International Health 2021; **13**: 143–150
doi:10.1093/inthealth/ihaa031 Advance Access publication 25 June 2020

ORIGINAL ARTICLE

Household motor vehicle ownership and obesity among Indian females and males: 2005–2016

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Received 20 January 2020; revised 6 April 2020; editorial decision 19 May 2020; accepted 3 June 2020

Background: To determine associations between household motor vehicle ownership and obesity among Indian adults.

Methods: Bivariate and multivariable analyses were conducted using the 2005–2006 and 2015–2016 Indian Demographic and Health surveys, with over 800 000 respondents.

Results: Obesity prevalence (body mass index ≥25 kg/m^2) rose in females (16.87% to 20.35%) and in males (12.55% to 18.74%). In 2005, having both types of vehicles (motorcycle/motor scooter and car) significantly increased the odds of obesity in females (OR, 1.63; 95% CI 1.50 to 1.76) and males (OR, 2.49; 95% CI 2.24 to 2.77) as well as in 2015 (OR, 1.10; 95% CI 1.07 to 1.13 and OR, 1.56; 95% CI 1.45 to 1.68, respectively). The wealthiest were more likely to be obese in 2005 (OR, 14.95; 95% CI 16.06 to 17.12 for females; OR, 12.69; 95% CI 10.17 to 15.70 for males) and in 2015 (OR, 7.69; 95% CI 7.43 to 7.95 for females and OR, 6.40; 95% CI 5.40 to 7.01 for males). Higher education levels, being younger and rural residence were significant protective factors in 2005 and 2015.

Conclusions: After adjusting for confounders, motor vehicle ownership was significantly associated with obesity at both time points, but the effect of vehicle ownership presents differently by gender. With obesity prevalence increasing in India, policies promoting active vs motorized transport could attenuate this problem.

Keywords: epidemiology, motor vehicles, obesity, public health.

Introduction

Obesity and its associated chronic diseases have become a worldwide problem that is not just limited to populations in developed countries.[1–4] According to the WHO, as of 2016 over 650 million adults around the world were classified as obese.[5] A recent commission report published in *The Lancet* described how the triple pandemics of obesity, undernutrition and climate change create a global syndemic driven by systems of food and agriculture, transportation, urban design and use of land.[6] In India, one of the world's largest and fastest growing economies, undernutrition remains a problem for some. Yet at the same time, a 'double burden' exists as obesity levels are rising rapidly.[7,8] While obesity in India may have been classified as problematic among the wealthy and among those in urban settings,[9] studies have found a rise in obesity among poorer populations and in rural settings.[10–12] Indian females tend to display higher levels of obesity than their male counterparts.[12] A study using the National Family Health Survey 2005–2006 found that, among women, obesity increased with age in both poor and non-poor groups.[13] Obesity has been found to be associated with a number of serious chronic health problems including heart disease, hypertension, diabetes and some types of cancer,[5,14,15] and Indians may be at greater risk than Caucasians for some of these obesity-related diseases.[16,17] Obesity is typically measured with height and weight and classified with a body mass index (BMI).[5] BMI cut-off values may need to be adapted for people from different ethnicities and backgrounds. A universal classification of obesity adopted and maintained by the WHO is a BMI ≥30 kg/m^2, but recent studies and a consensus statement specific to Indian

populations indicate that a cut-off of ≥25 may be more appropriate for measuring risk in Indian populations.[18–24]

A number of factors contribute to weight gain and obesity, including socioeconomic status, eating habits, age, gender and diminished physical activity levels. But other drivers include transportation, urban design and land use.[6] Most youth and adults in developing countries do not meet physical activity guidelines during times of leisure or work.[25] A growing dependence on household items like televisions, computers and motorized vehicles may contribute to physical inactivity and the larger problem of obesity.[26] While several studies have explored the relationship between sedentary leisure time activities and obesity, a select few have examined the relationship between obesity and vehicle ownership.[7,27–30] A 2009 study examining household motor vehicle use and weight status in adults in Columbia found an association between motor vehicle ownership and obesity among males.[31] A 2002 study found an increase in Chinese household vehicle ownership between 1989 and 1997 and greater odds of obesity in males who had acquired a vehicle over that time.[32] A recent study found that middle-aged and older Chinese adults living in densely populated neighborhoods who owned cars had higher odds of being overweight.[33]

