

Applying a classification and regression tree approach to identify individual, socioenvironmental, and psychological interactions associated with suicidal ideation among Latinx adolescents

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Abstract

Introduction: The present study sought to uncover previously unknown interactions stemming from individual, socioenvironmental, and psychological factors associated with suicidal ideation among Latinx adolescents using a classification and regression tree (CART) modeling approach.

Methods: This cross-sectional study included national data from a sample of 656 Latinx adolescents who participated in the 2018 National Survey on Drug Use and Health. Self-report data was collected on suicidal ideation, individual, socioenvironmental, and psychological factors.

Results: CART identified several interactions that classified Latinx adolescents as endorsing suicidal ideation. The first split identified parental monitoring as a significant predictor of suicidal ideation, successfully classifying over 50% of the sample (n = 360). The ensuing interaction occurred between lower parental monitoring and depression symptoms, followed by increased parental monitoring and BMI. Other interactions included sex, self-rated health, household size, and peer relationships. CART results suggest that BMI was the most influential variable associated with suicidal ideation, followed by self-rated health and parental monitoring.

Conclusion: Since suicidal thoughts and behaviors are malleable, utilizing an individual, socioenvironmental, and psychological framework would continue to provide comprehensive approaches to identifying data-driven interactions between risk and protective factors that may lessen the heightened risk of suicidal ideation among Latinx adolescents.

KEY WORDS: Adolescents; data analytics; Hispanic Americans; suicide, suicidal ideation.

INTRODUCTION

The problem of suicidality among Latinx adolescents continues to be a significant health concern. Although the rates of death by suicide are lower among Latinx adolescents than that of non-Hispanic Whites, Latinx adolescents are more likely to attempt suicide [1]. In 2019, a higher proportion of Latinx adolescents (8.9%) reported attempting suicide compared to non-Hispanic whites (7.9%) [1]. Other aspects of the suicide continuum have also amplified over time for this population. Suicide planning increased from 12.8% in 2007 to 13.5% in 2017 for Latinx adolescents, while suicide attempts increased from 15.9% in 2007 to 16.4% in 2017 [2].

Suicidal ideation, one facet of suicidality, also continues to be disproportionately higher among Latinx adolescents. Almost one in five Latinx adolescents reported experiencing suicidal ideations [1]. Suicidal ideation should be taken seriously because it is a significant risk factor and the first step towards a potential suicide attempt [3–5]. Although not all

adolescent suicide attempts are preceded by suicidal ideation, suicidal ideation has been shown to pave the way for a suicide attempt [6, 7]. Thus, suicide has become one of the greatest threats to the well-being of Latinx adolescents, an ethnic group that now comprises 23% of the total U.S. population under the age of 18 [8, 9].

Despite the need for suicide prevention and intervention, the literature on suicide among Latinx adolescents remains relatively sparse [10]. At its onset, early research focused on establishing the epidemiology of suicidal behaviors within the Latinx adolescent population. Once this occurred and the research progressed, scholars began to shift their attention towards prevention and intervention strategies. Specifically, researchers began to identify risk and protective factors that could be utilized in a practice setting. Since then, scholars have encouraged frameworks exploring individual, socioenvironmental, and psychological factors that shape suicidality among Latinx adolescents. However, the na-

TAKE-HOME MESSAGE

There exists a need for suicidality scholars to use data-driven approaches that utilize existing data to unearth interactions not previously known. As demonstrated by this study, such data-driven approaches, such as CART, can identify the co-occurrence of risk and protectors that successfully classify suicidal ideation among Latinx adolescents.

Competing interests - none declared.

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ture of their interaction with one another is less clear [11].

To date, commonly cited individual factors associated with suicidal ideation among Latinx adolescents include age, body mass index (BMI), household size, income, poverty, and sex. Research shows that late-stage adolescents (16-18 years of age) have higher notions of suicidal ideation than early adolescents (13-15 years of age) [1, 7, 12, 13]. Much of the empirical evidence shows that Latinx females endorse suicidal ideation much more than Latinx males [2, 14-16]. Latinx females also have some of the highest levels of suicidal ideation relative to other racial and ethnic groups [17]. Several studies showed that being overweight or obese is associated with suicidal ideation [18-20]. Amiri and Behnezhad's (2018) meta-analysis suggests that obese or overweight adolescents are 1.2 to 1.5 times more likely to experience suicidal ideation than their peers [21]. Empirical evidence also indicates that broader socioeconomic contextual factors are adversely associated with suicidal ideation. Cross-sectional and longitudinal study findings repeatedly indicate that lower household income is significantly associated with increased suicidal ideation among adolescents and Latinx individuals [22-25]. A study using national data showed that living in a socioeconomically disadvantaged community was positively related to suicidal ideation for Latinx and non-Latinx adolescents [26]. When research examines household size, empirical evidence suggests an inverse relationship between household size and suicidal ideation [27, 28].

