**Use of mid-upper arm circumference to screen for thinness among sub-Saharan African male detainees**

**On-line Supplementary Material**

**Supplemental Methods**

We performed several sensitivity analyses. First, we divided our population into high and low prevalence countries and comparing sensitivity and specificity between these groups. High prevalence countries were countries 5, 6, and 7, while low prevalence countries were 1,2,3,4 and 8. See table 2 for the prevalence of thinness in each of these countries. Second, because we hypothesized teenage and older detainees may have a different relationship between BMI and MUAC, we excluded detainees age <20 and >50 years. Third, given that few young adolescents were in our data, we repeated our analysis in the 4,166 detainees with missing or invalid age data. Fourth, we excluded the 8 possible duplicates identified in our dataset. Fifth, we fit three-level mixed-effects models that included month and year of data collection as an additional random-effect to examine whether variability over time biased our results.

**Supplemental Results**

The summary of our sensitivity analysis is shown in supplementary tables 1, 2, and 3 which shows AUROC, sensitivity, and specificity for any thinness, moderate or severe thinness, and severe thinness in each of our sensitivity analyses. Additionally, we recalculated AUROCC under each of the scenarios included in our sensitivity analyses and these results are presented in the table.

**High and Low Prevalence Countries**

Sensitivity for any thinness was 74.6% (95%CI: 61.3,88.0%) for our selected cut-off value of 25.5cm in high prevalence countries while in low prevalence countries, it was 79.8% (95% CI: 71.2,88.3). AUROC for any thinness was 0.83 in high prevalence and 0.88 in low prevalence countries, respectively. When examining our lower cutoff of 21.0cm, specificity was higher in high prevalence countries at 99.5% (95% CI: 99.0,100.0%) and slightly lower in low prevalence countries at 98.6% (95% CI: 97.0,100.0%). Of note AUROCC for severe thinness was less in high prevalence countries (0.87) compared to low prevalence countries (0.95).

**Excluding Detainees Under 20 Years and Over 50 Years**

When we excluded male adults <20 or >50 years old, sensitivity and specificity were virtually unchanged from our primary analysis. Specifically, sensitivity for any thinness was 76.2 (95% CI: 68.2,84.2) for our selected cutoff of 25.5cm. Similarly, for our lower cutoff of 21.0cm, specificity for severe thinness was similar at 98.9% (95% 97.8,100.1).

**Missing Age Data**

When we repeated our analysis in the 4,166 detainees who had missing/invalid age data and were thus excluded from our main analysis, we found nearly identical sensitivity of 77.9% (95% CI: 71.8,84.0%) for any thinness at our selected MUAC cutoff of 25.5 cm. Similarly, specificity for severe thinness was similar at 99.3% (95% CI: 98.9,99.7%). Additionally, AUROCC was similar in this population with similarly high AUROCC of 0.89, 0.91, and 0.94 for any, moderate or severe, and severe thinness respectively.

**Exclusion of possible duplicates**

As shown in Supplemental Tables 1, 2, and 3 there was no difference when the 8 possible duplicates were excluded.

**Model accounting for month and year of collection**

The performance of our cut-offs when three-level logistic regression models were fit that accounted for the month and year of collection were nearly unchanged. Specifically, sensitivity of our 25.5 cm cutoff for BMI <18.5 kg/m2 was 77.3% (95% CI: 69.9, 84.7) versus 77.0% (69.4,84.7) in the primary analysis and 91.6 (95% CI: 87.7, 95.5) for BMI < 16 kg/m2 versus 92.1 (88.4,95.7) in the primary analysis. Specificity of our low 21.0cm cut-off was also nearly unchanged with specificity of 99.0 (98.1-99.8) versus 99.0 (97.9,100.0) in the primary analysis.

