Group 7 Final Report

Jessica Barry, Allison Goldbeck, Ziou Jiang, Mingming Pan, & Guy Thomas

Abstract

Suicide is the second leading cause of death for young adults aged 15-to-24-years old. To understand how living environment factors -- including age, health, and social support -- influence adolescents' suicidal ideation, we analyzed data from a longitudinal study by the National Longitudinal Study of Adolescent to Adult Health (ADD Health). A total of 6504 adolescent participants (3356 females and 3148 males) had been interviewed in all four waves spanning from 1997 to 2009. 1446 participants (29%) among 6504 participants had seriously thought about suicide in the past 12 months by the survey time. We determined the association between suicidal ideation and various factors, including age, sex, weight perception, and support system score. A GEE model was fitted to determine the difference in the effect of age on females and males. For males, the odds of suicidality has a 27% significantly less decrease for each additional standard deviation increase in age compared to females (95% CI: 16% to 39% less decrease, $P = 2.3*10^{-7}$). GLMM models were fitted to determine the effects of factors, including age, support score, and weight perception, on individual participants. The odds of suicidality for a given person significantly decrease by 31.4% (95% CI: 34.75% decrease to 27.88% decrease, $P < 2*10^{-16}$) for each additional standard deviation increase in age. The odds of suicidality for a given person significantly decrease by 20.5% (95% CI: 23.1% decrease to 17.8% decrease, $P<2*10^{-16}$) for each additional point increase in support score. After adjusting for age, more deviance from perceiving themselves as "normal weight" corresponds to more increase of odds of suicidality.

Introduction

The rate of suicide has increased in the most recent decades. Between 2007 and 2018, the rate of suicide among ages 10 to 24 increased by almost 60%[1]. Understanding the lives of those experiencing suicidal ideation may allow for targeted campaigns to support those individuals and reduce suicide rates. There may be many reasons why an adolescent or young adult may experience suicidal ideation. Weight and body image, particularly in a media culture rife with idealized and unattainable beauty standards, may harm an individual's self-esteem or personal value. This may lead to harmful thoughts and mental health outcomes, including suicidal ideation. Additionally, support systems, either at home, school, or work, can influence an individual's feelings and how they deal with personal struggles. Social support and interactions can shape how an individual handles problems and guide constructive or destructive mental health patterns.

We propose that suicidal ideation is influenced by several factors throughout people's lives, including age, health, and social support. We aim to analyze how suicidal ideation changes directly with age. We also want to understand how perceived health (as defined by weight) and support systems (as defined by a range of covariates linked to family and friend relationships) influence suicidality. To analyze this outcome through data collected via the National Longitudinal Study of Adolescent to Adult Health (ADD Health). This project started in 1994 as a comprehensive, longitudinal survey of adolescents that followed them into adulthood, with five waves of survey data. To answer our relevant research questions and accommodate data limitations, we will build a total of four models. Three models will include various covariates that were collected across all four survey waves over time, while the other will include covariates only collected earlier in life in the first two waves. All models will seek to explore factors that influence suicidal ideation.

The following research questions will be explored through the model building process, using data from waves 1-4 and waves 1-2:

For Waves 1-4 (ages 11-34):

1. Does suicidal ideation change as subjects age?
2. Does suicidal ideation change differently for males as they age than for females?
3. Does suicidal ideation change on self-perceived weight?

For Waves 1-2 (ages 11-22):

4. For young individuals, does suicidal ideation change based on the level of support system they have, where support system is defined by perceived attention from family, frequency of lying to family, perceived caring from friends, frequency of talking to friends, and frequency of helping friends fight against others?

METHODS

Study Setting

This project used the data from a longitudinal study by The National Longitudinal Study of Adolescent to Adult Health (Add Health). The study includes over 20,000 adolescents who were in grades 7-12 during the 1994-95 school year and have been followed for four waves: Waves I & II, 1994–1996; Wave III, 2001–2002; Wave IV, 2007-2009. 6504 participants (3356 females and 3148 males) were included in the

1 Curtin, SC. State Suicide Rates Among Adolescents and Young Adults Aged 10–24: United States, 2000–2018. National Vital Statistics Report. 11 Sept 2020.

study. These individuals met the inclusion criteria of being interviewed in all four waves of interest. None were excluded.