In terms of socioenvironmental factors, several studies suggest that vulnerability factors such as lacking parental monitoring, peer substance use, fighting in school, and population density were significantly associated with suicidal ideation. Several studies point towards the school environment's influence on multiple adolescent outcomes. A meta-analysis examining the last 50 years of research on suicidal thoughts and behaviors revealed that the school context was one of the most salient predictors of suicidality [6]. Peer rela-

tionships and crowd affiliations during adolescence, whether positive or negative, can be a discrete risk domain due to early reliance on peers, not parents, as attachment figures [29]. Several studies have documented that deviant peer affiliation was significantly associated with suicidal ideation, particularly among Mexican American adolescents [31-34]. Another aspect of peer relationships at school centers on violence and suicidal ideation. Adolescents who reported getting into physical fights have also reported suicidal ideation [17, 35].

Existing research also shows that the act of parental monitoring is a significant socialization agent conveying values and beliefs that ultimately shape adolescent behaviors [35]. Research findings indicate that Latinx adolescents who lack parental monitoring are at a higher risk of suicidal ideation [15, 24]. Geographic location is also considered a risk factor for suicidal behaviors as suicide is highest in rural areas [36]. Over the past decades, the Latinx population in U.S. rural areas has seen tremendous growth [8]. Despite this growth, few studies use a Latinx sample of non-metropolitan regions. Much of the research suggests that suicidal ideation among this population has no statistically significant relationship to population density or urban-versus-rural residency [23]. However, other studies show that youth in more densely populated areas (i.e., urban areas) have higher rates of nonfatal suicide attempts than youth who live in rural areas [37, 38].

In terms of psychological factors, depression symptoms, self-rated health, and feelings about school are demonstrated predictors of suicidal ideation [39-41]. Depression symptoms are one of the most robust predictors for Latinx and non-Latinx youth alike [6]. A systematic review revealed that several studies of Peruvian adolescents had noted a significant association between poor or fair self-rated health and suicidal ideation [17, 41]. Also, endorsing more negative attitudes towards attending school has been shown to increase the odds of suicidal ideation [42].

A knowledge gap in suicidality literature on

Latinx adolescents is understanding what risk factors co-occur and elevate the likelihood for suicidal ideation. Moreover, there is a need for data-driven approaches that utilize existing data to unearth such instances of co-occurrence. Using a classification and regression tree (CART) data analysis approach can overcome the limitations of conventional linear regression techniques, which cannot identify significant co-occurring risk patterns [43, 44]. Such a data-driven approach is beneficial because it can screen large numbers of variables to uncover unspecified interactions. These interactions offer explainable, accurate, and meaningful predictions associated with suicidal ideation. Thus, this study used the CART approach to identify which individual, socioenvironmental, and psychological factors co-occur and more accurately classify patterns of suicidal ideation among Latinx adolescents. Such analysis is necessary given that suicidal ideation disproportionately burdens Latinx adolescents. To reduce this ethnic disparity, researchers should continue identifying precipitating attributes that contribute to increased suicidality risk. Such knowledge is essential to better understand the etiology of suicidality among Latinx adolescents and advance risk assessment within this high-risk population.

METHODS

Data source and sample

The data used in this cross-sectional study was extracted from the 2018 National Survey on Drug Use and Health (NSDUH) dataset, which provides annual estimates of the percentage of the U.S. civilian population that use drugs, alcohol, and tobacco. The NSDUH is a 50-state design that uses independent stratified, multistage, area probability samples from each state to generate findings that are deemed representative of the national population. The NSDUH dataset is compiled through anonymous surveys performed via a computer-assisted interview module [45]. All methods implemented in investigations with human participants were in accord with

the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all participants. Approval for this secondary data analysis was obtained from the Institutional Review Board of the first author's home institution. The sample in the current study consisted of 656 self-identified Latinx adolescents who were aged between 12 and 17 years old.

Study variables

The dependent variable was categorized as 'suicidal ideation', which was asked with a single item: "When problems were at their worst, did you think about killing yourself?" The response categories of this item are '1' (yes) and '2' (no).

