Preventive Medicine 105 (2017) 109–115

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Comparing percentages and ranks of adolescent weight-related outcomes among U.S. states: Implications for intervention development

Jennifer L. Moss[a,*], Benmei Liu[b], Li Zhu[c]

[a] Cancer Prevention Fellowship Program, Surveillance Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute, 9609 Medical Center Drive, Room 4E514, MSC 9765, Bethesda, MD 20892-9765, USA

[b] Statistical Research and Applications Branch, Surveillance Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute, 9609 Medical Center Drive, Room 4E540, MSC 9765, Bethesda, MD 20892-9765, USA

[c] Statistical Research and Applications Branch, Surveillance Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute, 9609 Medical Center Drive, Room 4E346, MSC 9765, Bethesda, MD 20892-9765, USA

ARTICLE INFO

Keywords:
Adolescent health
Cancer prevention
Geographic disparities
Physical activity
Fruit and vegetable consumption
Healthy weight
Nutrition
Body mass index
Overweight/obesity
Energy balance

ABSTRACT

Understanding statistical differences in states' percentages and ranks of adolescents meeting health behavior guidelines can guide policymaking. Data came from 531,777 adolescents (grades 9–12) who completed the Youth Risk Behavior Surveillance System survey in 2011, 2013, or 2015. We measured the percentage of adolescents in each state that met guidelines for physical activity, fruit and vegetable (F & V) consumption, and healthy weight status. Then we ranked states and calculated the ranks' 95% CI's using a Monte Carlo method with 100,000 simulations. We repeated these analyses stratified by sex (female or male) or race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic/Latino, or other). Pearson's and Spearman's correlation coefficients examined consistency in the percentages and ranks (respectively) across behaviors and subgroups. Meeting the physical activity and F & V consumption guidelines was relatively rare among adolescents (25.8% [95% CI = 25.2%–26.4%] and 8.0% [95% CI = 7.6%–8.3%], respectively), while meeting the healthy weight guideline was common (71.5% [95% CI = 70.7%–72.3%]). At the state level, percentages of adolescents meeting these guidelines were statistically similar; states' ranks had wide CI's, resulting in considerable overlap (i.e., statistical equivalence). For each behavior, states' percentages and ranks were moderately to highly correlated across adolescent subgroups (Pearson's r = 0.33–0.96; Spearman's r = 0.42–0.96), but across behaviors, only F & V consumption and healthy weight were correlated (Pearson's r = 0.34; Spearman's r = 0.37). Adolescents in all states could benefit from initiatives to support cancer prevention behaviors, especially physical activity and F & V consumption. Programs in states that ranked highly on all assessed health behaviors could be adapted for dissemination in lower-performing states.

Health behaviors related to energy balance, including physical activity and dietary intake, contribute to undue morbidity and mortality (Mokdad et al., 2004; Bauer et al., 2014). Several types of cancer have been linked to poor physical activity (Moore et al., 2016) and diet (including low fruit and vegetable (F & V) consumption) (Marmot et al., 2007). Overweight and obesity are closely related to these health behaviors (Sallis and Glanz, 2009) and also have been associated with increased cancer risk (Calle and Kaaks, 2004). These behaviors each cause 2–3% of all cancers diagnosed in high-income countries such as the United States (Danaei et al., 2005).

Healthy People 2020 sets objectives for these behaviors based on guidelines from public health organizations, but many people in the U.S., including adolescents, fail to reach these objectives (U. S. Department of Health and Human Services, 2016). In 2015, for example, 16% of high school students were overweight and another 14% were obese (Centers for Disease Control and Prevention (CDC), 2016a). Health during adolescence sets a foundation for health trajectories throughout the lifetime (Fuemmeler et al., 2009; Wright et al., 2001). For example, BMI during childhood is positively correlated with BMI during adulthood (Wright et al., 2001). In addition, health behaviors during adolescence may confer independent risks for chronic disease beyond health behaviors during adulthood (Fuemmeler et al., 2009;

Abbreviations: BMI, body mass index; CDC, centers for disease control and prevention; CI, confidence interval; DHHS, department of health and human services; F & V, fruit and vegetable; YRBSS, youth risk behavior surveillance system

* Corresponding author at: Cancer Prevention Fellow, Surveillance Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute, 9609 Medical Center Drive, Room 4E514, MSC 9765, Bethesda, MD 20892-9765, USA.

E-mail addresses: Jennifer.moss@nih.gov (J.L. Moss), liub2@mail.nih.gov (B. Liu), zhul2@mail.nih.gov (L. Zhu).

http://dx.doi.org/10.1016/j.ypmed.2017.09.006
Received 17 February 2017; Received in revised form 20 July 2017; Accepted 4 September 2017
Available online 06 September 2017
0091-7435/

Must et al., 1992), although this evidence is mixed (Wright et al., 2001).

Adolescent physical activity, diet, and overweight/obesity vary not only by important sociodemographic factors such as sex and race/ethnicity (Centers for Disease Control and Prevention (CDC), 2016a), but also by contextual factors such as social norms (Koehly and Loscalzo, 2009) and the built environment (Papas et al., 2007). Striking differences in these behaviors have emerged across states (Centers for Disease Control and Prevention (CDC), 2016a; Kramer et al., 2016). As noted above, nationally, 14% of high school students were obese in 2015, but this percentage ranged almost two-fold across states, from 10% in Montana to 19% in Mississippi (Centers for Disease Control and Prevention (CDC), 2016a).

