Bridging the Gap: Transitioning Suicidal Adolescents seen in the Pediatric Emergency Department to Home Using a Smartphone Application

Steven McGaughey, MD

Department of Emergency Medicine,

Oregon Health and Science University

Masters of Health and Clinical Informatics Candidate

ABSTRACT

Suicide is the second leading cause of adolescent death in the United States (US).[1] Unfortunately, this epidemic has only worsened in recent years with adolescents showing higher rates of depression and suicide in 2015 as compared with 2010. It is now estimated that between 13-20% of all children in the US have an active mental health disorder.[2]

With dwindling mental health resources, many of these patients present to the pediatric emergency department (PED) for care. When adolescents present to the PED, many are assessed and sent home with outpatient mental health resources. They then enter a highly vulnerable period as they await outpatient mental health care while at home. This gap is an extraordinarily high-risk period, as suicidal risk increases following discharge from the PED.[3] Further, follow up with a mental health specialist after a suicide attempt continues to be poor with rates reported as low as 64%.[4] There is a critical need to bridge the gap in mental health care for children and adolescents between the PED and home.

New technologies, including smartphone applications, can offer a way to bridge care. Since their introduction in the mid 2000s, smartphones are now used by 95% of adolescents.[5, 6] While there are many applications that target youths to promote mental health, there is a dearth of applications which focus on aiding adolescents after medical evaluation. Further, the majority of applications are not evidence-based, or are potentially detrimental to adolescents in a time of crisis.[7] Given these factors, our group developed an evidence-based, smartphone application, to help transition adolescents with suicidality from the PED to home. With the application built, we

have designed a pilot study to assess feasibility and utilization rates of this digital tool in a single center academic pediatric emergency department.

INTRODUCTION

Emergency department (ED) physicians are trained to care for and stabilize acutely and critically ill patients. In this role, they provide short-term care and either stabilize patients in order to receive further care in the hospital, or discharge patients to follow up with outpatient providers. The role of the ED physician, and his or her ability to provide adequate care to patients, relies deeply on a broader network of healthcare providers.

Historically, ED physicians focused on managing medical and surgical conditions; but today, they are increasingly responsible for managing acute mental health crises. The American College of Emergency Physicians now include mental health stabilization and treatment as one of the core responsibilities of emergency physicians.[8] This has become more and more important as the rates of both mental health disorders and suicide have risen, especially in children and adolescents.

Currently between 13-20% of all children in the United States have an active mental health disorder and this rate has only increased over the last decade.[9] Furthermore, mental health disorders are a strong predictor of suicide. Over 90% of those who commit suicide have a mental health diagnosis prior to their death.[10, 11] Thus it is unsurprising that the rate of suicide in adolescents in the United States is also rising, with an alarming 31% increase to 14.2/100,000 in 2015. While this still represents a decline from the peak in the mid 1990s, there has a been a steady upward trend over the last decade. Now over 7% of adolescents nationally report at least one suicide attempt over the past year.[1] Additionally, 17% of all high school students reported seriously considering suicide over the past year.[12] Beyond the human costs, mental health

disorders account for more than $247 billion USD in associated costs from healthcare and juvenile justice systems.[1, 2] Mental health disorders are thus one of the most expensive conditions treated in children and adolescents in the United States.[13] All of these factors have caused the American Academy of Pediatrics to declare a state of emergency regarding child and adolescent mental health in 2021.[14]

The ED is often the place of first contact after a patient attempts suicide. Therefore, the ED is a rational site for implementing an intervention geared towards improving mental health outcomes. However, traditional mental health interventions are time and labor-intensive, expensive, and historically have had low compliance. We propose a feasibility study of a smartphone-based application to provide an efficient, low-cost method to help support suicidal adolescents as they await outpatient care. This intervention would provide a critical step in helping to address our adolescent mental health crisis.