Measures

Demographic measures included sex and age. Survey questions covering the content of interest to the study were selected to form factor parameters. The main binary outcome of suicidality was indicated with whether the participant has seriously thought about committing suicide during the past 12 months. Weight perception, indicating how participants thought of themselves in terms of weight, was included as a factor variable with five levels. To define how participants were supported by their living environment, a support score was defined by the level of attention received from family, frequency of lying to family, level of caring perceived from friends, frequency of talking to friends, and fight frequency. Smaller support scores correspond to worse support systems.

Statistical Analysis

We used two bar plots to illustrate the percent of total frequency for dichotomous suicidality responses, categorized by survey wave and the distribution of age recorded for participants, grouped by dichotomous suicidality responses, respectively (Figures 1 & 2). To understand the impact of age, weight perception, and support score, separately, on individual participants, three different Generalized Linear Mixed Models (GLMM) as the binomial family with a logit link to assess the association between various factors and suicidality. The first GLMM model included age as the only fixed effect and both random intercepts and slope at the individual level (Table 2). Age was rescaled by subtracting its mean and divided by its standard deviation to handle fitting issues. All models used scaled age to maintain consistency. The second GLMM model included the weight perception and age as fixed effects and random intercepts at the individual level (Table 4). Weight perception at the normal level was set as the reference. The third GLMM model included the support score and age as fixed effects and random intercepts at the individual level (Table 5). We subtracted five from the total support score to set the reference level as 0. To understand the impact of age on females and males, we fit a Generalized Effects Equation (GEE) model for the binomial family with a logit link to assess the association between gender and suicidality adjusting for scaled age – the only deviation from our statistical analysis plan (Table 3). All tables were first generated in R and formatted in Microsoft Word for readability and clarity.

For the GEE model, the main working correlation structure used was the independent structure. We fitted models with exchangeable and unstructured working correlation structures to perform the sensitivity analysis. For GLMM models with continuous fixed effects variables, age, and support score, we fitted models with random intercept and corresponding reduced models without random intercept. We used the conservative ANOVA method to test the feasibility of including a random intercept. For the GLMM model, first, we tested if the categorical weight variable was significant. Then after determining the statistical significance of the weight variable we utilized a likelihood ratio test to compare the full and reduced models before testing the significance of each level of the weight variable. Missing data were handled through multiple imputations. Data analyses were performed with the use of R, version 4.0.1, and SAS OnDemand for Academics, version 9.4. All analyses used a significance level of 0.05.

RESULTS

Baseline Characteristics

All participants in the published dataset were retained for analysis purposes. Table 1 provides the frequency of each predictor during the baseline, when they took the first survey, and stratified into two groups according to the outcome of suicidality. If a person ever considered to commit suicide in any of the four surveys, it is stratified to "ever experiencing suicidality" column. Out of 6504 participants, 1446(29%) participants had considered committing suicide at some point of time, so the number of people for each covariate are different between the two stratified group. Information from table 1 showed the largest proportion of participants were females experiencing suicidality (60%). The majority of participants perceived themselves to be at about the right weight and they did not experience suicidality (55%), felt that their family paid quite a bit attention to them and did not experience suicidality (42%), never lied to their parents or guardians in the past 12 months and did not experience suicidality (51%), felt that their friends cared about them very much and did not experience suicidality (44%), and just hung out or talked with their friends 5 or more times in the past week and experienced suicidality (43%). Figure 1 showed the highest percent of total frequency of suicidality occurred in Wave 1, and the frequency had a decreasing trend in time. Figure 2 illustrated that most participants were aged 17. It also showed that the highest incidence of suicidality occurred at ages 14 to 18.