The following independent variables were selected to identify the patterns of suicidal ideation among adolescents: age, gender, population density, family income, poverty, overall health, household size, fighting at school, feeling about school, BMI, depression symptoms, parental monitoring, and peer substance use. For age, there were six response options (coded as: 12-13 years old = 1, 14-15 years old = 2, and 16-17 years old = 3). The response categories for gender included male (coded as 1) and female (coded as 2). The population density was operationalized using three categories (coded as: segment not in a core-based statistical area or CBSA = 1, segment in a CBSA with fewer than 1 million persons = 2, and segment in a CBSA with 1 million or more persons = 3). Family annual income was assessed with a single item with four response categories (coded as: less than \$20,000 = 1, \$20,000-\$49,999 = 2, \$50,000-\$74,999 = 3, and \$75,000 or more = 4). Poverty was also measured with a single item with three response categories (coded as: living in poverty = 1, income up to 2x the federal poverty level = 2, and income more than 2 times the federal poverty level = 3). Overall health status was operationalized with five response categories ranging from poor (coded as 5) to excellent (coded as 1). Household size was measured

based on five categories (2 people = 1, 3 people = 2, 4 people = 3, 5 people = 4, and 6 or more people = 5). The response option for fighting at school/work was a dichotomous variable: no (coded as 0) and yes (coded as 1). The question of “how you feel overall about going to school in the past 12 months” was labeled as “Feeling about school.” The variable has four response categories (I hate going to school = 1, I don’t like going to school very much = 2, I kind of like going to school = 3, and I like going to school a lot = 4). BMI was a continuous variable. Youth were instructed to report their weight in pounds and their height in feet. BMI was calculated using a youth’s self-reported weight and dividing it by height squared, then multiplied by a conversion factor of 703. Depression symptoms (Ever depressed in the past) were assessed with an item, “Ever had several days where you felt sad/empty/depressed.” Responses consist of two categories: 1 = yes and 2 = no. Parental monitoring was measured with five items: (1) parents check if you’ve done homework past 12 months; (2) parents helped you with homework past 12 months; (3) parents made you do work/chores past 12 months; (4) parents limited your amount of TV time past 12 months; and (5) = parents limited your timeout with friends past 12 months. Responses were measured based on four categories, with 1 = always, 2 = sometimes, 3 = seldom, and 4 = never. We used composite score after reversing score. The total possible scores ranged from 5 to 20, with higher scores indicating higher levels of parental monitoring. Cronbach’s alpha of these five items is .84. Lastly, four questions were asked to assess peer substance use: (1) “how many students you know in grade smoke cigarettes”; (2) “how many students you know in grade use marijuana”; (3) “how many students you know in grade drink alcohol; and (4) “how many students you know get drunk weekly.” Respondents answered using a 4-point Likert scale with 1 representing “none of them” and 4 denoting “all of them” with each statement. The composite score was used in the analysis. Cronbach’s alpha of these four items is .87.

Data analysis

Descriptive statistics were used to analyze the variables used in the analysis and establish sociodemographic characteristics of the study sample. The chi-square test and t-test were used to assess bivariate associations among selected variables. There was minimal missing data present; missing data for the dependent variable suicidal ideation was roughly 0.08%. Thus, pairwise deletion was used to address missing data. The principal analysis consisted of computing a CART analysis, a nonparametric technique for splitting Latinx adolescents based on responses to the suicidal ideation variable [46, 47]. CART analyses have become popular in multiple fields of study given their flexibility in data levels of measurement and their interpretability [48]. However, unlike typical regression models, decision trees divide data to reveal interactions between suicidal ideation and the independent variables [49]. Trees are hierarchical classifiers that can calculate group membership by recursively subdividing a data set into more homogeneous subgroups. This procedure is continued until a perfect tree is formed with all pure terminal nodes or preset conditions are met to terminate the tree’s growth. The assessment commences by pinpointing the most salient independent variable by which the participants will be split into two clusters, by means of preset branching condition. Nodes are then split based on their pureness using the Gini impurity function [46]. Pure nodes have no fluidity, whereas fully “impure” nodes hold a limited expectation [50]. A branching standard decides on the divergence that shows the greatest change amongst the impurity of the parent and the two child nodes [46]. We used the Gini impurity option to split the nodes because suicidal ideation was a binary measure, replicating the procedure with all subsamples until the subsample arrives at the smallest size or no other separations could occur. In general, the predictive ability of the data mining model is evaluated by its misclassification rates, which can be obtained from a cross-validation technique. The present study

used ten-fold cross-validation to estimate the actual misclassification rate. More specifically, the data were divided into ten groups. Nine groups were used for training (constructing) the model in each of the ten iterations, and the remaining group was used for testing the newly developed model. This process was replicated nine instances with alteration of testing groups to obtain the misclassification rate of each testing set. The final classification results from the ten different testing groups were then averaged to obtain the cross-validation error rates of the decision tree model. The analysis was computed using 2020 Salford System's CART software (<https://www.salford-systems.com/>).

Ethical aspects

Informed consent was obtained from all participants. Approval for this secondary data analysis was obtained from the Institutional Review Board of the first author's home institution. All relevant ethical guidelines were followed in the primary data collection.

