence decision making and cognitive function, especially when considering tasks such as studying; although, the extent and duration of dehydration leading to cognitive impairment and the cognitive functions most affected remain to be investigated (Lieberman, 2007). Furthermore, as noted in Gopinathan (1988) short-term memory, attention and arithmetic efficacy can

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be impaired when mild dehydration occurs; however, in situations where less severe dehydration occurs (such as when refraining from drinking for a relatively short period of time-up to a few hours), studies have generally failed to find evidence of cognitive impairment (Szinnai, 2005).

The amount of water needed to replace losses is the absolute requirement (Grandjean, 2005). However, establishing the recommendation that meets the needs of all is impossible Food and Nutrition Board (1989) and the fact that numerous factors affect fluid intake (Ramsay, 1991; Rozin, 1982). Thus, as a guide to preventing both mild and adverse effect of dehydration, IOM (2004) has established adequate intakes of water by age and gender. For adults (>18 years) 2.7 L (females) and 3.7 L (males) was recommended as adequate intake; Grandjean *et al.* (2004) presents the full list of the recommended adequate intake in other age groups. This requirements vary between individuals and depends on a number of factors including the person's diet (Popkin *et al*., 2001; Sanchez *et al*., 2008; Kant *et al*., 2009), demographics (Bellisle *et al*., 2010; Park *et al*., 2011; Assael *et al*., 2012; Van Loan *et al*., 1996), climate/environment (Welch *et al*., 1958; Sohn *et al*., 2001), physical activity/sedentary lifestyle (Noakes, 1993; Zapata *et al*., 2008) and a range of other factors.

Meanwhile, all the literatures cited above on water intake requirements are focused on developed countries (mostly US and Europe) with relatively little attention devoted to developing countries like Nigeria. Thus, the purpose of this cross-sectional study is to develop a model for the prediction of Daily Water Intake (DWI) by using students from a state-owned university in Nigeria with the aim of providing a framework for DWI requirements for nationally representative results. The study is also aimed at sensitizing and advising students on the importance of drinking adequate amount of water daily and the dangers of poor hydration practice.

As a result of these aims, the study is targeted at determining whether the predictors age, gender, weight and awareness of dietician's recommendation have any association with students' DWI. In other words, do the data provide sufficient evidence to indicate that these predictor variables significantly contribute information for the prediction of the students' DWI? Another question of interest that we intend to use this cross-sectional study to answer is does the knowledge and awareness of the recommended DWI by the dietician make any difference in the daily consumption of water by students?

## MATERIALS AND METHODS

**Study design and population:** A self-reported, student-based cross-sectional survey was conducted in February 2013 among 150 students at the Kwara State University (KWASU), Malete, Nigeria. The target population consists of all Nigerian students in tertiary institutions. However, the eligible population for this survey included all KWASU students that have completed their online registration for the Rain Semester in the 2012/2013 academic session from 100-400 Level as at the time of conducting this survey.

**Sample size and selection:** A total of 2876 students have completed their online registration by the time of conducting this survey. Using 2876 as the population size, the confidence level of 95% and 0.05 margin of error, the sample size for the study was found to be 339 which we rounded off to 350 students. We used Stratified Systematic Sampling technique described in Olufadi *et al.* (2012) to select the samples from the study population using students' College as the stratification variable. However, looking at the demographic characteristics of the 350 potential students to be contacted for possible participation in the survey we found that more than half of these students were below 18 years of age (age of minor - section 277 of the Child's Rights Act, Federal Republic Nigeria (2003). We therefore dropped these sets of students and finally contacted 167 students who are 18 years and above. An informed written letter of consent was sent to these students and only 150 students out of 167 students indicated their willingness to participate in the survey, the remaining 17 students declined.

**Validation of questionnaire:** The desired information in line with the objective of the study was elicited from participants through the design of self-administered questionnaire. The content of the questionnaire was pre-tested using 20 students who are exempted from the actual survey; this was done with the aim of validating whether the would-be participants are able to understand the questions being asked. Consequently, the questionnaire was validated and modified accordingly.

**Variable of interest:** The variable of interest is students' DWI. Students were asked, "How often do you drink sachets of "pure water" in the past one week?" We categorized the response into: none, once, 2-3, 4-6, 1 time/day, 2 times/day and more than 3 times/day. Further, students were asked, "What is the approximate quantity you drank each time?" and the response in this case was categorized: a quarter, half, more than half but not all and drank all. Lastly, the students were asked, "Please specify the size of the bottle" and the response in this case is categorized: 50 cl, 75 cl and 1 L.