EMERGENCY CARE

Shift in the Care Model: A Historical Perspective

Mental health disorders place a unique burden on the ED. Today, adolescents who experience suicidality often seek care in the ED. Historically, however, this was not the case. In the 1960s, a period of "deinstitutionalization" led to the closure of stand-alone inpatient mental health facilities in favor of outpatient and community-based treatment options; since the 1970s, there has been a 62% decrease in inpatient psychiatric beds or an 89% decrease in beds per capita.[15, 16]

Overall, this model has helped to destigmatize mental health conditions. Unfortunately, in the last several years, the demand for outpatient care has far exceeded the capacity of current mental health facilities, leaving a gap for vulnerable patients.[3]

With dwindling community resources and rising costs associated with outpatient mental health care, many individuals, and especially adolescents, are now seeking first-line care for mental health disorders in the emergency department.[16, 17] A recent review confirmed this at multiple east coast academic pediatric hospitals, and in Washington state, mental health disorders are now the leading cause of hospitalization in adolescents, representing one third of the total hospital days for 5–19-year-olds.[16, 18] Unfortunately, the Coronavirus Disease 19 (COVID) pandemic has only exacerbated this crisis. The number of ED visits, proportion of ED visits, and proportion of ED visits admitted to the hospital for mental health conditions have all increased significantly during the pandemic.[19]

The ED is a poor setting for most suicidal patients. After a patient has been stabilized, he or she can spend hours or even days awaiting further care before discharge. The ED is a fast paced, highly stimulating environment which can exacerbate agitated patients. Further, formal psychiatric evaluations are also best conducted in quiet, private areas where patients feel comfortable and this is frequently infeasible in the ED setting. Finally, many pharmacologic treatments used for chronic mental health conditions are not effective in the acute period and require long-term follow up and care.[20] In addition, patients with mental health crises have disproportionately long stays in the ED; boarding, or staying in the ED for over 24 hours, occurs at 5 times the rate as compared to non-mental health patients.[21] [15, 18] Furthermore, when patients

cannot be safely discharged home, they must wait for hours to days to transfer to a psychiatric facility.[20]

Even if a patient is safe to return home, the process of safe discharge is highly complex and prone to failure. Research shows that suicidal patients benefit from (1) an initial, substantive discussion about suicide coupled with (2) rapid follow up to provide sustained support by a trained professional. In the best of cases, large academic hospitals can use their resources to address the initial assessment; a team consisting of social workers, psychiatrists, and ED providers evaluate patients to determine whether a suicidal adolescent is stable for discharge. However, even if a hospital has the social workers to coordinate outpatient care, many patients are still lost to follow up.[22] This is particularly concerning as the period between discharge and outpatient evaluation is the highest risk time for injury or death after a suicide attempt.[3] This creates a cycle where suicidal adolescents present repeatedly to the ED with mental health crises but do not establish with an outpatient professional, creating even more strain for both the patients and the system as a whole.[9]

As EDs struggle to manage our mental health epidemic, other patients suffer. There are fewer beds and resources for other critically ill patients, forcing EDs to close their doors to ambulances, reserving evaluation to only the most critically ill patients, and leaving many patients without the opportunity to be seen by a provider in a timely manner.[15, 18] Together this deprives communities of critical medical care.

Safety Plans

In order to improve the mental health crisis, we need broader utilization of tools that help physicians assess and discuss suicidality while also providing patients with coping skills. One such current tool is the safety plan.

After a patient in a mental health crisis is evaluated and determined to be stable to discharge home, providers commonly use a safety plan to discuss suicidality and coping mechanisms. The most widely used form is the Stanley Brown safety plan which can help risk-stratify suicidality in the ED and provide risk mitigation techniques at home.[23, 24] This plan is crafted jointly by a medical specialist and the patient and consists of six components:

a. "*recognizing warning signs of an impending suicidal crisis*
b. *employing internal coping strategies*
c. *utilizing social contacts as a means of distraction from suicidal thoughts*
d. *contacting family members or friends who may help to resolve the crisis*
e. *contacting mental health professionals or agencies*
f. *reducing the potential use of lethal means."* [24]

The premise behind this plan is that patients are led through a structured interview and identify strategies to self-manage and de-escalate when having imminent suicidal thoughts. This specific safety plan was developed for acute care or emergent settings such as EDs, trauma units, crisis lines, or emergency response units. A recent randomized control trial in US Army solders has

shown this safety plan is effective at decreasing suicidal ideation, attempts, and hospitalization days.[25]

Traditional standardized safety plans are a valuable means of providing streamlined counseling on suicidality and coping mechanisms. However, anecdotally, adolescent patients lose this piece of paper after discharge and therefore do not use it at a time of crisis. Therefore, transitioning this intervention to a digital platform is a promising method for both engaging adolescent patients and ensuring they have their coping strategies at a time of crisis.