Comparing and ranking states on their performance on health indicators may motivate policies and programs to improve public health (Peppard et al., 2008; Oliver, 2010), but often such ranks ignore error in estimates derived from survey data (Gerzoff and Williamson, 2001; Zhang et al., 2014; Wolter, 2007). This practice can lead to over-interpretation of ranks that do not differ statistically (Zhang et al., 2014; Arndt et al., 2013). Our study aimed to examine the percentages of cancer-preventing energy balance indicators among adolescents across states and to evaluate differences in their ranks, using several years of population-based data.

1. Materials and methods

1.1. Data source

Data came from the Youth Risk Behavior Surveillance System (YRBSS), a biennial, school-based survey coordinated by the Centers for Disease Control and Prevention (CDC) to monitor adolescent health behaviors (Centers for Disease Control and Prevention (CDC), 2016b). YRBSS surveys representative samples of students in grades 9–12 in each state using a three-stage clustered sampling design (Centers for Disease Control and Prevention (CDC), 2016c). In states with ≥ 60% response rates, YRBSS staff produce survey weights to account for student non-response and to increase generalizability of the findings (Centers for Disease Control and Prevention (CDC), 2016c).

The present study analyzed data from 531,777 respondents in the 2011, 2013, and 2015 YRBSS surveys to estimate state-specific percentages of adolescent energy balance behaviors. Forty-seven states completed a YRBSS survey with an adequate response rate during at least one of these years (see Supplementary Table S1 for sample sizes across years and subgroups) (Centers for Disease Control and Prevention (CDC), 2016b).

1.2. Measures

We measured adherence to behavioral guidelines (U. S. Department of Health and Human Services, 2016) about physical activity, F & V consumption, and weight status among adolescents. State YRBSS surveys used the items quoted below or slight variations.

1.2.1. Physical activity

The Physical Activity Guidelines for Americans from the U.S. Department of Health and Human Services (DHHS) recommend that adolescents engage in at least 60 min of aerobic physical activity per day (Department of Health and Human Services, 2016). YRBSS survey items read: “During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?” (Centers for Disease Control and Prevention (CDC), 2016c). We coded respondents as meeting the guideline if they were active for at least 60 min during 7 of the past 7 days.

1.2.2. F & V consumption

The Dietary Guidelines for Americans, 2015–2020, from the U.S. DHHS recommend that adolescents eat at least two servings of fruits and three servings of vegetables every day (Department of Health and Human Services, 2015). Six YRBSS survey items assessed F & V consumption; all items began with “During the past 7 days, how many times did you…” and finished with “drink 100% fruit juices such as orange juice, apple juice, or grape juice?,” “eat fruit?,” “eat green salad?,” “eat potatoes?,” “eat carrots?,” and “eat other vegetables?” (Centers for Disease Control and Prevention (CDC), 2016c) YRBSS staff calculated the number of servings of fruits and vegetables respondents ate per day. We coded respondents as meeting the guideline if they consumed the recommended amount of fruits and vegetables.

Four states did not include comparable survey items on F & V consumption (Delaware, Hawaii, Maine, and New York); thus analyses of this outcome are restricted to 43 states (Centers for Disease Control and Prevention (CDC), 2016c).

1.2.3. Weight status

The CDC recommends that adolescents maintain a normal weight, defined as below the 85th percentile of age- and sex-specific BMI (Centers for Disease Control and Prevention (CDC), 2015). YRBSS respondents self-reported height and weight (biologically-implausible responses for height or weight were recoded to missing), and YRBSS staff calculated their BMI percentile (Centers for Disease Control and Prevention (CDC), 2016c). We coded respondents as meeting the guideline if they were below the 85th percentile of age- and sex-specific BMI.

1.2.4. Other variables

Respondents self-reported their sex (male; female; or missing). In addition, they self-reported their race and ethnicity, which YRBSS classified as non-Hispanic white, non-Hispanic black, Hispanic/Latino, other, or missing. Respondent state came from YRBSS records.

1.3. Statistical analysis

First, we calculated the percentage of respondents adhering to each of the guidelines described above for the overall population, by demographic subgroup, and by state. We used chi-squared tests to compare the percentages of adolescents meeting these guidelines across subgroups. Scatterplots depict the observed percentages and 95% confidence intervals (CI's) for states' adherence to each behavioral guideline. As a supplementary figure, we include choropleths to depict the states' adherence levels.

Next, we ranked states according to their observed percentages and estimated the error around the ranks via a Monte Carlo method to generate simultaneous CI's for each state's rank for each indicator. (Zhang et al., 2014; Wright et al., 2014) This approach used 100,000 replications assuming a normal distribution of percentages across states. For each replication, we simulated the percentage of adolescents meeting each guideline in each state given the observed percentage and standard error. Then we ranked the states in each replication and calculated each state's median rank and the 95% CI. We iteratively compared each state to all other states to examine their ranks. Scatterplots depict the ranks and associated CI's for states' adherence to each behavioral guideline. To gain further understanding of how these patterns vary by adolescent subgroups, we repeated these analyses stratifying by adolescent sex and by adolescent race/ethnicity.

