Israel Diego (UMID: israeldi)
Stats 504
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BMI variation in the US across several ethnic groups

We aim to study the relationship between BMI and factors such as age, sleep, gender, and ethnicity. In order to capture the multidimensional relationship between predictors and the response, we plot several cross-sections of expected BMI against age and compare relative relationships between males and females as we vary the average number of hours of sleep. Our modeling choices were motivated by trying to capture as much of the dependence between predictors while still being able to observe and interpret trends in BMI for ethnic subgroups of people.

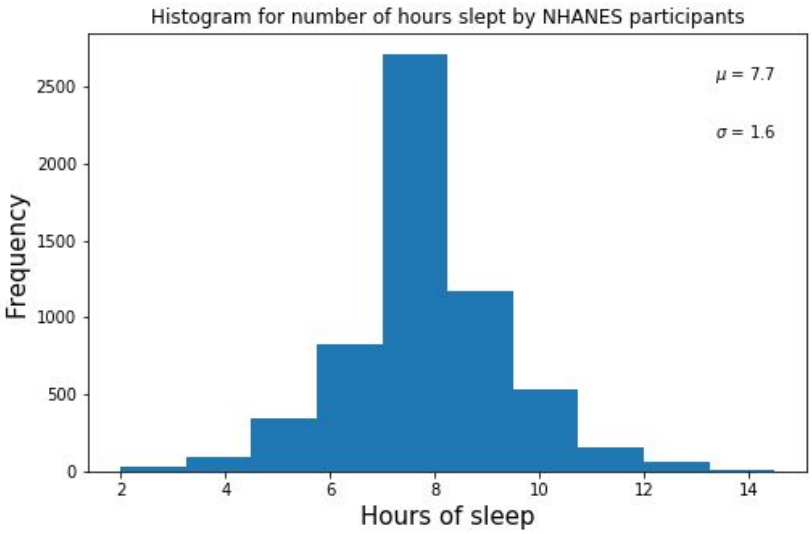
In order to study BMI variation, we used a linear regression approach. The dependent variable of our model is BMI,, which is calculated by dividing the weight of an individual by the square of their height, which has units (kg/m^2). The independent variables in the regression model are:

- **RIDAGEYR:** Age in years of the participant at the time of screening. Individuals 80 and over are topcoded at 80 years of age.
- **SLD012:** number of hours usually slept at night on weekdays or workdays?
- **Gender:** Male or Female
- **RIDRETH1:** 1: Mexican American, 2: Other Hispanic, 3: Non-Hispanic White, 4: Non-Hispanic Black, 5: Other Non-Hispanic Races

Our linear regression model which regresses BMI on age, sleep, gender, and ethnicity is formulated as follows. We model age and sleep nonlinearities using basis splines, where the number of basis functions/degrees of freedom was determined by minimizing AIC. We also introduce two three-way interactions: gender/age/ethnicity and gender/sleep/ethnicity. The regression formula is shown in the title of Figure 2 (page 4). In order to analyze the relationship between sleep and BMI, we consider three different categories of sleep: undersleep, ideal sleep, and oversleep. We determined these levels of sleep by labeling “ideal sleep” as the

average number of hours slept for the entire dataset (rounded up to the nearest integer), which resulted in eight hours of sleep. Since the distribution of sleep is symmetric about the mean, we take the lower and upper levels of sleep as two standard deviations away from the mean number of hours of sleep, in this case resulting in five and eleven hours of sleep respectively. See Figure 1.

