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The Association of Body Mass Index with Emergency Department Resource Utilization

By

Mallika Manyapu
Masters in Public Health

Global Epidemiology

Signature:_______________________________________
Stephen R. Pitts MD, MPH
Committee Chair

Abstract Cover Page

The Association of Body Mass Index with Emergency Department Resource Utilization

By

Mallika Manyapu

Bachelor in Science
Emory University
2014

Faculty Thesis Advisor: Stephen Pitts MD, MPH

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Global Epidemiology
2019

Abstract

The Association of Body Mass Index with Emergency Department Resource Utilization
By Mallika Manyapu

Background:
Obesity is a growing epidemic in the United States with increasing burden to the health care system [1]. The management of obesity poses challenges to Emergency Departments (ED) [2]. While resources are being directed to the chronic treatment and management of the overweight and obese, little is known about the impact of overweight on clinical decision making for adult acute care.

Methods:
Clinical encounter data were obtained from the Grady Memorial Hospital data warehouse, including consecutive adult ED visits from Oct 31, 2010 to Feb 28, 2015. Personal identifiers (name, medical record number, and encounter number) were replaced by randomly assigned arbitrary numbers, separately for encounter number and medical record number. Information was collected on various aspects including but not limited to patient's age and sex, diagnoses, admission and disposition information, and weight and height. The outcome of interest was admission status, and the main exposure was body mass index (BMI), aggregated into 5 categories: underweight, normal, overweight, obese, and morbidly obese. Covariates chosen *a priori* included sex, age, ambulance arrival, triage acuity (using the Emergency Severity Index), and payer status. The study results were analyzed using SAS 9.4.

Results:
Participants categorized as underweight and morbidly obese had an increased risk of admission from the ED, after controlling for all covariates. The adjusted odds ratio for underweight was 2.012 (95% CI 1.914, 2.114) and for morbidly obese was 1.075 (95% CI 1.031, 1.121). There was significant interaction with sex and BMI, indicating obese or underweight males were more likely to be admitted as well. The adjusted odds ratio for underweight males was 2.12 (95% CI 2.03, 2.33) and for morbidly obese males was 1.37 (95% CI 1.28, 1.47). In contrast, the adjusted odds ratio for underweight females 1.82 (95% CI 1.69, 1.96) and morbidly obese females was 0.93 (95% CI 0.88, 0.98).

Conclusion:
Admission rates from the ED are higher for the lowest and highest BMI categories, and lowest for the overweight category, independent of sex, age, payer status, mode of arrival, and triage acuity.

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Emory Emergency Medicine Department

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Manuscript

Introduction: Background and Literature Review

Obesity is a growing epidemic in the United States with increasing burden to the health care system, with the management of obesity posing a unique challenge to healthcare facilities across the nation [1]. States of overweight and obesity are viewed as epidemiologic risk factors for higher healthcare cost and adverse outcomes in population-based studies [3]. In fact, multiple studies have shown that obesity is an independent risk factor for increased healthcare and economic utilization [3], [4]. While obesity is multifactorial, it is also potentially preventable [5]. Nevertheless, it still affects over a third of the world's population today [5], [6]. In the United States, projections indicate trends to over 85% of adults being overweight or obese by 2030 [4]. Resources are being directed to the treatment and management of the obese, but little research investigates the impact of body weight on medical decision-making and resource use, particularly in resource-intensive adult acute care settings. More information exists related to pediatric populations, with evidence indicating that higher BMI's suggest more frequent hospital visits, but not necessarily more frequent hospital admissions [2], [7]. Less evidence is present for adults with BMI and hospital admission, emergency department (ED) visits, or frequency of visits.

Body Mass Index (BMI) is defined as the person's weight in kilograms divided by the square of height in meters, and is usually an indicatory of level of body fat. It is often used as a screening tool for weight categories and related health problems but is not a diagnostic measure of the overall health of an individual (Centers for Disease Control). However, increasing BMI has a known association with decreasing health status and increasing primary care resource utilization and cost [3]. Higher BMI was also associated with worse outcomes in trauma patients [8], [9].

Underweight adults also have higher odds of hospitalization, ED visits and mortality. Low BMI is also associated with low nutritional status and adverse health outcomes such as sepsis, functional debility, and early death related to falls and fractures, and increased susceptibility to illness [10]. Particularly in older patients, both high BMI and low BMI are associated with adverse effects, albeit for potentially different reasons [1]. Within large populations, a “J curve” relationship has been observed for individuals with the highest and lowest BMIs who are at the greatest risk for mortality [11].