Digital Tools

Smartphone applications are an ideal method to bridge care between the ED and home. Smartphones are nearly ubiquitous; since their introduction in the mid 2000s, smartphones are now used by 95% of adolescents.[5, 6] In addition, a survey conducted in a psychiatric outpatient clinic noted close to 70% of respondents are interested in using a mobile application to help track their mental health.[26] Despite this desire, adolescents currently have very few choices for high-quality applications: of the nearly nine million applications currently available, only a fraction focus on mental health. A recent systematic review found that, of 123 smartphone applications that claim to address suicide or deliberate self-harm, only 24 applications focused on suicide prevention.[27] The applications that do exist focus on a single suicide-prevention strategy such as access restriction, self-screening, crisis support, psychotherapy, safety plans, and ongoing outreach and none of the applications provided comprehensive evidence-based suicide prevention. Even more worrisome: several applications that branded themselves as ‘suicide applications’ provided dangerous content, including lists of means of instant death, or suggested

risky behavior. Less than 90% of the total applications identified via systematic searching had any suicide prevention strategy.[7]

CURRENT PUBLISHED WORK

Fortunately, researchers have identified the need for better digital tools for suicidality. A recent prospective trial evaluated a smartphone-based application to provide continued care after hospital discharge. The application provided a digital safety plan, emotional regulation skills, and distress tolerance strategies. Their primary outcome was harm reduction. The authors found a trend in decreased suicide attempts, although they did not find statistical difference with their intervention. Importantly they did demonstrate feasibility of an application-based intervention and showed that over 70% of participants used the application at least once.[28] A similar application is being tested by a group in Denmark which also includes safety planning, coping strategies, hotlines, and directions to the nearest ED. Focus groups supported their application design, however their findings are not yet published.[29] Similarly, the government of Belgium has funded development of an application that provides an evidence-based, multimodal approach to suicide prevention. Their tool contains emergency contacts, coping strategies, safety plan, and a repository of positive self-selected elements to combat hopelessness. Their application was vetted by a multidisciplinary team of experts but has not yet published results on its utility or deployment.[30]