RESULTS

Descriptive and bivariate results

Of the 656 respondents with reported responses, 54.9% ($n = 360$) reported suicidal ideation. As described in Table 1, the results from the chi-square tests showed that there were statistically significant differences in suicidal ideation by gender ($\chi^2 = 7.56, P < .01$) and fighting at school/work ($\chi^2 = 6.27, P < .01$). Female adolescents were more likely to have suicidal ideation than male adolescents. Specifically, 74.7% of females ($n = 269$) and 25.3% of males ($n = 91$) reported suicidal ideation. Adolescents who had the experience of fighting at school/work were less likely to have suicidal ideation than those who did not have the experience. Approximately 24% of the adolescents ($n = 87$) who had the experience of fighting at school/work reported they had suicidal ideation compared to 76% of those ($n = 272$) who did not have the experience. Approximately 99% of the participants ($n =$

356) who had several days where they felt sad/empty/depressed in the past were more likely to have suicidal ideation than 1.1% of those who did not have the experience ($n = 4$). As described in Table 1, the results from the independent samples t-tests also showed significant mean differences in depression symptoms ($t = 9.04, P < .01$), BMI ($t = -2.09, P < .05$), and parental monitoring ($t = 3.67, P < .001$) between those adolescents with and without suicidal ideation. Adolescents who experienced suicidal ideation reported higher BMI levels ($M = 25.56$) than those who had never experienced suicidal ideation ($M = 24.48$). In addition, adolescents who experienced suicidal ideation showed lower levels of parental monitoring ($M = 13.55$) compared to those who had never experienced suicidal ideation ($M = 14.44$).

Regression tree results

The CART model for recognizing factors significantly associated with suicidal ideation among Latinx adolescents (12-17 years old) is shown in Figure 1. The algorithm builds a tree model by splitting the independent variable space into regions with similar response variables. The final regions are specified by the terminal nodes of the tree. Each node of the tree specifies conditions that split an existing region. The top-most rectangle in Figure 1 is referred to as the 'root node', which represents 100% of the participants who marked '1' for yes or '2' for no, of which 54.9% ($n = 360$) of Latinx adolescents reported "has suicidal ideation." Among the sample, 45.1% ($n = 298$) met criteria for 'no suicidal ideation'.

The first split of the entire sample ($n = 656$, 1 = has suicidal ideation [54.9%] and 2 = had no suicidal ideation [45.1%]) was based on respondents' perceived parental monitoring. Latinx adolescents with lower than a score of 11.50 on perceived parental monitoring branched leftward ($n = 126$) and downward to a terminal node (no further splitting/classification possible) where 68.3% of 126 Latinx youth ($n = 86$) expressed suicidal ideation and reported depression symptoms. These results indicate an interaction between lower perceived paren-

Table 1. Chi-Square and Independent Samples t-test for Independent Variables ($n = 656$).

Variables	Suicidal Ideation		χ^2 or t
	No (n = 296)	Yes (n = 360)	
	% (n)	% (n)	
Age			
12-13 years old	16.6 (49)	20.3 (73)	1.63
14-15 years old	38.2 (113)	37.8 (136)	
16-17 years old	45.3 (134)	41.9 (151)	
Gender			
Male	35.1 (104)	25.3 (91)	7.56**
Female	64.9 (192)	74.7 (269)	
Population density			
Segment not in a CBSA	51.0 (151)	46.7 (168)	1.91
Segment in a CBSA with fewer than 1 million	46.3 (137)	49.2 (177)	
Segment in a CBSA with 1 million or more persons	2.7 (8)	4.2 (15)	
Family Income			
Less than \$20,000	15.9 (47)	18.9 (68)	1.32
\$20,000 - \$49,999	40.9 (121)	39.7 (143)	
\$50,000 - \$74,999	16.9 (50)	17.5 (63)	
\$75,000 or more	26.4 (78)	23.9 (86)	
Poverty			
Living in poverty	27.0 (80)	29.4 (106)	1.10
Income up to 2x federal poverty Threshold	33.1 (98)	29.4 (106)	
Income more than 2x federal poverty Threshold	39.9 (118)	41.1 (148)	
Overall Health			
Excellent	21.6 (64)	21.1 (76)	5.82
Very Good	41.6 (123)	37.2 (134)	
Good	28.7 (85)	30.0 (108)	
Fair	8.1 (24)	10.3 (37)	
Poor	0.0 (0)	1.4 (5)	
Household size			
2 people in household	4.1 (12)	5.3 (19)	2.05
3 people in household	20.6 (61)	20.8 (75)	
4 people in household	29.4 (116)	32.2 (116)	
5 people in household	23.6 (70)	23.1 (83)	
6 or more people in household	22.3 (66)	18.6 (67)	
Fighting at school/work			
One or more	16.3 (48)	24.2 (87)	6.27**
None	83.7 (247)	75.8 (272)	
Feeling about going to school			
Liked a lot/Kind of Liked	74.1 (212)	62.1 (215)	10.27**
Didn't like very much/Hated	25.9 (74)	37.9 (131)	
Ever depressed in the past			
No	5.1 (15)	94.9 (281)	9.04**
Yes	1.1 (4)	98.9 (356)	
BMI	24.48 (6.09)	25.56 (6.45)	-2.09*
Parental monitoring	14.44 (2.93)	13.55 (3.08)	3.67***
Peer substance use	8.60 (2.22)	8.77 (2.36)	-0.88

