and aligned largely to WHO's joint statement. Policies were examined rather than performance. Future work should include ongoing monitoring of changes to funders' policies and adherence to these policies by trialists, as recommended by WHO.

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## Trends in Obesity and Severe Obesity Prevalence in US Youth and Adults by Sex and Age, 2007-2008 to 2015-2016

Obesity prevalence has been increasing since the 1980s among adults, but among youth, prevalence plateaued between 20052006 and 2013-2014. ${ }^{1,2}$ We analyzed trends in obesity prevalence among US youth and adults between 2007-2008 and 2015-2016 in order to determine recent changes.

Methods | The National Health and Nutrition Examination Survey (NHANES) is a cross-sectional survey with a complex, multistage probability design that represents the civilian, noninstitutionalized population with a response rate of $75.4 \%$ in 2007-2008 and 58.7\% in 2015-2016. ${ }^{3}$ Participants 18 years or older provided written consent, youth aged 7 to 17 years provided written assent, and parental permission was obtained in writing for youth younger than 18 years. NHANES was approved by the National Center for Health Statistics research ethics review board. Standardized measurements of weight and height were obtained. ${ }^{3}$

Among adults aged 20 years and older, obesity was defined as a body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) of 30 or more and severe obesity was defined as a BMI of 40 or more. ${ }^{4}$ Among youth aged 2 to 19 years, obesity was defined as a BMI at or above the 95th percentile of sex-specific BMI-for-age and severe obesity was defined as a BMI at or above $120 \%$ of the 95th percentile. ${ }^{1}$ Pregnant females were excluded.

Prevalence and $95 \%$ CIs of obesity and severe obesity were estimated overall ${ }^{5}$ and stratified by sex and age (2-5, 6-11, $12-19,20-39,40-59$, and $\geq 60$ years). Linear and quadratic trends overall and stratified by sex and age were examined in regression models with 2 -year survey cycles modeled as an orthogonal polynomial and in adjusted models (including survey cycle, sex, age, race/Hispanic origin [non-Hispanic white, nonHispanic black, Hispanic, or other], education [high school graduate or less, some college, and college graduate; education of household head for youth], and, among adults, smoking status [never, former, or current smoker]) to determine if trends could be explained by these factors. Interactions between survey cycle with sex and age were tested among youth and adults separately to supplement stratified analyses and were not significant. A 2 -sided $P$ value of .05 was used to assess statistical significance.

Statistical analyses accounted for the complex survey design, including examination sample weights, which adjusted for nonresponse and took into account loss between the screener and interview and between the interview and the examination. Analyses were conducted using R (R statistics), version 3.4.1 ${ }^{6}$; SAS (SAS Institute), version 9.4; and SUDAAN (RTI International), version 11.0.

Results | Data from 16875 youth (Table 1) and 27449 adults (Table 2) were analyzed. Among youth, obesity prevalence was $16.8 \%$ ( $95 \%$ CI, $14.2 \%-19.8 \%$ ) in 2007-2008 and $18.5 \%$ ( $95 \%$ CI, $15.8 \%-21.3 \%$ ) in 2015-2016. Based on the unadjusted model, there were no significant linear trends in the prevalence of obesity or severe obesity overall, by sex or age

Table 1. Trends in Prevalence of Obesity and Severe Obesity Among US Youth Aged 2 to 19 Years, by Sex and Age Group, 2007-2008 to 2015-2016 ${ }^{\text {a,b }}$