As opportunities spread throughout a larger proportion of growing economies, household asset ownership patterns change and more families are able to afford motorized transportation. A 2013 study analyzing 2011 Indian census data found that household scooter/motorcycle/moped ownership increased by 9.5% between 2001 and 2011, and car/jeep/van ownership increased by 2.2%.[34] With both vehicle ownership and obesity rising in India it is an ideal time to examine the relationship between the two, as has been done in other rapidly growing economies.[31–33] While numerous factors contribute to the rapidly increasing levels of obesity in females and males in India, no study, to our knowledge, has examined these factors and the relationship between household vehicle ownership and obesity using nationally representative data in India. The purpose of this study is to compare the associations between household motor vehicle ownership and obesity, while controlling for a number of other factors, among Indian females and males in 2005 and again in 2016.

Methods

Study design and population

Four cross-sectional analyses were conducted (two each for females and males) using the two rounds (2005–2006 and 2015–2016) of the National Family Health Survey of India.[35,36] These surveys were administered as part of the Demographic and Health Surveys (DHS) program, which has collected and disseminated nationally representative demographic and health and family welfare data in over 90 countries since 1984.[37] Response rates in 2005 were 95% for females and 87% for males, and in 2015 the response rates were 97% for females and 92% for males.[35,36] Technical details about the surveys including sampling design, sampling frame and sample implementations are published in analytical and final survey reports.[35–37]

This study included 102 597 females (aged 18–49 y) in 2005, 593 151 females (18–49) in 2015, 59 593 males (18–49) in 2005 and 91 615 males (18–49) in 2015. Individuals who were aged <18 y were dropped from our analysis because they would not have been of legal driving age in India.[38] In addition, females who identified as pregnant were excluded from the analysis because pregnancy status could confound the obesity measure based on BMI. As less than 1% of cases had missing data, all cases with complete data were included.

Outcome variables

For the outcome variable, obesity, a BMI variable was included in the data sets based on height and weight measurements taken by trained staff. Height was assessed using a Seca 213 stadiometer (Seca; Medical Measuring Systems and Scales, Hamburg, Germany) and was accurate to the nearest 0.1 cm.[35,36] Weight was recorded using the Seca 874 digital scale with accuracy to within ±100 g.[35,36] BMI was calculated as weight in kg divided by height in m squared.[35,36] A dichotomous variable labeled obesity was defined as those individuals with a BMI ≥25 kg/m^2, a level used with Indian.[23,24]

Independent variables

Vehicle ownership was defined in four categories as household ownership of at least one motorcycle/motor scooter (MC/MS), a car or both types of vehicles: MC/MS and car, with having no vehicle as the reference group. Other control variables included the age of the respondent, which we grouped into one of three categories (18–29, 30–39 or 40–49 y) for greater clarity in the bivariate χ^2 tests and kept as a continuous variable for multivariate logistic regression analysis, a wealth index, urban/rural residence and education level of the respondent. The wealth index was categorized into the following quintiles: poorest, poorer, middle, richer and richest. The DHS program categorized households into these quintiles based on ownership of certain assets, house construction materials, and water and sanitation facility access.[39] Urban status was defined using the standard DHS format as residency in a capital city, a large city with a population of over 1 million, a small city with a population of over 50 000 and towns. Rural status was defined as residency in a countryside area.[40] Education was categorized by the DHS program as no education, primary, secondary and higher. Due to the small number of responses in the no education and primary education categories, these were then combined into one category called primary (or lower).

Statistical analysis

χ^2 tests were conducted to analyze the relationship between the outcome variable of obesity status and the predictor variable of vehicle ownership in addition to the relationships between obesity status and age, wealth, setting and education. Multivariate logistic regression models were developed to estimate the association between obesity and the predictor variable of interest, vehicle ownership, while controlling for age, wealth, setting and education in adult Indian females and males. Predictor and other control variables were tested for

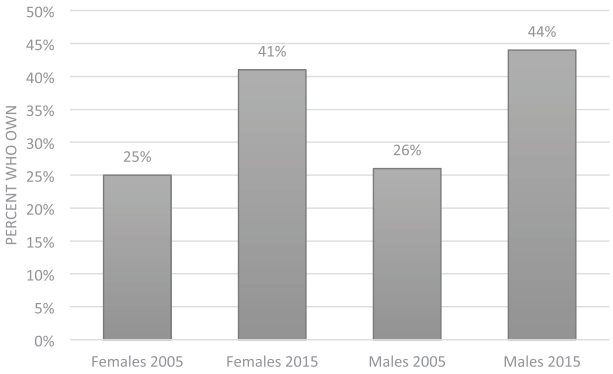

Figure 1. Indian household motor vehicle ownership (2005–2015)

