Novel Methods to Predict Suicide Attempts by Young Adults using Personal Communication and Social Media Data

Alicia L. Nobles[†], Jeff J. Glenn[‡], Bethany A. Teachman[‡], Laura E. Barnes[†],
[†]Department of Systems & Information Engineering,
[‡]Department of Psychology,
University of Virginia
{aln2dh,jjg9ac,bat5x,lbarnes}@virgnia.edu

ABSTRACT

Suicide is the second leading cause of death among young adults but the challenges of preventing suicide are significant because the signs often seem invisible. Research has shown that clinicians are not able to reliably predict when someone is at greatest risk. In this paper, we describe the experimental design and collection of a multimodal dataset, including a clinical interview of mental health history, text messages, call history, emails, social media data, and web browsing activity from individuals with a history of suicidal thoughts and behaviors. By reconstructing the timeline of recent suicidal behaviors through a retrospective clinical interview, this study utilizes a prospective research design to understand which features in text communications predict suicide attempts (vs. periods of suicidal ideation or depression). Identifying subtle clues in communication indicating when someone is at heightened risk of a suicide attempt may allow for more effective prevention of suicide.

Author Keywords

suicide, mental health, social media, depression, text messages

ACM Classification Keywords

H.1.2 User/Machine Systems; I.5 Pattern Recognition; J.3 Life and Medical Sciences: Health; J.4 Social and Behavioral Sciences: Psychology

INTRODUCTION

Suicide is a serious public health problem with increasing prevalence. The overall suicide rate in the U.S. rose by 24% from 1999 to 2014, according to the National Center for Health Statistics [27]. In fact, in the U.S. one person attempts suicide every 38 seconds and an average of 94 individuals complete a fatal suicide attempt each day. [8]. Millennials, the first generation to be immersed in technology and social media [29], are an especially vulnerable population as suicide is the second-leading cause of death among individuals aged 25 to 34 and third-leading cause among individuals aged 15 to 24 [8, 5].

Given the staggering toll of suicide, it is catastrophic that our methods for identifying those at highest risk of suicide remain woefully ineffective. Thus far, the majority of suicide research has focused on identifying general risk factors for suicide (e.g., age, gender, psychiatric history), and our chief method for assessing acute suicide risk remains clinicians' judgments, which, unfortunately, do not accurately predict future suicidal behaviors [18]. Thus, there is an urgent need for novel, data-driven tools to assess acute suicide risk. We need to predict not only who, in general, is at heightened risk for suicide, but also when that person is especially at risk.

According to Pew Research Center, 99% of Millennials use the internet and 92% own a smartphone in the U.S. [22]. The rising use of smartphones and content-sharing services such as email, blogs, crowd-source sites, and social media has resulted in a proliferation of unstructured text data. Applying text mining techniques to person-generated data, such as text messages and web browsing history, may identify how communication patterns and media use change as an individual's risk state increases (e.g., from depression to suicidal ideation to suicide attempt) [16].

Recent data-driven suicide research efforts apply text mining techniques to person-generated text data from clinicians' notes recorded in electronic medical records (EMRs), suicide notes, patient responses to an interview inquiring about suicidal intent conducted by a social worker, and social media data collected via application programming interfaces (APIs) coupled with inferences about the individual's mental state (e.g., Reddit or Twitter data) [24, 20, 21, 6, 4]. However, these studies identify *who*, not *when* someone is at risk. Additional limitations of these studies include using text data that is subject to clinicians' judgment or data collected post-attempt.

Previous suicide research in the field of psychology has primarily focused on the difference between individuals with suicidal ideation and controls [15]. However, the level of risk dramatically increases as an individual progresses in suicidal thoughts and behaviors: 34% of suicide ideators go on to make a suicide plan; 72% of individuals with a suicide plan go on to make an attempt; and 26% of ideators without a plan make an unplanned attempt [16].

In this paper, we describe the experimental design and collection of a multimodal dataset built specifically to identify unique patterns of communication that occur in advance of a suicide attempt, providing insight into when someone is at heightened risk. The dataset includes personal communication (i.e., short message service [SMS], emails, and call

history), social media data (i.e., Twitter and Facebook), web browsing history, and mental health history. To the best of our knowledge, this is the first multimodal dataset with known mental health outcomes for suicide research. Applying data-driven techniques to this dataset will help address a serious gap in suicide research by allowing for within-subject comparisons as an individual transitions into higher risk states.