|  | 2007-2008 |  | 2009-2010 |  | 2011-2012 |  | 2013-2014 |  | 2015-2016 |  | $P$ Value for Trend ${ }^{\text {c }}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | No. of Participants | \% (95\% CI) | No. of Participants | \% (95\% CI) | No. of Participants | \% (95\% CI) | No. of Participants | \% (95\% CI) | No. of Participants | \% (95\% CI) | Linear | Quadratic |
| Obesity ${ }^{\text {d }}$ |  |  |  |  |  |  |  |  |  |  |  |  |
| Overall | 3249 | $\begin{aligned} & 16.8 \\ & (14.2-19.8) \end{aligned}$ | 3408 | $\begin{aligned} & 16.9 \\ & (15.4-18.4) \end{aligned}$ | 3355 | $\begin{aligned} & 16.9 \\ & (14.8-19.2) \end{aligned}$ | 3523 | $\begin{aligned} & 17.2 \\ & (14.9-19.6) \end{aligned}$ | 3340 | $\begin{aligned} & 18.5 \\ & (15.8-21.3) \end{aligned}$ | . 35 | . 53 |
| Boys | 1701 | $\begin{aligned} & 17.7 \\ & (14.8-20.9) \end{aligned}$ | 1777 | $\begin{aligned} & 18.6 \\ & (16.4-21.1) \end{aligned}$ | 1713 | $\begin{aligned} & 16.7 \\ & (13.8-19.8) \end{aligned}$ | 1794 | $\begin{aligned} & 17.2 \\ & (14.6-20.1) \end{aligned}$ | 1696 | $\begin{aligned} & 19.1 \\ & (15.6-23.0) \end{aligned}$ | . 78 | . 43 |
| Girls | 1548 | $\begin{aligned} & 15.9 \\ & (12.8-19.4) \end{aligned}$ | 1631 | $\begin{aligned} & 15.0 \\ & (13.3-16.9) \end{aligned}$ | 1642 | $\begin{aligned} & 17.2 \\ & (14.7-19.9) \end{aligned}$ | 1729 | $\begin{aligned} & 17.1 \\ & (13.8-20.8) \end{aligned}$ | 1644 | $\begin{aligned} & 17.8 \\ & (15.3-20.6) \end{aligned}$ | . 17 | . 86 |
| 2-5 y | 853 | $\begin{aligned} & 10.1 \\ & (7.7-12.9) \end{aligned}$ | 903 | $\begin{aligned} & 12.1 \\ & (9.8-14.8) \end{aligned}$ | 871 | $\begin{aligned} & 8.4 \\ & (5.8-11.7) \end{aligned}$ | 843 | $\begin{aligned} & 9.4 \\ & (6.8-12.6) \end{aligned}$ | 814 | $\begin{aligned} & 13.9 \\ & (11.6-16.5) \end{aligned}$ | . 20 | . 04 |
| 6-11 y | 1197 | $\begin{aligned} & 19.6 \\ & (17.1-22.4) \end{aligned}$ | 1213 | $\begin{aligned} & 18.0 \\ & (15.9-20.3) \end{aligned}$ | 1268 | $\begin{aligned} & 17.7 \\ & (14.4-21.5) \end{aligned}$ | 1294 | $\begin{aligned} & 17.4 \\ & (13.8-21.4) \end{aligned}$ | 1268 | $\begin{aligned} & 18.4 \\ & (14.9-22.3) \end{aligned}$ | . 52 | . 35 |
| $12-19$ y | 1199 | $\begin{aligned} & 18.1 \\ & (14.6-22.0) \end{aligned}$ | 1292 | $\begin{aligned} & 18.4 \\ & (15.7-21.3) \end{aligned}$ | 1216 | $\begin{aligned} & 20.5 \\ & (16.9-24.4) \end{aligned}$ | 1386 | $\begin{aligned} & 20.6 \\ & (16.2-25.6) \end{aligned}$ | 1258 | $\begin{aligned} & 20.6 \\ & (16.4-25.2) \end{aligned}$ | . 22 | . 69 |
| Severe Obesity ${ }^{\text {e }}$ |  |  |  |  |  |  |  |  |  |  |  |  |
| Overall | 3249 | 4.9 (3.7-6.5) | 3408 | 5.6 (4.3-7.1) | 3355 | 5.6 (4.2-7.3) | 3523 | 6.0 (4.8-7.3) | 3340 | 5.6 (4.0-7.6) | . 43 | . 55 |
| Boys | 1701 | 5.5 (3.9-7.5) | 1777 | 6.4 (4.5-8.8) | 1713 | 5.7 (4.0-7.9) | 1794 | 5.6 (4.5-7.0) | 1696 | 6.3 (4.3-8.9) | . 77 | . 96 |
| Girls | 1548 | 4.3 (2.9-6.2) | 1631 | 4.7 (3.5-6.2) | 1642 | 5.5 (3.9-7.5) | 1729 | 6.3 (4.4-8.6) | 1644 | 4.9 (3.2-7.2) | . 29 | . 27 |
| 2-5 y | 853 | 1.8 (0.6-3.9) | 903 | 2.7 (1.6-4.1) | 871 | 1.6 (0.7-3.2) | 843 | 1.7 (0.8-3.3) | 814 | 1.8 (0.8-3.4) | . 63 | . 77 |
| 6-11 y | 1197 | 5.7 (4.3-7.5) | 1213 | 5.1 (3.7-6.8) | 1268 | 6.9 (5.2-8.9) | 1294 | 4.3 (3.0-6.1) | 1268 | 5.2 (3.7-7.2) | . 46 | . 67 |
| $12-19$ y | 1199 | 5.9 (3.9-8.6) | 1292 | 7.4 (4.8-10.8) | 1216 | 6.6 (4.4-9.5) | 1386 | 9.1 (7.0-11.5) | 1258 | 7.7 (5.0-11.2) | . 18 | . 60 |