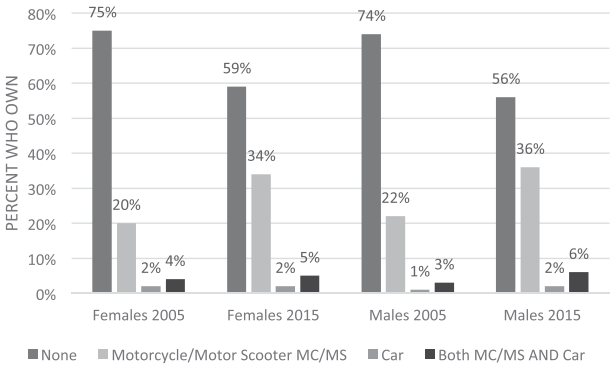

Figure 2. Indian household motor vehicle ownership by category (2005–2015)

multicollinearity by performing a linear regression and calculating the variance inflation factor. The results are presented in the form of ORs with 95% CIs. All analyses were performed in STATA/SE 15.1.[41]

Results

Vehicle ownership prevalence

Figure 1 highlights increases in household vehicle ownership among females (25% vs 41%) and males (26% vs 44%) from 2005 to 2016, respectively. Figure 2 displays Indian household vehicle ownership by the following categories for females and males in 2005 and 2015: none, MC/MS, car and both MC/MS and car. MC/MS ownership increased more among both females and males between 2005 and 2015 than other categories of vehicle ownership (20% vs 34% in females and 22% vs 36% in males).

Obesity prevalence

The prevalence of obesity in India has also been rising. In females, it was 16.9% in 2005 and 20.4% in 2015, a 20.7% increase. In males, it was 12.6% in 2005 and 18.7% in 2015, a 48.4% increase (Table 1). Table 1 highlights the prevalence of obesity and non-obesity by selected characteristics of Indian females and males in 2005 and then again in 2015. Prevalence of obesity and reported household vehicle ownership varied by gender and over time. Prevalence of obesity was higher among females with cars in the household in 2005 than it was in 2015 (29.2% vs 31.4%, $p<0.001$). For males who reported owning a car, obesity prevalence increased from 2005 to 2015 (20.0% vs 29.7%, $p<0.001$).

Prevalence of obesity varied by other characteristics as well (Table 1). The 40–49 y age category of respondents showed the highest prevalence of obesity for both females and males in both time periods. Wealthier females and males also had a higher level of obesity at both time points. In 2005, only 2.2% of the poorest females were obese in contrast to 32.5% of the richest females ($p<0.001$). In 2015, 6.2% of the poorest females were obese and 36.5% of the richest were obese ($p<0.001$). The pattern is similar with males. In 2005, 1.7% of the poorest males were obese, as opposed to 26.0% of the richest ($p<0.001$). In 2015, 5.6% of the poorest males were obese and 33.7% of the richest were obese ($p<0.001$). Obesity was more prevalent among females and males in urban vs rural settings in both 2005 ($p<0.001$) and 2015 ($p<0.001$). Obesity was also highest among those with the least amount of education (17.1% of females in 2005, 20.7% of females in 2015, 12.8% of males in 2005 and 19.1% of males in 2015 [$p<0.001$]).

Predictors of obesity

Results of the logistic regression analysis are presented in Table 2. After controlling for each of the independent variables in the multivariate analysis, vehicle ownership, greater wealth, urban residence, less education and older age were all significantly associated with obesity among both females and males in 2005 and 2015. When compared with those without motorized vehicles, having both types of vehicles (MC/MS and car) increased the odds of obesity in 2005 among females and males (OR, 1.63; 95% CI 1.50 to 1.76 and OR, 2.49; 95% CI 2.24 to 2.77, respectively) and in 2015 (OR, 1.10; 95% CI 1.07 to 1.13 and OR, 1.56; 95% CI 1.45 to 1.68, respectively). When compared with the poorest quintile, the wealthiest quintile was more likely to be obese in 2005 (OR, 14.95; 95% CI 13.06 to 17.12 for females and OR, 12.69; 95% CI 10.27 to 15.70 for males) and in 2015 (OR, 7.69; 95% CI 7.43 to 7.95 for females and OR, 6.40; 95% CI 5.40 to 7.01 for males). The odds of being obese were at least three times as great for females and males classified as middle class (in reference to the poorest) in 2005 (OR, 3.96; 95% CI 3.46 to 4.55 for females and OR, 3.54; 95% CI 2.77 to 4.24 for males) and 2015 (OR, 3.64; 95% CI 3.54 to 3.75 for females and OR 3.29; 95% CI 3.03 to 3.57 for males). Higher levels of education, youth and rural residence were found to be significant protective factors among both females and males in 2005 and 2015. Multicollinearity was not found to be problematic because the variance inflation factor values were low (<2) for the independent variables of interest.[42] In addition, multicollinearity would not change our interpretation of the ORs.[43]

