Who attempts suicide among medical students?

Marcon G, Massaro Carneiro Monteiro G, Ballester P, Cassidy RM, Zimerman A, Brunoni AR, von Diemen L, Hauck S, Passos IC. Who attempts suicide among medical students?

Objective: To identify factors associated with a history of suicide attempt in medical students.

Methods: A Web-based survey was sent out to a sample of medical students. A multi-predictor Poisson regression was performed to identify factors associated with a history of suicide attempt. In addition, an elastic net regularization was used to build a risk calculator to identify students at risk for attempted suicide.

Results: A total of 4,840 participants were included in the study. Prevalence of suicide attempts in the sample was 8.94%. Risk factors associated with past suicide attempt in the multi-predictor Poisson regression were as follows: female gender ($P < 0.001$); homosexuality ($P < 0.001$); low income ($P = 0.026$); bullying by university peers ($P = 0.006$); childhood ($P = 0.001$) or adult ($P = 0.001$) trauma; family history of suicide ($P = 0.005$); suicidal ideation within the last month ($P < 0.001$); daily tobacco use ($P = 0.037$); and being at severe risk for alcohol abuse ($P = 0.023$). Our elastic net model performed well with an AUC of 0.83.

Conclusions: This study identifies a number of key factors associated with a history of suicide attempts among medical students. Future longitudinal studies should assess the causal relationship between these factors and suicide attempts.

Significant Outcomes

- The sociodemographic and personal variables associated with a history of suicide attempt were as follows: female gender; homosexuality or bisexuality; low income; poor sleep; low quality of friendships; and negative family relationships.
- The variables related to the medical student domain associated with a past suicide attempt were as follows: current enrollment in the first four years of medical school (preclinical); repeating a class or entire year; bullying; thoughts about withdrawing from medical school; and having sought psychiatric or psychological help during university enrollment.
- Significant variables from the mental health risk factor domain were as follows: childhood or adult trauma; a family history positive for suicide; daily tobacco use; and being at severe risk for alcohol abuse.

Limitations

- The high response rate for first-year students may reduce the generalizability to medical students in the latter years of study.
- It is possible that students with suicide ideation or a history of suicide attempt chose not to respond due to the topic’s sensitivity—or, conversely, are overrepresented because of increased interest in the subject.
- The prevalence of past suicide attempts in our sample may be biased since only participants with easy access to the Internet were likely and able to participate in the present study.
Introduction

Suicide is a major cause of death worldwide; unlike many diseases, the rate of mortality due to suicide has not declined over the past two decades (1). In 2017, about 800,000 people died by suicide (2). In this context, several high-profile case reports demonstrate the difficulties faced by modern medical students (3–5). Here, as is common across a variety of related literature, the term suicide attempt is used to mean ‘any non-fatal suicidal behaviour’ and refers to ‘intentional self-inflicted poisoning, injury or self-harm, which may or may not have a fatal intent or outcome’ (6).

A recent study in the United States found that the prevalence of suicidal ideation among medical students is 11% (7), twice as high as in the general population of people aged 18–29 years (8). A second study of 874 U.S. medical students reported a lifetime prevalence of suicide attempt of 6.9% (9). Similarly, a study looking at medical students in China found a prevalence of 4.3% (10). The closest comparison is with college students; a recent meta-analysis with almost 635,000 students found a lifetime prevalence of suicide attempt of 3.2% (11). This indicates that medical students of multiple ethnicities have elevated rates of suicide attempt compared to their peers, especially when the prevalence of suicide attempts in the general population is 2.7%, according to a cross-national study carried out in 17 countries (12). We were unable to find in the literature a prevalence for suicide attempts by graduated physicians; however, it is well established that they have a higher suicide rate compared to the general population (13). For males, there is a 70% increase; for females, there is a 400% increase (14).

Several risk factors related to increased risk of developing a mental disorder have been reported among medical students. These include a highly stressful environment, competitiveness, excessive workload, sleep deprivation, peer pressure, and many other personal, curricular, institutional, and affective factors (15, 16). It is important to mention the impact of mental health problems among medical students. Not only do they affect the lives of students in terms of academic performance, drop-out rate, and professional development (17), but also in terms of increased risk of comorbid conditions such as alcohol and other substance abuse (18).

However, the unique factors associated with suicide attempts in medical students are not established. This diminishes the capacity to identify and intervene with at-risk medical students.

Aims of the study

The present study aims to identify factors associated with suicide attempts in medical students. We conducted an exploratory analysis through a Web-based survey. Factors related to mental health, lifestyle, demographics, and university were included in the study. We also built a risk algorithm to identify patterns of behaviour in students who attempted suicide.