EXPERIMENTAL DESIGN

Prior to data collection, an online survey was distributed to the Department of Psychology's undergraduate participant pool at the University of Virginia (UVa) [11] to evaluate students' communication habits using various electronic services. Of the 796 students who participated in this survey, individuals highly endorsed regularly using SMS (95.1%) and email (87.7%) for writing personal messages intended for an individual or group to see, followed by Facebook (63.7%) and Twitter (31.9%). Those endorsing text messages reported sending personal messages many times a day, compared to other services, which were used once a day (e.g., email) or less than once a day (e.g., Facebook, Twitter). On a Likert scale from 1 to 5 of likelihood of using a particular service to send emotionally expressive messages, text messages had the highest likelihood (3.9), followed by Facebook (2.9), Twitter (2.7), and email (1.6).

The data collection process consisted of two phases: recruitment and the laboratory study, as described below. Figure 1 presents the steps involved in the data collection process. The study protocol was approved by the institutional review board of UVa.

Recruitment

Participants were recruited from the undergraduate participant pool to complete a 2-hour laboratory session. Participants received either course credit or $40 for participating in the study. Prior to a participant being invited into the laboratory, participants were pre-screened using two online surveys and a phone screen.

Online Survey Screen

An initial online survey was distributed to the undergraduate participant pool. The initial survey included the question "Have you ever had a period of sadness in the past during which you felt hopeless?" and included an option to be contacted about possible participation in studies asking about this time period in their life. Of the 2,377 students who participated in the initial survey, 1,478 (62.2%) indicated a period of past sadness.

A follow-up two-question survey was emailed to individuals who answered yes to the initial survey question and consented to be contacted (n=1,211). The second survey included the questions: "Have you ever made a suicide attempt?" and "Have you ever had thoughts of wanting to kill yourself?". Of the 871 students who participated in the follow-up survey, 593 (68.1%) indicated thoughts of killing themselves and 87 (10.0%) endorsed a past suicide attempt. Individuals who endorsed a past suicide attempt were emailed and invited to participate in a phone screen to see if they qualified for the study.

Phone Screen

During the phone screen, participants were provided with more information about the study and the interviewer ensured that inclusion criteria for the study were met. Inclusion criteria included: (1) confirmation of past suicidal thoughts and behaviors; (2) adult status (at least 18 years old); (3) availability and access to personal messaging data dating back to prior significant life events (i.e., suicide attempts); and (4) minimal or no self-reported current desire to die (determined by a suicide risk assessment tool and no current suicide plan or intent). Any individuals who were determined to be at high or imminent risk were excluded from participation and referred to clinical care. Of the 77 students who consented to a phone screen, 52 (67.5%) completed the phone screen and 42 (80.7%) qualified to complete the laboratory study.

Laboratory Study

The laboratory procedure included downloading the participants communication data, an interview with the participant, and completion of questionnaires.

Data Download

For transparency, participants downloaded their own data with the assistance of the experimenter. The downloaded data included SMS, call history, Facebook, Twitter, Gmail, Google Hangouts, and Chrome search history. SMS and call history were downloaded using third-party software. The remaining data were downloaded using the API provided by the platform.

Interview: Identification of Close Relationships

Participants were asked by the experimenter to list the names of up to 10 people who they frequently discuss their emotions with and to categorize the relationship with the person (e.g., friend, family, significant other, mental health professional, or school/work colleague).

Interview: Identification of Mental Health Episodes

Participants were asked by the experimenter to identify up to three episodes for four types of events in their life: (1) recent suicide attempts, (2) suicidal ideation (with no attempt), (3) depression (with no suicidal ideation or attempt), and (4) positive mood (with no depression, suicidal ideation, or attempt). In addition to providing specific dates for the episodes, the participants were asked of their certainty of the identified dates and to provide details and context surrounding the episodes. Interview questions for each episode included questions about suicidal thoughts and behaviors, depressive symptoms, mood, and alcohol/substance abuse. These questions were selected from standardized questionnaires, including the Self-Injurious Thoughts and Behaviors Interview (SITBI) [17], Columbia-Suicide Severity Rating Scale (C-SSRS) [23], Suicide Intent Scale (SIS) [2], Beck Scale for Suicidal Ideation (BSS) [1], Beck Depression Inventory-II (BDI-II) [2], Patient Health Questionnaire-4 (PHQ-4) [13], and Daily Drinking Questionnaire [7].