Effect of Age on Suicidal Ideation

Table 2 showed the result of the fixed effect of the GLMM model for suicidal ideation on age, which addressed the research question "Does suicidal ideation change as subjects get older?" As a result, we found that the odds of suicidality for an average person at the average age of 21 years old is 0.047 (95% CI: 0.043 to 0.053, $P < 2*10^{-16}$). In addition, for a given person, the odds of suicidality significantly decreases by 31.4% (95% CI: 34.8% decrease to 27.9% decrease, $P < 2*10^{-16}$) for each additional standard deviation (5.8 years) increase in age. In addition, when testing the statistical significance of the random intercept in this GLMM model, we found that the random intercept was highly statistically significant with a p-value of $4.5 * 10^{-118}$ and that there could be large between-individual variation. Therefore, a random intercept that could capture individual effects should be retained in the model.

Effect of Age and Gender on Suicidal Ideation

Table 3 shows the results of the GEE model for suicidal ideation on gender in addition to age, which addressed the question, "Does suicidal ideation change differently for males as they age than for females?" Biological sex and the interaction between biological sex and scaled age were added to the previous model on the relationship between suicidality and age. The inclusion of this interaction allowed us to test for effect modification of gender on age: a highly significant interaction term between biological sex and age indicated that the trend of suicidality change on age is significantly different between males and females. Specifically, the odds of suicidal ideation for males has a 27% significantly less decrease for each additional standard deviation increase in age compared to females (95% CI: 16% to 39% less decrease, $P = 2.3*10^{-7}$). Comparing males and females of average age, the odds of suicidality is 25.5%, significantly lower for males than that for females (95% CI: 32.7% to 17.4% lower, $P = 1.9*10^{-8}$). Specifically for females, the odds of suicidality is 0.109 (95% CI: 0.102 to 0.117, $P < 2*10^{-16}$) at the

average age of 21 years old, and their odds then significantly decreased by 34.1% for each additional standard deviation increase in age (95% CI: 38% to 29.9% decrease, $P<2*10^{-16}$). In addition, for males at the population average age of 21 years old, their odds of having suicidal ideation is 0.082, and their odds decrease by 16.4% for each additional standard deviation increase of age. To conclude, we found that the decline in suicidal ideation when people age is significant regardless of gender, and the magnitude of decreasing is also significantly different between genders.

Effect of Weight on Suicidal Ideation Adjusted for Age

The third research question we tried to answer was "Does suicidal ideation change on the self-perceived level of weights after adjusting for age?" Weight perception is split into 5 levels and the reference level for weight is the "normal weight" level. The results of the fixed effect of the GLMM model we fitted to address this research question were shown in Table 4. By performing a likelihood ratio test between the model with and without the weight covariate, we found a common p-value less than $2*16^{-16}$ for all levels of weight as a whole indicated that the categorical weight covariates were highly significant overall, and therefore the significant weight effect was worth analyzing. For the possible confounder of age, we again found a significant decrease in suicidality as people age, for a given person adjusted for self-perceived weight levels, and the odds of suicidality at the average age of 21 for an average person perceiving themselves as "normal weight" is 0.04 (95% CI: 0.035 to 0.045, $P <2*10^{-16}$).

Results for weight perception levels showed that after adjusting for age, the odds of suicidality for a given person perceiving himself/herself as "very underweight" is 166.5% (95% CI: 85.7% to 282.5% higher, $P =1*10^{-7}$) significantly higher compared to a given person perceiving themselves as "normal weight", and there was no significant difference in odds of suicidality between a given person perceiving himself as slightly underweight and a given person who perceived himself as normal weight after adjusting for age. On the other hand, for people who perceived themselves as overweight, the odds of suicidality adjusted for age for a given person perceived themselves as "slightly overweight" was found to be 38% significantly higher (95% CI: 23% to 55% higher, $P=3.8*10^{-8}$) compared to that of a given person perceived himself as "normal weight", and the odds of suicidality adjusted for age for a given person perceived himself as "very overweight" was again found to be 105% significantly higher (95% CI: 68% to 151% higher, $P=1.3*10^{-12}$) compared to the age-adjusted odds of suicidality for a given person who perceived himself as "normal weight". In conclusion, after adjusting for age, more deviance from perceiving themselves as "normal weight" corresponds to more increase of odds of suicidality. In addition to modeling, we also tested for the significance of including a random intercept. A p-value of $1.2*10^{-109}$ strongly suggested that a random intercept should be retained in the model to account for the large between-subject variation.