Methods

This is a cross-sectional study of undergraduate medical students in Brazil. The data were collected over thirty days using an online survey. The study was approved by the research ethics committee of the Hospital de Clínicas de Porto Alegre (Brazil). We used boosted Facebook advertising to reach medical students living in Brazil who liked pages related to medicine. The advertisement explicitly stated that the survey was anonymous. All participants consented to take part in the study. After completion, telephone and electronic contact information for suicide prevention and support centers located in Brazil were provided on the questionnaire.

The choice of an electronic questionnaire was based on a recently published study (19), which demonstrates the interest for participation and the need for instruments that are compatible with the current reality of effectively reaching a large number of students in a non-threatening environment. Despite its biases, far more students can be reached using this approach. Additionally, conditions of anonymity are more credible in this setting and self-report questionnaires allow participants to freely express their symptoms, feelings, and opinions about the variables being assessed without stigma. In this sense, it has recently been reported that compared to those who are not depressed,
medical students suffering from depression: (i) felt more strongly that telling a counselor would be risky and that asking for help might indicate that the student’s coping skills were inadequate; (ii) agreed more strongly that, if depressed, others might consider them less able to handle medical school responsibilities; (iii) reported feeling that, if depressed, fellow medical students would be less likely to respect their opinions (20).

In order to help capture and classify information correctly, students were asked to identify their training path; they could select ‘Medicine’ or ‘Other’ with a written specification. Only those who responded ‘Medicine’ were included in this analysis. In addition, students provided the name of their university and only Brazilian universities were included. Exclusion criteria were met if the responder was not Brazilian or did not attend a Brazilian medical school.

Survey instruments

A survey was administered, which contained questions regarding the following: sociodemographic data, personal information, university status, mental health variables including depressive symptoms, child or adult trauma (including harassment, neglect, discrimination, and/or abuse), bullying, alcohol and drug use, suicide ideation, lifetime suicide attempt, and family history of suicide. We did not ask specifically about suicide attempt in medical school—instead asking about lifetime history—because specifying a time period may influence recall bias. Both a Portuguese and a translated English version of the questionnaire were provided in the supplemental material (see Method S1). The instruments used had been validated in Portuguese.

The survey included the Patient Health Questionnaire-2 (PHQ-2) to measure depressive symptoms. This consists of two questions related to symptoms of depression during the previous two weeks(21). A score equal to or greater than 3 on the PHQ-2 is considered a positive screening result for depression. PHQ-2 has a sensitivity of 83% and a specificity of 92% for depressive episode (21).

The AUDIT-C was used to evaluate alcohol use (22). It is a widely used three-item alcohol screening tool that can help identify persons who are high-risk drinkers or have active alcohol use disorder. It is a modified version of the 10-question AUDIT instrument (23). The AUDIT-C is scored on a scale of 0–12 (scores of 0 reflect no alcohol use). In men, a score of 4 or more is considered positive; in women, a score of three or more is considered positive. Based on the literature (24), we used a more detailed stratification to better evaluate the risk of alcohol use. For men, a score of 0–3 is considered low risk; between 4 and 5 points, moderate risk; between 6 and 7 points, high risk; and 8–12 points, severe risk. For women, a score of 0–2 is considered low risk; between 3 and 5 points, moderate risk; between 6 and 7 points, high risk; and between 8 and 12 points, severe risk. The questions about tobacco, cocaine, and cannabis were based on the ASSIST (Alcohol, Smoking and Substance Involvement Screening Test) instrument, asking about use over the previous three months (25).

Statistical analysis

Descriptive analyses were reported as means or absolute and relative frequencies. We divided participants into two groups: with or without a history of a suicide attempt. First, we used chi-squared or Student’s t-tests to analyze demographic and clinical variables between these two groups. Then, we used hierarchical multi-predictor Poisson regression analysis as described below. The variables were allocated in four different domains: (i) Sociodemographic; (ii) Personal; (iii) Medical student; and (iv) Mental health. We then calculated prevalence ratios (PR) and respective confidence intervals (95% CI) for each domain using univariate analysis, considering p-values below 0.20 as statistically significant. Next, we sequentially added significant variables into the Poisson regression, starting from the most distal domain to the most proximal (variables related to mental health). The variables that presented \( P < 0.10 \) in the entry stage remained in the model until the end, even if they lost their significance in later stages, and those with \( P < 0.05 \) were considered significant. All analyses were performed in spss V21.0. (IBM, North Castle, NY, USA)

Elastic net regularization

We applied a method called elastic net regularization from the field of machine learning (26). The elastic net is a machine learning method that combines feature selection characteristics with regularization and classification. Through a cost function composed of both \( l_1 \) and \( l_2 \) weight magnitude penalties, the method is able to remove predictors with low impact on the outcome while regularizing for improved generalization. As our dataset is composed of several attributes, identifying the most important of these enables wider applicability and more practical use of our risk calculators. Elastic net is a combination of LASSO (least
absolute shrinkage and selection operator) and ridge regression. Like LASSO regularization, it results in sparse solutions; however, it also has the advantage of performing well with highly correlated variables. Our script is available online (https://github.com/Ballester/suicide-attempt-medicine). Analysis was performed with R software (version R 3.3.1) (27) and R Studio (version 0.99.902) with the R package caret (version 6.0-73) (28).