EVIDENCE BASED APPLICATION ON ADOLESCENT SUICIDE PREVENTION

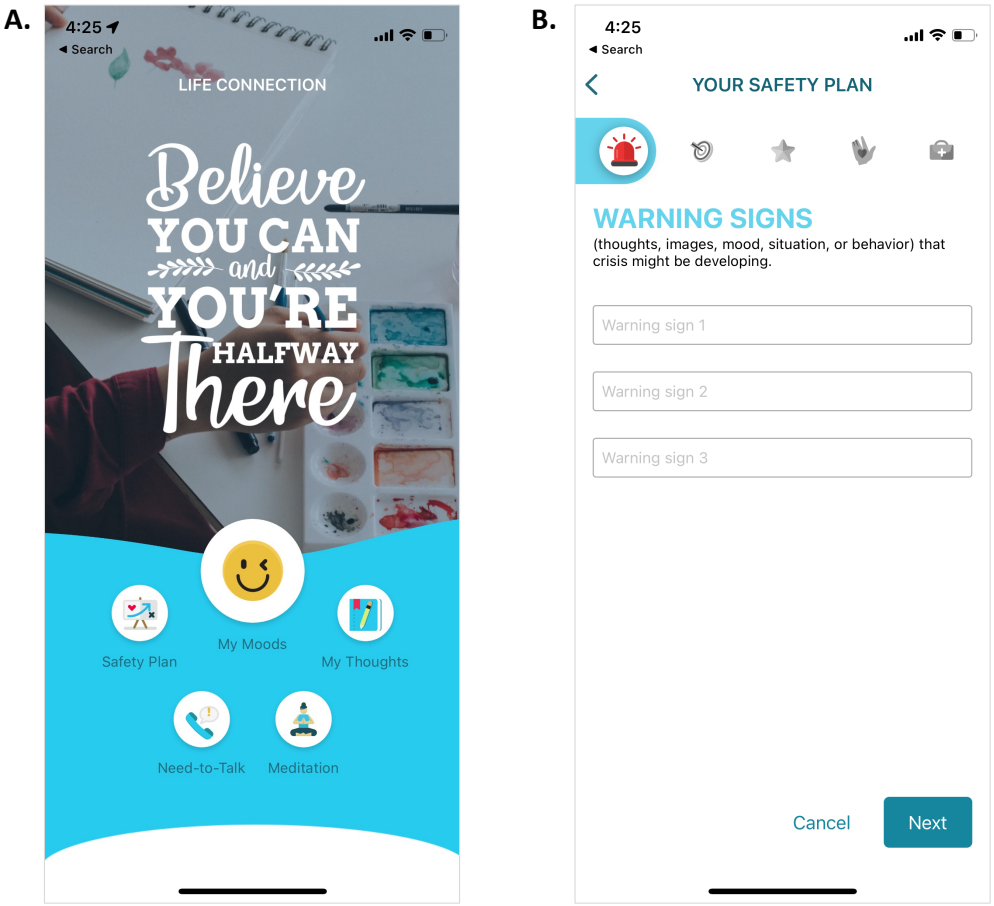
Development

To the best of our knowledge, there are currently no English language, freely available, evidence-based, application for suicide prevention. The applications that show promise are either regionally-restricted, or academic research tools that are not available to the general public.[7, 31] Our group therefore developed an application that fills this gap. Starting in 2018, a multidisciplinary group of academic pediatric hospitalists, child and adolescent psychiatrists, and pediatric emergency medicine physicians was assembled with the aim of helping transition adolescents with suicidality from the pediatric emergency department to home. The first prototype application was designed in 2018 by local university engineering students. After completion, we partnered with adolescents from YouthEra, a national youth advocacy group that provided feedback to further refine our prototype. Our group then performed an extensive literature search to determine evidence-based suicide prevention strategies that could be translated into a digital format. Using our adolescent user feedback in conjunction with our literature search, we reached consensus on deploying an application with a collection of features: a personalized safety plan, mood tracking, emergency contacts, personalized coping skills, medication and appointment reminders, and electronic postcards. Given the current research, we opted to focus first on building an application that centers around an already established tool in the ED—the paper-based safety plan. We subsequently secured three internal grants—Hedges Emergency Department grant, the pediatric specific Talwalker Grant, and the Tartar Trust grant. These funds were used to hire a dedicated application development team. Over 9 months, our multidisciplinary group worked with this design team to create an Apple iOS specific mobile

application. After an iterative process, with input from pediatricians, child and adolescent psychiatrists, and pediatric emergency medicine physicians, a pilot application was developed and subsequently launched for the public on the Apple iOS application store in 2021 (fig 1.). The application provides several components— a home screen (fig. 1a) with quick links to personalized and region-specific emergency contacts and, a personalized safety plan mirrored off the standard Stanley Brown plan (fig. 1b). The application also provides hyperlinks to national and local hotlines (fig. 1c) and mood tracking and journaling function (fig. 1d). This daily mood tracker was further developed to allow free text comments to these daily entries. From this, we then developed a simple algorithm that prompted users to reach out to support individuals or hotlines if a threshold of low mood was met.

Figure 1

Bridging the Gap iOS Application



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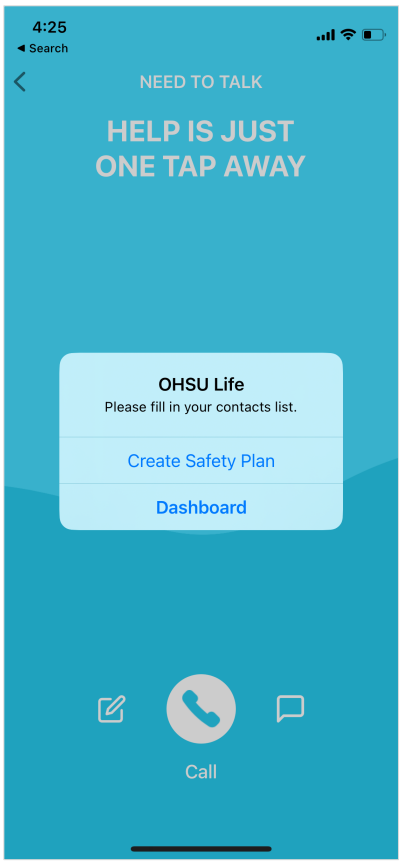