Finally, we examined the consistency in percentages and ranks across subgroups and outcomes to estimate the similarity of these behaviors for different subgroups; marked differences in percentages and ranks could indicate states' failure to address a given behavior for a given subgroup. We used Pearson's correlation coefficients to measure the association between percentages and Spearman's rank correlation coefficients to measure the association between ranks for the overall population compared to each of the subgroups (female; male; non-Hispanic white; non-Hispanic black; Hispanic/Latino; other race/ethnicity). In addition, for the overall population, we examined pairwise

comparisons between physical activity, F & V consumption, and healthy weight guidelines; similarities in percentages and ranks could indicate a common cause underpinning engagement in these behaviors that could be examined in future research.

Sample weights were used to obtain population estimates that accounted for student non-response (Centers for Disease Control and Prevention (CDC), 2016c), and design information was incorporated to calculate standard errors accounting for the complex survey design (Wolter, 2007). Below, we present unweighted frequencies and weighted percentages. Analyses were conducted in SAS version 9.3 (Cary, NC) with an alpha value of 0.05.

2. Results

Across survey years, 531,777 adolescents participated in YRBSS. Of these, about half were female (48.8%) and half male (50.7%) (0.5% missing). More than half of participants were non-Hispanic white (52.5%), with smaller groups of non-Hispanic blacks (15.3%), Hispanics/Latinos (21.2%), or other race/ethnicity (8.5%) (2.5% missing).

2.1. Meeting the adolescent physical activity guideline

Altogether, 491,093 participants from 47 states reported their physical activity, and 25.8% (95% CI = 25.2%–26.4%) of adolescents met this guideline (Table 1). Meeting this guideline was higher among males than females ($\chi^2 = 16{,}568$, $p < 0.0001$) and among non-Hispanic whites than other races/ethnicities ($\chi^2 = 989$, $p < 0.0001$).

Across states, the percentage of adolescents meeting this guideline ranged from 20.2% (Utah) to 34.6% (Oklahoma) (Table 2, Fig. 1A).

Table 1
Frequencies and percentages of adolescents meeting guidelines for physical activity, fruit and vegetable consumption, and healthy weight status, 2011–2015 Youth Risk Behavior Surveillance System.

	n	*N*	%	(95% CI)	*p*
	Physical activity				
Total	118,167	491,093	25.8%	(25.2%–26.4%)	
Sex					
Female	42,533	249,715	17.7%	(17.1%–18.3%)	
Male	75,036	237,957	33.8%	(33.1%–34.6%)	< 0.0001
Race/ethnicity					
Non-Hispanic white	66,265	256,967	27.7%	(27.0%–28.4%)	
Non-Hispanic black	12,887	60,859	23.6%	(22.7%–24.5%)	
Hispanic/Latino	16,978	77,819	23.7%	(22.6%–24.7%)	
Other	19,216	82,448	24.1%	(22.2%–26.0%)	< 0.0001
	Fruit and vegetable consumption				
Total	37,809	488,149	8.0%	(7.6%–8.3%)	
Sex					
Female	17,623	248,831	7.1%	(6.8%–7.5%)	
Male	19,822	236,173	8.7%	(8.2%–9.1%)	< 0.0001
Race/ethnicity					
Non-Hispanic white	18,210	250,077	7.1%	(6.8%–7.4%)	
Non-Hispanic black	4650	64,463	8.2%	(7.7%–8.8%)	
Hispanic/Latino	6254	78,444	9.0%	(8.4%–9.7%)	
Other	7537	82,367	9.8%	(8.3%–11.4%)	< 0.0001
	Healthy weight status				
Total	355,603	490,919	71.5%	(70.7%–72.3%)	
Sex					
Female	188,033	248,691	74.8%	(74.1%–75.6%)	
Male	167,570	242,228	68.3%	(67.2%–69.3%)	< 0.0001
Race/ethnicity					
Non-Hispanic white	194,365	257,731	75.0%	(74.4%–75.6%)	
Non-Hispanic black	42,983	64,712	65.8%	(64.9%–66.7%)	
Hispanic/Latino	52,572	77,613	65.1%	(63.6%–66.6%)	
Other	58,179	80,264	76.1%	(73.3%–78.8%)	< 0.0001

Note. Frequencies are unweighted, and percentages are weighted. *P*-values indicate results of chi-square tests of independence of health behaviors for sex or race/ethnicity subgroups. CI = confidence interval.

Table 2
Percentages of adolescents meeting guidelines for physical activity, fruit and vegetable consumption, and healthy weight status by state, 2011–2015 Youth Risk Behavior Surveillance System.