${ }^{\text {a }}$ Data source: National Health and Nutrition Examination Survey (NHANES). Prevalence estimates are weighted to represent the civilian, noninstitutionalized US population aged 2 to 19 y; weighting accounts for differential probabilities of selection and survey nonresponse.
${ }^{\mathrm{b}}$ Age at the time of examination.
${ }^{c} P$ values for trends were calculated using regression models, with the 2-y survey cycles modeled as an orthogonal polynomial.
${ }^{\mathrm{d}}$ Obesity was defined as a body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) at or above the sex-specific 95th percentile on the US Centers for Disease Control and Prevention (CDC) BMI-for-age growth charts.
${ }^{\text {e }}$ Severe obesity was defined as a BMI at or above $120 \%$ of the sex-specific 95th percentile on the CDC BMI-for-age growth charts.

Table 2. Trends in Prevalence of Obesity and Severe Obesity Among US Adults 20 Years or Older by Sex and Age Group, 2007-2008 to 2015-2016a,b

|  | 2007-2008 |  | 2009-2010 |  | 2011-2012 |  | 2013-2014 |  | 2015-2016 |  | $P$ Value for Trend ${ }^{\text {c }}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | No. of Participants | \% (95\% CI) | No. of Participants | \% (95\% CI) | No. of Participants | \% (95\% CI) | No. of Participants | \% (95\% CI) | No. of Participants | \% (95\% CI) | Linear | Quadratic |
| Obesity (BMI $\geq 30$ ) |  |  |  |  |  |  |  |  |  |  |  |  |
| Overall | 5550 | $\begin{aligned} & 33.7 \\ & (31.5-36.1) \end{aligned}$ | 5926 | $\begin{aligned} & 35.7 \\ & (33.8-37.7) \end{aligned}$ | 5181 | $\begin{aligned} & 34.9 \\ & (32.0-37.9) \end{aligned}$ | 5455 | $\begin{aligned} & 37.7 \\ & (35.8-39.7) \end{aligned}$ | 5337 | $\begin{aligned} & 39.6 \\ & (36.1-43.1) \end{aligned}$ | . 001 | . 50 |
| Men | 2746 | $\begin{aligned} & 32.2 \\ & (29.3-35.2) \end{aligned}$ | 2889 | $\begin{aligned} & 35.5 \\ & (31.9-39.2) \end{aligned}$ | 2585 | $\begin{aligned} & 33.5 \\ & (30.7-36.5) \end{aligned}$ | 2638 | $\begin{aligned} & 35.0 \\ & (32.8-37.3) \end{aligned}$ | 2583 | $\begin{aligned} & 37.9 \\ & (33.1-42.8) \end{aligned}$ | . 05 | . 70 |