Effect of Support System on Suicidal Ideation Adjusted for Age

Table 5 shows the results of a GLMM fixed effects model for suicidal ideation on support system adjusted for age. Addressing the last research question using this model, we wanted to analyze whether individuals with stronger support systems (as defined by perceived more attention from family, low frequency of lying to family, perceived more caring from friends, high frequency of talking to friends, and high frequency of fighting with friends against others) experience different suicidal ideation than

individuals with less robust support systems after adjusting for age. From the results, the odds of suicidality for an average person at average age with an adjusted support score of 0 is 0.671 (95% CI: 0.474, 0.951, P=0.025). The odds of suicidality for a given person significantly decrease by 20.5% (95% CI: 23.1% decrease to 17.8% decrease, $P<2*10^{-16}$) for each additional point increase in support score after adjusting for age. However, a notable result from this table was that the effect of age on suicidality was no longer significant after adjusting for support system scores, with a p-value of 0.890. In conclusion, an increase in support score corresponds to a significant decrease in odds of suicidality, while age no longer has a significant effect on odds of suicidality.

Sensitivity Analyses

For the GEE model we fitted to assess the effect of age and gender and its interaction on suicidal ideation, two additional models were fitted using different correlation structures to test whether our finding was robust. The table of the full detailed model results can be found in Table F and G in the Appendix. Table 7 shows the comparison between the resulting odds ratio and its 95% confidence interval among three different working correlations: independent, exchangeable, and unstructured. In all model fits, the results were highly statistically significant. Looking at Table 7, it was clear that the estimates calculated using the different working correlation structures resulted in estimates that are extremely similar to one another. This met our expectations since the GEE model uses the sandwich variance estimator.

Discussion

In conclusion, our project assessed some factors and tested whether people's odds of thinking about committing suicide would change when these factors change. For all factors we chose to assess, age, gender, weight (measured by self-perceived levels), and support system, we found significant differences in suicidal ideation for most of them. For the first two research questions, we tested whether suicidality would significantly change when people age and whether that change was different between biological sex. The results showed that there was a significant effect of age on suicidality, where suicidality significantly decreased as people grew older, and this effect was also significantly different for different genders. Namely, the females experienced a larger decline in the trend of decreasing suicidality over time (grow in age) compared to males. In addition, we also found that males at the average age of 21 have significantly lower odds of suicidal ideation than females at that average age. A possible explanation could be that females tend to be more emotional and sensitive than males, so it might be easier for females to have an idea on suiciding if they were suffering from something, but that thought may be temporary, as they may forget about if something good happened in their lives. This might explain why females have higher odds than males but also have a faster decrease in odds as they age when compared to males.

Considering the third research question and its corresponding results, more deviance from perceiving themselves as "normal weight" corresponds to an increase in odds of suicidality. The most drastic finding is that the odds of suicidality significantly increased by 167% for a given person of average age who perceives themselves as "very underweight" compared to a given person of average age who

perceives themselves as “normal weight.” Media messaging designed to target adolescents, as well as the body dysmorphia and mental health issues that follow are one hypothesized rationale behind the increased odds in suicidality as weight perception deviates further from “normal weight.” The singular instance lacking statistical significance lies within the odds of suicidality for a given person of average age perceiving themselves as “slightly underweight” compared to a given person of average age perceiving themselves as “normal weight.” This is hypothesized to be both because the perception was not far from normal weight perception, and there is likely less societal stigma around being slightly underweight versus being very underweight, slightly overweight, or very overweight.

Considering the last research question, again, we found a significant decreasing trend of odds of suicidality when the level of support system people has increased. However, it's important to note that even though the scaled age covariate was found to be significant in all first three models, it was no longer significant – with a p-value greater than 0.05 – in the last GLMM model where we assessed the change of suicidality on support system and had scaled age as a potential confounder to adjust for. One hypothesis is that as people increase in age their support system also increases through developing their own family or learning to cope with supporting themselves. From this, the effect of the support system score outweighed the impact of age on suicidality, and therefore scaled age was no longer significant when modeled together with the support system.