We split our data into training (75% of the whole sample) and test datasets (25%). We deployed a standard machine learning study protocol with 10-fold cross-validation, feature selection, hyperparameter tuning, and class imbalance correction in the training dataset (Figure S1). We repeated 10-fold cross-validation 10 times to improve tuning. Class imbalance usually leads to very different sensitivity and specificity scores in the model; to account for this, we balanced each class predominance with class weighting. Each class was weighted inversely proportional to its frequency in the training set. Class weighting allows us to use the whole training set instead of relying on downsampling techniques.

We created ‘individual-level predicted suicide attempt probabilities’ based on the elastic net algorithm. Then, a receiver operating characteristic (ROC) curve was generated and, to evaluate prediction accuracy, the area under the curve (AUC) was calculated. Elastic net regularization-predicted probabilities were then discretized into quintiles (five groups of equal size ordered by percentiles) and cross-classified with observed suicide attempts.

Machine learning approaches are superior to traditional multiple regression analyses because: (i) coefficients are unstable when high correlations exist among predictors, which leads to low replication of predictions in independent samples; (ii) traditional regression assumes additivity, whereas the predictors considered here might have non-additive effects (29).

### Results

A total of 6806 participants responded to the questionnaire and 4840 were included in our sample after excluding 1976 individuals (712 were excluded because they did not fill out the survey fully, 1047 were excluded because they were not medical students, and 207 were excluded because they did not attend Brazilian medical schools). Our sample represents almost 5% of all of Brazilian medical students (30). The prevalence of lifetime attempted suicide was 8.94% (432 of 4840 usable responses).

#### Univariate analysis

The mean age of the suicide attempt group was $21.6 \pm 3.42$ years; it was $21.8 \pm 3.23$ in those without suicide attempt ($P = 0.22$). Females were overrepresented in both the group with (346 of 432, 80.09%) and without (3349 of 4407, 75.97%) suicide attempts; there was trend, but no statistically significant difference in suicide attempts by sex ($P = 0.06$). Demographic and personal characteristics of respondents are shown in Table 1.

Several factors related to medical student domain were associated with past suicide attempt (Table 2). Students who reported being in the first, second, third, or fourth years of school ($P = 0.003$), having low-quality relationships with colleagues ($P < 0.001$) or professors ($P < 0.001$), or who suffered bullying during university ($P < 0.001$) were significantly more likely to have a history of suicide attempt.

Table 3 describes variables related to mental health. We found a significant increase in percentage of suicide attempt if students were positive on the PHQ-2 diagnosis ($P < 0.001$); had suffered child ($P < 0.001$) and/or adult trauma ($P < 0.001$); had a positive family history of suicide ($P < 0.001$); or had had suicidal ideation in the previous month ($P < 0.001$). Students with a history of tobacco ($P < 0.001$), marijuana ($P < 0.001$), and cocaine ($P = 0.031$) use in the previous three months, or at high ($P < 0.001$) or severe ($P < 0.001$) risk of alcohol abuse were also more likely to have a history of suicide attempt.

#### Multi-predictor analysis

The multi-predictor Poisson regression model (Table 4) revealed the following risk factors were associated with past suicide attempt: female gender ($P < 0.001$); homosexuality ($P < 0.001$) or bisexuality ($P < 0.001$); low income ($P = 0.026$); poor sleep ($P = 0.001$); low-quality friendships ($P = 0.005$); good ($P = 0.002$), regular ($P < 0.001$), or low ($P < 0.001$) quality of family relationships (compared to ‘excellent’, all lower quality ratings were significantly associated with suicide attempt); current enrollment in the first/second ($P = 0.003$) and third/fourth years ($P = 0.02$); repeating a class or entire year ($P = 0.009$); suffering bullying AT university ($P = 0.006$); thoughts of withdrawal from medical school ($P = 0.003$); history of utilizing psychiatric or psychological help during university enrollment ($P < 0.001$); history of child ($P = 0.001$) or adult trauma ($P = 0.001$); a family
history positive for suicide \((P = 0.005)\); endorsed suicidal ideation in the last month \((P < 0.001)\); daily tobacco use \((P = 0.037)\); and estimated to be at severe risk for alcohol abuse \((P = 0.023)\). The same model also identified higher income \((P = 0.004)\) as a protective factor. We also calculated the interaction between the variables sexual orientation and bullying; however, the interaction was not significant \((P = 0.653)\).