There are difficulties in accurately obtaining BMI, particularly in emergency rooms and especially in adult settings [12]. A multi-center study in the United States revealed that only 65.7% of patients were weighed within the first 36 hours of admission [13], [12]. This inaccurate weight recording could potentially lead to adverse outcomes such as incorrect medication dosages [13]. However, accurately measuring weight and height could also determine prognosis in admission, mortality, and morbidity rates within healthcare settings.

While weight is not always easily obtained in ED visits, evidence suggests that weight could be used as an indicator and predictor for ED resource utilization and admission [14]. BMI, both low and high, poses a unique challenge to acute care settings, but little research has been conducted eliciting the relationship of weight with acute care setting resource utilizations. The ED has become both the primary provider for acute outpatient care and for acute unscheduled care requiring hospitalization. Given the greater role of the ED in the management of acute illness, health proxies and policy-makers impacting hospitalization decision making will need to focus their attention on ED-based caregivers [15].

We hypothesize that an increased BMI is a risk factor for hospital admission and frequency of ED visits, independent of ambulance arrival, triage acuity, payer status, age, and sex.

Methods

Study Design:

In order to investigate the relationship between BMI and hospitalization, we undertook a cross-sectional study of all ED visits. The data used in this thesis were obtained from the Grady Memorial Hospital data warehouse for a prior Masters in Public Health (MPH) thesis, including all adult emergency room visits from October 31, 2010 to February 28, 2015. Personal identifiers such as name, medical record number, and encounter number, were replaced by randomly assigned arbitrary numbers, separately from encounter number and medical record number.

Setting:

Grady Memorial Hospital is the largest hospital in the state of Georgia with an ED volume of over 120,000 visits a year, and is the public hospital for the city of Atlanta. Grady's Emergency Department (ED) treats adult medical, surgical, and trauma patients and is one of only two level 1-trauma centers in Atlanta.

Data analyses:

The primary variable of interest was BMI, calculated as weight in kilograms divided by height in meters squared. The BMI was obtained from the electronic medical record. The BMI was categorized based upon Centers for Disease Control and World Health Organization criteria. We categorized patients with a BMI < 18.5 as underweight and the remaining BMIs as follows: 18.5–24.99 as normal weight; 25–30 as overweight; 30–40 as obese; and ≥40.0 as morbidly obese. Of the total participants of 493,460, observations without a known BMI were excluded resulting in total 171,903 observations used for all analyses (See Figure 1 for further illustration).

The goal of the analyses was to measure the probability of admission across BMI categories. These associations were examined using multivariable logistic regression models with covariates chosen *a priori*. The covariates included were age in years, gender, payer status, ambulance arrival, and acuity levels using the Emergency Severity Index (ESI). All of these variables were obtained from the EMR. Age was divided into four categories based off common age categories as follows: less than 14 years old, 15-24 years old, 25-64 years old, and above 65 years old. Payer status included Medicare, Medicaid, private insurance, uninsured and other/unknown. Mode of arrival was a binary variable defined as with ambulance or through other means (including walk-ins). Acuity was categorized with the ESI index which has 5 levels labeled resuscitation, emergent, urgent, less urgent, and non-urgent.

All models were examined for two-way interactions between BMI and each of the covariates in the model, with normal BMI as reference, and outcome as admission using individual logistic regression analyses. For all models including the fully adjusted model, "other/unknown" payer status, females, EMS category "other than ambulance", age category 25-64 years, ESI level 5 (non-urgent), and normal BMI category were used as references in the analyses. Multiple variables were analyzed for the presence of significant interaction (two sided p-value <0.05). The final fully adjusted model included all variables of interest found to be significant from individual analyses. These variables included payer status, sex, mode of arrival (EMS), age category, and ESI level. The results of each model were expressed as adjusted odds ratios (OR) and corresponding the 95% confidence intervals (CI). All data analyses were performed using SAS (SAS Institute Inc., Cary, NC).

