Using Classification Tree Analysis for Adolescent Suicide Ideation Prediction: A Statistical and Ethical Review

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Introduction

Adolescent suicide is a grave public health issue, representing one of the leading causes of death among youth worldwide[1]. Early identification of adolescents at risk for suicide ideation is critical, as it enables timely, potentially life-saving interventions. In an effort to improve detection and support at-risk adolescents, Hill, Oosterhoff, and Kaplow (2017)[2] proposed a predictive model using Classification Tree Analysis (CTA) to identify adolescents who may be at risk. This approach provides community organizations and schools with a tool to identify potential cases of suicide ideation before they escalate. While CTA offers practical benefits for large-scale screening, the risk of misclassification raises significant ethical concerns. In particular, the occurrence of false positives and false negatives has profound implications for adolescents' well-being, resource allocation, and their trust in mental health support systems.

The ethical dilemma posed by misclassification extends beyond technical issues, highlighting a need to balance sensitivity (catching as many at-risk cases as possible) and specificity (avoiding false positives). These conflicting goals complicate the model's application in high-stakes mental health settings, where false positives and false negatives could have lasting consequences[3]. Adolescents, as a vulnerable population, face both personal and social challenges that could be intensified by errors in identifying their risk status, raising critical questions about the model's ethical suitability. This paper explores the consequences of misclassification, emphasizing the need for a model that can support adolescent mental health while respecting their autonomy and minimizing harm.

Summary of Methodology

Classification Tree Analysis (CTA) is a statistical method for predicting categorical outcomes based on multiple independent variables. In this study, CTA was used to identify adolescents at risk for suicide ideation, drawing on data from the National Longitudinal Study of Adolescent to Adult Health (Add Health). The study's 4,799 adolescent participants provided demographic and psychosocial data, which served as inputs for the CTA model. Factors analyzed included depressive symptoms, social support, hours of sleep, and history of suicide ideation or attempts among family and friends.

The CTA approach applied here is recursive, successively partitioning data into subgroups by identifying optimal cutoff points within variables to predict a binary outcome—in this case, the likelihood of suicide ideation. Each subgroup, or "node," splits based on the factor that minimizes prediction error for the target outcome. The study derived three classification trees with varying sensitivities and specificities to address the distinct needs of different settings. These models offer trade-offs between sensitivity (the ability to detect true positives) and specificity (the ability to avoid false positives).

- Tree 2: Prioritizes specificity, accurately identifying adolescents at risk with fewer false positives, based primarily on prior suicide ideation.
- Tree 4: Balances sensitivity and specificity, considering depressive symptoms, social support, and family suicide history.

- Tree 5: Optimizes sensitivity, incorporating all previous factors and adding demographic markers such as gender and ethnicity. This tree identifies a higher number of at-risk adolescents but also produces more false positives. In essence, CTA allows organizations to implement screening options based on their resources, adjusting the balance between identifying a maximum number of at-risk individuals and minimizing misclassification.

Normative Concern: The Risk of Misclassification

The normative concern of misclassification is particularly serious in the context of suicide risk prediction for adolescents. Misclassification in this model entails both false positives (incorrectly flagging individuals as at-risk) and false negatives (failing to detect genuinely at-risk individuals). Both types of misclassification present distinct, significant risks that could impact the mental, social, and emotional well-being of adolescents, especially given their unique developmental vulnerabilities.

Impact of False Positives

False positives pose substantial risks for adolescents' mental health and social standing. Adolescents misclassified as at-risk may be subject to interventions that, while well-intentioned, could lead to adverse effects such as social stigma and emotional distress. Being identified as a potential suicide risk could cause these adolescents to feel alienated from their peers, as they may feel labeled or misunderstood by authority figures and friends alike. This social stigma can deeply impact adolescents' sense of belonging and self-esteem, which are critical during these formative years. Furthermore, misclassification can erode an adolescent's trust in mental health systems. Experiencing an intervention based on a misjudgment may lead them to question the validity of mental health resources, potentially deterring them from seeking help in situations where they genuinely need it.

In academic contexts, false positives may disrupt learning and affect educational opportunities. Adolescents who are misclassified may be required to attend frequent counseling sessions, which could conflict with school schedules and reduce their academic engagement. Over time, this interruption can negatively affect academic performance, especially if counseling is not needed. In addition, a false positive classification can also lead to unnecessary familial stress. Parents or guardians, receiving news of their adolescent's perceived risk status, may feel undue anxiety or pressure to intervene. Such interventions, whether through counseling or changes in home dynamics, could disrupt the adolescent's personal and social environment. The long-term effects of such misclassification are not only psychological but can also create lasting distrust in both familial relationships and mental health institutions.