State	Physical activity	Fruit and vegetable consumption	Healthy weight status
Alabama	26.2%	7.2%	66.9%
Alaska	21.1%	10.5%	72.4%
Arizona	24.2%	10.2%	75.4%
Arkansas	28.1%	8.0%	66.5%
California	25.3%	11.2%	69.6%
Colorado	29.2%	12.6%	82.0%
Connecticut	25.8%	8.4%	73.5%
Delaware	24.4%	–	69.6%
Florida	24.7%	10.9%	73.9%
Georgia	24.9%	8.6%	69.7%
Hawaii	21.1%	–	72.3%
Idaho	27.8%	8.8%	75.2%
Illinois	25.1%	8.5%	73.4%
Indiana	24.7%	5.5%	69.4%
Iowa	29.1%	9.1%	72.3%
Kansas	29.2%	7.8%	73.5%
Kentucky	21.5%	7.4%	66.4%
Louisiana	24.2%	6.8%	67.4%
Maine	22.5%	–	73.4%
Maryland	20.5%	9.6%	73.4%
Massachusetts	23.2%	4.8%	75.4%
Michigan	26.2%	7.9%	71.3%
Mississippi	24.3%	8.9%	67.7%
Missouri	26.6%	6.8%	71.6%
Montana	28.4%	8.5%	77.0%
Nebraska	30.0%	8.1%	72.8%
Nevada	26.2%	8.7%	73.4%
New Hampshire	22.6%	10.9%	74.0%
New Jersey	27.6%	8.2%	75.5%
New Mexico	29.4%	11.8%	71.1%
New York	24.7%	–	74.3%
North Carolina	25.4%	8.1%	70.4%
North Dakota	25.1%	8.0%	72.4%
Ohio	25.6%	7.5%	70.6%
Oklahoma	34.6%	8.2%	68.9%
Pennsylvania	24.8%	6.9%	70.2%
Rhode Island	23.5%	9.3%	73.6%
South Carolina	24.5%	6.8%	68.5%
South Dakota	27.7%	7.3%	74.0%
Tennessee	27.3%	7.5%	66.5%
Texas	28.6%	7.6%	68.6%
Utah	20.2%	10.5%	80.9%
Vermont	24.1%	12.5%	74.5%
Virginia	24.4%	8.6%	72.3%
West Virginia	28.6%	11.1%	67.9%
Wisconsin	25.9%	4.2%	75.0%
Wyoming	27.0%	10.8%	75.9%

Note. Percentages are weighted.

Thus, Oklahoma was ranked first (1, 95% CI = 1–1) and Utah last (47, 95% CI = 43–47). The CI's for the percentages and ranks of meeting the physical activity guideline overlapped for many states. For example, the CI for California's rank, 25th (8–42; Supplementary Table S2), overlapped 33 other ranks.

In stratified analyses, states' percentages and ranks for meeting physical activity guidelines across subgroups were fairly consistent. Percentages in the overall population were correlated with those observed in subgroups (females: $r = 0.84$; males: $r = 0.93$; non-Hispanic white: $r = 0.88$; non-Hispanic black: $r = 0.54$; Hispanic/Latino: $r = 0.62$; other race/ethnicity: $r = 0.65$; all $p < 0.05$). Similarly, ranks were correlated for the overall population versus subgroups (females: $r = 0.84$; males: $r = 0.91$; non-Hispanic white: $r = 0.88$; non-Hispanic black: $r = 0.45$; Hispanic/Latino: $r = 0.63$; other race/ethnicity: $r = 0.63$; all $p < 0.05$) (Supplementary Table S2). For example, Oklahoma was ranked in the top five states for meeting the physical activity guideline, and Utah in the bottom three, across most subgroups.