While many of our models are interpretable and provide unique insight into suicidal ideation, it’s important to keep in mind some of the limitations of our analyses. First, there was a relatively low frequency of suicidal ideation in each wave of survey data (Figure 1) and there were a limited number of models we could fit. Many models that we thought could be valuable and interesting encountered fitting issues. As a result, the number of covariates we included in each model was pretty small. Additionally, we did not weigh our data with the survey weights provided by the ADD health team. Potentially, some survey participants could share some characteristics more in common than others. Both of these make our model potentially less generalizable, as we cannot properly conclude our findings extend to the population of interest, namely adolescents and young adults in the US. Finally, our support score system is a novel method for assessing the degree of social support and would require validation before publishing this analysis.

For future directions of research, it would be useful to add additional parameters to the support score to increase the variable’s illustration of support level for a participant. Along with this, designing a new or different method for representing support to analyze the effects that support systems have on suicidality is another option. It would also be beneficial to use these results for further model-building; such as adding one’s socioeconomic status as a potential confounder or adding weight perception to the final model. After testing these new potential predictors/confounders testing further interactions between these variables would also be advantageous.

Figures and Tables

Table 1 summarizes the values for the covariates of interest retained for analysis for each participant at baseline, along with relevant keywords used throughout the statistical analysis plan to describe the covariate.

Table 1: Predictors and outcomes of interest stratified by all-time suicidality			
Parameter		**Participants Experiencing Suicidality** n=1446 (29%)	**Participants Never Experiencing Suicidality** n=5058 (71%)
Sex	*Female*	874 (60%)	2482 (49%)
	Male	572 (40%)	2576 (51%)
Age Median (range)		14.9 (12,20)	15.1 (11,20)
How do you think of yourself in terms of weight?	*Very overweight*	92 (6.4%)	146 (2.9%)
	Slightly overweight	504 (35%)	1304 (26%)
	About the right weight	607 (42%)	2774 (55%)
	Slightly underweight	201 (14%)	734 (15%)
	Very underweight	41 (2.9%)	86 (1.7%)
	Unknown	0	14
How much do you feel that your family pays attention to you?	*Very much*	275 (19%)	1702 (34%)
	Quite a bit	501 (35%)	2116 (42%)
	Somewhat	456 (32%)	950 (19%)
	Very little	178 (12%)	198 (3.9%)
	Not at all	32 (2.2%)	59 (1.2%)
	Unknown	4	31
During the past twelve months, how often did you lie to your parents or guardians?	*1 to 2 times*	436 (30%)	1445 (29%)
	3 to 4 times	196 (14%)	451 (9%)
	5 or more times	286 (20%)	541 (11%)
	Never	517 (36%)	2570 (51%)
	Unknown	11	51
How much do you feel that your friends care about you?	*Very much*	571 (40%)	2214 (44%)
	Quite a bit	593 (41%)	2103 (42%)
	Somewhat	231 (16%)	586 (12%)
	Very little	34 (2.4%)	97 (1.9%)
	Not at all	13 (0.9%)	29 (0.6%)
	Unknown	5	29
During the past week, how many times did you just hang out or talk with friends?	*1 to 2 times*	332 (23%)	1183 (23%)
	3 to 4 times	343 (24%)	1410 (28%)
	5 or more times	625 (43%)	1970 (39%)
	Not at all	146 (10%)	489 (9.7%)
	Unknown	0	6
In the past 12 months, how often did you take part in a fight where a group of your friends was against another group?	*1 or 2 times*	267 (19%)	689 (14%)
	3 or 4 times	57 (4%)	92 (1.8%)
	5 or more times	46 (3.2%)	82 (1.6%)
	Never	1067 (74%)	4152 (83%)
	Unknown	0	0
Support Score Median (range)		14.9 (7-21)	15.7 (8-22)

Figure 1 illustrates the percent of total frequency for suicidality response of “Yes”, categorized by each time or survey wave.