Discussion

The overall objective of this study was to compare the associations between household motor vehicle ownership and obesity, while controlling for a number of other factors, among Indian females and males in 2005 and again in 2016. Our results show that

Table 1. Prevalence of obesity by selected characteristics of Indian females and males

	2005–2006, females (n=102 597)				2015–2016, females (n=593 151)				2005–2006, males (n=59 593)				2015–2016, males (n=91 615)			
	Obese		Non-obese		Obese		Non-obese		Obese		Non-obese		Obese		Non-obese	
Characteristics	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
All participants	17 312	16.9	85 285	83.1	120 712	20.4	472 439	79.7	7 481	12.6	52 112	87.5	17 169	18.7	74 446	81.3
Age groups, y		***				***				***				***		
18–29	4 154	8.7	43 425	91.3	29 236	11.1	233 419	88.9	1 946	7.1	25 646	93.0	4 722	11.7	35 513	88.3
30–39	6 862	20.9	25 999	79.1	46 002	25.2	136 631	74.8	2 923	16.1	15 198	83.9	6 554	23.2	21 759	76.9
40–49	6 296	28.4	15 861	71.6	45 474	30.8	102 389	69.3	2 612	18.8	11 268	81.2	5 893	25.6	17 174	74.5
Wealth		***				***				***				***		
Poorest	248	2.2	11 307	97.9	6 759	6.2	102 989	93.8	100	1.7	5 672	98.3	835	5.6	14 210	94.5
Poor	649	4.5	13.794	95.5	14 577	11.7	110 090	88.3	239	2.9	8 140	97.2	1 954	10.3	17 019	89.7
Middle	1 671	1.8	17 795	91.4	23 900	19.1	100 979	80.9	715	5.9	11 445	94.1	3 398	17.0	16 633	83.0
Richer	4 296	17.2	20 667	82.8	33 754	28.3	85 638	71.7	1 837	11.7	13 817	88.3	4 747	24.9	14 308	75.1
Richest	10 448	32.5	21 722	67.5	41 722	36.5	73 743	63.6	4 590	26.0	13 038	74.0	6 235	33.7	12.278	66.3
Setting		***				***				***				***		
Urban	11 951	25.7	34.499	74.3	54 612	31.2	120 453	68.8	5 429	18.1	24 495	81.9	7 714	26.8	21 038	73.2
Rural	5 361	9.6	50 786	90.5	66 100	15.8	351 986	84.2	2 052	6.9	27 617	93.1	9 455	15.0	53 408	85.0
Education		***				***				***				***		
Primary (or lower)	17 221	17.1	83 298	82.9	119 999	20.7	458 919	79.3	7 428	12.8	50 584	87.2	17 031	19.1	71 965	80.9
Secondary	46	3.7	1 190	96.3	365	4.3	8 068	95.7	33	3.0	1 068	97.0	74	4.4	1 603	95.6
Higher	36	5.8	580	94.2	348	6.0	5 435	94.0	15	4.1	350	95.9	64	6.8	874	93.2
Vehicle ownership		***				***				***				***		
None	9 565	12.5	66 923	87.5	54 124	15.4	296 791	84.6	3 606	8.2	40 385	91.8	6 584	12.9	44 484	87.1
MC/MS	5 785	27.9	14 978	72.1	51 513	25.8	148 099	74.2	3 032	23.4	9 953	76.7	8 071	24.2	25 274	75.8
Car	483	29.2	1 173	70.8	3 227	31.4	7 051	68.6	150	20.0	600	80.0	510	29.7	1207	70.3
Both MC/MS and car	1 479	40.1	2 211	59.9	11 848	36.6	20 498	63.4	693	37.1	1 174	62.9	2 004	36.5	3 481	63.5

MC/MS = motorcycle or motor scooter.
***p<0.001.