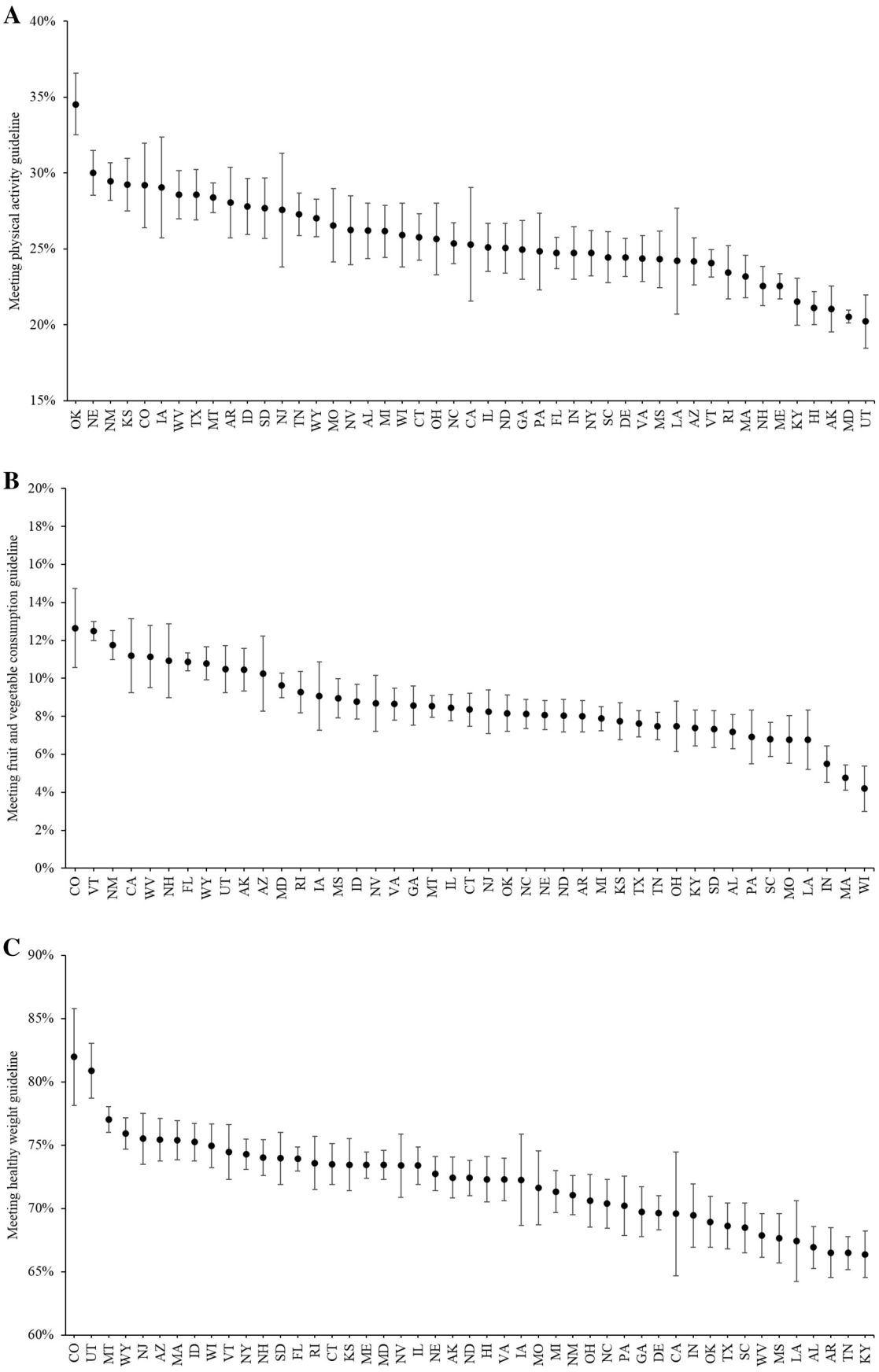

Fig. 1. State percentages of adolescents meeting guidelines for (A) physical activity, (B) fruit and vegetable consumption, and (C) healthy weight status, 2011–2015 Youth Risk Behavior Surveillance System.

2.2. Meeting the adolescent F & V consumption guideline

Altogether, 488,149 participants from 43 states reported their F & V consumption, and 8.0% (95% CI = 7.6%–8.3%) of adolescents met this guideline (Table 1). Meeting this guideline was higher among males than females ($\chi^2 = 387$, $p < 0.0001$) and varied by race/ethnicity ($\chi^2 = 665$, $p < 0.0001$).

Across states, the percentage of adolescents meeting this guideline ranged from 4.2% (Wisconsin) to 12.6% (Colorado) (Table 2, Fig. 1B). Thus, Colorado was ranked first (1, 95% CI = 1–8) and Wisconsin last (43, 95% CI = 41–43). The CI's for the percentages and ranks of meeting the F & V consumption guideline overlapped for many states. For example, the CI for Connecticut's rank, 22nd (14–33; Supplementary Table S3), overlapped 18 others.

In stratified analyses, states' percentages and ranks for meeting F & V consumption guidelines across adolescent subgroups were fairly consistent. Percentages in the overall population were highly correlated with those observed in subgroups (females: $r = 0.92$; males: $r = 0.94$; non-Hispanic white: $r = 0.95$; non-Hispanic black: $r = 0.75$; Hispanic/Latino: $r = 0.70$; other race/ethnicity: $r = 0.67$; all $p < 0.05$). Similarly, ranks were highly correlated for the overall population versus subgroups (females: $r = 0.90$; males: $r = 0.92$; non-Hispanic white: $r = 0.94$; non-Hispanic black: $r = 0.59$; Hispanic/Latino: $r = 0.68$; other race/ethnicity: $r = 0.62$; all $p < 0.05$) (Supplementary Table S3). For example, Colorado was ranked in the top four states for meeting the F & V consumption guideline, and Wisconsin in the bottom two, across most subgroups.

2.3. Meeting the adolescent healthy weight status guideline

Altogether, 490,919 participants from 47 states reported on their weight status, and 71.5% (95% CI = 70.7%–72.3%) of adolescents met this guideline (Table 1). Meeting this guideline was higher among females than males ($\chi^2 = 2589$, $p < 0.0001$) and varied by race/ethnicity ($\chi^2 = 5249$, $p < 0.0001$).

Across states, the percentage of adolescents meeting this guideline ranged from 66.4% (Kentucky) to 82.0% (Colorado) (Table 2, Fig. 1C). Thus, Colorado was ranked first (1, 95% CI = 1–2) and Kentucky last (45, 95% CI = 40–47; tied with two other states). The CI's for the percentages and ranks of meeting the healthy weight guideline overlapped for many states. For example, the CI for North Dakota's rank, 24th (15–30; Supplementary Table S4), overlapped 14 others.

In stratified analyses, states' percentages and ranks for meeting healthy weight guidelines across adolescent subgroups were fairly consistent. Percentages in the overall population were correlated with those observed in subgroups (females: $r = 0.96$; males: $r = 0.93$; non-Hispanic white: $r = 0.84$; non-Hispanic black: $r = 0.47$; Hispanic/Latino: $r = 0.33$; other race/ethnicity: $r = 0.53$; all $p < 0.05$). Similarly, ranks were correlated for the overall population versus subgroups (females: $r = 0.96$; males: $r = 0.92$; non-Hispanic white: $r = 0.82$; non-Hispanic black: $r = 0.53$; Hispanic/Latino: $r = 0.42$; other race/ethnicity: $r = 0.50$; all $p < 0.05$) (Supplementary Table S4). For example, Colorado was ranked in the top two states for meeting the healthy weight guideline, and Kentucky in the bottom seven, across most subgroups.

Across behavioral indicators, states' percentages and ranks were not highly correlated. States that had high percentages for the F & V consumption guideline tended to also have high percentages for the healthy weight guideline ($r = 0.34$), but the associations were smaller for the physical activity and F & V consumption guidelines ($r = -0.02$) and for the physical activity and healthy weight guidelines ($r = -0.09$). Similarly, states that were ranked highly for F & V consumption tended to also rank highly for healthy weight ($r = 0.37$), but the associations were smaller for physical activity and F & V consumption ($r = -0.06$) and for physical activity and healthy weight ($r = -0.07$).