Note. CBSA: A core-based statistical area. BMI: Body Mass Index. * $P < .05$, ** $P < 0.01$, *** $P < 0.001$.

tal monitoring and experiencing depression symptoms. More specifically, having experienced depression symptoms were significantly associated with suicidal ideation for the Latinx adolescents who report lower levels of parental monitoring (< 11.50). The second split shows

that, for Latinx adolescents who report levels of parental monitoring of higher than 11.50 ($n = 530$), they moved rightward and downward to a child node (further splitting/classification possible), where 51.7% of 530 ($n = 274$) expressed suicidal ideation corresponding to BMI.

This result indicates an interaction between increased levels of parental monitoring and a reported BMI score of 23.18 or lower.

The next split was done based on BMI among those with higher than 11.50 parental monitoring. Respondents with a BMI lower than 23.18 branched leftward ($n = 240$) to a child node associated with the sex variable. More specifically, Latinx females, 54.2% ($n = 130$) of the 240 respondents who had BMI scores lower than 23.18 did not report suicidal ideation. All Latinx adolescents who had BMI scores higher than 23.18 branched rightward ($n = 290$) to a child node, which was another level of BMI (lower than 39.71). The results suggest that suicidal ideation was present for Latinx adolescents with a BMI score of lower than 39.71 (56.6% [$n = 164$]) but higher than 23.18. Figure 1 also shows that sex and overall health were significant predictors of suicidal ideation among participants who had a score higher than 11.50 of parental monitoring with lower than 23.18 of BMI (leftward nodes). An interaction exists among adolescents who experienced suicidal ideation and reported parental monitoring levels above 11.50, a BMI score of lower than 23.18, who identified as Latinx females, and who were in fair or poor health. Other results indicate that household size, age, peer substance use, overall health, and other levels of BMI (39.71, 34.33, 32.65, and 31.84) are significant predictors of suicidal ideation among participants who reported higher than 11.50 of parental monitoring and a BMI of higher than 23.18 (rightward nodes). This corresponds to interactions of household size, age, peer substance use, and other specific levels of BMI (23.33, 34.33, 32.65, and 31.84). Interactions for suicidal ideation were also found among Latinx adolescents who reported a BMI score of lower than 39.71 and 34.57 but higher than 23.18 who reported a household size of three people. Another interaction of suicidal ideation was found among Latinx adolescents with a BMI score higher than 23.18, but lower than 34.33, 32.65, 31.84; these were younger adolescents (12-15 years old) who have fewer friends who engage in substance use.

Results indicate that the highest prediction accuracy was achieved in suicidal ideation (54.88%), followed by no suicidal ideation (45.12%). For variable selection, CART provides 'variable importance scores'. The variable that receives a score of 100 indicates the most influential independent variable associated with suicidal ideation, followed by other variables based on their relative importance. Based on the variable importance scores, BMI was the most prominent variable (100%), followed by overall health (55.80%), parental monitoring (37.13%), peer substance use (27.32%), gender (23.36%), population density (14.84%), household size (13.80%), age (12.11%), fighting at school/work (12.07%), and depression symptoms (8.77%).

DISCUSSION

Using an individual, socioenvironmental, and psychological framework, the present study addresses the knowledge gap associated with suicidal ideation among Latinx adolescents using CART to identify the co-occurrence of multiple risk factors. For Latinx adolescents who endorsed suicidal ideation, the CART model identified eight influencing factors (BMI, overall health, parental monitoring, peer substance use, gender, household size, age, and depression symptoms) on an 11-stage tree for suicidal ideation. BMI (variable importance score = 100%) was the most influential factor for predicting suicidal ideation among Latinx adolescents. Consistent with existing studies, the adolescents with higher BMI scores had a higher chance of having suicidal ideation than participants with lower BMI [19-21]. Being overweight and obese among adolescents are public health priorities, given that its high prevalence is related to negative physical and psychosocial consequences. This finding has to be of concern given that Latinx adolescents are more likely to be overweight and obese than all other racial/ethnic groups in the U.S. and exceed the target values established in the Healthy People 2020 goals [51, 52]. Also, it is well established that adolescents who are obese experience more relational peer victimization than their