Results

The study population was divided into five BMI categories of underweight, normal weight, overweight, obese, and morbidly obese. Survey participants that were categorized as underweight, obese, and morbidly obese had an increased risk of admission from the ED when controlling for sex, age, payer status, mode of arrival, and ESI level. Underweight patients had the highest likelihood of admission in the fully adjusted model. Table 1 shows the frequency distributions of all variables, including disposition, admission, sex, age category, mode of arrival (ambulance vs. other), payer status, and ESI level. Interactions were statistically significant for sex with underweight and overweight BMI categories, with p-values <0.05.

Adjusted Association with Payer Status

In the adjusted analysis, there was statistically significant overall association between an individual's payer status and their risk of admission ($p < 0.0001$). Of payer categories, Medicare had the highest risk of admission (OR 2.44, 95% CI 2.16, 2.74), while uninsured had the lowest (OR 1.20, 95% CI 1.07, 1.35). See Figure 2 for graphical illustration and Table 2 for the summary of these findings.

Adjusted Association with Mode of Arrival

In the adjusted analysis, there was statistically significant overall association between EMS and admission ($p < 0.0001$). Mode of arrival via EMS was OR 1.58 (95% CI 1.55, 1.62). See Figure 4 for graphical illustration. These findings are summarized in Table 2.

Adjusted Association with Age Category

However, in the adjusted analysis, there was not a statistically significant overall association between age category and admission. Results were as follows: children less than 14 years old OR 0.04 (95%, 0.036, 0.045); age group 15-24 years old OR 0.45 (95% 0.43, 0.47);

and age group above 65 years old OR 1.90 (95% CI 1.83, 1.96). See Figure 5 for graphical illustration. These findings are summarized in Table 2.

Adjusted Association with Acuity

In the adjusted analysis, there was statistically significant overall association between sex and admission ($p < 0.0001$). Results were as follows: resuscitation OR 147.5 (95% CI 126.0, 172.5); emergency OR 44.2 (95% CI 38.3, 50.9); urgent OR 20.9 (95% ci 18.2, 24.1); and less urgent OR 3.47 (95% CI 3.00, 4.02). See Figure 6 for graphical illustration. These findings are summarized in Table 2.

Adjusted Association with Sex

In the adjusted analysis, there was statistically significant overall association between sex and admission ($p < 0.0001$), with additional significant interaction. Males across all BMI categories had increased admission compared to females, especially underweight males (OR 2.12, 95% CI 2.03, 2.33) and morbidly obese (OR 1.37, 95% CI 1.28, 1.47). Other BMI categories were as follows: overweight (OR 0.87, 95% CI 0.85, 0.90), and obese (OR 0.94, 95% CI 0.90, 0.97). See Table 4 for the summary of these findings. Being male across all BMI categories also had an increased risk of admission (OR 1.24, 95% CI 1.21, 1.26). See Figure 3 for graphical illustration and Table 2 for the summary of these findings.

Multivariable Adjusted Association

For the multivariable adjusted model, all the above variables were included to adjust for all confounding variables. Controlling for all covariates, underweight had the highest risk of admission (OR 2.01, 95% CI 1.91, 2.11). Morbidly obese also had a significant increased risk of admission (OR 1.08, 95% CI 1.03, 1.12). Other BMI categories were as follows: overweight (OR

0.87, 95% CI 0.85, 0.89) and obese (OR 0.90, 95% CI 0.88, 0.92). These findings are summarized in Table 3.

Discussion: Summary, Public Health Implications, and Possible Future Directions

Summary:

In this cross-sectional study of 171,903 ED visits, our findings suggest that extremes of BMI are independent determinants of the hospital admission decision in emergency departments. After controlling for multiple confounding variables, our study illustrates that very low or very high BMI increases the odds of hospitalization, with underweight patients being admitted 2.01 more times and morbidly obese patients being admitted 1.08 more times than normal weight patients regardless of sex, age, acuity, mode of arrival, or payer status. While underweight status or morbidly obese status may have a lower prevalence, patients who fall into these categories are at a higher risk for hospitalization, but also may be amenable to intervention. In addition, there was significant interaction of gender admission. This may indicative of possible other variables at play that could affect the BMI-admission relationship.

The strengths of this analysis include a large dataset with many variables of interest for detailed analysis. The consistent findings across all analyses also add further strength to our hypothesis.

Public Health Implications:

Our study adds findings to previous research in adverse outcomes in underweight or obese patients. However, our study is unique in illustrating obese versus underweight and risk of admission from the emergency room. To our knowledge, no other studies have analyzed this relationship in the adult acute care setting. Both extremes, while individually researched, are not usually construed to have the same risks of admission. However, our study suggests that both patient groups are at risk for increased hospitalization. While these patient groups are at risk for different reasons, both groups clearly require attention, needs and added resources more than a normal BMI population.