Questionnaires

At the end of the laboratory session, participants completed the following questionnaires: (1) demographics, (2) online

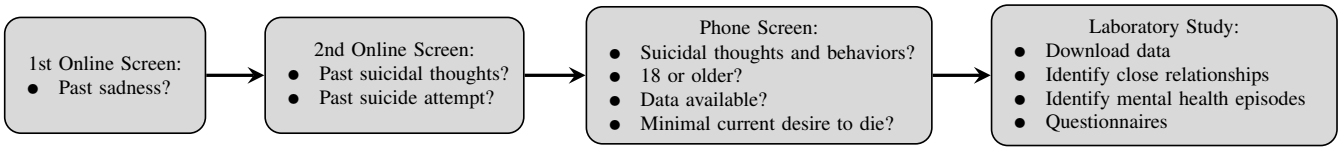

Figure 1. Data collection process.

communication habits, (3) mental health and treatment history (items adapted from World Health Organization World Mental Health-Composite International Diagnostic Interview (WHO WMH-CIDI) [12]), (4) suicidal thoughts and behaviors (SITBI, SIS, BSS), (5) depression and anxiety symptoms (Depression Anxiety Stress Scales (DASS) [14]), (6) general mood (modified 12-item version of the Positive and Negative Affect Schedule (PANAS) [28]), (7) hopelessness (Beck Hopelessness Scale (BHS) [3]), (8) optimism (Revised Life Orientation Test (LOT-R) [26]), (9) future self-judgments (Modified Future Self Scales (MFSS) [9]), and (10) perceived social support (Multidimensional Scale of Perceived Social Support (MSPSS) [30]).

DESCRIPTION OF THE COMPLETED DATASET

Tables 1, 2, and 3 present the descriptive statistics about the participants, identified episodes of mental health events, and types of data collected, respectively. With the exception of web browsing history, all available data types were collected from the participant. Of those missing data types, either the participant indicated that they did not have an account for the service or did not use it for personal messaging, or a software error occurred during data collection. Five participants declined collection of their web browsing data.

Ethical Considerations

Prior research indicates that asking young adults with a history of suicide attempts about suicide does not cause an increase in psychological distress or increase suicidal thoughts or behaviors, either immediately following an assessment [10] or several years after an assessment [25]. Nonetheless, to assess any changes as a consequence of the laboratory study, participants were asked to rate their negative mood and desire to die (measured on Likert scales from 0 to 10) at the beginning and end of the laboratory study. Risk mitigation plans were in place for participants who experienced a significant increase in negative affect or suicidality. Fortunately, as expected based on prior research, no participants expressed a significant increase in their desire to die following the interview. Only one participant reported an increase in their desire to die (1 pre-interview to 2 post-interview). On average, participants' negative mood did not change significantly (3.7 pre-interview to 3.9 post-interview) and desire to die decreased slightly (0.8 pre-interview to 0.6 post-interview).

LIMITATIONS

Selection bias was reduced by using a case-crossover design (i.e., the individual case serves as his/her own control), but we are limited by studying only participants in the UVa undergraduate community, limiting generalizability. Also, the results may be affected by recall bias if participants inaccurately recalled the time periods of episodes. To help address

No. of Participants	
Total	33
Gender	
Female	28
Male	5
Ethnicity	
Hispanic	4
Non-Hispanic	29
Race	
White	21
Asian	6
Black	3
Multiple/Other	3

Table 1. Descriptive statistics about the participants.

No. of Episodes	
Suicide Attempts	67
Certain	34
Uncertain	33
Average Episodes per Participant	2
Suicidal Ideation	71
Certain	53
Uncertain	18
Average Episodes per Participant	2
Depression	82
Certain	71
Uncertain	11
Average Episodes per Participant	2
Positive	84
Certain	79
Uncertain	5
Average Episodes per Participant	2

Table 2. Descriptive statistics about the episodes.

No. of Participants with Data Type	
SMS	30
Call History	23
Facebook	31
Twitter	8
Gmail/Google Hangouts	32
Chrome Browser History	12

Table 3. Descriptive statistics about the types of data collected.

this concern, participants were allowed to look back through their calendars, social media, and SMS when selecting the dates of each episode. Additionally, participants were asked how certain they were when identifying the date(s) of the episode (i.e., ranging from very certain that the recalled date is correct to the date may be incorrect by more than two weeks).

Another limitation of the study is use of third-party software to extract smartphone data (i.e., SMS and call history). Smartphone data is limited to SMS and call history currently stored on the phone and the format of the data varies based on the software. Collection of Facebook, Twitter, Gmail, Google Hangouts, and Chrome search history were done through platform-dependent APIs, capturing a more robust and longer history of data.

Finally, the financial and time commitment for the data collection is substantial. Crowdsourcing an online data collection process, such as [19], may be an option for the future to reduce study costs and labor.