3. Conclusions

Among more than half a million adolescents, we found considerable statistical overlap in states' percentages and ranks of meeting guidelines for cancer prevention behaviors (physical activity, F & V consumption, and weight status). Overall, meeting guidelines for physical activity and F & V consumption was rare, but meeting healthy weight guidelines was more common. While ranking states on these indicators may galvanize public health action around a particular prevention behavior (Peppard et al., 2008; Oliver, 2010), statistically, many states had equivalent ranks. Ranking smaller geographic areas (e.g., counties) with correspondingly smaller population and survey sample sizes would be prone to even more uncertainty. Rankings for each behavior were similar for the overall population and subgroups defined by sex; lower (but still statistically-significant) correlations observed for the overall population and subgroups defined by race/ethnicity could be explained by the smaller sample sizes. Additional research is needed to examine potential differences in adolescent cancer prevention behaviors across states to support interventions to improve these patterns.

These findings indicate that adolescents in all states would benefit from interventions to promote cancer prevention behaviors. States' percentages and ranks for meeting guidelines were correlated only for F & V consumption and healthy weight. Some state-level conditions may similarly underpin these two behaviors (and therefore interventions may be able to target both simultaneously), but independent interventions may be needed for other adolescent health behaviors. Notably, Colorado was ranked first overall for F & V consumption and healthy weight, and sixth for physical activity. Future research should explore (Mokdad et al., 2004) the reliability of inter-state rankings on these health behaviors and (Bauer et al., 2014) the characteristics of states with especially high performance on all three adolescent health indicators to understand which policies or programs can be implemented in other states.

However, at least four study limitations should be acknowledged when interpreting these findings. First, several states (and Washington, D.C.) were absent from this analysis (Centers for Disease Control and Prevention (CDC), 2016c). The consequence is that the range of ranks did not extend to 50 or 51, and none of the states can be designated as “best” or “worst,” even if they had the best or worst performance in this dataset. Second, due to differences in YRBSS sampling schemes and the availability of data, state sample sizes were quite variable and not necessarily what one would expect based on population (Centers for Disease Control and Prevention (CDC), 2016b). If sampling procedures had been identical across states, the CI's would have been different, perhaps resulting in more precision and less overlap around states' percentages and ranks; the influence of sample size on the width of the CI's and, as a result, conclusions about statistical differences is crucial. However, in the current analysis states had samples between 1125 and 112,301 participants, affording a great deal of precision (even among states with relatively small samples). However, the sample sizes for the supplementary analyses of adolescent subgroups were necessarily smaller, resulting in some instability in the estimates; caution should be used in interpreting these findings, particularly for non-Hispanic blacks. Third, YRBSS is cross-sectional and relies on self-reported data; biases in survey data are well-recognized (Groves, 2006). In particular, adolescents' self-reported weight may be underestimated while self-reported height may be overestimated (Elgar et al., 2005). Fourth, state-level estimates of percentages and ranks of adolescents engaging in these behaviors do not account for other individual- and area-level correlates of physical activity, F & V consumption, and healthy weight status; analyzing the influence of these correlates (and other excluded variables) was outside the scope of the current analysis.

Despite these limitations, this study has several strengths. Analyzing YRBSS data allowed us to examine behaviors among more than half a million adolescents. Samples of adolescents were representative of the populations in their respective states. We conducted rigorous statistical

analysis of the error in states' ranks; ranks are often presented as error-free (i.e., without confidence intervals), which could bias their interpretation (Gerzoff and Williamson, 2001; Zhang et al., 2014). Finally, we evaluated adolescents' behaviors in reference to nationally-established guidelines that promote public health (U. S. Department of Health and Human Services, 2016; Department of Health and Human Services, 2016; Department of Health and Human Services, 2015; Centers for Disease Control and Prevention (CDC), 2015).

Overall, only a quarter of adolescents met the guideline for physical activity (Department of Health and Human Services, 2016), with higher levels among males than females (+15% points) and non-Hispanic whites than the other races/ethnicities (+4% points). These differences could reflect differential self-efficacy, beliefs, and attitudes about physical activity (by sex) (Sallis et al., 1996) or differential access to parks and recreational facilities (by race/ethnicity) (Sallis et al., 1996; Gordon-Larsen et al., 2000). At the state level, states in the middle part of the country (e.g., Oklahoma, Nebraska, New Mexico, Kansas, and Colorado; Supplementary Fig. S1) had particularly high percentages of meeting the guideline (all > 29%). States with especially low percentages were more dispersed. Differences across states may reflect variations in the natural and built environments (Papas et al., 2007; Gordon-Larsen et al., 2006) or school policies (Story et al., 2009), and states with low adolescent physical activity may benefit from additional efforts to promote this behavior, such as school-based programming (van Sluijs et al., 2007).

Less than one-tenth of adolescents met the F & V consumption guideline, with slightly higher levels among males than females (+2% points) and minority racial/ethnic groups than non-Hispanic whites (+1–3% points). Previous studies have had mixed findings regarding differences in adolescent F & V consumption by sex and race/ethnicity, although the differences observed in the current study are quite small (Rasmussen et al., 2006). At the state level, meeting this guideline ranged threefold from 4.2% to 12.6% (Supplementary Fig. S1). State differences in this behavior could be attributable to differences in access to healthy foods (Rasmussen et al., 2006) and to school policies (Chriqui et al., 2014). Some of the states that performed poorly in the overall population had higher ranks for select subgroups (e.g., Louisiana ranked 38th overall but 5th for Hispanics/Latinos). These states may have characteristics or programs that are particularly supportive of F & V consumption among different adolescent subgroups.