Because much of the United States population uses emergency rooms as their first point of care, it is important to analyze the unique needs of particular patients [15]. Indeed, as our population veers towards overweight and obesity, this is a patient population with growing needs specifically within the ED ranging from added personnel to different beds to potentially decompensating quicker [3, 7]. In contrast, being underweight is probably an effect of morbidity rather than a cause or "risk factor". The illness itself may in turn lead to hospitalization [10]. Additionally, weight plays a role in our healthcare system since providers may require additional training, special equipment, social support, and additional public health education.

The interaction of sex and admission could be because of multiple reasons. Discrimination against gender, unconscious bias towards males as being unhealthier, or the known health differentials between males and females could explain why males were more likely to be admitted across all BMI levels as compared to females.

Limitations:

There are many limitations to this analysis. This model does not account for many other potentially important determinants of hospital admission, such as clinical findings and diagnostic category. This could alternately decrease or increase our impact depending, and may not be applicable to all BMI categories due to the complexity of clinical gestalt in an acute care setting. In addition, BMI has a large missing fraction, which may be related to patient mobility and other factors that may in turn be related to both BMI and hospital admission. Missing data would likely decrease the odds ratio for hospitalization, but would likely not have differed substantially across BMI groups. In addition, within our analysis, due to the multivariate approach, all interactions were not included in the final fully adjusted model. This, however, did not likely affect our outcomes drastically. Also, there is issue of data accuracy with the electronic health record, especially measurement accuracy such as weight or height, as EMR's are generally designed for billing rather than patient care. This could have reduced the potential impact of our findings, particularly in higher BMI groups. Lastly, there may be other factors that could serve as confounders that we did not take into account in our final model. This study was also conducted with data from a hospital population that is predominantly underserved, lower socioeconomic status, and thus many not be generalizable to all populations.

Future Directions:

Further studies should be conducted to further illustrate the role of BMI in acute care settings. Analyses that include variables like the frequency of ED visits, utilization of ED imaging and personnel, mortality/morbidity from the ED, and other factors, could illustrate the effect of BMI on the emergency room resource utilization.

Conclusion:

In conclusion, extreme BMI's, whether underweight or morbidly obese, have significant associations with hospital admission. Future policy and hospital decision-making should include the importance of BMI with hospital resource utilization, particularly in the emergency room.

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Tables

Table 1: Characteristics of Survey Participants

Admission	**Frequency**	**Percent (%)**
Not admitted (0)	417065	84.52
Admitted (1)	76395	15.48 9
Sex	**Frequency**	**Percent (%)**
Female (0)	212026	42.97
Male (1)	281434	57.03
BMI categories	**Frequency**	**Percent (%)**
Underweight, BMI ≤ 18.5 (1)	10425	3.32
Normal, BMI 18.5 –24.99 (2)	120036	38.22
Overweight, BMI 25 –29.99 (3)	93458	29.76
Obese, BMI 30 –39.99 (4)	70472	22.44
Morbidly obese, BMI ≥ 40 (5)	19679	6.27
Age categories	**Frequency**	**Percent (%)**
Age ≤ 14 years old (1)	88734	17.98
Age 15-24 years old (2)	50470	10.23
Age 25-64 years old (3)	314108	63.65
Age ≥ 65 years old (4)	40148	8.14
EMS	**Frequency**	**Percent (%)**
*Other** (1)*	335625	68.01
Ambulance (0)	157835	31.99
Payer status	**Frequency**	**Percent (%)**
Private (1)	44775	9.07
Medicare (2)	72334	14.66
Medicaid (3)	99120	20.09
Uninsured (4)	272955	55.31
Other (5)	4276	0.87
ESI (Acuity Level)***	**Frequency**	**Percent (%)**
Resuscitation (1)	4710	1.50
Emergency (2)	45372	14.45
Urgent (3)	164985	52.53
Less Urgent (4)	75805	24.14
Non - Urgent (5)	23198	7.39
Total participants	493460	-
Total participants with known BMI	171903	34.84

*AMA = Against medical advice
**Other includes walk in, within hospital transfer. Ambulance includes EMS via ambulance, helicopter, or outside hospital transfer.
*** ESI = Emergency Severity Index Triage