Table 2. Predictors of obesity in Indian females and males

Predictors	Obese females, 2005–2006		Obese females, 2015–2016		Obese males, 2005–2006		Obese males, 2015–2016	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age, y	1.08***	1.08 to 1.08	1.06***	1.07 to 1.07	1.06***	1.06 to 1.07	1.05***	1.05 to 1.05
Wealth								
Poorest (reference)	1		1		1		1	
Poorer	2.07***	1.78 to 2.40	2.05***	2.00 to 2.11	1.67***	1.32 to 2.12	1.93***	1.77 to 2.10
Middle	3.96***	3.46 to 4.55	3.64***	3.54 to 3.75	3.54***	2.77 to 4.24	3.29***	3.03 to 3.57
Richer	8.03***	7.03 to 9.18	5.80***	5.62 to 5.98	6.53***	5.31 to 8.04	4.86***	4.47 to 5.29
Richest	14.95***	13.06 to 17.12	7.69***	7.43 to 7.95	12.69***	10.27 to 15.70	6.40***	5.84 to 7.01
Setting								
Urban (reference)	1		1		1		1	
Rural	0.64***	0.62 to 0.67	0.74***	0.73 to 0.75	0.73***	0. 69 to 0.78	0.82***	0.79 to 0.86
Education								
Primary or lower (reference)	1		1		1		1	
Secondary	0.43***	0.32 to 0.58	0.44***	0.40 to 0.49	0.39***	0.27 to 0.56	0.40***	0.31 to 0.50
Higher	0.47***	0.34 to 0.66	0.46***	0.41 to 0.51	0.37**	0.22 to 0.62	0.49***	0.38 to 0.64
Vehicle ownership								
None (reference)	1		1		1		1	
MC/MS	1.18***	1.13 to 1.24	0.98*	96 to 1.00	1.60***	1.50 to 1.69	1.24***	1.18 to 1.29
Car	1.07	0.96 to 1.21	1.07**	1.03 to 1.13	1.14	0.95 to 1.36	1.38***	1.23 to 1.55
Both MC/MS and car	1.63***	1.50 to 1.76	1.10***	1.07 to 1.13	2.49***	2.24 to 2.77	1.56***	1.45 to 1.68

MC/MS = Motorcycle or motor scooter.
**p<0.01; ***p<0.001.

obesity prevalence was greater among females and males who owned vehicles than those who did not own vehicles at both time points. The association between motor vehicle ownership and obesity was significant, even when controlling for other predictors of obesity. Obesity prevalence increased among Indian females and males between 2005 and 2015 by 20.62% and 49.32%, respectively, and vehicle ownership in India increased dramatically over the 10-y time period as well. This is consistent with findings from Columbia and China and *The Lancet* report.[6,31–33] As the prevalence of vehicle ownership increases, so does obesity status. Traveling by motorized vehicle replaces more active forms of transportation like walking and cycling, and this increase in inactivity could be linked to obesity.[44,45] Vehicle ownership will likely increase in India with growing household wealth and the ability to purchase one or multiple vehicles, and, without intervention, obesity prevalence will continue to escalate. Interestingly, our study shows that the greatest increase for the type of vehicles owned between 2005 and 2015 was in motorcycles/motor scooters, with a 70% increase among women respondents and a 64% increase among men respondents. This increase in two-wheeled vehicle ownership is likely due to their relative affordability compared with automobiles.[45]

Some may argue that weight gain occurs with increased wealth, regardless of vehicle ownership. Our findings showed that obesity increased among Indian vehicle owners even when controlling for wealth, but the wealthiest women and men were most likely to be obese in both 2005 and 2015. The fact that, in our study, the odds of being obese were at least three times as great for women and men classified as middle class (in reference to the poorest) in 2005 and 2015 should be a cause for concern. With economic growth, obesity is spreading across the Indian population and it is not just a problem among the wealthiest in urban settings. This is consistent with the findings of Lear et al., who examined the association between ownership of household devices and obesity in high-, middle- and low-income countries.[26] Interestingly, a 2016 study of obesity among rural Indian females found that obesity increased from 7% to 24% between 1975 and 2012.[46] Regions of India are growing at different rates and efforts to control obesity should focus on even poorer areas of the country. As it continues to develop, India faces the unique challenge of the dual burden of malnutrition and obesity.[8,47]

