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SHORT COMMUNICATION

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Differences in body mass index based on self-reported versus measured data from women veterans

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Summary

Objective: The objective was to compare differences in body mass index (BMI) calculated with self-reported versus clinically measured pre-conception data from women veterans in California.

Methods: Veterans Health Administration (VHA) and California state birth certificate data were used to develop a cohort of women who gave birth from 2007–2012 and had VHA data available to calculate BMI (*N* = 1,326 mothers, 1,473 births). Weighted Kappa statistics assessed concordance between self-reported and measured BMI. A linear mixed-effects model with maximum likelihood estimation, adjusted for mother as a random effect, assessed correlates of differences in BMI.

Results: Mean BMI was in the overweight range based on self-reported (26.2 kg/m^2, SD: 5.2) and measured (26.8 kg/m^2, SD: 5.2) data. Weighted Kappa statistics indicated good agreement between self-reported and measured BMI (0.73, 95% CI: 0.70, 0.76). Compared to the normal weight group, groups with overweight or obesity were significantly more likely to have lower BMIs when calculated using self-reported versus measured heights and weights, in unadjusted and adjusted models. The finding was pronounced for class 3 obesity, which was associated with a BMI underestimation of 6.4 kg/m^2.

Conclusions: Epidemiologic research that guides the clinical care of pregnant women should account for potential under-estimation of BMI in heavier women, and perform direct measurement where feasible.

KEYWORDS
BMI, pregnancy, women

1 | INTRODUCTION

The prevalence of overweight and obesity continue to rise in the United States.[1] Rates of obesity among women who are pregnant or considering pregnancy are of public health importance as obesity and excessive gestational weight gain are positively associated with risk for obesity-related pregnancy complications, such as hypertensive disorders of pregnancy, gestational diabetes, and pre-term birth.[2]Self-reportedpre-pregnancy weight is often used to assess weight gain and body mass index (BMI) during pregnancy, which in turn is used to prevent and/or manage the aforementioned complications. Self-reportedpre-pregnancy weight can also be used for epidemiological surveillance, which in turn can be used to facilitate public health interventions and population health. Such work is especially important for health care systems, such as the Veterans Health Administration (VHA), where care for pregnant patients is relatively new. Further, given the increasing use of telemedicine across health care systems in the US and abroad, understanding differences between self-reported and measured weights is increasingly important.

Past work suggests that self-reported weights are slightly lower than measured weights.[3] However, there are mixed findings regarding concordance between self-reported and measured weights and BMI among subpopulations of women, including specific obesity classes, ages, races, and ethnicities.[3–6] A recent systematic review of bias between self-reported and measured pre-pregnancy weights found that the risk of bias was generally small to moderate, particularly for normal weight women. However, they found that women of colour and women with overweight or obesity had increased risk of bias.[3] These discrepancies could lead to improper risk assessments among potentially high-risk groups. While not conducted among pregnant women, the results of Flegal et al.'s[5] comparison of self-reported and measured, height, weight, BMI, and obesity prevalence are notable. The study found that differences between self-reported and measured weights varied across different subpopulations and noted that "secondary measures such as BMI and obesity prevalence calculated from self-reported weight and height may exhibit unpredictable types of bias." (5, p1718).

Women veterans are an ideal population to expand the literature on self-reportedpre-pregnancy weight and BMI as they are one of the fastest growing veteran subpopulations and they come from diverse racial and ethnic backgrounds (i.e., roughly 42% are not white). In addition, over 95% of VHA patients are weighed at each medical visit.[7] As a result, we know that roughly 42% of women veterans using VHA have overweight or obesity.[8] Further, individuals reporting military service are more likely to underestimate their weight than those who do not report military service[9] and veterans who use VHA tend to have more chronic conditions and lower incomes than those who do not use VHA.[10] In addition, obstetrical deliveries among women veteran VHA patients increased 14-fold between fiscal years 2000 and 2015.[11] As a result, women veterans are an important subpopulation to investigate for potential bias between self-reported and measured BMI,[5] particularly because VHA increasingly provides pregnancy-related care. The present study compared differences in BMI calculated with self-reported versus clinically measured preconception weights among women veterans in California, with the hypothesis that BMIs based on self-report would be lower than those based on measured data.

2 | METHODS

2.1 | Cohort

VHA and California state birth certificate data were used to develop a cohort of women who gave birth in California between 2007 and 2012,[12] used VHA within 1 year prior to delivery (2,679 unique mothers, 3,097 unique births), and had centralized VHA data available to calculate BMI. The final cohort was made up of 1,326 unique mothers who had 1,473 unique births.

2.2 | Measures

2.2.1 | Self-reportedpre-pregnancy BMI

Weights and heights collected during California birth certificate interviews were used to calculate self-reportedpre-pregnancy BMI. To collect this information, a clerk first checks the medical record for relevant information (e.g., patient's height) and then interviews the person who gave birth to obtain information not available in the medical record. The amount of information available in the medical record varies by how integrated the hospital's electronic medical record system is with that of the referring obstetrician. For example, in integrated systems more data will be available in the medical record.