Elastic net regularization

Figure 1 shows the ROC curve from our elastic net model. This model found an AUC of 0.83, sensitivity of 0.75, and specificity of 0.73 in the test dataset (see Table S1). Also, the positive predictive value (PPV) found was 0.21 and the negative predictive value (NPV) was 0.97. In the supplemental material, Figure S2 shows variable importance for the

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**Table 1. Variables related to sociodemographic and personal domains**

| Variables | No suicide attempt \(n = 4408\)No. (%) | With suicide attempt \(n = 432\)No. (%) | \(t\)-test or \(\chi^2\) | Prevalence ratio (95 % CI) | \(P\)-value |
|-----------|---------------------------------|---------------------------------|----------------|-------------------------|-------------|
| Age†      | 21.852 ± 3.23                  | 21.645 ± 3.42                  | 1.203          | 0.99 (0.99–1.00)         | 0.2293      |
| Gender†   |                                 |                                |                |                         |             |
| Male      | 1059 (24.02)                   | 86 (19.90)                     | 3.468          | 0.99 (0.96–1.02)         | 0.0625      |
| Female    | 3349 (75.97)                   | 346 (80.09)                    | 1.00           |                         |             |
| Sexual orientation‡ |  |                                |                |                         |             |
| Heterosexual | 3851 (87.36)               | 299 (69.21)                    | 108.67         | 1.00                     | <0.0001     |
| Homosexual | 249 (5.64)                     | 52 (12.03)                     | 1.13 (1.07–1.19)|                         |             |
| Bisexual  | 258 (5.85)                     | 88 (15.74)                     | 1.18 (1.11–1.25)|                         |             |
| Other     | 50 (1.13)                      | 13 (3.00)                      | 1.22 (1.05–1.41)|                         |             |
| Gender identification‡ |  |                                |                |                         |             |
| Female    | 3285 (74.52)                   | 342 (79.80)                    | 5.5598         | 1.00                     | 0.0620      |
| Male      | 1095 (24.84)                   | 86 (19.90)                     | 0.99 (0.96–1.02)|                         |             |
| Other     | 26 (0.56)                      | 4 (0.92)                       | 1.10 (0.89–1.36)|                         |             |
| Marital status‡ |  |                                |                |                         |             |
| No partner | 2137 (48.5)                   | 211 (48.8)                     | 0.009          | 1.00                     | 0.926       |
| With partner | 2271 (51.5)                   | 221 (51.2)                     | 0.99 (0.97–1.02)|                         |             |
| Income‡   |                                 |                                |                |                         |             |
| <454      | 368 (8.34)                     | 69 (15.97)                     | 49.651         | 1.10 (1.05–1.16)         | <0.0001     |
| 454–909   | 609 (13.81)                    | 84 (19.44)                     | 1.05 (1.01–1.09)|                         |             |
| 909–1515  | 704 (15.97)                    | 57 (13.19)                     | 0.99 (0.96–1.02)|                         |             |
| 1515–3030 | 1170 (26.54)                   | 74 (17.12)                     | 0.97 (0.94–0.99)|                         |             |
| >3030     | 1557 (35.32)                   | 148 (34.25)                    | 1.00           |                         |             |
| Children‡ |                                 |                                |                |                         |             |
| No        | 4316 (97.91)                   | 423 (97.91)                    | 8.736          | 1.00                     | 0.005       |
| 1–2       | 87 (2.00)                      | 6 (1.4)                        | 0.72 (0.33–1.58)|                         |             |
| ≥3        | 5 (0.1)                        | 3 (0.7)                        | 4.20 (1.71–10.3)|                         |             |
| Live with‡ |                                 |                                |                |                         |             |
| Alone     | 1372 (31.12)                   | 131 (30.32)                    | 5.3663         | 1.00                     | 0.1199      |
| With partner or relative | 2053 (47.48)                   | 213 (49.30)                    | 1.00 (0.98–1.03)|                         |             |
| With friends | 763 (17.30)                   | 62 (14.35)                     | 0.99 (0.95–1.02)|                         |             |
| University residence | 180 (4.08)                     | 29 (6.01)                      | 1.05 (0.98–1.13)|                         |             |
| Sleep‡    |                                 |                                |                |                         |             |
| Poor      | 1066 (24.18)                   | 193 (44.67)                    | 99.1           | 3.42 (2.21–5.29)         | <0.001      |
| Regular   | 1704 (38.65)                   | 156 (36.11)                    | 1.87 (1.19–2.91)|                         |             |
| Good      | 1191 (27.01)                   | 62 (14.35)                     | 1.10 (0.68–1.79)|                         |             |
| Very good/excellent | 447 (10.1)                     | 21 (4.9)                       | 1.00           |                         |             |
| Physical activity‡ |  |                                |                |                         |             |
| Yes       | 1592 (36.11)                   | 127 (29.39)                    | 7.4627         | 0.97 (0.95–0.99)         | 0.006       |
| No        | 2816 (63.88)                   | 305 (70.60)                    | 1.00           |                         |             |
| Quality of family relationships‡ |  |                                |                |                         |             |
| Low       | 125 (2.83)                     | 61 (14.12)                     | 224.44         | 6.85 (5.21–9.00)         | <0.001      |
| Regular   | 710 (16.10)                    | 130 (30.09)                    | 3.23 (2.54–4.11)|                         |             |
| Good      | 1326 (30.08)                   | 128 (29.62)                    | 1.84 (1.44–2.35)|                         |             |
| Very good/excellent | 2247 (51.0)                     | 113 (26.02)                    | 1.00           |                         |             |
| Quality of friend relationships‡ |  |                                |                |                         |             |
| Low       | 119 (2.69)                     | 39 (8.02)                      | 99.49          | 4.23 (3.07–5.81)         | <0.001      |
| Regular   | 956 (21.49)                    | 99 (22.91)                     | 2.44 (1.91–3.13)|                         |             |
| Good      | 1566 (35.52)                   | 162 (37.5)                     | 1.61 (1.29–2.00)|                         |             |
| Very good/excellent | 2128 (48.3)                     | 132 (30.6)                     | 1.00           |                         |             |