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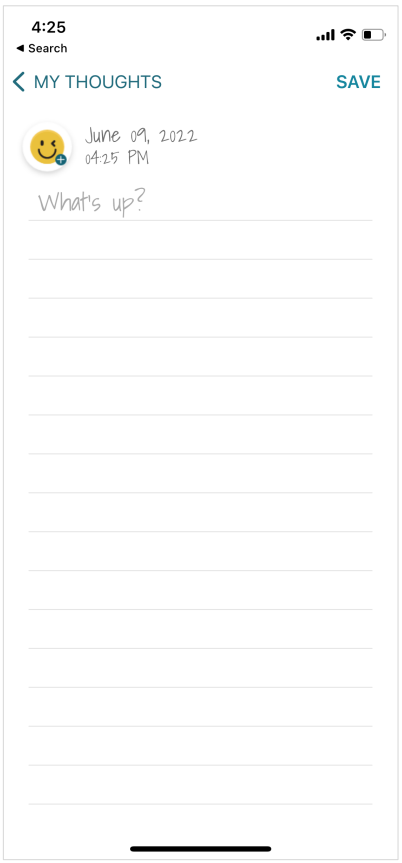


Standard Treatment

At our academic pediatric hospital, suicide adolescents may present to the ED with suicidality or following a suicide attempt. These patients are then assessed by a team including an ED social worker and/or by the child and adolescent psychiatry consult-liaison team, which consists of a specialized pediatric mental health social worker and a child and adolescent psychiatry physician. Together, this team determines whether the patient is safe to discharge home or requires further care in an inpatient psychiatric facility. If a patient is safe for discharge, they then work with the patient to develop a safety plan. This plan is a paper document that is created

in conjunction with the patient—highlighting personal risk factors for suicidality, and determining resources in the time of crisis.[23]

While this document remains the standard of care, many have hypothesized that its use is limited as it is often not available during a mental health crisis. We therefore developed a pilot study with an aim to study our newly developed smartphone application versus this standard of care in adolescents after presenting to the PED with suicidality.

PILOT STUDY

Methods

Participants are 13–17 years old adolescents who present to a single academic PED with suicidal ideation or attempt over a 3-month time period. Additional inclusion criteria include access to an Apple iOS smartphone and the ability to be discharged safely to home. Exclusion criteria include diagnosis of autism spectrum disorder, intellectual disability, and/or psychosis. The study was approved by the local institutional review board. Written assent by the adolescent and consent by the legal guardian will be obtained prior to enrollment.

Study Design

Our study is a prospective, observational, internally controlled study that utilizes validated scales. Our main outcome is utilization rates of a smartphone application versus standard of care.

Participants will receive standard of care and the Bridging the Gap iOS application. Demographic data will be collected on enrollment (Fig. 2). This data will include race, ethnicity, insurance, prior ED admission, prior inpatient psychiatric admissions, prior suicide attempts, and history of self-injurious behavior. Participants will then be contacted via a phone survey at 2 and 4 weeks**.** Follow up surveys will gather data on application utilization and characteristics, outpatient mental health care, re-presentation to the ED, thoughts of suicidality, and suicidal attempts. Additional assessments include the Columbia Suicide Severity Score to assess suicidality and the Health Information Technology Usability Evaluation Scale (Health-ITUES) to assess participant satisfaction with the application.[32] The Health-ITUES is a 20 point questionnaire with a 5 point Likert scale that was customized specifically for our application (table 1).