ONGOING AND FUTURE WORK

This dataset was created to investigate temporally sensitive patterns in communications that predict acute suicidal behaviors. By comparing communication patterns on multiple platforms among suicide attempters during periods immediately preceding an attempt versus other periods of their life, we aim to isolate specific attributes of communications that characterize states of acute suicide risk.

To do this, we will use applied machine learning to model: (1) within subject differences in communications of individuals with a past non-fatal suicide attempt during time periods preceding an attempt versus other identified mental health episodes, and (2) between episode differences in the aggregated data of individuals with a past non-fatal suicide attempt.

This research will provide insight into how language patterns change across multimodal media as an individual transitions from suicidal ideation to a suicide attempt indicating an increasing level of suicide risk. Previous literature has generated little knowledge about the differences between periods of suicidal ideation versus periods when an actual attempt is imminent [15]. Employing data-driven techniques, such as those developed in this study, could identify individuals at risk and help direct appropriate resources to these individuals. As Nock et al. [16] report,"the biggest shortcoming in suicide research to date" is "the inability to dramatically decrease rates of suicidal behavior and mortality despite decades of research and associated commitment of resources." This research may enable new ways to identify not just who is at risk for a suicide attempt, but also when a given person increases in their risk state and acutely needs services.

ACKNOWLEDGMENTS

The authors thank Abbie Starns for her help with organizing data for this study. The work was supported by the Presidential Fellowship in Data Science at UVa and NIH T32 LM012416-01.

REFERENCES

1. Beck, A., Kovacs, M., and Weissman, A. Assessment of suicidal intention: The Scale for Suicide Ideation. *Journal of Consulting and Clinical Psychology 47*, 2 (apr 1979), 343–52.
2. Beck, A., Steer, R., and Brown, G. *Manual for the Beck Depression Inventory-II*. Psychological Corporation, San Antonio, TX, 1996.
3. Beck, A., Weissman, A., Lester, D., and Trexler, L. The measurement of pessimism: The Hopelessness Scale. *Journal of Consulting and Clinical Psychology 42*, 6 (dec 1974), 861–865.
4. Braithwaite, S. R., Giraud-Carrier, C., West, J., Barnes, M. D., and Hanson, C. L. Validating Machine Learning Algorithms for Twitter Data Against Established Measures of Suicidality. *JMIR Ment Health 3*, 2 (2016), e21.
5. Centers for Disease Control and Prevention: National Center for Health Statistics. Leading Causes of Death, 2016. http://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm.
6. Choudhury, M., Kiciman, E., Dredze, M., Coppersmith, G., and Kumar, M. Discovering Shifts to Suicidal Ideation from Mental Health Content in Social Media. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)* (2016), 2098–2110.
7. Collins, R. L., Parks, G. A., and Marlatt, G. A. Social determinants of alcohol consumption: The effects of social interaction and model status on the self-administration of alcohol. *Journal of Consulting and Clinical Psychology 53*, 2 (apr 1985), 189–200.
8. Emory University. Emory Cares 4 U: Suicide Statistics, 2017. http://www.emorycaresforyou.emory.edu/resources/suicidestatistics.html.
9. Ersner-Hershfield, H., Garton, M. T., Ballard, K., Samanez-Larkin, G. R., and Knutson, B. Don't stop thinking about tomorrow: Individual differences in future self-continuity account for saving. *Judgment and Decision Making 4*, 4 (2009), 280–286.
10. Gould, M. S., Marrocco, F. A., Kleinman, M., Thomas, J. G., Mostkoff, K., Cote, J., and Davies, M. Evaluating Iatrogenic Risk of Youth Suicide Screening Programs: A Randomized Controlled Trial. *JAMA 293*, 13 (apr 2005), 1635–43.
11. Institutional Review Board for Social and Behavioral Sciences at University of Virginia. Psychology Pool, 2014. http://www.virginia.edu/vpr/irb/sbs/resources_guide_pools_existing_psych.html.
12. Kessler, R. C., Abelson, J., Demler, O., Escobar, J. I., Gibbon, M., Guyer, M. E., Howes, M. J., Jin, R., Vega, W. A., Walters, E. E., Wang, P., Zaslavsky, A., and Zheng, H. Clinical calibration of DSM-IV diagnoses in

the World Mental Health (WMH) version of the World Health Organization (WHO) Composite International Diagnostic Interview (WMH-CIDI). *International Journal of Methods in Psychiatric Research 13*, 2 (2004), 122–39.