†Student’s \(t\)-test.
‡\(\chi^2\) test.

Bold values indicate significance of \((P < 0.05)\).
elast net model and Figure S3 presents the concentration risk for suicide attempt based on model output probability. All subjects were ranked based on their probability of belonging to the positive class and separated into quintiles. We then evaluated the percentage of positive and negative class samples at each quintile based on their expected outcomes. This demonstrates that over half of the student population that endorsed a history of suicide attempt were recognized to be at the highest risk of such an attempt, and over 80% were categorized as at highest or second-to-highest risk of suicide attempt quintiles.

Discussion

This is one of the first studies to identify factors associated with a history of suicide attempt among medical students in a large sample size. We demonstrated both some of the factors associated with suicide attempt in medical students and an elastic net model that accurately recognized the probability of suicide attempt using easily accessible student characteristics. In addition, the prevalence of attempted suicide found in our study is higher when compared to other studies (9, 10), although methodological variability may contribute to such variations. An important point is that the WHO definition of suicide attempts likely includes what DSM-5 labels ‘non-suicidal self-injury’, defined as the deliberate, self-inflicted destruction of body tissue without suicidal intent and for purposes not socially sanctioned (31). It is possible that this form of interpretation may have influenced the values found.

Most of our respondents were in either their first or second years of medical school; therefore, the greatest absolute number of students reporting suicide attempts were in this group (263 of 432), we established the two last years as our

Table 2. Variables related to medical student domain

| Variables | No suicide attempt (n = 4408) No. (%) | With suicide attempt (n = 432) No. (%) | t-test or χ² | Prevalence ratio (95% CI) | P-value |
|-----------|-------------------------------------|--------------------------------------|-------------|--------------------------|--------|
| Year‡     |                                     |                                      |             |                          |        |
| First/second | 2444 (55.4) | 263 (60.9) | 12.365 | 1.74 (1.27–2.40) | 0.003  |
| Third/fourth | 1269 (28.8) | 128 (29.6) | 1.65 | 1.17–2.31 |        |
| Fifth/sixth | 695 (15.8)  | 41 (9.5)  | 1.00 |            |        |
| Quality of colleague relationships‡ | | | | | |
| Low | 286 (6.49) | 63 (14.58) | 3.33 | 2.09 (1.29–3.40) | <0.001 |
| Regular | 1046 (23.72) | 141 (29.26) | 2.10 | 1.64 (1.52–2.00) |        |
| Good | 2011 (45.62) | 167 (38.65) | 1.42 | 1.07 (1.00–1.88) |        |
| Very good/excellent | 1065 (24.2) | 61 (14.1)  | 1.00 |            |        |
| Quality of professor relationships‡ | | | | | |
| Low | 164 (3.72) | 74 (16.7) | 7.07 | 2.00 (1.31–2.34) | <0.001 |
| Regular | 954 (21.64) | 126 (29.16) | 1.58 | 1.22 (1.25–2.00) |        |
| Good | 2160 (49.00) | 182 (42.12) | 1.05 | 0.87 (0.03–1.34) |        |
| Very good/excellent | 1065 (24.2) | 61 (14.1)  | 1.00 |            |        |
| Bullying‡ | | | | | |
| Yes | 855 (19.39) | 63 (14.58) | 3.69 | 3.23 (1.62–3.85) | <0.0001 |
| No | 3553 (80.60) | 293 (67.82) | 1.00 |            |        |
| Repeat‡ | | | | | |
| Yes | 550 (12.5) | 74 (16.7) | 7.07 | 2.00 (1.31–2.34) | <0.0001 |
| No | 3858 (87.52) | 282 (63.3) | 1.00 |            |        |
| Satisfaction status‡ | | | | | |
| Very unsatisfied | 124 (2.81) | 28 (6.48) | 48.22 | 1.00 | <0.001 |
| Unsatisfied | 388 (8.80) | 55 (12.73) | 0.96 | 0.77–0.96 |        |
| Indifferent | 641 (14.54) | 39 (21.52) | 0.87 | 0.79–0.97 |        |
| Satisfied | 2458 (55.76) | 199 (42.68) | 0.82 | 0.74–0.90 |        |
| Very satisfied | 797 (18.08) | 57 (13.19) | 0.82 | 0.74–0.91 |        |
| Did you think about quitting college‡ | | | | | |
| Yes | 1861 (42.21) | 269 (62.26) | 63.37 | 1.09 (1.06–1.12) | <0.0001 |
| No | 2547 (57.78) | 163 (37.73) | 1.00 |            |        |
| Do you consider that suicide is a discussed topic in your academic formation‡ | | | | | |
| Yes | 576 (13.08) | 71 (16.43) | 3.5865 | 0.83 (1.00, 1.06) | 0.05698 |
| No | 3832 (86.92) | 361 (83.56) | 1.00 |            |        |
| Have you ever seek psychiatric or psychological assistance because of problems in your academic performance‡ | | | | | |
| Yes | 1534 (34.80) | 247 (57.17) | 83.739 | 1.09 (1.07, 1.11) | <0.0001 |
| No | 2874 (65.19) | 185 (42.82) | 1.00 |            |        |