| Women | 2804 | $\begin{aligned} & 35.4 \\ & (33.1-37.8) \end{aligned}$ | 3037 | $\begin{aligned} & 35.8 \\ & (34.0-37.7) \end{aligned}$ | 2596 | $\begin{aligned} & 36.1 \\ & (32.6-39.9) \end{aligned}$ | 2817 | $\begin{aligned} & 40.4 \\ & (37.6-43.3) \end{aligned}$ | 2754 | $\begin{aligned} & 41.1 \\ & (37.8-44.5) \end{aligned}$ | <. 001 | . 45 |
| 20-39 y | 1773 | $\begin{aligned} & 30.7 \\ & (26.4-35.1) \end{aligned}$ | 1957 | $\begin{aligned} & 32.6 \\ & (28.9-36.4) \end{aligned}$ | 1808 | $\begin{aligned} & 30.3 \\ & (26.5-34.5) \end{aligned}$ | 1810 | $\begin{aligned} & 34.3 \\ & (31.1-37.6) \end{aligned}$ | 1780 | $\begin{aligned} & 35.7 \\ & (31.7-39.8) \end{aligned}$ | . 05 | . 47 |
| $40-59$ y | 1791 | $\begin{aligned} & 36.2 \\ & (32.7-39.9) \end{aligned}$ | 2005 | $\begin{aligned} & 36.6 \\ & (34.5-38.7) \end{aligned}$ | 1727 | $\begin{aligned} & 39.5 \\ & (36.0-43.0) \end{aligned}$ | 1896 | $\begin{aligned} & 41.0 \\ & (36.5-45.5) \end{aligned}$ | 1785 | $\begin{aligned} & 42.8 \\ & (37.3-48.5) \end{aligned}$ | . 009 | . 83 |
| $\geq 60$ y | 1986 | $\begin{aligned} & 35.1 \\ & (32.9-37.3) \\ & \hline \end{aligned}$ | 1964 | $\begin{aligned} & 39.7 \\ & (36.6-43.0) \\ & \hline \end{aligned}$ | 1646 | $\begin{aligned} & 35.4 \\ & (31.2-39.7) \\ & \hline \end{aligned}$ | 1749 | $\begin{aligned} & 38.5 \\ & (35.0-42.1) \\ & \hline \end{aligned}$ | 1772 | $\begin{aligned} & 41.0 \\ & (36.9-45.3) \\ & \hline \end{aligned}$ | . 03 | . 56 |
| Severe Obesity ( $\mathrm{BMI} \geq 40$ ) |  |  |  |  |  |  |  |  |  |  |  |  |
| Overall | 5550 | 5.7 (4.9-6.7) | 5926 | 6.3 (5.7-7.0) | 5181 | 6.4 (5.2-7.7) | 5455 | 7.7 (6.3-9.4) | 5337 | 7.7 (6.6-8.9) | . 001 | >. 99 |
| Men | 2746 | 4.2 (3.3-5.3) | 2889 | 4.4 (3.6-5.2) | 2585 | 4.4 (2.6-6.8) | 2638 | 5.5 (4.2-7.0) | 2583 | 5.6 (4.3-7.2) | . 04 | . 74 |
| Women | 2804 | 7.3 (6.2-8.5) | 3037 | 8.1 (7.1-9.2) | 2596 | 8.3 (6.9-9.8) | 2817 | 9.9 (8.1-12.1) | 2754 | 9.7 (8.4-11.2) | . 002 | . 73 |
| 20-39 y | 1773 | 5.9 (4.4-7.7) | 1957 | 5.9 (4.7-7.2) | 1808 | 5.6 (4.4-7.1) | 1810 | 8.0 (6.3-10.0) | 1780 | 7.8 (6.0-9.9) | . 02 | . 44 |
| 40-59 y | 1791 | 6.4 (5.2-7.7) | 2005 | 6.8 (5.7-8.1) | 1727 | 7.7 (6.1-9.4) | 1896 | 8.6 (6.2-11.6) | 1785 | 8.5 (6.6-10.7) | . 02 | . 75 |
| $\geq 60$ y | 1986 | 4.5 (3.3-5.9) | 1964 | 6.3 (4.7-8.3) | 1646 | 5.6 (3.7-8.0) | 1749 | 5.8 (4.2-7.7) | 1772 | 6.3 (4.6-8.4) | . 19 | . 62 |