Table 2: Odds Ratio with Confidence Intervals for Each Individual Covariate

		Crude OR	Adjusted OR	95% CI for Adjusted OR	
BMI					
	Underweight	2.46	2.01	1.91,	2.11
	Normal	Referent	Referent	Referent	Referent
	Overweight	0.90	0.87	0.85,	0.89
	Obese	0.93	0.90	0.88,	0.92
	Morbidly Obese	1.17	1.08	1.03,	1.12
Pay Status					
	Private	1.62	1.44	1.28,	1.63
	Medicare	3.36	2.44	2.16,	2.74
	Medicaid	1.91	2.43	2.16,	2.74
	Uninsured	0.78	1.20	1.07,	1.35
	Other	Referent	Referent	Referent	Referent
EMS					
	Other	Referent	Referent	Referent	Referent
	Ambulance	3.54	1.58	1.55,	1.62
Sex					
	Female	Referent	Referent	Referent	Referent
	Male	1.11	1.24	1.21,	1.26
Age					
	Age ≤ 14 years old	0.02	0.04	0.036,	0.045
	Age 15-24 years old	0.48	0.45	0.43,	0.47
	Age 25-64 years old	Referent	Referent	Referent	Referent
	Age ≥ 65 years old	3.20	1.90	1.83,	1.96
ESI					
	Resuscitation	297.7	147.5	126.0,	172.5
	Emergency	86.9	44.2	38.3,	50.9
	Urgent	32.9	20.9	18.2,	24.1
	Less Urgent	4.01	3.47	3.00,	4.02
	Non - Urgent	Referent	Referent	Referent	Referent

Table 3: Odds Ratio with Confidence Intervals for Fully Adjusted Model for BMI

Model 6*	OR	95% CI
Underweight	2.01	1.91, 2.11
Overweight	0.87	0.85, 0.89
Obese	0.90	0.88, 0.92
Morbidly Obese	1.08	1.03, 1.12

Table 4: Odds Ratio with Confidence Intervals for Fully Adjusted Model w/ Sex as Effect Modifier

	Adjusted OR	95% CI	Adjusted OR	95% CI
	Females		***Males***	
Underweight	1.82	1.69, 1.96	2.12	2.03, 2.33
Normal weight	Referent	Referent	Referent	Referent
Overweight	0.86	0.83, 0.90	0.87	0.85, 0.90
Obese	0.85	0.81, 0.88	0.94	0.90, 0.97
Morbidly Obese	0.93	0.88, 0.98	1.37	1.28, 1.47

*Reference: normal BMI, other/unknown payer status, female sex, other mode of transportation, age category 25-64 yo, ESI 5 (non-urgent)