†X² test.

Bold values indicate significance of (P < 0.05).
baseline of comparison. To put this into context, Brazilian medical schools primarily enroll students who do not have a bachelor’s degree; the curriculum is six years. The first two years correspond to the last two premedical years in North America, whereas the remainder correspond to the American medical school curriculum. Because the curricula for the study of medicine differ according to the country, there is no consensus in the literature about the most at-risk period in relation to mental health problems (20, 32, 33). We found that being in the first four years was a risk factor for a history of suicide attempt. Other studies have reported that students in this preclinical portion of their training are more likely to have negative views of depression; they support the notion that depressed medical students are likely to provide inferior care to their patients and would be unable to cope with medical school stress (20). In Brazil, during the last two years of medical school, students gain more autonomy and independence and are involved in clinical care. It may be the case that clinical work provides greater meaning and experience to cope with issues such as depression.

Bullying was also a risk factor for a history of suicide attempt; this correlates with previous studies that found that medical students who are bullied have a suicide attempt rate of 25–66% (34–36). A strong institutional stance against bullying, combined with mechanisms for dispute resolution and separating bullied students from bullies, may be an approach to explore in the future. Also, answering in the affirmative to the questions ‘have repeated any class or year’, ‘have thought about withdrawal from medical school’, and ‘have sought psychological or psychiatrist assistance’ also correlated with a history of suicide attempt. These variables are non-specific but an awareness of them can help in the process of identifying the students at higher risk.