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided $\quad \geq 60$. In 2015-2016, the crude prevalence among adults overall was $39.8 \%$ ( $95 \%$ by height in meters squared).
${ }^{\text {a }}$ Data source: National Health and Nutrition Examination Survey (NHANES). Prevalence estimates are weighted to represent the civilian noninstitutionalized US population aged $\geq 20$ y; weighting accounts for differential probabilities of selection and survey nonresponse. Prevalence estimates overall and by sex were age standardized using the direct method to the 2000 projected US census population using age groups 20-39, 40-59, and
$\geq 60$. In 2015-2016, the crude prevalence among adults overall was $39.8 \%$ ( $95 \%$

${ }^{\mathrm{b}}$ Age at the time of interview.
${ }^{\text {c }} P$ values for trends were calculated using regression models, with the 2-y survey cycles modeled as an orthogonal polynomial. Models for overall trends and those for men and women additionally included age group (20-39, $40-59$, and $\geq 60 \mathrm{y}$ ).
group ( $P$ range $=.17$ to .78 ) (Table 1). Obesity prevalence among children aged 2 to 5 years showed a quadratic trend ( $P=.04$ ), decreasing from $10.1 \%$ in 2007-2008 to $8.4 \%$ in 2011-2012 and then increasing to $13.9 \%$ in 2015-2016. Adjusted overall linear and quadratic trends for obesity and severe obesity among youth aged 2 to 19 years remained nonsignificant.

Age-standardized prevalence of obesity among adults increased from 33.7\% (95\% CI, 31.5\%-36.1\%) in 2007-2008 to $39.6 \% ~(95 \%$ CI, $36.1 \%-43.1 \%$ ) in 2015-2016 ( $P=.001$ )(Table 2). Prevalence increased among women, and in adults aged 40 to 59 years and 60 years or older. The observed increases in men and adults aged 20 to 39 years did not reach statistical significance. There were no significant quadratic trends. The adjusted model also showed a significant overall linear trend for obesity among adults ( $P$ < .001; data not shown).

Age-standardized prevalence of severe obesity in adults increased from 5.7\% (95\% CI, 4.9\%-6.7\%) in 2007-2008 to 7.7\% (95\% CI, 6.6\%-8.9\%) in 2015-2016 ( $P=.001$ ). Prevalence increased in men, women, and adults aged 20 to 39 years and 40 to 59 years. There was no significant linear trend among adults 60 years and older. There were no significant quadratic trends. The adjusted model also showed a significant overall linear trend for severe obesity ( $P<.001$; data not shown).

Discussion | Over the most recent decade between 2007-2008 and 2015-2016, increases in obesity and severe obesity prevalence persisted among adults, whereas there were no overall significant trends among youth. Changes in demographics did not explain the observed trends. Limitations include small sample sizes in the youngest age group. Residual bias due to incomplete nonresponse adjustment is possible and may vary with changing response rates. Additional NHANES data will allow continued monitoring of trends in obesity and severe obesity prevalence among US youth and adults.

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## COMMENT \& RESPONSE

## Machine Learning Compared With Pathologist Assessment

To the Editor The rise of machine learning is changing diagnostic medicine. Dr Ehteshami Bejnordi and colleagues reported the researcher challenge competition (CAMELYON16) ${ }^{1}$ comparing diagnostic performance between deep learning algorithms and expert pathologists' diagnosis of lymph node metastases in women with breast cancer. We would like to highlight 3 important criteria for fair algorithm-physician comparisons.

First, physician diagnoses should follow a protocol (when available) and be made in settings that closely correspond to diagnosis in clinical practice. In principal, the physicians should work under realistic time constraints and have access to all regular diagnostic information, including relevant additional diagnostic testing, unless there are compelling reasons not to do so. Second, the output generated by algorithms and physicians should be evaluated on the same scale. Third, performance over-optimism should be avoided. The CAMELYON16 competition seems to have deviated from these criteria.

The participating pathologists were not given access to immunohistochemistry testing, although the authors ${ }^{1}$ claimed that immunohistochemistry testing is common to resolve diagnostic uncertainty in clinical practice.

The algorithms produced a continuous score on a probability scale, whereas the pathologist was allowed only a

