**Methods**

Factors associated with self-reported hypertension were assessed using logistic regression. Variables for inclusion in the logistic regression model were *a priori* specified in consultation with a clinician. Non-linear associations with continuous predictors were examined by expanding variables using restricted cubic splines with 3 or 4 knots selected based on the AIC. For ease of interpretation, we only included non-linear terms that were found to be statistically significant. Subjects with missing CD4 count (n=162, 6.5%) were removed from the analyses. (Ideally we would have multiply imputed missing CD4 so that we would not lose these patients in analyses.) An ordered logistic regression model and a linear regression model were fitted to examine factors associated with Joint National Committee blood pressure classification and diastolic blood pressure, respectively. These additional models used the same covariates as in the logistic regression model, and continuous variables were expanded using natural splines in the same manner as in the logistic regression model. A sensitivity analysis used a cumulative probability model to examine associations between the covariates and diastolic blood pressure.

Analysis code is posted at https://biostat.app.vumc.org/NigeriaWorkshop2023.

**Results**

A total of 368 (15%) of patients had self-reported hypertension. The adjusted associations between variables and hypertension are shown in Table 1. Age was strongly associated with hypertension and in a non-linear manner (p=0.014, test for non-linearity; Figure 1A). Holding all other variables constant, the odds of hypertension was 2.64 times higher for a 50 year-old than a 40-year old (95% confidence interval [CI] 2.00, 3.48). Sex was not associated with hypertension (adjusted odds ratio [aOR] = 1.10, 95% CI 0.82-1.48). There was no evidence of an interaction between sex and age on hypertension (p=0.77, test for interaction). Body mass index (BMI) was strongly associated with hypertension (p<0.0001); the odds of hypertension increased 56% per 5 kg/m2 increase in BMI (aOR=1.56, 95% CI=1.38-1.77). Lower eGFR was associated with higher odds of hypertension although in a non-linear manner (p<0.0001 for overall association, p=0.006 for test of non-linearity; see Figure 1B). Similarly lower potassium was associated with higher odds of hypertension in a non-linear manner (p=0.0009 for overall association, p=0.017 test for non-linearity; see Figure 1C). Higher levels of sodium (aOR=1.29 for 10 unit increase, 95% CI 1.01-1.64) and CD4 cell count (aOR=1.07 per 100 cells/mm3 increase, 95% CI 1.02-1.12) were associated with higher odds of retention after adjusting for other variables. Surprisingly, smoking was associated with a lower odds of hypertension in adjusted analyses (aOR=0.45, 95% CI 0.21-0.96). Diabetes, which was rare in our cohort (prevalence of 2%), was not statistically associated with hypertension in adjusted analyses (aOR=1.41, 95% CI 0.72-2.77), despite being associated with hypertension prior to adjusting for other variables (unadjusted OR=2.65, 95% CI 1.45-4.82).

**Table 1.** Adjusted odds ratios for hypertension.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Odds ratio | 95% Confidence Interval | | p-value |
| Age (years) |  |  |  | <0.0001 |
| 20 vs. 40 | 0.23 | 0.06 | 0.94 |  |
| 30 vs. 40 | 0.38 | 0.25 | 0.60 |  |
| 40 (reference) | 1 |  |  |  |
| 50 vs. 40 | 2.64 | 2.00 | 3.48 |  |
| 60 vs. 40 | 3.78 | 2.50 | 5.73 |  |
| Male sex | 1.10 | 0.82 | 1.48 | 0.54 |
| BMI (per 5 kg/m2) | 1.56 | 1.38 | 1.77 | <0.0001 |
| Smoking | 0.45 | 0.21 | 0.96 | 0.038 |
| eGFR |  |  |  | <0.0001 |
| 25 vs. 100 | 5.87 | 2.95 | 11.69 |  |
| 50 vs. 100 | 2.79 | 1.87 | 4.15 |  |
| 75 vs. 100 | 1.35 | 1.12 | 1.63 |  |
| 100 (reference) | 1 |  |  |  |
| 125 vs. 100 | 1.07 | 0.82 | 1.39 |  |
| 150 vs. 100 | 0.86 | 0.42 | 1.78 |  |
| 175 vs. 100 | 0.68 | 0.18 | 2.59 |  |
| Potassium |  |  |  | 0.0009 |
| 3 vs. 4 | 2.44 | 1.48 | 4.04 |  |
| 4 (reference) | 1 |  |  |  |
| 5 vs. 4 | 0.78 | 0.60 | 1.01 |  |
| 6 vs. 4 | 0.82 | 0.43 | 1.56 |  |
| Sodium (per 10 units) | 1.29 | 1.01 | 1.64 | 0.040 |
| Diabetes | 1.41 | 0.72 | 2.77 | 0.31 |
| CD4 (per 100 cells/mm3) | 1.07 | 1.02 | 1.12 | 0.007 |

**Figure 1.** Association between hypertension and age (A), eGFR (B), and potassium (C).







Next, we examined the association between Joint National Committee blood pressure classification and risk factors. In our cohort, 65% were classified as normal, 22.2% pre-hypertension, 8.4% stage 1 hypertension, and 4.4% stage 2 hypertension. Results were fairly similar to those reported for self-reported hypertension (Table 2). Age, BMI, eGFR, and potassium remained strong predictors of JNC blood pressure classification, and the relationships were similar to that seen for self-reported hypertension (Figure 2). Sex was now associated with JNC blood pressure classification: The odds of being in a worse JNC blood pressure category were 2.34 times higher for males than females (95% CI 1.88-2.90). Sodium, diabetes, and CD4 were not associated with a higher JNC blood pressure classification