**Independent variable:** In this study, we shall focus our attention on three demographic variables; namely, self-reported age at last birthday, weight (students were weighed barefooted using electronic balance scale) and

gender. The other factor to be examined as one of the predictors of students' DWI is the students' awareness of dietician's recommendation on water intake. For this predictor (awareness), students were asked, "Do you know the daily water intake recommended by the dietician's for optimal performance of human body systems?" and the response was categorized as Yes and No. They were then asked to state the recommended amount if there response was yes. Many other questions were asked but are not presented here.

**Statistical analysis:** The descriptive summary measure of the variable of interest and predictor variables (gender, age, weight and awareness) were summarized as follows. Categorical variables were expressed as proportions and continuous variables were expressed as the mean± standard deviation (SD). The chi-square test was used to compare categorical data and the t-test was used for continuous variables. A further analysis of the residuals was performed to identify the categories responsible for significant chi-square values. To explore the association between students' DWI and predictor variables: age, weight and awareness, multiple linear regression (MLR) model was used. The choice of MLR is justified through the different exploratory data analysis carried out on the raw data since we have no a priori information (theoretical background) about the form of the model. We only present the coefficient of the MLR models, its $R^2$ and the associated p-value for test of significance. Regression analysis is valid for prediction and estimation only when certain assumptions hold. We note that we have applied the validation procedures for the examination of the validity of the suggested models and found no evidence of model misspecification.

For the analysis, gender is equal to 1 if the student is a female and 0 otherwise. Also, the awareness variable is coded 1 if the student is aware of the dietician's recommendation and 0 otherwise. The results were considered statistically significant when $p<0.05$. Standard statistical software STATA (Version 10; College Station, TX, 77845, USA) was used for the data management and statistical analyses.

## RESULTS

Result of the analysis for the study population consisting of 150 students reveals that the awareness rate is lower in male students (44%) than in female students (57%) and slightly above half for the both gender as evident in Table 1. On average, the mean DWI of males students falls between 2.91 and 3.64 L/day with the possibility of increasing or decreasing by about 200 ml/day; that of female students lies between 2.76 and 3.27 L/day (likely to goes up or down by 120 mL/day).

The results of the chi-square test performed to test the hypothesis of no association (independence) between the various variables reveals an evidence of association between DWI and awareness ($p = 0.004$), DWI and weight ($p = 0.0050$), weight and gender ($p = 0.0001$), weight and awareness ($p = 0.0050$), age and awareness ($p = 0.0407$) and age and weight ($p = 0.0001$).

Table 1: Description of study population

| Variables | Males (n = 57) Mean±SD | Female (n = 93) Mean±SD | Both (n = 150) Mean±SD |
|---|---|---|---|
| DWI | 3.27±1.37 | 3.02±1.25 | 3.11±1.30 |
| Age | 20.74±2.17 | 20.02±1.86 | 20.41±1.99 |
| Weight | 61.77±8.50 | 56.09±9.12 | 58.25±9.28 |
| Awareness | 0.44±0.50 | 0.57±0.50 | 0.52±0.50 |

Of these significant associations and in line with one of the objectives of this study, we are particularly interested in the relationship between students' DWI and awareness of dieticians' recommendation. To examine this association more fully, we classify students DWI into the following categories: very low intake (less than 2 L), low intake (between 2 and 3 L), adequate intake (3 to 4 L) and high intake (more than 4 L). We present in Table 2 the results of odds ratios and two-sided Z-test to determine whether the odds ratios differ significantly from what we would expect if there were no difference in the odds of students' levels of DWI and awareness of dietician's recommendation. We would interpret the Z-value as "not much evidence of strong association" if Z-value is less than two and "strong evidence of association" if Z is more than or equal to two.

For example, looking at the association between the levels (VLI and LI) and awareness of dieticians' recommendation, the odds ratio is 2.13. This tells us that the odds in favour of a student drinking less than two L of water daily if the student is unaware of dieticians' recommendation are 2.13 times the odds in favour of drinking less than two litres if the student is aware of dieticians recommendation. And $Z = 1.49$ indicates that there is not much evidence of a strong association between awareness and levels of intake (VLI and LI), even though the odds ratios is 2.13.