### Table 3. Variables related to mental health domain

| Variables                      | No suicide attempt (n = 4408) No. (%) | With suicide attempt (n = 432) No. (%) | t-test or χ² | Prevalence ratio (95% CI) | P-value |
|--------------------------------|--------------------------------------|---------------------------------------|--------------|--------------------------|---------|
| PHQ†                           |                                      |                                       |              |                          |         |
| Yes                            | 2595 (58.87)                         | 346 (80.09)                           | 73.438       | 1.10 (1.08–1.13)         | <0.0001 |
| No                             | 1813 (41.12)                         | 86 (19.90)                            | 1.00         |                          |         |
| Child trauma†                  |                                       |                                       |              |                          |         |
| Yes                            | 968 (21.96)                          | 203 (46.99)                           | 133.04       | 1.16 (1.12–1.19)         | <0.0001 |
| No                             | 3440 (78.03)                         | 229 (53.00)                           | 1.00         |                          |         |
| Adult trauma†                  |                                       |                                       |              |                          |         |
| Yes                            | 669 (15.17)                          | 165 (38.19)                           | 144.54       | 1.18 (1.14–1.23)         | <0.0001 |
| No                             | 3739 (84.82)                         | 267 (61.80)                           | 1.00         |                          |         |
| Family history of suicide†     |                                       |                                       |              |                          |         |
| Yes                            | 493 (11.18)                          | 82 (18.98)                            | 22.11        | 1.09 (1.05–1.14)         | <0.0001 |
| No                             | 3915 (88.81)                         | 350 (81.01)                           | 1.00         |                          |         |
| Suicidal ideation in the last month† |                                       |                                       |              |                          |         |
| Yes                            | 719 (16.31)                          | 217 (50.23)                           | 288.03       | 1.28 (1.24–1.33)         | <0.0001 |
| No                             | 3689 (83.69)                         | 215 (49.76)                           | 1.00         |                          |         |
| Suicide ideation life          |                                       |                                       |              |                          |         |
| Yes                            | 1811 (41.1)                          | 421 (97.5)                            | 503.1        | 44.7 (24.6–81.2)         | <0.0001 |
| No                             | 2597 (58.9)                          | 11 (2.5)                              | 1.00         |                          |         |
| Tobacco use in the last 3 months† |                                       |                                       |              |                          |         |
| No                             | 3570 (80.98)                         | 302 (69.9)                            | 50.248       | 1.00         | <0.0001 |
| 1–2 times                      | 487 (11.04)                          | 58 (13.42)                            | 1.01 (0.98–1.05) |                         |         |
| Monthly                        | 136 (3.08)                           | 26 (6.01)                             | 1.11 (1.02–1.20) |                         |         |
| Weekly                         | 116 (2.63)                           | 17 (3.93)                             | 1.06 (0.98–1.14) |                         |         |
| Daily                          | 99 (2.24)                            | 29 (6.71)                             | 1.23 (1.11–1.36) |                         |         |
| Cannabis use in the last 3 months† |                                       |                                       |              |                          |         |
| No                             | 3695 (83.59)                         | 323 (74.76)                           | 23.838       | 1.00         | <0.001  |
| 1-2 times/Monthly              | 576 (13.1)                           | 81 (18.8)                             | 1.53 (1.22–1.92) |                         |         |
| Weekly/Daily                   | 147 (3.3)                            | 28 (6.6)                              | 1.99 (1.39–2.93) |                         |         |
| Cocaine use in the last 3 months† |                                       |                                       |              |                          |         |
| Yes                            | 37 (0.8)                             | 8 (1.9)                               | 3.348        | 2.01 (1.07–3.79)         | 0.031   |
| No                             | 4371 (99.16)                         | 424 (98.14)                           | 1.00         |                          |         |
| Audit-C†                       |                                       |                                       |              |                          |         |
| Low                            | 2103 (47.70)                         | 170 (39.39)                           | 43.338       | 1.00         | <0.0001 |
| Moderate                       | 1470 (33.34)                         | 135 (30.6)                            | 1.01 (0.98–1.03) |                         |         |
| High                           | 623 (14.13)                          | 77 (17.82)                            | 1.04 (1.01–1.08) |                         |         |
| Severe                         | 212 (4.80)                           | 50 (11.57)                            | 1.19 (1.11–1.29) |                         |         |

†X² test.

Bold values indicate significance of (P < 0.05).
Factors associated with suicide attempts

As described in the literature (36), our study also found a higher risk for suicide attempt in the female gender. A further relevant finding in our study was the relation between sexual orientation and past suicide attempt; homosexuality and bisexuality both significantly correlated with this outcome. We did not find other results in the literature to be able to compare this variable in medical students. Although we believe that this positive relation may be related to the fact that this population suffers more discrimination and difficulty of acceptance, often isolating themselves and presenting a higher prevalence of depressive.
symptoms, we were unable to identify a significant interaction between history of bullying and sexuality. As described in the literature, homosexual-lesbian/gay, bisexual, and questioning students had more stressful life events, perceived stress, bullying victimization, functional limitations, and depressive symptoms than heterosexual peers (37, 38). Future work should assess suicide attempts in other groups of students and compare their findings with our findings.

Some significant risk factors found in our study, such as child and adult trauma, low income, and low quality of both friendships and family relationships, are well established as risk factors for suicide (36). Regarding the last variable in particular, it is known that people who share close, personal, and enduring relationships and values typically have a sense of purpose, security, and connectedness (39, 40). Friends and family can be a significant source of social, emotional, and financial support, and can buffer the impact of external stressors. In our work, we found that ‘poor’, ‘regular’, and ‘good’ family relationships were related to past suicide attempts, but we were able to observe that there is a decrease in the PR as the quality of relationships improves, concluding that there is a tendency that the better the relationships, the lower the risk for suicide. Low-quality sleep was also a significant risk factor, which is also in accordance with the literature (41). A meta-analysis of sleep disturbance and suicidal thoughts and behaviours found that sleep disturbance was significantly associated with an increased relative risk for suicidal ideation, suicide attempt, and suicide (42).