**Table 2.** Adjusted odds ratios for higher JNC blood pressure classification.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Odds ratio | 95% Confidence Interval | | p-value |
| Age (years) |  |  |  | <0.0001 |
| 20 vs. 40 | 0.09 | 0.04 | 0.21 |  |
| 30 vs. 40 | 0.34 | 0.25 | 0.45 |  |
| 40 (reference) | 1 |  |  |  |
| 50 vs. 40 | 1.69 | 1.40 | 2.04 |  |
| 60 vs. 40 | 2.14 | 1.55 | 2.96 |  |
| Male sex | 2.34 | 1.88 | 2.90 | <0.0001 |
| BMI (per 5 kg/m2) | 1.77 | 1.62 | 1.95 | <0.0001 |
| Smoking | 0.77 | 0.51 | 1.16 | 0.21 |
| eGFR |  |  |  | 0.0025 |
| 25 vs. 100 | 2.89 | 1.60 | 5.22 |  |
| 50 vs. 100 | 1.81 | 1.29 | 2.55 |  |
| 75 vs. 100 | 1.16 | 1.01 | 1.33 |  |
| 100 (reference) | 1 |  |  |  |
| 125 vs. 100 | 1.24 | 1.03 | 1.48 |  |
| 150 vs. 100 | 1.42 | 0.96 | 2.11 |  |
| 175 vs. 100 | 1.63 | 0.79 | 3.34 |  |
| Potassium |  |  |  | 0.025 |
| 3 vs. 4 | 1.72 | 1.16 | 2.55 |  |
| 4 (reference) | 1 |  |  |  |
| 5 vs. 4 | 0.94 | 0.78 | 1.12 |  |
| 6 vs. 4 | 1.09 | 0.70 | 1.71 |  |
| Sodium (per 10 units) | 1.09 | 0.92 | 1.30 | 0.31 |
| Diabetes | 1.54 | 0.90 | 2.61 | 0.11 |
| CD4 (per 100 cells/mm3) | 1.01 | 0.97 | 1.04 | 0.70 |

**Figure 2.** Adjusted odds ratios for being in a worse JNC blood pressure category as a function of age (A), eGFR (B), and potassium (C).







Finally, we examined the associations between these variables and diastolic blood pressure (DBP). The median DBP was 73 mm Hg (interquartile range 66 to 81, with minimum of 43 and maximum of 150). Associations with DBP (Table 3) were largely consistent with what we saw using JNC blood pressure categories. Higher age was strongly predictive of higher blood pressure (p<0.0001) in a non-linear manner (Figure 3A). Holding all other factors constant, males had DBP 5.89 mm Hg higher than females on average (95% CI 4.77-7.00). For a 5-kg/m2 increase in BMI, the expected DBP was increased 3.76 mm Hg. Lower and higher eGFR were associated with higher DBP (Figure 3B). Lower potassium was associated with higher blood pressure (Figure 3C). A 10-unit increase in sodium was associated with a 1.39 mm Hg increase in DBP (95% CI 0.53, 2.25). Smoking status, diabetes, and CD4 cell count were not associated with DBP in adjusted analyses. Results were largely consistent in a sensitivity analysis fitted using a cumulative probability model (data not shown).

**Table 3.** Adjusted effects (differences in conditional expectations) of predictor variables on diastolic blood pressure (mm Hg).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Effect | 95% Confidence Interval | | p-value |
| Age (years) |  |  |  | <0.0001 |
| 20 vs. 40 | -8.32 | -10.97 | -5.67 |  |
| 30 vs. 40 | -4.23 | -5.16 | -3.31 |  |
| 40 (reference) | 1 |  |  |  |
| 50 vs. 40 | 2.07 | 1.19 | 2.95 |  |
| 60 vs. 40 | 1.47 | -0.34 | 3.27 |  |
| Male sex | 5.89 | 4.77 | 7.00 | <0.0001 |
| BMI (per 5 kg/m2) | 3.76 | 3.30 | 4.22 | <0.0001 |
| Smoking | -1.64 | -3.75 | 0.46 | 0.13 |
| eGFR |  |  |  | <0.0001 |
| 25 vs. 100 | 7.45 | 4.30 | 10.59 |  |
| 50 vs. 100 | 4.24 | 2.43 | 6.05 |  |
| 75 vs. 100 | 1.13 | 1.41 | 1.85 |  |
| 100 (reference) | 1 |  |  |  |
| 125 vs. 100 | 1.27 | 0.39 | 2.15 |  |
| 150 vs. 100 | 2.20 | 0.40 | 3.99 |  |
| 175 vs. 100 | 3.09 | -0.17 | 6.35 |  |
| Potassium |  |  |  | 0.033 |
| 3 vs. 4 | 2.60 | 0.64 | 4.56 |  |
| 4 (reference) | 1 |  |  |  |
| 5 vs. 4 | -0.42 | -1.34 | 0.50 |  |
| 6 vs. 4 | 0.18 | -2.05 | 2.41 |  |
| Sodium (per 10 units) | 1.39 | 0.53 | 2.25 | 0.002 |
| Diabetes | 2.33 | -0.76 | 5.42 | 0.14 |
| CD4 (per 100 cells/mm3) | 0.09 | -0.08 | 0.26 | 0.30 |

**Figure 3.** Estimated effects (difference in conditional expectations) of diastolic blood pressure (mm Hg) as (A) a function of age, (B) a function of eGFR, and (C) a function of potassium.

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