Regression analysis (simple and multiple) controlling for age, weight, gender and awareness of dietician's recommendation was performed for separate and combined gender using 150 sampled data. We present the summary of these analyses in Table 3, 4 and 5.

For the combined data of males and females, 12% of variation in students' DWI could be explained by the regression model when weight and awareness of dieticians' recommendation are used as the explanatory variables. A further 0.3 and 0.5% improvement is observed when three variables (gender, weight and awareness) and four variables (age, gender, weight and awareness) were used as the explanatory variables. Thus, we would prefer a simpler model since the gain in explaining the variation in students DWI is negligible.

Table 2: Odds ratio and Z test for levels of DWI and awareness of dietician's recommendation

| | VLI vs LI | VLI vs AI | VLI vs HI | LI vs AI | LI vs HI | AI vs HI |
|---|---|---|---|---|---|---|
| Odds ratios | 2.13 | 1.50 | 5.99 | 0.71 | 2.82 | 3.99 |
| Z | 1.49 | 0.71 | 3.23 | -0.74 | 2.33 | 2.69 |

where, VLI = very low intake LI = low intake AI = adequate intake HI = high intake

Table 3: Model equations for both males and females

| Variables | Regression equations | MSE | F test | $R^2$ |
|---|---|---|---|---|
| $X_1$ | $3.13-0.0009X_1$ | 1.697 | 0 (0.0000) | 0.000 |
| $X_2$ | $1.12+0.0342X_2$ | 1.595 | 9.41 (0.0026) | 0.06 |
| $X_4$ | $2.79+0.6224X_4$ | 1.599 | 9.07 (0.0030) | 0.058 |
| $X_1$ and $X_2$ | $1.61-0.0265X_1+0.0351X_2$ | 1.603 | 4.81 (0.0095) | 0.061 |
| $X_1$ and $X_4$ | $2.86-0.0033X_1+0.6227X_4$ | 1.61 | 4.51 (0.0126) | 0.058 |
| $X_2$ and $X_4$ | $0.82+0.0393X_2+0.6173X_4$ | 1.509 | 9.7 (0.0001) | 0.117 |
| $X_1$, $X_3$ and $X_4$ | $3.29-0.0147X_1-0.3522X_2+0.667X_3$ | 1.592 | 3.93 (0.0099) | 0.075 |
| $X_2$, $X_3$ and $X_4$ | $1.06+0.031X_2-0.162X_3+0.638X_4$ | 1.514 | 6.63 (0.0003) | 0.12 |
| $X_1$, $X_2$, $X_3$ and $X_4$ | $1.67-0.03X_1+0.03X_2-0.175X_3+0.64X_4$ | 1.52 | 5.05 (0.0008) | 0.122 |

where: Y = DWI $X_1$ = Age $X_2$ = Weight $X_3$ = gender $X_4$ = Awareness P-values in parenthesis

Table 4: Model equations for male students

| | Regression equations | MSE | F test | $R^2$ |
|---|---|---|---|---|
| $X_1$ | $0.04-0.0373X_1$ | 1.912 | 0.19 (0.6634) | 0.004 |
| $X_2$ | $1.12+0.0342X_2$ | 1.595 | 9.41(0.0026) | 0.06 |
| $X_4$ | $3.02+0.5852X_4$ | 1.831 | 2.63 (0.1109) | 0.046 |
| $X_1$ and $X_2$ | $2.13-0.1006X_10.0523X_2$ | 1.762 | 2.94 (0.0615) | 0.098 |
| $X_1$ and $X_4$ | $4.1-0.0526X_1+0.6098X_4$ | 1.852 | 1.49 (0.234) | 0.052 |
| $X_2$ and $X_4$ | $0.05+0.0476X_2+0.6541X_4$ | 1.697 | 4.1 (0.022) | 0.132 |
| $X_1$, $X_2$ and $X_4$ | $1.98-0.13X_1+0.0579X_2+0.7278X_4$ | 1.659 | 3.53 (0.0208) | 0.167 |

where: Y = DWI $X_1$ = Age $X_2$ = Weight $X_3$ = gender $X_4$ = Awareness P-values in parenthesis