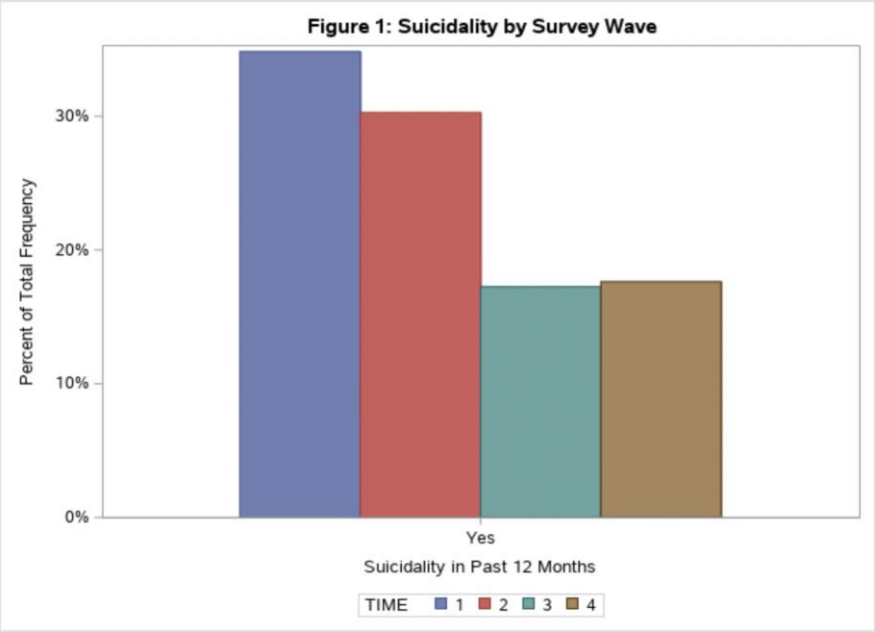

Figure 2 expresses the distribution of age recorded for participants, grouped by dichotomous suicidality responses.

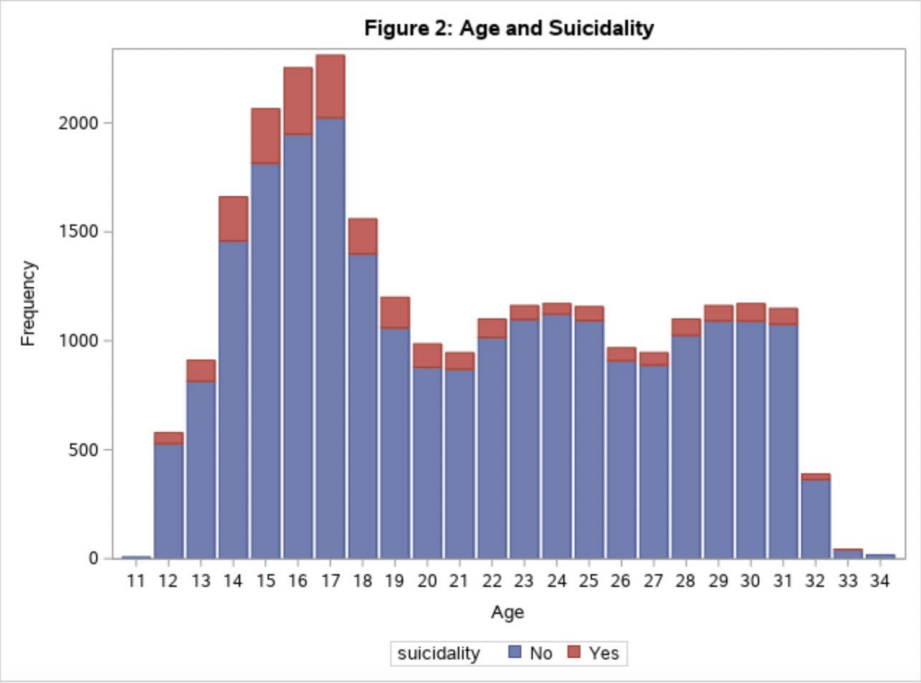

Table 2: Fixed Effect of GLMM Model for Suicidal Ideation on Age[1]					
Coefficients	**Estimate**	**95% CI of Estimate**	**Odds Ratio**	**95% CI of Odds Ratio**	**P-Value**
β_0 (Intercept)	-3.048	(-3.150 , -2.946)	0.047	(0.043 , 0.053)	$< 2*10^{-16}$
β_1 (Scaled Age)	-0.377	(-0.427 , -0.327)	0.686	(0.652 , 0.721)	$< 2*10^{-16}$

[1]The GLMM model contains a random intercept, and uses Binomial distribution with logit link.