There is also an interesting point to be made regarding our data on symptoms of depression. While our univariate analysis showed that positive assessment for depression on the PHQ-2 was associated with past suicide attempt, this did not retain significance after the multi-predictor analysis. The PHQ-2 assesses for symptoms of depression, rather than its origin; further, it only relates to current symptomatology. Our multi-predictor regression isolated the independent risk factors for past suicide attempt—in this case, the known stressors of medical school (year of training, academic performance, bullying, etc.). Notably, these are all environmental factors that occurred in the past and are thus more likely around the time of suicide attempt. This may support the importance of focusing on environmental variables in preventing suicide attempts.

Finally, our study demonstrated that substance use among medical students was also associated with a history of suicide attempt. Both heavy alcohol consumption and daily tobacco use were associated with increased risk for suicide attempt, which is in keeping with the literature on suicide. Both substances are legal, and their use is easily underestimated. However, heavy alcohol and tobacco consumption are disproportionately prevalent in this population (32.4% (43) and 21% (44) respectively). The reasons for this may be attributed to medical student culture, which encourages students to drink and smoke more than the average person of their age. While our univariate analysis did identify a relation with cocaine and cannabis use, this was not retained after multi-predictor analysis; not many students reported this behaviour and it is also possible that they were polysubstance users. Focusing on medical school-specific cultural factors that drive students to increase their consumption of psychoactive substances in general (45, 46) may be a point of intervention for the future.

With the elastic net method, we identified the pattern of variables that are associated with someone at risk for suicide in this population, based on the well-documented information that a prior suicide attempt increases the risk for completed suicide in the future (2). This could manifest in clinical practice by implementing a Web-based risk stratification calculator built on the algorithm that allows input of a student’s relevant variables. In this context, we draw attention to these variables: sexual orientation, low quality of family relationships, and cocaine use, which are among the most important predictors for the elastic net model. With the exception of cocaine use, these variables were also significant in the Poisson regression model. We believe that the small number of participants reporting a positive use of cocaine \( n = 45 \) explains their non-significance in this last model.

This study has several strengths that are worth discussing. First, the high number of responses allows meaningful statistical analysis of several factors and the generation of a useful risk stratification algorithm. Second, it represents the experiences of a national sample of the medical school student population rather than any specific medical school. Third, the anonymity and lack of university staff contact reduced the chance of students withholding their experiences due to fear of retaliation.

As with any self-report cross-sectional survey of a complex and sensitive issue like suicide attempt, there are limitations to this study. First and foremost, causality cannot be inferred with this study design. Second, there may be variations regarding the way some questions are interpreted by participants since it is self-report. We recognize the possibility of differing levels of understanding of what
may be considered a ‘suicide attempt’ among the participants. Third, the response rate for first-year students was high. This may reflect that younger students had greater opportunity and time to respond. Regardless, this reduces the generalizability of results for the later years. Fourth, our risk algorithm had poor PPV to identify the pattern of the students who attempted suicide, which leads to a higher number of false positives. Another limitation is reporting bias stemming from several sources. It is possible that students with suicide ideation or history of suicide attempt chose not to respond because of the sensitivity of the topic. Conversely, it is possible that students with these symptoms would be more willing to respond because of concerns about their medical school experience and their interest in the subject. Finally, only participants with easy access to the Internet were likely and able to participate in the present study. Our group and others hope to identify a ‘signature’ of patients who attempt suicide (1, 47, 48). Studying this aspect causes an inherent dilution of the strength of our findings, as some responders may attempt suicide in the near future and thus have the signature without the history. Future studies should investigate interactions between variables assessed in the present work with regard to their relation to suicide attempts among medical students. They also should propose mechanistic models to further explain our findings.

In conclusion, suicide prevention requires a vision, a plan, and a set of strategies. The literature has shown that investing in programs that promote education about, and remove the stigma of, mental disorders, as well as a counseling system with trained professionals and a screening tool that proactively identifies and refers individuals at risk of suicide can be an effective prevention strategy (49, 50). The results of our study help to identify high-risk groups in medical school that should be the target of selective psychosocial interventions. Future longitudinal studies should assess causality for some variables, build predictive accurate models, and assess their subsequent utility in facilitating the selection of interventions to prevent suicide.

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Declaration of interest

Marcon G, Monteiro GMC, Ballester P, Cassidy RM, Zimerman A, Brunoni AR, Diemen LV, and Hauck S have nothing to disclose. Passos IC receives research support from CAPES, FINEP, and CNPq.

Data availability statement

Data statement is available upon request: Dr. Ives Cavalcante Passos - ivescpl1@gmail.com.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Machine Learning Protocol

Figure S2. The most important predictors for the Elastic Net model.

Figure S3. Concentration of risk for suicide attempts among medical students.

Figure S4. CONSORT chart-like diagram with total sample included

Table S1. Algorithm performance in identifying individual suicide attempters from non-attempters among medical students. Method S1. Portuguese and a translated English version of the questionnaire applied.