Consequences of False Negatives

False negatives—where truly at-risk adolescents are not flagged by the model—are arguably more serious as they represent missed opportunities for life-saving interventions. Adolescents who are genuinely at risk may lack alternative support systems, relying on educational or community screenings as their only access to mental health resources. Failing to identify these individuals due to a model's oversight can have life-threatening implications, depriving them of the support they need to manage their mental health and address suicidal ideation.

In cases where an at-risk adolescent's symptoms worsen or result in a suicide attempt, the failure to identify them could be seen as an ethical lapse in the duty of care, particularly when preventable through improvements in model accuracy. The severity of missing even one individual at risk underscores the necessity for a model that prioritizes sensitivity, even if it requires additional resources or intervention efforts. False negatives in mental health assessments do not merely represent missed predictions but constitute a fundamental failure to provide for adolescents in vulnerable positions, placing their well-being at significant risk.

Resource Allocation Implications

Misclassification also has a substantial impact on resource allocation, particularly in settings with limited mental health resources, such as schools and community centers. False positives can strain these resources by diverting attention, counseling, and monitoring efforts to individuals who may not truly be at risk. This misallocation is especially problematic where mental health resources—counseling hours, intervention staff, follow-up programs—are limited. When directed toward individuals inaccurately identified as at risk, these resources may be depleted, leaving fewer resources available for those genuinely in need. For example, a school with only one or two counselors may be forced to prioritize based on flawed model predictions, potentially overlooking students in genuine need.

High rates of false negatives, on the other hand, mean that adolescents who require resources may not receive them. In cases where funding and support are scarce, effective resource allocation becomes essential. An over-reliance on models that prioritize specificity over sensitivity could lead to underutilization of resources for genuinely at-risk adolescents, particularly harmful in underfunded settings. Balancing sensitivity and specificity is thus a critical ethical consideration, as effective resource allocation ensures that interventions are directed where they are most needed. This balance challenges policy-makers to weigh the ethical trade-offs involved in model deployment in mental health contexts.

Implications for Autonomy and Trust

Misclassification also impacts autonomy and trust—two factors especially critical during adolescence, a stage marked by personal development and a search for independence. High rates of false positives may lead adolescents to feel as though their privacy and autonomy are compromised, with over-surveillance creating an environment where they feel watched and misunderstood. Adolescents who perceive this lack of trust in their self-management may develop resentment toward authority figures in their communities and schools.

This impact on autonomy is particularly relevant given that adolescence is a key period for developing self-identity and confidence. An experience with misclassification that leads to invasive or unwarranted intervention could impact the adolescent's perception of mental health support systems in the long term, potentially making them less likely to seek assistance in the future. When adolescents are forced into interventions based on misclassification, they may begin to distrust not only the institutions that labeled them but also mental health resources more broadly, creating barriers to future help-seeking behaviors.

Conclusion

The misclassification risks inherent in suicide risk prediction models, such as Classification Tree Analysis (CTA), present substantial normative concerns. False positives can disrupt adolescents' lives, leading to stigma, social isolation, and distrust of mental health resources, while false negatives represent missed opportunities to intervene in potentially life-threatening situations. Additionally, misclassification affects the allocation of finite mental health resources, posing practical challenges in community and school settings where effective intervention is needed most.

Addressing these concerns requires a commitment to optimizing the balance between specificity and sensitivity and improving model accuracy to ensure that resources are allocated effectively and adolescents' rights to autonomy and privacy are respected. In light of these ethical and practical challenges, further research and sensitivity adjustments in prediction models are essential to create balanced, supportive frameworks for adolescent mental health. Reducing the prevalence of false positives and false negatives can build a system that not only safeguards adolescent well-being but also upholds principles of trust, fairness, and compassion—vital components for ethical mental health intervention.

Notes

[1]World Health Organization. (n.d.). Suicide. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/suicide#:~:text=Key%20facts,%E2%80%9329%2Dyear%2Dolds.

[2]Hill, R. M., Oosterhoff, B., & Kaplow, J. B. (2017). Prospective identification of adolescent suicide ideation using classification tree analysis: Models for community-based screening. Journal of Consulting and Clinical Psychology, 85(7), 702–711. https://doi.org/10.1037/ccp0000218

[3]Linthicum, K. P., Schafer, K. M., & Ribeiro, J. D. (2019). Machine learning in suicide science: Applications and ethics. Behavioral Sciences & the Law, 37(3), 214–222. https://doi.org/10.1002/bsl.2392