Supplemental Table 1 – Sensitivity Analysis for Any Thinness (BMI<18.5 kg/m2)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Overall Results | Any Thinness (BMI<18.5 kg/m2) | | | | | | | | | | | | | |
|  | Full Dataset  (n=11917) | | High Prevalence  (n=3642) | | Low Prevalence  (n=8275) | | Age <20 and >50 years excluded (n=10663) | | Missing Age Data  (n=4164) | | Possible Duplicates Excluded  (n=11909) | | Adjusted for Month/Year of Collection  (n=11917) | |
| AUROC | 0.87 | | 0.83 | | 0.88 | | 0.87 | | 0.89 | | 0.87 | | 0.87 | |
| MUAC (cm) | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC |
| <19.0 | 0.6 | 99.9 | 0.4 | 100.0 | 0.7 | 99.8 | 0.7 | 99.9 | 2.6 | 99.5 | 0.6 | 99.9 | 0.6 | 99.9 |
| <19.5 | 1.2 | 99.8 | 0.7 | 99.9 | 1.7 | 99.7 | 1.2 | 99.8 | 2.8 | 99.8 | 1.2 | 99.8 | 1.4 | 99.8 |
| <20.0 | 2.2 | 99.8 | 0.8 | 99.9 | 3.4 | 99.7 | 2.1 | 99.8 | 2.6 | 99.9 | 2.2 | 99.8 | 2.2 | 99.8 |
| <20.5 | 4.1 | 99.6 | + | + | 5.8 | 99.3 | 3.9 | 99.5 | 3.2 | 99.9 | 4.1 | 99.6 | 4.3 | 99.5 |
| <21.0 | 5.9 | 99.5 | 2.7 | 99.7 | 8.4 | 99.3 | 5.8 | 99.5 | 4.2 | 99.8 | 5.9 | 99.5 | 5.9 | 99.5 |
| <21.5 | 9.5 | 99.3 | 5.0 | 99.5 | 13.1 | 99.0 | 9.3 | 99.3 | 8.1 | 99.7 | 9.5 | 99.3 | 10.0 | 99.3 |
| <22.0 | 13.5 | 99.2 | 7.6 | 99.5 | 18.0 | 99.0 | 13.1 | 99.3 | 11.8 | 99.4 | 13.5 | 99.2 | 14.8 | 99.2 |
| <22.5 | 19.9 | 98.5 | 11.9 | 99.2 | 25.1 | 97.9 | 19.3 | 98.5 | 23.2 | 98.5 | 19.9 | 98.5 | 22.3 | 98.3 |
| <23.0 | 26.4 | 97.8 | 18.7 | 98.4 | 31.6 | 97.3 | 25.8 | 97.9 | 28.5 | 97.9 | 26.4 | 97.8 | 29.5 | 97.5 |
| <23.5 | 37.4 | 95.7 | 29.3 | 96.7 | 42.9 | 94.9 | 36.7 | 95.8 | 36.4 | 96.6 | 37.4 | 95.7 | 40.3 | 95.3 |
| <24.0 | 45.2 | 93.9 | 39.3 | 94.1 | 50.1 | 93.5 | 44.6 | 94.1 | 44.3 | 94.9 | 45.2 | 93.9 | 47.1 | 93.4 |
| <24.5 | 58.2 | 89.7 | 54.2 | 89.0 | 62.5 | 89.8 | 57.2 | 90.0 | 57.2 | 91.6 | 58.2 | 89.7 | 59.1 | 89.4 |
| <25.0 | 65.5 | 86.5 | 61.9 | 84.4 | 69.9 | 87.3 | 64.8 | 87.0 | 65.6 | 88.6 | 65.5 | 86.6 | 66.1 | 86.3 |
| <25.5 | 77.0 | 79.6 | 74.6 | 76.4 | 79.8 | 80..7 | 76.2 | 80.2 | 77.9 | 83.7 | 77.1 | 79.6 | 77.3 | 79.5 |
| <26.0 | 83.6 | 74.3 | 83.2 | 68.8 | 84.7 | 76.9 | 83.3 | 75.0 | 84.7 | 78.8 | 83.7 | 74.3 | 83.4 | 74.6 |
| <26.5 | 90.3 | 64.6 | 90.7 | 58.7 | 90.2 | 67.9 | 90.0 | 65.4 | 91.8 | 68.8 | 90.3 | 64.6 | 90.1 | 65.2 |

SENS – Sensitivity calculated using mixed effects logistic regression model

SPEC – Specificity calculated using mixed effects logistic regression model

Grayed out cells indicate unstable estimate due to cell count <10.

+ indicates model would not converge due to sparse data.