2.2.2 | Measured pre-pregnancy BMI

Heights and weights from clinical encounters extracted from VHA administrative data and an existing algorithm[8] were used to calculate a mother's BMI +/− two months from conception. The algorithm used the patient's modal height and the patient's weight within two months of conception. Both self-reported and measured BMI were categorized as: 1) underweight: BMI < 18.5 kg/m^2; 2) Normal weight: 18.5 ≤ BMI < 25 kg/m^2; 3) Overweight: 25 ≤ BMI < 30 kg/m^2; 4) Obesity class 1: 30 ≤ BMI < 35 kg/m^2; 5) Obesity class 2: 35 ≤ BMI < 40 kg/m^2; and 6) Obesity class 3: BMI ≥ 40 kg/m^2.

2.2.3 | Sociodemographic information

Information on race, ethnicity, and age came from VHA administrative data, including the electronic medical record.[12]

2.3 | Analysis

Weighted Kappa statistics were used to assess concordance in BMI classification between self-reported and measured BMI. A linear mixed-effects model with maximum likelihood estimation, adjusted for mother as a random effect was used to assess correlates of differences between self-reported and measured BMI. Correlates were chosen based on factors associated with outcomes in past work: measured BMI classification, age, race, and ethnicity.[3,4,6] Given the potential for type 1 error due to the sample size and number of predictors, p values ≤0.001 were considered statistically significant. Analyses were conducted in SAS v9.2 (Cary, North Carolina). This work was approved by the Stanford University institutional review board.

3 | RESULTS

Among the 1,326 women included in the cohort, mean age of the mothers at birth was 29 years (SD: 4.6). Mean BMI was in the overweight range when assessed with both self-reported (26.2 kg/m^2, SD: 5.16) and measured (26.8 kg/m^2, SD: 5.19) data. Figure 1 provides information about BMI classification rates for self-reported and measured data. Among the cohort, roughly 71% of the women were White, 12% were Black, and 6% were Asian. About 31% of the women were Hispanic. Additional characteristics are provided in Table 1.

Weighted Kappa statistics indicated good agreement between BMI assessed with self-reported and measured data (0.70, 95% CI: 0.67, 0.73), with BMI based on self-report being somewhat lower than BMI based on clinical measurements (mean difference: −0.55 kg/m^2; 95% confidence interval: −0.71, −0.39). BMI classification concordance between self-reported and measured BMI differed among BMI classes. Concordance was highest for women in the normal weight group (88%), followed by women in the underweight group (85%), then the overweight (67%), obesity class 1 (66%), obesity class 3 (50%), and obesity class 2 (49%) groups.

Compared to the normal weight group, groups with overweight or obesity were significantly more likely to have lower self-reported BMI than measured BMI in both unadjusted and adjusted multivariable regression models (Table 2). The magnitude of underestimation increased linearly with increasing obesity class. Class 1 obesity was associated with a roughly 1.1 kg/m^2 underestimation and class 2 obesity was associated with a roughly 2.6 kg/m^2 underestimation. The finding was particularly pronounced for class 3 obesity, which was associated with underestimating BMI by 6.4 kg/m^2. In sensitivity analyses, results were robust to excluding repeat pregnancies.

TABLE 1 Characteristics of the cohort of 1,326 women veteran VHA users who gave birth in California between 2007 and 2012

	N	%
Age		
19–24 years	178	13.4
25–29 years	609	45.9
30–34 years	361	27.2
35–39 years	139	10.5
40–49 years	39	2.9
Race		
Black	157	11.8
White	944	71.2
Asian	80	6.0
Multi-race	82	6.2
Unknown/Other	63	4.8
Hispanic ethnicity	414	31.2
Measured BMI		
Underweight	18	1.4
Normal weight	534	40.3
Overweight	466	35.2
Any obesity	308	23.2
Obesity class 1	201	15.2
Obesity class 2	83	6.3
Obesity class 3	24	1.8

VHA: Veterans Health Administration; BMI: Body mass index; Underweight: BMI < 18.5 kg/m^2; Normal weight: 18.5 ≤ BMI < 25 kg/m^2; Overweight: 25 ≤ BMI < 30 kg/m^2; Any obesity: BMI ≥ 30 kg/m^2; Obesity class 1 : 30 ≤ BMI < 35 kg/m^2; Obesity class 2: 35 ≤ BMI < 40 kg/m^2; Obesity class 3: BMI ≥ 40 kg/m^2.