Table 1

Customized Health Information Technology Usability Evaluation Scale (Health-ITUES)

Item	Concept
Quality of Work Life	
I think the Bridging the Gap Application has been a positive addition to my life	System impact-career mission
Perceived Usefulness	

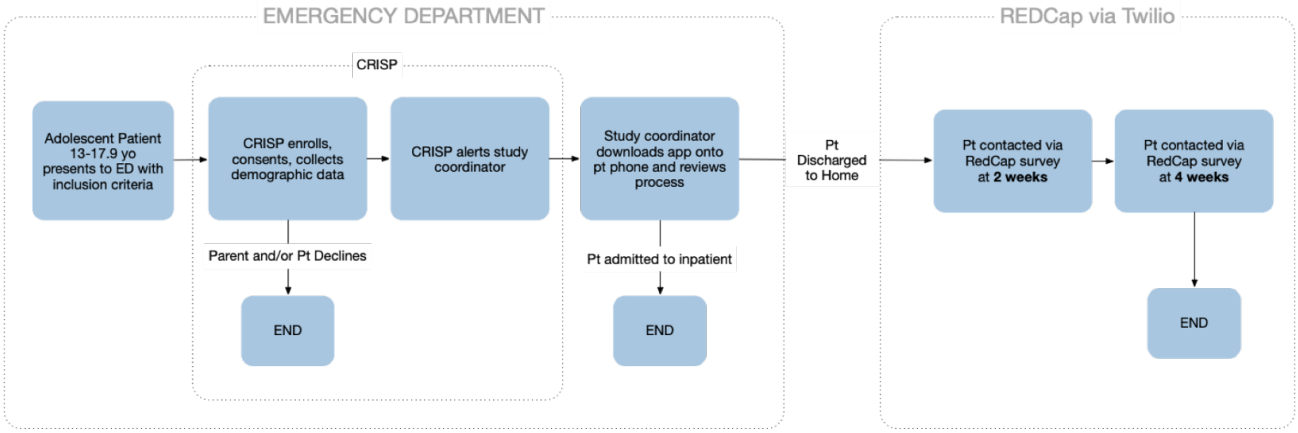
	Using the Bridging the Gap Application makes it easier to self-manage my self-harm thoughts	Productiveness
	Using the Bridging the Gap Application enables me to self-managed my self-harm thoughts more quickly	Productiveness
	Using the Bridging the Gap Application makes it more likely that I can self-manage my self-harm thoughts	Productiveness
	I am satisfied with the Bridging the Gap Application for self-harm thoughts	General satisfaction
	I self-manage my self-harm thoughts in a timely manner because of the Bridging the Gap Application	Performance speed
	Using the Bridging the Gap Application increases my ability to self-manage my self-harm thoughts	Productiveness
	I am able to self-manage my self-harm thoughts whenever I use the Bridging the Gap Application	Information needs
Perceived Ease of Use		
	I am comfortable with my ability to use the Bridging the Gap Application	Competency
	Learning to operate the Bridging the Gap Application is easy for me	Learnability
	It is easy for me to become skillful at using the Bridging the Gap Application	Competency
	I find the Bridging the Gap Application easy to use	Ease of use

I can always remember how to use the Bridging the Gap Application	Memorability
User Control	
The Bridging the Gap Application gives error messages that clearly tell me how to fix problems	Error Prevention
Whenever I make a mistake using the Bridging the Gap Application, I recover easily and quickly	Error Prevention
The information provided with the Bridging the Gap Application is clear	Information needs

Data usage will be extracted from the application that includes the number of application launches, time of usage, number of mood data entered, and activation of resources. For feasibility to deploy in the ED, time of enrollment will be recorded. Total time in minutes is defined as the time our research coordinator spent with each participant. This time includes downloading the application, entering personalized data, and answering all relevant questions.

Figure 2

Enrollment Flowchart



Application

Bridging the Gap is a suicide safety planning application specifically designed to address adolescents with suicidality presenting to the emergency room. The Stanley-Brown Safety Plan is currently standard of care and will be continued to be used in our pilot study. For each participant, our research coordinator will take participant generated information from the paper safety plan and enter the data into the application to create a digitized safety plan. Participants continued to receive the standard of care, the paper-based safety plan document.

Treatment as Usual

All individuals with suicidality who are seen at our PED are evaluated by both an ED or child psychiatry social worker and a pediatric emergency medicine physician. At the discretion of the treating physician, the child psychiatry team can be consulted. All participants will receive a paper-based safety plan prior to discharge.