Table 5: Model equations for female students

| Variables | Regression equations | MSE | F test | $R^2$ |
|---|---|---|---|---|
| $X_1$ | $2.73+0.014X_1$ | 1.574 | 0.04 (0.8424) | 0.0004 |
| $X_2$ | $1.49+0.0272X_2$ | 1.512 | 3.75 (0.0560) | 0.040 |
| $X_4$ | $2.61+0.7143X_4$ | 1.447 | 8.04 (0.0056) | 0.081 |
| $X_1$ and $X_2$ | $1.21+0.0136X_1+0.0272X_2$ | 1.528 | 1.87 (0.1596) | 0.040 |
| $X_1$ and $X_4$ | $2.24+0.0182X_1+0.7158X_4$ | 1.462 | 4.02 (0.0214) | 0.082 |
| $X_2$ and $X_4$ | $1.37+0.0227X_2+0.6622X_4$ | 1.42 | 5.46 (0.0058) | 0.108 |
| $X_1$, $X_2$ and $X_4$ | $1.01+0.0178X_1+0.02266X_2+0.6636X_4$ | 1.557 | 3.63 (0.016) | 0.109 |

where: Y = DWI $X_1$ = Age $X_2$ = Weight $X_3$ = gender $X_4$ = Awareness P-values in parenthesis

Therefore, our proposed model for combined data is:

DWI = 0.82+0.0393 weight + 0.6173 awareness (1)

where, as a results of the little difference (±1, in terms of the $R^2$ values) between model equation (1) and the two separate models suggested for males and females (equations (2b) and (3) and since we found no evidence of association between gender and DWI (p = 0.3452), we present different model for males and female students. Although, the use of separate models for males and females students would not afford us the opportunity of testing for gender effect on students DWI. It thus affords us the opportunity of using a more homogenous population with an expectation of obtaining improved results.

For male students' population, three regression models were found to be significant (Table 4). However, it was decided based on the values of $R^2$ and mean square error, that the following model provides the best fit:

DWI = 1.98 - 0.13 age + 0.0579 weight + 0.7278 awareness (2a)

The following simpler model is also suggested:

DWI = 0.0455+0.0476 weight + 0.6541 awareness (2b)

As for the separate estimate for females, four models were found to be significant (Table 5), with weight and awareness being the most significant variables. In this case, we again recommend multiple regression models involving two variables (weight and awareness) as the prediction model of female students DWI over the one with three variables which produces only 0.1% improvement in explaining the variation in female students' DWI and for the fact that it has the smallest mean square error. The suggested model is presented below:

DWI = 1.37 + 0.0227 weight + 0.6522 awareness (3)

The two models (2b and 3), suggested for the estimation of students' DWI assumes that the relationship between students' DWI and weight is linear but the constant term of the outcome variable (usually referred to as the intercept) differ depending on awareness of dieticians recommendation on DWI. Although, this model allows for awareness differences, it assumes that change in students' DWI, for every 1 unit increase in weight (say, a kilogram) does not depend on students' awareness of dietician's recommendation.

## DISCUSSION

More than 90% of the students agreed that drinking adequate amount of water daily can make valuable contribution to their performance in class and that dehydration, even at mild level may negatively affect their mental and physical performance. Although, knowledge and awareness of dieticians' recommendation on DWI shows a positive and significant association with DWI ($p = 0.004$), there appears to be a low rate of awareness among students (44% male, 57% female and 52% for combined gender). This awareness rate is equally-likely to increase or decrease (Table 1). Thus, in a busy environment like university, the benefits of sensitizing students on the importance of adequate intake of water cannot be over emphasized. Failure of the students to recognize (awareness) the dangers of poor hydration practice may contribute to a decline in students' productivity; for example: decision making and cognitive function (Gopinathan *et al*., 1988; Kenefick *et al*., 2007), low level of concentration, tiredness, dizziness, headaches and reduced alertness (Szinnai *et al*., 2005; Kolasa *et al*., 2009) and could be associated with low performance in students' academic achievement.

In line with the recommendation of IOM (2004), it is evident from the results that the DWI varies by gender with male students drinking more than their female counterparts; although, the awareness rate is higher in females than males. Furthermore, our findings indicated that nearly half of participants (44%) drank less than 2.7 L of water (bottled or tap water) per day, 25% between 2.7 and 3.7 L/day and 31% reported drinking more than 3.7 L of water/day. These results are consistent with those based on 2005-2008 and 1999-2006 NHANES data, studied by IOM (2004), Sebastian *et al*. (2011) and also reported in Goodman *et al*. (2013).