Supplemental Table 2 – Sensitivity Analysis for Moderate or Severe Thinness (BMI<17 kg/m2)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Overall Results | Moderate or Severe Thinness (BMI<17 kg/m2) | | | | | | | | | | | | | |
|  | Full Dataset  (n=11917) | | High Prevalence  (n=3642) | | Low Prevalence  (n=8275) | | Age <20 and >50 years excluded (n=10663) | | Missing Age Data  (n=4164) | | Possible Duplicates Excluded  (n=11909) | | Adjusted for Month/Year of Collection  (n=11917) | |
| AUROC | 0.90 | | 0.86 | | 0.93 | | 0.90 | | 0.91 | | 0.90 | | 0.90 | |
| MUAC (cm) | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC |
| <19.0 | 1.5 | 99.9 | 1.2 | 99.9 | 1.8 | 99.8 | 1.7 | 99.9 | 3.7 | 99.4 | 1.5 | 99.9 | 1.6 | 99.9 |
| <19.5 | 3.2 | 99.8 | 1.9 | 99.9 | 4.1 | 99.7 | 3.1 | 99.8 | 4.2 | 99.7 | 3.2 | 99.8 | 3.5 | 99.8 |
| <20.0 | 5.8 | 99.7 | 2.6 | 99.9 | 8.4 | 99.6 | 5.4 | 99.7 | 5.4 | 99.7 | 5.8 | 99.7 | 5.9 | 99.7 |
| <20.5 | 10.0 | 99.4 | 5.3 | 99.8 | 13.3 | 99.1 | 9.4 | 99.4 | 6.8 | 99.7 | 10.0 | 99.4 | 9.8 | 99.4 |
| <21.0 | 13.7 | 99.3 | 6.9 | 99.7 | 18.3 | 99.0 | 13.4 | 99.2 | 8.9 | 99.5 | 13.7 | 99.3 | 12.7 | 99.3 |
| <21.5 | 20.0 | 98.8 | 12.9 | 99.4 | 24.4 | 98.2 | 19.3 | 98.8 | 18.1 | 99.1 | 20.0 | 98.8 | 20.1 | 98.7 |
| <22.0 | 28.1 | 98.4 | 18.5 | 99.2 | 34.1 | 97.8 | 27.6 | 98.5 | 24.9 | 98.4 | 28.1 | 98.4 | 28.6 | 98.3 |
| <22.5 | 37.3 | 97.0 | 26.7 | 98.1 | 45.1 | 96.2 | 37.0 | 97.2 | 43.7 | 96.4 | 37.3 | 97.0 | 38.2 | 96.7 |
| <23.0 | 47.3 | 95.7 | 37.5 | 96.2 | 56.9 | 95.2 | 46.9 | 95.9 | 54.5 | 95.3 | 47.3 | 95.7 | 48.2 | 95.1 |
| <23.5 | 61.2 | 92.2 | 52.8 | 92.6 | 69.7 | 91.7 | 60.4 | 92.5 | 64.0 | 93.0 | 61.2 | 92.2 | 61.8 | 91.5 |
| <24.0 | 71.4 | 89.4 | 66.1 | 88.3 | 77.3 | 89.7 | 70.7 | 89.7 | 70.1 | 90.0 | 71.4 | 89.3 | 71.3 | 88.7 |
| <24.5 | 82.1 | 83.2 | 80.2 | 80.0 | 85.2 | 84.6 | 81.1 | 83.7 | 80.5 | 94.9 | 82.1 | 83.2 | 81.4 | 82.8 |
| <25.0 | 86.7 | 78.9 | 84.6 | 73.8 | 89.9 | 81.5 | 85.8 | 79.5 | 84.6 | 80.7 | 86.8 | 78.9 | 86.2 | 78.7 |
| <25.5 | 92.1 | 70.2 | 90.8 | 62.8 | 94.1 | 74.3 | 91.5 | 71.0 | 92.5 | 74.3 | 92.0 | 70.2 | 91.6 | 70.2 |
| <26.0 | 95.5 | 64.2 | 95.2 | 53.7 | 96.4 | 70.3 | 95.4 | 64.9 | 94.0 | 68.4 | 95.5 | 64.2 | 95.0 | 64.7 |
| <26.5 | 96.6 | 54.6 | 96.1 | 42.9 | 97.6 | 61.5 | 96.5 | 55.4 | 97.7 | 59.2 | 96.6 | 54.6 | 96.3 | 55.5 |

SENS – Sensitivity calculated using mixed effects logistic regression model

SPEC – Specificity calculated using mixed effects logistic regression model

Grayed out cells indicate unstable estimate due to cell count <10.