4 | DISCUSSION

Among women who gave birth in California and used VHA between 2007 and 2012, higher measured BMI was associated with more pronounced underestimation of BMI via self-report. This finding was extreme for class 3 obesity, which was associated with underestimating BMI by 6.4 kg/m^2. The clinical significance of this difference depends on individual patients, for example, at the lower end of the class 3 obesity range, underestimation by 6.4 kg/m^2 would place a person in the class 1 obesity category, which is associated with lower medical risk. Therefore, caution is warranted when using self-reported birth certificate data to calculate BMI for women veterans with obesity, particularly for those in higher obesity classes. At the same time, differences in BMI calculated with self-reported data were generally accurate for normal weight women and those in the overweight group, consistent with past research.[3,4,6]

The present findings add to past work by describing results separately by obesity class. This is important as women with class 3 obesity had the largest discrepancies between self-reported and measured BMI. Perhaps because more finely-grained BMI categories were used, concordance results differ from past work which found concordance highest among women with normal weight, followed by those with obesity, then those with overweight.[4,6] In contrast, the current work found highest concordance among women with underweight or normal weight, with lower, but similar rates for women with overweight

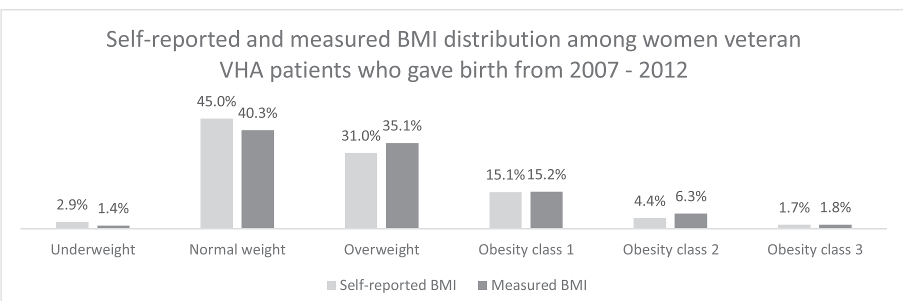

FIGURE 1 Self-reported and measured BMI distribution among women veteran VHA patients who gave birth in California from 2007–2012

TABLE 2 Factors predicting difference in BMI (self-reported versus measured BMI), adjusted for multiple births per mother (n = 1,473 births), from multivariable regressions

	Unstandardized Regression Coefficients	
	Model 1	Model 2
Intercept	0.14	−0.12
Measured BMI (reference: normal weight)		
Underweight	−0.05	0.08
Overweight	**−0.68**	**−0.71**
Obesity class 1	**−1.11**	**−1.19**
Obesity class 2	**−2.63**	**−2.68**
Obesity class 3	**−6.39**	**−6.40**
Age category (reference: 19–24 years)		
25–29 years	--	0.34
30–34 years	--	0.44
35–39 years	--	−0.05
40–49 years	--	−0.13
Race (reference: White)		
Black	--	0.31
Asian	--	−0.44
Multi-race	--	−0.66
Unknown/Other	--	−0.51
Hispanic ethnicity (reference: not Hispanic)	--	0.23

Bold indicates significant at $p \leq 0.001$.
BMI: Body mass index; Underweight: BMI < 18.5 kg/m^2; Normal weight: 18.5 ≤ BMI < 25 kg/m^2; Overweight: 25 ≤ BMI < 30 kg/m^2; Any obesity: BMI ≥ 30 kg/m^2; Obesity class 1: 30 ≤ BMI < 35 kg/m^2; Obesity class 2: 35 ≤ BMI < 40 kg/m^2; Obesity class 3: BMI ≥ 40 kg/m^2.

or obesity, and lowest rates for women with class 2 or 3 obesity. Bannon et al.[4] suggest that direct measurement may be especially important for people who fall near the cut-off for obesity (e.g., BMI = 29.9). The results reported in this paper extend that conclusion, suggesting that direct measurement may be especially important for women near cut-offs for specific obesity classes.

Unlike past work,[3,4,6] Black race (or any race/ethnicity) was not associated with underestimating BMI. This may be due to differences between veterans who use VHA and the general population. For example, veterans using VHA are likely to be weighed at every primary care appointment.[7] As a result, veterans of colour may be more likely to have measured weights and be included in analyses as compared to prior work which found fewer Black women and women of other race/ethnicity had measured weights in the electronic medical record compared to White women.[4] Regarding age, the findings add to the equivocal state of the research described in a recent systematic review.[3] The present study did not find a significant association between age and underestimation of BMI, while two studies published since the review found opposite effects, i.e., one found older age associated with greater risk of bias[6] and another found older age associated with lower risk of bias.[4]

Limitations include a focus on veterans using VHA and the possibility that in some cases, self-reported weight may be more reflective of a person's true average weight than a single weight measured in a clinical setting. Another limitation of this study is that it did not assess discrepancies between self-reported and measured height. Given the BMI calculation (kg/m^2), such discrepancies have an exponential effect and should be assessed in future work. In addition, we did not have information on patients' bariatric surgery status, although research among bariatric surgery patients suggests concordance between self-reported weights taken with a personal scale and self-report of weights taken by professionals.[13] However, these limitations are outweighed by strengths, including the large, diverse sample and the availability of regularly measured heights and weights. Further, a recent study comparing differences between self-reported and measured height, weight, and BMI in three nationally representative surveys found variability across populations,[5] highlighting the importance of confirming and expanding past findings in the special and growing population of women veterans.

5 | CONCLUSIONS

Epidemiologic research that guides the clinical care of pregnant women should account for potential under-estimation of BMI in heavier women and perform direct measurement where feasible.

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DISCLOSURE

The authors declare no conflict of interest.

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