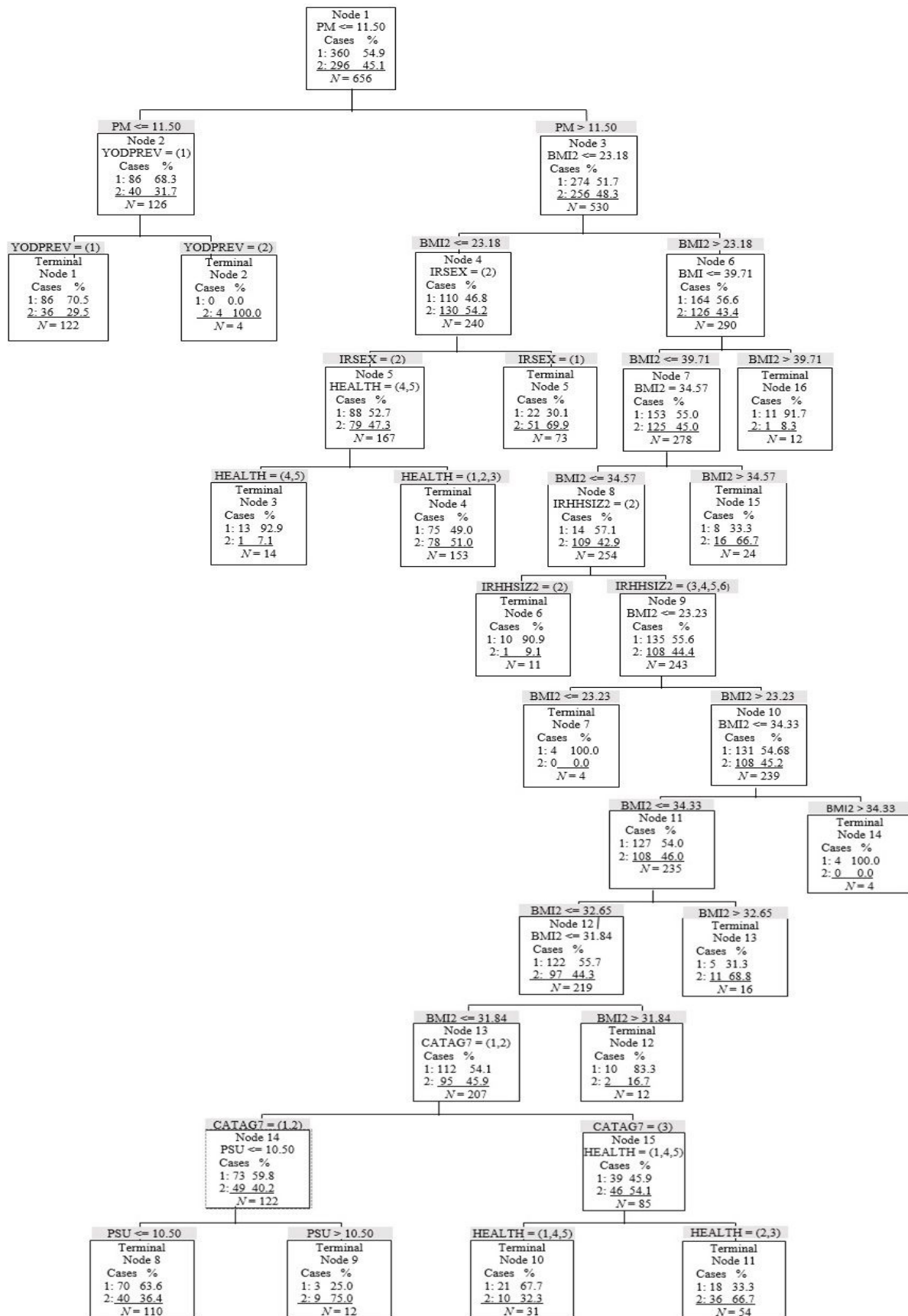


Figure 1. Classification and regression tree of suicidal ideation among Latinx adolescents.

Note: PM = Parenting monitoring. YODPERV = Ever had several days when felt sad/empty/depressed. Health = Overall health. IRHHSIZ2 = The number of persons in household. PSU = Peer substance use.

average-weight peers [53], which is a known risk factor for suicidal ideation and attempt. In the current study, BMI was a key variable among the students with a parental monitoring level higher than 11.5 in predicting suicidal ideation. For this group, BMI played an essential role in identifying mutually exclusive and exhaustive subgroups of the participants whose members share similar characteristics that could affect suicidal ideation. This result also indicates that only depression symptoms were significant for suicidal ideation for the group who received less parental monitoring (< 11.50). In other words, depression symptoms were a significant risk factor only for the students with less parental monitoring but not an important factor for the adolescents who were raised with more parental monitoring. Thus, among Latinx adolescents who receive less parental monitoring, more attention should be given to those who have depressive symptoms. One interesting finding in Figure 1 is that there are eight BMI internal nodes, nodes 4, 6, 7, 8, 10, 11, 12, and 13 ('internal node' is a node that has a parent node and gives two children nodes). Additionally, there was not much difference in the cut-off values among the BMI nodes. For example, the difference in cut-off values between the consecutive node 12 (32.33) and 13 (31.84) is only 0.81. Also, when the cut-off values increased by a unit of 0.81 from BMI node 13 to 12, the possibility of having suicidal ideation was increased by 1.6%. This result emphasizes that even a slight change in BMI could make a meaningful variation in suicidal ideation. Thus, we assume that BMI was the most critical and sensitive factor in predicting suicidal ideation among Latinx adolescents in the model.