Figures/Figure Legends

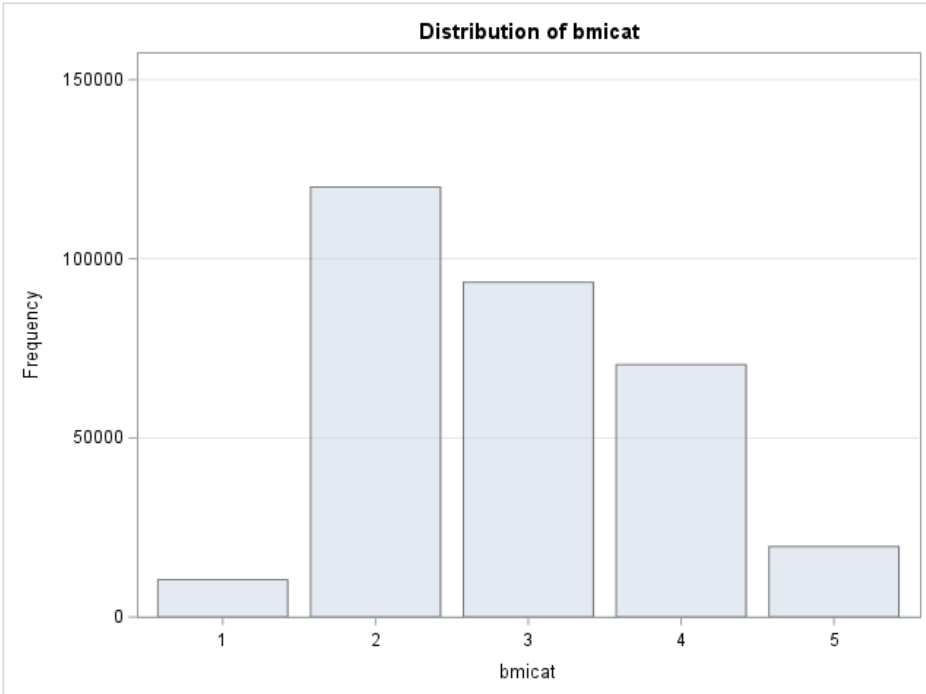

Figure 1: *Distribution of BMI by category (1 = underweight, 2 = normal, 3 = overweight, 4 = obese, 5 = morbidly obese)*

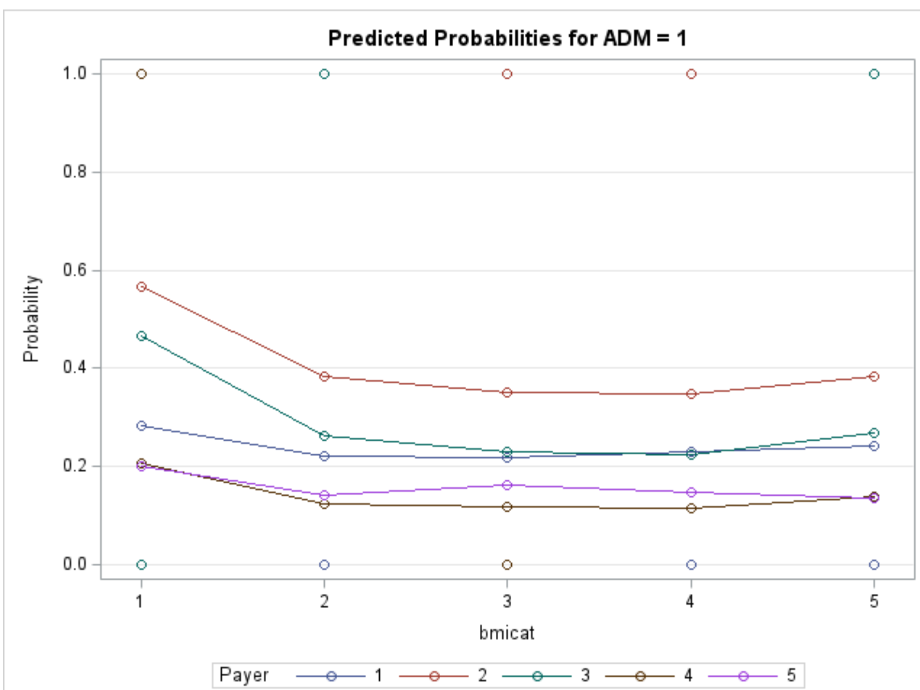

Figure 2: *Likelihood of Admission by BMI category and Payer Status (1 = underweight, 2 = normal, 3 = overweight, 4 = obese, 5 = morbidly obese) (Payer 1 = private, Payer 2 = Medicare, Payer 3 = Medicaid, Payer 4 = Uninsured, Payer 5 = Other)*