Finally, almost two-thirds of adolescents met the healthy weight guideline, with higher levels among females than males (+7% points) and non-Hispanic whites and other races/ethnicities than non-Hispanic blacks and Hispanics/Latinos (+9–11% points). Differences in healthy weight by adolescent sex or race/ethnicity could reflect biases in self-reporting (Sherry et al., 2007) or maturational processes (Wang, 2002). At the state level, distinct clusters emerged of the highest-performing states (e.g., Colorado, Utah, Montana, and Wyoming, all ≥76%) and lowest-performing states (e.g., Kentucky, Tennessee, Arkansas, Alabama, and Louisiana, all < 68%) (Supplementary Fig. S1). As noted above, states' performance on the healthy weight guideline was correlated with their performance on the F & V consumption guideline. Thus, geographic differences in healthy weight status may be driven by differences in F & V consumption and by factors such as the social environment (Singh et al., 2008).

In conclusion, meeting the guidelines for adolescent physical activity and F & V consumption was relatively rare, although meeting the guideline for healthy weight was relatively common. However, the CI's around many states' percentages and ranks overlapped, indicating that they were statistically equivalent. The ranks were fairly consistent across adolescent sex or race/ethnicity, suggesting that the factors underpinning whether adolescents met these guidelines operated similarly across subgroups. Considerable room for improvement exists for (Mokdad et al., 2004) surveillance surveys, in terms of increasing overall sample sizes (and precision) and ensuring equivalence of procedures across sampling locations and, (Bauer et al., 2014) cancer prevention efforts among all adolescents in all states, especially in promoting physical activity and F & V consumption. More research is needed on geographic differences in adolescent behaviors related to cancer prevention. A potentially promising next step is to adapt programs or policies in states with high ranks for all three health behaviors (e.g., Colorado) for implementation in states with low ranks to improve preventive health behaviors.

Funding source

This research was conducted as part of active duty at the National Cancer Institute. The National Cancer Institute was not involved in the study design; collection, analysis, and interpretation of data; writing of the report; or decision to submit the manuscript for submission.

Conflicts of interest

The authors have no potential conflicts of interest to disclose.

Acknowledgments

The authors wish to acknowledge the assistance of the CDC and the state health agencies that conducted the YRBSS surveys and shared their data. This manuscript was prepared or accomplished by the authors in their personal capacity. The opinions expressed in this article are the authors' own and do not reflect the view of the National Institutes of Health, the Department of Health and Human Services, or the United States government.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2017.09.006.

References

Arndt, S., Acion, L., Caspers, K., Blood, P., 2013. How reliable are county and regional health rankings? Prev. Sci. 14 (5), 497–502. http://dx.doi.org/10.1007/s11121-012-0320-3.

Bauer, U.E., Briss, P.A., Goodman, R.A., Bowman, B.A., 2014. Prevention of chronic disease in the 21st century: elimination of the leading preventable causes of premature death and disability in the USA. Lancet 384 (9937), 45–52.

Calle, E.E., Kaaks, R., 2004. Overweight, obesity and cancer: epidemiological evidence and proposed mechanisms. Nat. Rev. Cancer 4 (8), 579–591.

Centers for Disease Control and Prevention (CDC), 2015. About Child & Teen BMI. http://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html.

Centers for Disease Control and Prevention (CDC), 2016a. Adolescent Obesity Prevalence: Trends Over Time. http://www.cdc.gov/healthyschools/obesity/obesity-youth.htm.

Centers for Disease Control and Prevention (CDC), 2016b. Youth Risk Behavior Surveillance System (YRBSS) Overview. http://www.cdc.gov/healthyyouth/data/yrbs/overview.htm.

Centers for Disease Control and Prevention (CDC). 2015 YRBS Data User's Guide. https://www.cdc.gov/healthyyouth/data/yrbs/pdf/2015/2015_yrbs-data-users-guide.pdf. 2016c.

Chriqui, J.F., Pickel, M., Story, M., 2014. Influence of school competitive food and beverage policies on obesity, consumption, and availability: a systematic review. JAMA Pediatr. 168 (3), 279–286.

Danaei, G., Vander Hoorn, S., Lopez, A.D., Murray, C.J., Ezzati, M., 2005. Comparative Risk Assessment collaborating group (Cancers). Causes of cancer in the world: comparative risk assessment of nine behavioural and environmental risk factors. Lancet 366 (9499), 1784–1793.

Department of Health and Human Services, 2015. Dietary Guidelines for Americans, 2015–2020. https://health.gov/dietaryguidelines/2015/guidelines/.

Department of Health and Human Services, 2016. Physical Activity Guidelines for Americans: Active Children and Adolescents. https://health.gov/paguidelines/guidelines/chapter3.aspx.

Elgar, F.J., Roberts, C., Tudor-Smith, C., Moore, L., 2005. Validity of self-reported height and weight and predictors of bias in adolescents. J. Adolesc. Health 37 (5), 371–375.

Fuemmeler, B.F., Pendzich, M.K., Tercyak, K.P., 2009. Weight, dietary behavior, and physical activity in childhood and adolescence: implications for adult cancer risk. Obes Facts. 2 (3), 179–186. http://dx.doi.org/10.1159/000220605.