FIGURE 1

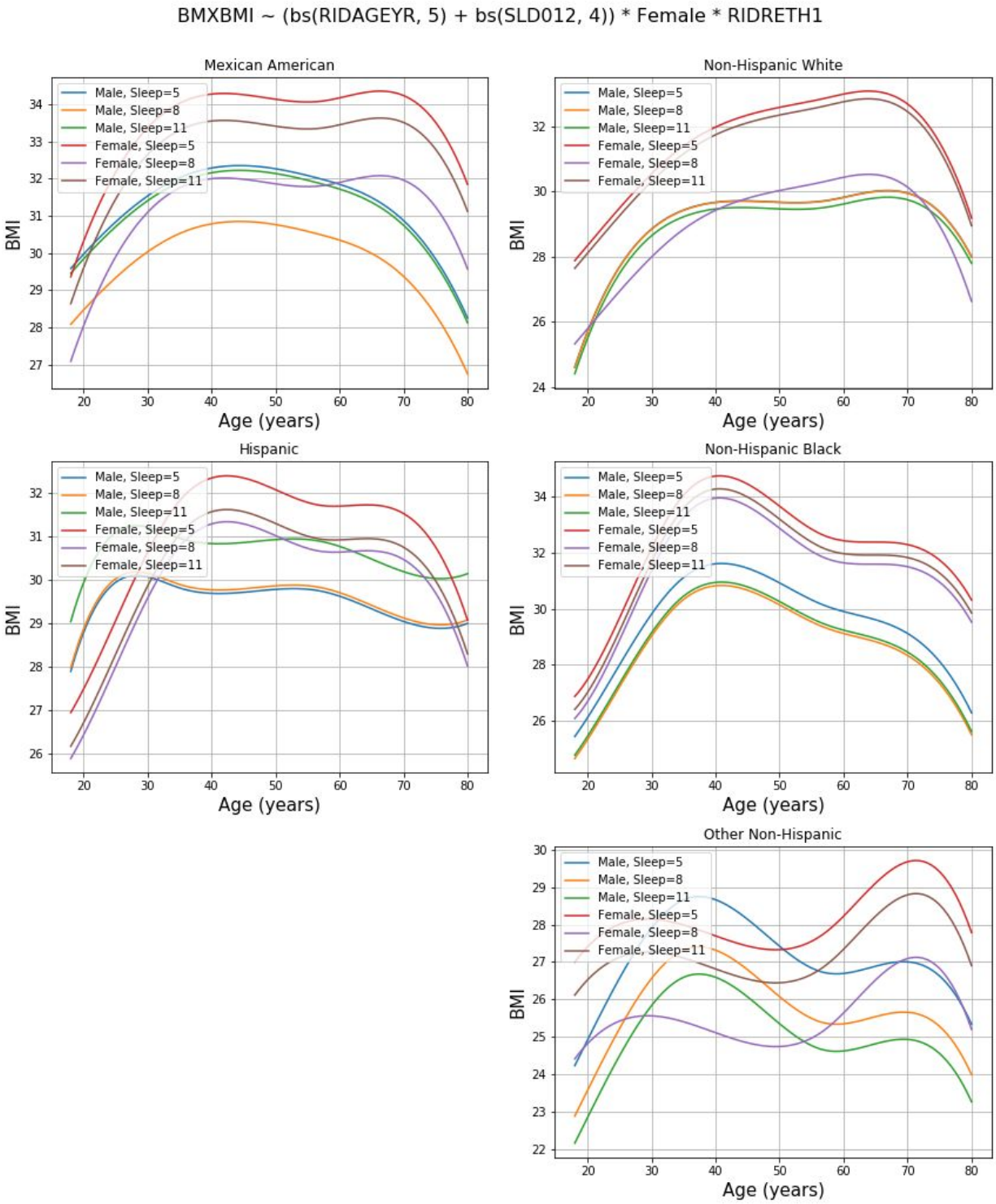


We isolate each ethnicity to assess the impact of predictors per ethnicity. We included the three-way interactions stated in the regression model due to our assumption that cultural factors contribute differently to disparities in BMI for each ethnic group. Indeed, according to our regression model, there is a unique story to tell about the differences in BMI for each ethnic group. Below we describe overarching relationships between predictors and BMI that tend to hold for all ethnicities (See Figure 2 on page 4):

- **Age effect:** BMI tends to be lower for adults younger than 30 and adults over 70. Average BMI remains higher and relatively constant for adults between 30 and 70.
- **Gender effect:** Women have higher mean BMI than men. In every ethnic group, women that sleep mpre tend have the highest BMI, followed by women that undersleep also having elevated BMI. An ideal amount of sleep corresponded to the lowest expected BMI for women. The same cannot be seen for men.
- **Sleep effect:** Undersleep or oversleep result in higher BMI versus having an adequate amount of sleep. This relationship holds mainly women, but not for men.

Next, we observe ethnicity-specific effects. Male BMI for Hispanics tends to remain constant over all ages, and for any sleep level, while female BMI follows the same age and sleep effects described above. The highese BMI for Non-Hispanic Blacks occurs at about 40 years of age. For Other Non-Hispanic men, BMI is generally higher than women before the age 50-60. Afterwards, women's BMI exceeds men's BMI. This example provides an exception to the gender effect. Thus having included the three-way interaction variables illustrate that relationships between BMI and its predictors vary by ethnicity and gender. In addition, we find support that adequate sleep leads to healthier levels of BMI.

FIGURE 2


BMXBMI ~ (bs(RIDAGEYR, 5) + bs(SLD012, 4)) * Female * RIDRETH1
Mexican American
Non-Hispanic White
Hispanic
Non-Hispanic Black
Other Non-Hispanic
Male, Sleep=5
Male, Sleep=8
Male, Sleep=11
Female, Sleep=5
Female, Sleep=8
Female, Sleep=11
BMI
Age (years)