In our study, the variables for vehicle ownership and obesity presented themselves differently by gender. The prevalence of obesity among females increased by 20.6% between 2005 and 2015 and, among males, obesity prevalence increased by more than double that (49.3%). Luhar et al. found that Indian females tend to display higher levels of obesity than their male counterparts,[12] but levels may be increasing faster for males. Prevalence of obesity was slightly higher among females with cars in the household in 2005 than it was in 2015, but not with ownership of MC/MS, or both MC/MS and a car in the household. By contrast, for males who reported owning a car, obesity prevalence had a greater increase, from 20.00% to 29.70% from 2005 to 2015, and increases in obesity prevalence were also observed with MC/MS ownership. Furthermore, in the multivariable analysis, the ORs for the association between vehicle ownership and obesity in males were larger than they were for females for each type of vehicle in each year. This is consistent with a study of motorized transportation and obesity in China.[32] The obesity impact was less realized among females. In both of these countries and other developing countries, because of gender norms, men may be the predominant operators of vehicles. It is possible that women in India are reporting ownership of vehicles but that they are rarely the individuals in their households who are driving them. A 2012 report found that more women than men in India depend on public transportation[48] and, in 2015, only 11% of those driving in India were women.[49] The number of women driving in India may increase as social norms and women's roles continue to change.

Limitations

Because the DHS program does not collect data on daily food intake or physical activity and exercise, we are not able to control for important factors related to weight status. Related to this, ownership of a vehicle might affect both the food environment and daily physical activity. The ability to take more food home from the market or having more meals in restaurants impacts food intake, which may be linked to ease of transportation. As development broadens across India, food choices may be changing as well. People may be eating less at home and consuming more high energy-dense calories, such as fried foods, away from home.[50] Vehicle ownership makes it easier to access these kind of foods. Indian families address concerns for low birthweight babies with an increase in high energy-dense foods and less physical activity, which in turn may lead to risks of obesity, even among younger populations.[47,51] Vehicle ownership may also impact daily physical activity and risks of obesity. We cannot conclude in our study whether owning a motor vehicle decreases activities like cycling and walking, although research has shown that developed countries with more active citizens have lower obesity rates.[52]

This study did not include females and males over the age of 49 y because anthropometric data were only collected from females up to the age of 49 y. Also, we do not know who is driving those vehicles reported as being owned by households, although research seems to indicate that women are driving much less than men in India.[48,51] The data do not show if a household has more than one of type of vehicle. Time spent in traffic would also vary greatly depending upon what part of the country people live in. Travel and time use studies can perform a more in-depth investigation into understanding these relationships.

Implications

This study reveals the complex system of the obesity pandemic within a developing country and the leverage points that may influence change within the system. We often limit our understanding of obesity to measuring physical activity and calorie intake without considering the contexts surrounding activity and eating behavior. With prevalence of obesity and vehicle ownership increasing in India, policies aimed at promoting active vs motorized transport, in both urban and rural settings, could be one leverage point in attenuating this growing problem. Policies should include directing funds towards improved and safer mass transit and community-influenced active commuting

interventions rather than only funding road and highway infrastructure. In addition, policies that regulate vehicle ownership and use could be instituted and enforced. Finally, support for evaluation of local, state and national transportation policies and an examination of gendered mobility behavior would elucidate the impact on population health outcomes.

Conclusions

After adjusting for important confounders like age, wealth, setting and education, household ownership of motor vehicles was found to be significantly associated with obesity in both females and males at both the 2005 and 2015 time points, but the effect of vehicle ownership seems to present differently by gender.

Authors' contributions: DK, DW and JM conceived the study; DK, DW, SL, IG, PA and JM designed the study protocol; DK carried out the analysis and all authors provided an interpretation of these data. DK drafted the manuscript; DW, JM and SL critically revised the manuscript for intellectual content. All authors read and approved the final manuscript.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Competing interests: None to declare.

Ethical approval: This study was a secondary analysis of two existing and de-identified DHS survey data sets. DHS surveys have been reviewed and approved by ICF International Institutional Review Board (IRB) and complies with the U.S. Department of Health and Human Services regulations for the protection of human subjects (45 CFR 46) and the laws and the norms of the host country. The DHS obtained informed consent from all survey respondents.

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