Gerzoff, R.B., Williamson, G.D., 2001. Who's number one? The impact of variability on rankings based on public health indicators. Public Health Rep. 116 (2), 158–164.

Gordon-Larsen, P., McMurray, R.G., Popkin, B.M., 2000. Determinants of adolescent

physical activity and inactivity patterns. Pediatrics 105 (6), E83.
Gordon-Larsen, P., Nelson, M.C., Page, P., Popkin, B.M., 2006. Inequality in the built environment underlies key health disparities in physical activity and obesity. Pediatrics 117 (2), 417–424 (doi: 117/2/417).
Groves, R.M., 2006. Nonresponse rates and nonresponse bias in household surveys. Public Opin. Q. 70 (5), 646–675.
Koehly, L.M., Loscalzo, A., 2009. Adolescent obesity and social networks. Prev. Chronic Dis. 6 (3), A99.
Kramer, M.R., Raskind, I.G., Van Dyke, M.E., Matthews, S.A., Cook-Smith, J.N., 2016. Geography of adolescent obesity in the US, 2007–2011. Am. J. Prev. Med. 51 (6), 898–909.
Marmot, M., Atinmo, T., Byers, T., et al., 2007. Food, Nutrition, Physical Activity, and the Prevention of Cancer: A Global Perspective. http://www.aicr.org/assets/docs/pdf/reports/Second_Expert_Report.pdf.
Mokdad, A.H., Marks, J.S., Stroup, D.F., Gerberding, J.L., 2004. Actual causes of death in the United States, 2000. JAMA 291 (10), 1238–1245.
Moore, S.C., Lee, I., Weiderpass, E., et al., 2016. Association of leisure-time physical activity with risk of 26 types of cancer in 1.44 million adults. JAMA Intern. Med. 176 (6), 816–825.
Must, A., Jacques, P.F., Dallal, G.E., Bajema, C.J., Dietz, W.H., 1992. Long-term morbidity and mortality of overweight adolescents: a follow-up of the Harvard growth study of 1922 to 1935. N. Engl. J. Med. 327 (19), 1350–1355.
Oliver, T.R., 2010. Population health rankings as policy indicators and performance measures. Prev Chronic Dis. 7 (5), A101 (doi: A101).
Papas, M.A., Alberg, A.J., Ewing, R., Helzlsouer, K.J., Gary, T.L., Klassen, A.C., 2007. The built environment and obesity. Epidemiol. Rev. 29, 129–143 (doi: mxm009).
Peppard, P.E., Kindig, D.A., Dranger, E., Jovaag, A., Remington, P.L., 2008. Ranking community health status to stimulate discussion of local public health issues: the Wisconsin county health rankings. Am. J. Public Health 98 (2), 209–212. http://dx.doi.org/10.2105/AJPH.2006.092981.
Rasmussen, M., Krølner, R., Klepp, K., et al., 2006. Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part I: Quantitative studies. Int. J. Behav. Nutr. Phys. Act. 3 (1), 1.
Sallis, J.F., Glanz, K., 2009. Physical activity and food environments: solutions to the obesity epidemic. Milbank Q. 87 (1), 123–154.
Sallis, J.F., Zakarian, J.M., Hovell, M.F., Hofstetter, C.R., 1996. Ethnic, socioeconomic, and sex differences in physical activity among adolescents. J. Clin. Epidemiol. 49 (2), 125–134.
Sherry, B., Jefferds, M.E., Grummer-Strawn, L.M., 2007. Accuracy of adolescent self-report of height and weight in assessing overweight status: a literature review. Arch. Pediatr. Adolesc. Med. 161 (12), 1154–1161.
Singh, G.K., Kogan, M.D., van Dyck, P.C., 2008. A multilevel analysis of state and regional disparities in childhood and adolescent obesity in the United States. J. Community Health 33 (2), 90–102.
van Sluijs, E.M., McMinn, A.M., Griffin, S.J., 2007. Effectiveness of interventions to promote physical activity in children and adolescents: systematic review of controlled trials. BMJ 335 (7622), 703 (doi: bmj.39320.843947.BE).
Story, M., Nanney, M.S., Schwartz, M.B., 2009. Schools and obesity prevention: creating school environments and policies to promote healthy eating and physical activity. Milbank Q. 87 (1), 71–100.
U. S. Department of Health and Human Services, 2016. Healthy People 2020 Cancer Objectives. http://www.healthypeople.gov/2020/topicsobjectives2020/objectiveslist.aspx?topicid=5.
Wang, Y., 2002. Is obesity associated with early sexual maturation? A comparison of the association in American boys versus girls. Pediatrics 110 (5), 903–910.
Wolter, K., 2007. Introduction to Variance Estimation. Springer Science & Business Media.
Wright, C.M., Parker, L., Lamont, D., Craft, A.W., 2001. Implications of childhood obesity for adult health: findings from thousand families cohort study. BMJ 323 (7324), 1280–1284.
Wright, T., Klein, M., Wieczorek, J., 2014. Ranking populations based on sample survey data. Res. Rep. Ser. 12.
Zhang, S., Luo, J., Zhu, L., et al., 2014. Confidence intervals for ranks of age-adjusted rates across states or counties. Stat. Med. 33 (11), 1853–1866. http://dx.doi.org/10.1002/sim.6071.