Table 3: GEE Model for Suicidal Ideation on Age and Sex[1]					
Coefficients	**Estimate**	**95% CI of Estimate**	**Odds Ratio**	**95% CI of Odds Ratio**	**P-Value**
β_0 (Intercept)	-2.213	(-2.281 , -2.144)	0.109	(0.102 , 0.117)	$< 2*10^{-16}$
β_1 (Biological Sex, Female as reference)	-0.294	(-0.396 , -0.191)	0.745	(0.673 , 0.826)	$1.9*10^{-8}$
β_2 (Scaled Age)	-0.417	(-0.478 , -0.355)	0.659	(0.620 , 0.701)	$< 2*10^{-16}$
β_3 (Interaction between Sex and Scaled Age)	0.238	(0.148 , 0.328)	1.269	(1.160 , 1.389)	$2.3*10^{-7}$

[1]The GEE model uses a Binomial distribution with logit link and an independent working correlation structure.

Table 4: Fixed Effect of GLMM Model for Suicidal Ideation on Weight Adjusted for Age[1]						
Coefficients	**Estimate**	**95% CI of Estimate**	**Odds Ratio**	**95% CI of Odds Ratio**	**P-Value for Weight as a Whole**	**P-Value**
β_0 (Intercept)	-3.222	(-3.339 , -3.105)	0.040	(0.035 , 0.045)		$< 2*10^{-16}$
β_1 (Very underweight)	0.980	(0.619 , 1.342)	2.665	(1.857 , 3.825)	$2.33 * 10^{-16}$	$1*10^{-7}$
β_2 (Slightly underweight)	0.116	(-0.048 , 0.28)	1.123	(0.953 , 1.323)	$2.33 * 10^{-16}$	0.17
β_3(Slightly overweight)	0.325	(0.209 , 0.441)	1.384	(1.233 , 1.554)	$2.33 * 10^{-16}$	$3.8*10^{-8}$
β_4 (Very overweight)	0.720	(0.521 , 0.919)	2.055	(1.684 , 2.507)	$2.33 * 10^{-16}$	$1.3*10^{-12}$
β_5 (Scaled age)	-0.417	(-0.469 , -0.365)	0.659	(0.626 , 0.694)		$< 2*10^{-16}$

[1]The GLMM model contains a random intercept, and uses Binomial distribution with logit link.

Table 5: Fixed Effect of GLMM Model for Suicidal Ideation on Support System Adjusted for Age[1]					
Coefficients	**Estimate**	**95% CI of Estimate**	**Odds Ratio**	**95% CI of Odds Ratio**	**P-Value**
β_0 (Intercept)	-0.399	(-0.748 , -0.051)	0.671	(0.474 , 0.951)	0.025
β_1 (Support)	-0.229	(-0.262 , -0.196)	0.795	(0.769 , 0.822)	$< 2*10^{-16}$
β_2 (Scaled Age)	-0.005	(-0.077 , 0.067)	0.995	(0.926 , 1.069)	0.89

[1]The GLMM model contains a random intercept, and uses Binomial distribution with logit link.

Table 6: Comparing GEE Models for Suicidal Ideation on Age and Sex with 3 Different Correlation Structures[1]

Coefficients	Independent		Exchangeable		Unstructured	
	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI
β_0 (Intercept)	0.109	(0.102 , 0.117)	0.109	(0.102 , 0.117)	0.108	(0.101 , 0.116)
β_1 (Biological Sex, Female as reference)	0.745	(0.673 , 0.826)	0.747	(0.674 , 0.827)	0.748	(0.675 , 0.828)
β_2 (Scaled Age)	0.659	(0.620 , 0.701)	0.653	(0.614 , 0.694)	0.655	(0.616 , 0.697)
β_3 (Interaction between Sex and Scaled Age)	1.269	(1.160 , 1.389)	1.265	(1.155 , 1.385)	1.257	(1.147 , 1.377)

[1]All three GEE models use Binomial distribution with logit link.