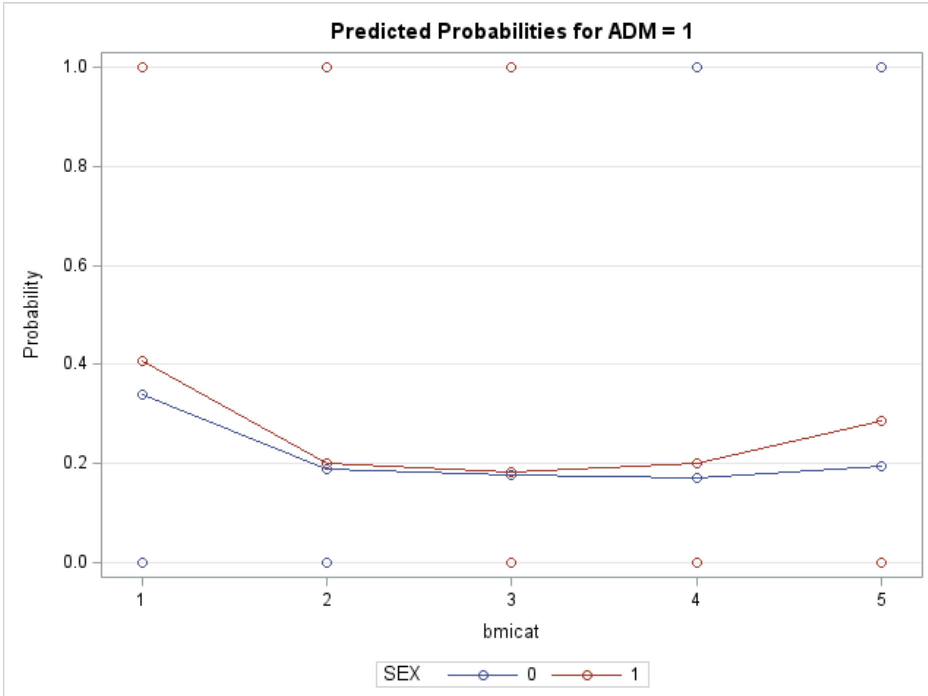

Figure 3: *Likelihood of Admission by BMI category and Sex (1 = underweight, 2 = normal, 3 = overweight, 4 = obese, 5 = morbidly obese) (sex 0 = female, sex 1 = male))*

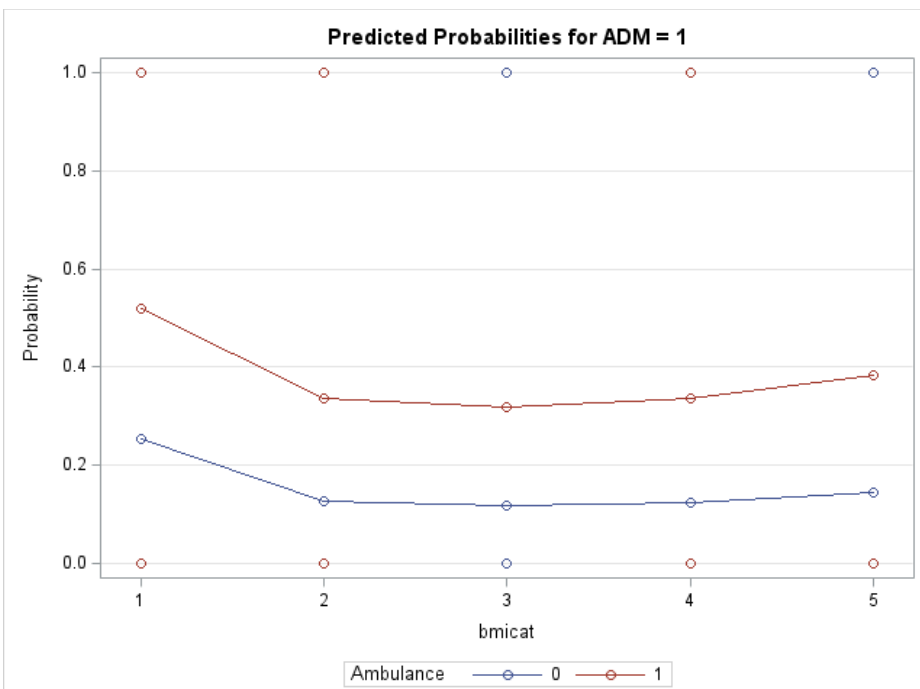

Figure 4: *Likelihood of Admission by BMI category and EMS arrival ((1 = underweight, 2 = normal, 3 = overweight, 4 = obese, 5 = morbidly obese) (Ambulance 0 = ambulance/EMS, Ambulance 1 = other mode of transportation))*