When computing tree results to find interaction patterns, the results indicate that lower levels of parental monitoring and experiencing depressive symptoms were risk factors that were significantly associated with suicidal ideation among Latinx adolescents. This finding is consistent with numerous studies highlighting these relationships [39–41, 54], especially since family is the first and last

line of defense within the Latinx community in terms of helping adolescents cope with suicidal thoughts [55]. By engaging in parental monitoring practices, parent(s) can respond and appropriately redirect anti-social behaviors that emerge during this challenging developmental stage [56]. However, when parental monitoring is low, it may leave Latinx adolescents without a sense of belonging, particularly when concurrently experiencing symptoms of depression. This finding is concerning given that experiencing depression symptoms peaks during adolescence, a stage of development when many adolescents struggle to maintain a strong relationship with their parents [57].

For the respondents who perceived receiving higher levels of parental monitoring (> 11.50), sex, household size, age, peer substance use, and overall health were significant factors for predicting suicidal ideation. In comparison to Latinx males, Latinx females showed higher chances of having suicidal ideation. This finding is compatible with a previous study that showed higher suicidal ideation among Latinx females than Latinx males [2]. Concerning household size, adolescents who live with fewer family members showed an increased level of suicidal ideation. This result is also in line with the current studies suggesting an inverse relationship between household size and suicidal ideation [27, 28]. The findings indicate that an interaction exists between having higher perceptions of parental monitoring, lower levels of BMI, identifying as a Latina, having poorer health perceptions, and endorsing suicidal ideation. This interaction underscores that even when their home life appears to be stable based, Latinx females perceived higher levels of parental monitoring, suicidal ideation can also be present in their lives. This result is consistent with existing research suggesting that for Latinx females who have attempted suicide, excessive forms of parental involvement, such as micromanagement, invasion of privacy, dictating whom they engage with in terms of romantic relationships, can be detrimental [58].

There were several unexpected results. A ne-

gative association was found between age and suicidal ideation (see nodes 14 and 15), indicating that younger adolescents reported higher levels of suicidal ideation. This result contradicts other nationwide data and research suggesting that suicidal ideation is higher among older Latinx adolescents [12, 13]. One study did reveal that as adolescents age, they are less likely to report suicidal ideation [59]. This finding could imply that early-stage adolescents experience a psychological vulnerability that places them at elevated risk of psychological distress, such as suicidal ideation. However, they may not yet know how to cope with or process such adverse cognitive thoughts because they are younger [3]. It is also plausible that they may not feel comfortable asking for help when they experience psychological distress, which may not be accurate for late-stage adolescents. The current study also showed that suicidal ideation was higher among adolescents who had fewer peers using substances (see nodes 8 and 9). This finding is inconsistent with existing research suggesting that having more deviant peer affiliations was a significant predictor of suicidality among adolescents [33]. These two unexpected results could stem from the fact that age and peer substance use were significant predictors specifically for respondents whose BMI levels were between 31.84 and 32.65, meaning it may not be generalizable to all the Latinx respondents.

The results also indicate that overall health showed a mixed finding in nodes 10 and 11. The CART algorithm divided participants who answered response categories 2 and 3 in one group and 1, 4, and 5 in the other group. These unexpected results may stem from the limited number of cases tested in the CART model that might have yielded biased results. For example, only 12 cases tested in node nine might not be enough to generate an unbiased and accurate prediction. In addition, population density and fighting at school/work were also significant factors but were omitted from Figure 1 because of the low variable importance scores, 4.84% and 12.07%, respectively. As shown in Table 1 and Figure 1, no signi-

ficant effects of family income, poverty, and school feelings predicted suicidal ideation. This finding contradicts existing research that showed a significant association between suicidal ideation and household income [22, 25], living in a socioeconomically disadvantaged community [26], and school satisfaction [60]. The current study used a single item asking family annual income and poverty level based on the federal poverty threshold to measure family income and poverty level. It is plausible that using a debt-to-income ratio, which compares how much individuals owe to how much they earn, instead of family income or poverty level, could be a more practical and accurate measure to assess financial status. Also, a single item was used to measure feeling about school. Asking overall feelings about going to school by using four response categories from 1 (I don't like going to school very much) to 4 (I like going to school a lot) may not be specific or sensitive enough to examine diverse aspects of school adaptation (i.e., school satisfaction, relationship with teachers or peers, and academic stress). It is recommended that future research use more comprehensive and accurate measurements to deal with this potential weakness of this study.