Furthermore, this study developed and suggested two models for the estimation of students' DWI. The two models reveal a positive association between the students' DWI and the predictors' weight and awareness of dietician's recommendation. These unsurprising results is also confirmed by the chi-square test of association (students' DWI vs. weight, $p = 0.005$) and (students' DWI vs. awareness of dietician's recommendation, $p = 0.004$). These results indicate that as the weight of students becomes higher, she is likely to lose more water (say, through sweating) and as a result of this, she needs more water-water balance Manz *et al*. (2012). More so, for a student that is aware of the dangers of poor hydration, we expect her to be conscious of her DWI.

One interesting thing to note about the overall model (for both males and females) is that the proportion of variations in students' DWI explained by the predictor variables weight and awareness of dieticians' recommendation is quite low. This low $R^2$ value is expected because we are dealing with a cross-sectional data (not time series) and when working with cross-sectional data, typically one obtains a low $R^2$ value possibly because of the diversity of the units in the sample Gujarati (2004). Nonetheless, it appears that for a better explanation of students' DWI, we have to take into consideration other factors like intensity of physical exercise, climatic condition, sweat rate, individual metabolic and physiological features, food habit (e.g., salt intake), etc.

It is difficult at this stage to compare our data (results) with some of the works reviewed in this study because ours is not a nationally or geographically representative survey of the general population. However, some of our results appear to be consistent with their findings. For instance, we found no association between students' DWI and gender variable (both chi-square test and regression confirms this), this is in line with findings of Kant *et al*. (2006), Park *et al*. (2011); though, the concept of association between water intake and gender remains controversial (Pintar *et al*., 2009). Our results suggest that students' DWI decline with age but increases with weight, consistent with our findings, though for older age groups (Volkert *et al*., 2005), Zizza *et al*. (2009) found that water intake declines with age; however, the findings by De Castro *et al*. (1992), Bossingham *et al*. (2005) are contrary as they found no differences in DWI and age.

Arguably, this cross-sectional study presents for the first time the description of students DWI among Nigerian students and fills the gap in the literature by developing two separate models for the estimation of students' DWI. However, it is not without its limitations. One drawback of this cross-sectional study is the use of weekly recall interview. Water intake may vary from day to day, thus, the possibility of cognitive impairment which may affect students' ability to recall the DWI could not be ruled out. More so, being a cross-sectional study, results can only show an association between variable under study and predictors, not a causal relationship. In addition, inaccuracy, under reporting or over-reporting can be an issue with self-reported (except for weight) survey data such as our weekly water intake survey.

However, Hedrick *et al*. (2010) found no significant difference between water intake that was self-reported on a questionnaire and water intake determined through 4-day food intake records (r = 0.7). Another important drawback of this study is our inability to control for environmental variables (geographical location, seasonality) that could influence students' DWI. Finally, our study suffered from the use of KWASU students only there is a need for a national or geographically representative survey that would allow us to generalize to the Nigerian population.

An advantage of our study is that for the first time, we were able to examine Nigerian students' DWI, which will serve as an eye-opener and provide a framework for nationally or geographically representative results. Furthermore, as noted by Fulgoni (2007), Kant *et al*. (2010), there is limited data on fluid intake; this cross- sectional study presents a significant data about the DWI among Nigerian students using students from a state-owned university. This data may prove very useful in preventing dehydration and its various consequences among Nigerian students.

**Conclusions:** There is limited information on the hydration status of Nigerians. Using some demographic and awareness variables, this cross-sectional study describes the DWI among Nigerian students between the ages 18 and 26 years. The study fills the gap in literature by developing two models for the estimation of students' DWI. Two factors (weight and awareness of dietician's recommendation on DWI) provided evidence of strong association with students' DWI. Overall, about half of the population of KWASU students is unaware of the minimum DWI as advised by the dieticians, although, the awareness rate is higher in females than males. Further, we found that students DWI decline with age but increases with weight. In light of the significance of the knowledge and awareness of Dieticians' recommendation on DWI (as evidence in this study) and the low awareness rate existing among the students; nutrition and health promotion program on the benefits of adequate DWI by schools and health organizations is extremely important. More so, since media holds an important place in disseminating information and creating awareness, media can be used to convey healthful messages such as the dangers involved in poor hydration practice. This has the potential of improving the health of students. In future, we shall focus on investigating the DWI of students and its effect on students' academic performance.

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