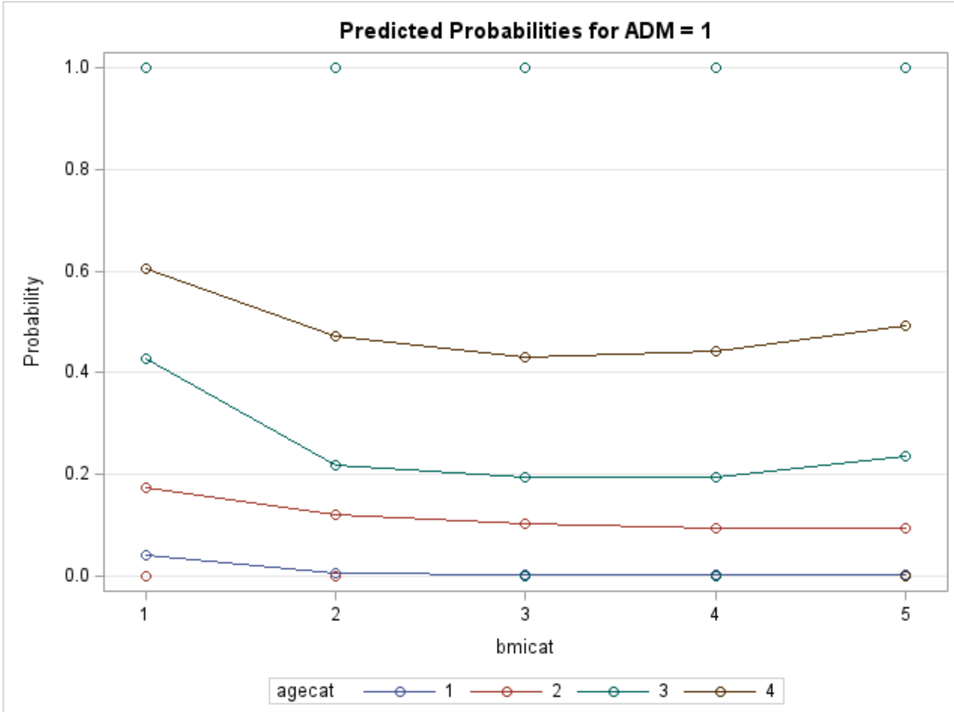

Figure 5: *Likelihood of Admission by BMI category and Age category ((1 = underweight, 2 = normal, 3 = overweight, 4 = obese, 5 = morbidly obese) (Age category 1, <14 years old, Age category 2, 14-24 years old, Age category 3, 25-64, Age category 4, >65 years old)*

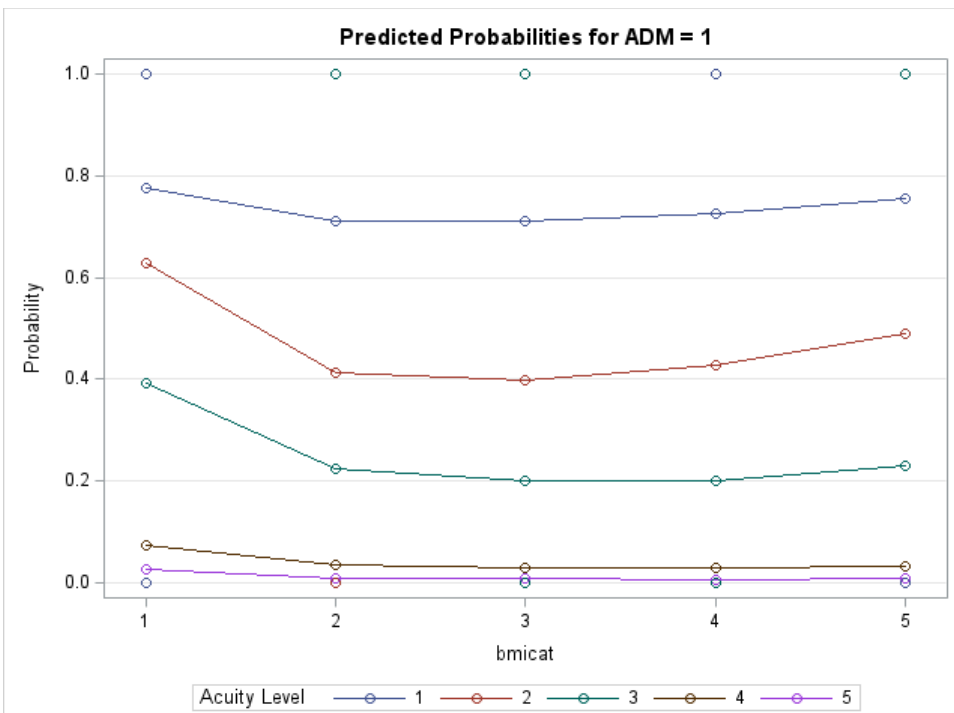

Figure 6: *Likelihood of Admission by BMI category and ESI category ((1 = underweight, 2 = normal, 3 = overweight, 4 = obese, 5 = morbidly obese) (ESI category 1 = Resuscitation, ESI category 2 = Emergency, ESI category 3 = Urgency, ESI category 4 = Less Urgency, ESI category 5 = Non-Urgent)*