Study limitations

This study has limitations that should be recognized. First, this study used cross-sectional data, precluding us from making any causal inferences among study variables. Future research should utilize longitudinal data to explore the temporal ordering among the study variables. Second, self-report instruments used in the current study may have an issue with identifying objective accuracy. Utilizing diverse assessment methods such as using multiple informants should be carried out in future studies to address potential response bias. Third, suicidal ideation was measured by a single item, which may not sensitively capture the constructs of interest. Future studies can benefit from using well-validated multi-item measures [61, 62]. Related, we only examined one aspect of the suicidality spectrum. The

results would likely differ if we had analyzed suicide planning, active suicide intensity and frequency, and suicide attempt. Fourth, time may also limit this study. Assessing suicidal ideation and depression symptoms with an “ever” measure instead of a more recent time frame may introduce recall bias. Fifth, the Latinx community is not a monolithic group, and there are noted cultural and socioeconomic differences within the various subgroups [63]. Cultural attitudes and practices related to suicidal thoughts and behaviors may differ between Mexican youth and youth of Puerto Rican ancestry. However, such differences will go unobserved because all Latinx subgroups were pooled in the analysis. Lastly, although we used an actual BMI value to assess participants’ BMI, it is recommended that future studies test BMI percentiles. Because weight and height may significantly change during adolescence, their BMI results must be interpreted relative to other adolescents of the same sex and age [64]. For this reason, future studies should include BMI-for-age weight status and the corresponding percentile categories: underweight (< 5%), normal (5-84%), overweight (85-94%), and obese (> 95%), which are the most used indicators to measure the size and growth patterns of adolescents in the U.S. [64]. In addition, future researchers might want to examine body image in conjunction with BMI. If BMI is an objective measure of weight to height ratio, body image is a subjective mental image of one’s body. Perceived weight is equally or more important for predicting suicidal behaviors than BMI; thus, comparing the effects of body image and BMI on suicidal ideation could be meaningful to explore [65, 66].

Conclusion and implications for policymakers

The present study adds more support to prior findings of suicidal ideation among Latinx adolescents and extends the existing literature by identifying individual, socioenvironmental, and psychological co-occurring risk factors that predict suicidal ideation using the CART modeling approach. This research

has practical implications and can assist professionals in identifying co-occurring risk factors that place Latinx adolescents at elevated risk of endorsing suicidal ideation. The current study’s findings suggest that Latinx adolescents with higher BMI counts that co-occur with a smaller household size of three people, being a younger adolescent (12-15 years old), and having fewer friends who engage in substance use are at higher risk for suicidal ideation. Mental health practitioners should assess BMI information, along with the other co-occurring factors identified in this study. Including these co-occurrences in suicide screening can identify those Latinx adolescents who could become at even greater risk of suicidal ideation and need further assessment and intervention.

The current findings suggest that interactions between overall health, parental monitoring, peer substance use, gender, household size, age, and depression symptoms may be significant risk/protective factors for suicidal ideation among Latinx adolescents. Therefore, those factors should be assessed and evaluated thoroughly in Latinx adolescents as they may be at elevated risk of experiencing suicidal ideation. This calls for suicide prevention programming to move away from a one-size-fits-all approach and take a more tailored approach. An individualized suicide prevention strategy accounting for co-occurring factors should be developed to more effectively recognize and prevent suicidal behaviors. For example, more attention should be given to adolescents who receive low parental monitoring and express depression symptoms. This may be particularly more salient for Latinx youth, as evidenced by a qualitative study involving Mexican-origin adolescents revealed that they valued parental monitoring because they view it as a form of caring and thus was seen as a positive parenting attribute [67]. One study revealed that youth viewed parents as ‘negligent’ when parents allowed their children to run around irresponsibly [67]. Thus, the interaction between lower parental monitoring and depression symptoms should be considered when assessing for suicidal idea-

tion. Finally, our findings support the value of investigating how individual, socioenvironmental, and psychological factors are associated with suicidal ideation among Latinx adolescents. Future research is expected to utilize a similar framework by adding diverse levels of risk and protective factors, such as sexual orientation, history of trauma, and peer victimization, to discover complex interactions among constructs associated with suicidal thoughts and behaviors. This is particularly important because no single factor can account for suicide [68]. Since suicide thoughts and behaviors are malleable, utilizing the same framework and pattern-centered approach would continue to provide comprehensive approaches to identifying data-driven interactions between risk and protective factors that may lessen the heightened risk of suicidal ideation among Latinx adolescents.

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