13. Kroenke, K., Spitzer, R. L., Williams, J. B., and Löwe, B. An Ultra-Brief Screening Scale for Anxiety and Depression: The PHQ-4. *Psychosomatics 50*, 6 (2009), 613–621.

14. Lovibond, S., and Lovibond, P. *Manual for the Depression Anxiety Stress Scales*, 2nd ed ed. Pscyhology Foundation, Sydney, 1995.

15. May, A. M., and Klonsky, E. D. What Distinguishes Suicide Attempters From Suicide Ideators? A Meta-Analysis of Potential Factors. *Clinical Psychology: Science and Practice 23*, 1 (mar 2016), 5–20.

16. Nock, M. K., Borges, G., Bromet, E. J., Cha, C. B., Kessler, R. C., and Lee, S. Suicide and Suicidal Behavior. *Epidemiologic Reviews 30*, 1 (2008), 133–154.

17. Nock, M. K., Holmberg, E. B., Photos, V. I., and Michel, B. D. Self-Injurious Thoughts and Behaviors Interview: Development, reliability, and validity in an adolescent sample. *Psychological assessment 19*, 3 (sep 2007), 309–317.

18. Nock, M. K., Park, J. M., Finn, C. T., Deliberto, T. L., Dour, H. J., and Banaji, M. R. Measuring the suicidal mind: implicit cognition predicts suicidal behavior. *Psychological Science 21*, 4 (apr 2010), 511–517.

19. OurDataHelps. OurDataHelps.org: The world needs more Data Donors, 2016. ourdatahelps.org/.

20. Pestian, J., Nasrallah, H., Matykiewicz, P., Bennett, A., and Leenaars, A. Suicide Note Classification Using Natural Language Processing: A Content Analysis. *Biomedical Informatics Insights 2010*, 3 (aug 2010), 19–28.

21. Pestian, J. P., Grupp-Phelan, J., Cohen, K. B., Meyers, G., Richey, L. A., Matykiewicz, P., and Sorter, M. T. A Controlled Trial Using Natural Language Processing to Examine the Language of Suicidal Adolescents in the Emergency Department. *Suicide and Life-Threatening Behavior 46*, 2 (2016), 154–159.

22. Pew Research Center. Smartphone Ownership and Internet Usage Continues to Climb in Emerging Economies, 2016. http://www.pewglobal.org/2016/02/22/smartphone-ownership-and-internet-usage-continues-to-climb-in-emerging-economies/.

23. Posner, K., Brown, G. K., Stanley, B., Brent, D. A., Yershova, K. V., Oquendo, M. A., Currier, G. W., Melvin, G. A., Greenhill, L., Shen, S., and Mann, J. J. The Columbia-Suicide Severity Rating Scale: Initial Validity and Internal Consistency Findings From Three Multisite Studies With Adolescents and Adults. *The American Journal of Psychiatry 168*, 12 (dec 2011), 1266–1277.

24. Poulin, C., Shiner, B., Thompson, P., Vepstas, L., Young-Xu, Y., Goertzel, B., Watts, B., Flashman, L., and McAllister, T. Predicting the Risk of Suicide by Analyzing the Text of Clinical Notes. *PLOS ONE 9*, 1 (jan 2014), e85733.

25. Reynolds, S. K., Lindenboim, N., Comtois, K. A., Murray, A., and Linehan, M. M. Risky Assessments: Participant Suicidality and Distress Associated with Research Assessments in a Treatment Study of Suicidal Behavior. *Suicide & Life-Threatening Behavior 36*, 1 (feb 2006), 19–34.

26. Scheier, M. F., Carver, C. S., and Bridges, M. W. Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): A reevaluation of the Life Orientation Test. *Journal of Personality and Social Psychology 67*, 6 (dec 1994), 1063–1078.

27. Tavernise, S. U.S. Suicide Rate Surges to a 30-Year High, 2016. http://www.nytimes.com/2016/04/22/health/us-suicide-rate-surges-to-a-30-year-high.html.

28. Watson, D., and Clark, L. A. *The PANAS-X: Manual for the positive and negative affect schedule*. University of Iowa, 1994.

29. Williams, D. L., Crittenden, V. L., Keo, T., and McCarty, P. The use of social media: an exploratory study of usage among digital natives. *Journal of Public Affairs 12*, 2 (may 2012), 127–136.

30. Zimet, G. D., Dahlem, N. W., Zimet, S. G., and Farley, G. K. The Multidimensional Scale of Perceived Social Support. *Journal of Personality Assessment 52*, 1 (mar 1988), 30–41.