Supplemental Table 3 – Sensitivity Analysis for Severe Thinness (BMI<16 kg/m2)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Overall Results | Any Thinness (BMI<16 kg/m2) | | | | | | | | | | | | | |
|  | Full Dataset  (n=11917) | | High Prevalence  (n=3642) | | Low Prevalence  (n=8275) | | Age <20 and >50 years excluded (n=10663) | | Missing Age Data  (n=4164) | | Possible Duplicates Excluded  (n=11909) | | Adjusted for Month/Year of Collection  (n=11917) | |
| AUROC | 0.92 | | 0.87 | | 0.95 | | 0.91 | | 0.94 | | 0.92 | | 0.92 | |
| MUAC (cm) | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC | SENS | SPEC |
| <19.0 | 4.2 | 99.9 | 2.8 | 99.9 | 6.1 | 99.8 | 4.9 | 99.9 | 4.0 | 99.6 | 4.2 | 99.9 | 4.3 | 99.9 |
| <19.5 | 7.2 | 99.8 | 4..2 | 99.9 | 9.1 | 99.7 | 7.3 | 99.8 | 7.0 | 99.8 | 7.2 | 99.8 | 7.7 | 99.7 |
| <20.0 | 13.5 | 99.7 | 5.5 | 99.9 | 19.6 | 99.5 | 13.1 | 99.7 | 9.2 | 99.6 | 13.5 | 99.7 | 13.4 | 99.7 |
| <20.5 | 20.6 | 99.8 | 11.1 | 99.7 | 27.2 | 98.9 | 19.7 | 99.3 | 13.5 | 99.6 | 20.6 | 99.3 | 19.5 | 99.3 |
| <21.0 | 25.4 | 99.0 | 13.6 | 99.5 | 35.4 | 98.6 | 24.6 | 98.9 | 17.1 | 99.3 | 25.4 | 99.0 | 23.1 | 99.0 |
| <21.5 | 35.6 | 98.3 | 24.2 | 99.0 | 45.1 | 97.7 | 33.7 | 98.3 | 33.1 | 98.7 | 35.6 | 98.3 | 34.1 | 98.2 |
| <22.0 | 44.8 | 97.7 | 33.0 | 98.5 | 54.8 | 97.0 | 43.6 | 97.7 | 41.8 | 97.7 | 44.8 | 97.7 | 43.0 | 97.3 |
| <22.5 | 54.6 | 95.9 | 43.6 | 97.0 | 66.0 | 95.1 | 54.0 | 96.1 | 58.1 | 95.0 | 54.6 | 95.9 | 53.5 | 95.2 |
| <23.0 | 62.6 | 94.0 | 54.7 | 95.2 | 74.1 | 93.6 | 62.8 | 94.2 | 69.6 | 93.4 | 62.6 | 94.0 | 61.6 | 92.9 |
| <23.5 | 72.7 | 89.7 | 65.4 | 89.1 | 84.5 | 89.8 | 72.8 | 90.1 | 79.5 | 90.8 | 72.7 | 89.7 | 71.7 | 88.5 |
| <24.0 | 80.9 | 86.3 | 77.7 | 83.8 | 87.7 | 87.5 | 81.0 | 86.7 | 85.9 | 87.7 | 80.9 | 86.3 | 79.9 | 85.2 |
| <24.5 | 88.8 | 79.6 | 89.0 | 74.6 | 91.0 | 82.4 | 86.9 | 80.1 | 90.7 | 82.3 | 88.8 | 79.6 | 87.7 | 78.9 |
| <25.0 | 90.6 | 75.2 | 90.5 | 68.2 | 93.2 | 79.2 | 89.1 | 75.8 | 92.6 | 77.9 | 90.6 | 75.2 | 89.8 | 74.7 |
| <25.5 | 93.1 | 66.7 | 92.8 | 57.3 | 95.5 | 72.1 | 92.0 | 67.4 | 96.2 | 71.5 | 93.1 | 66.7 | 92.5 | 66.4 |
| <26.0 | 95.6 | 60.9 | 96.0 | 48.6 | 96.6 | 68.1 | 94.9 | 61.6 | 97.4 | 65.7 | 95.6 | 60.9 | 95.0 | 61.2 |
| <26.5 | 96.1 | 51.8 | 95.9 | 38.7 | 97.7 | 59.6 | 95.4 | 52.5 | 98.8 | 56.7 | 96.1 | 51.8 | 95.7 | 52.5 |

SENS – Sensitivity calculated using mixed effects logistic regression model

SPEC – Specificity calculated using mixed effects logistic regression model

Grayed out cells indicate unstable estimate due to cell count <10.