Outcome Measures

Our study has three aims:

Aim 1: study the utilization rates of our mobile suicide prevention application via participant surveys and application derived data. Our working hypothesis is that adolescents will utilize the mobile safety plan at a higher frequency than the standard of care paper-based safety document.

Aim 2: Determine the impact, perceived usefulness, and ease of use of a suicide prevention application through the Health-ITUES validated scoring system. Our working hypothesis is that adolescents will find the mobile application impactful, useful, and easy to use.

Aim 3: Assess the feasibility of integrating the mobile application intervention into the discharge care work flow through recruitment rates and time of deployment in the PED. Our working hypothesis is that the mobile application can be integrated into ED discharge care with less than 1 hour deployment time, and we will be able to enroll up to 20 patients per month.

Primary Endpoints:

- Utilization rate: as defined as times of self-reported application and standard of care use over a 2-week and 4-week study period.

Secondary Endpoints:

- Numerical Health-ITUES survey score on impact, usefulness, and ease of use of the application
- Recruitment and attrition rates
- Time of application deployment: as defined as the average time a study member spends with each participant in the ED to deploy the user specific mobile application
- Mood tracking: average numerical rating (1-5) of participant's in-application mood
- Emergency contact use: defined as numbers of times a participant contacts an emergency contact during the study period

Data Analysis

Data management will be through REDCap. Statistical analysis will be performed via STATA or SPSS. Descriptive statistics regarding the demographics of the participants, enrollment and attrition rates, frequency of application and safety plan usage, and Health-ITUES survey data will be calculated. A student's t-test and/or chi-squared tests will be utilized to compare characteristics of participants utilizing or choosing not to utilize the mobile application.

Ethical Concerns

By nature of the study, we will deal with a vulnerable patient population as all participants are minors. Furthermore, the participants are likely to be in a vulnerable state, given their chief complaint. After discussions with key leaders in the Departments of Child Psychiatry and Pediatric Emergency Medicine, outpatient mental health representatives, and outpatient psychiatric providers, the study was felt to introduce little harm. We took recommendations from the group to mitigate undue stress to this patient population. All data will be collected in a Health Insurance Portability and Accountability Act (HIPPA) compliant, password protected, secure research database. Participants will be anonymized and data will be deidentified. Additional precautions will be taken with qualitative data to ensure that participants cannot be identified.

Study Implementation

Our pilot study was scheduled to begin in Spring of 2020. Prior to the launch, our institution, like many others, suspended clinical research and restricted in-person staff to essential workers only. This led to a number of specific challenges to our study. First, our group lost funding for the ancillary staff who work to initiate and run our clinical research. Second, our application developer has faced financial challenges and is no longer able to continue to work on this project. This setback has left our application in a state where we are not yet able to pull user data which is essential before our study launches. Lastly, COVID has placed an enormous strain on our ED; we have lost personnel and have taken on greater clinical time, making academic research more challenging. These factors led to unforeseen delays in our study. However, our

group still plans to move forward with our pilot study in the near-future. As COVID has only exacerbated the mental health crisis in the US, this research is of continued importance.[19]

DISCUSSION

Over the last decade, suicide rates have risen in US adolescents and are currently the second leading cause of death in this age group. An estimated one fifth of all adolescents in the US have an active mental health disorder. Unfortunately, outpatient psychiatric resources cannot meet this demand and families and individuals are turning towards the ED for access to mental health help. The downstream effects of this mental health care model shift are wide-reaching. Currently, the average wait time in the ED for an adolescent with a mental health crisis is greater than 5 hours. These patients are admitted to the hospital while awaiting further resources at rates that far exceed non mental health patients. Often when inpatient hospitals do not have the capacity for this large influx of patients, they remain in the ED for days. Together these factors have strained resources, limited medical bed capacity, and forced EDs to close to ambulances which ultimately strips communities of acute care resources.

We believe that technology can be used to aid suicidal adolescents as they transition from the ED to home. Research shows that early and substantive discussion about suicide is key to mitigating future suicide attempts. The structured format of the safety plan provides this intervention while also guiding patients to develop their own coping mechanisms. However, safety plans can only be utilized in a time of crisis when they are easily accessible. Anecdotally, these safety plans are commonly lost or discarded by adolescents after discharge. With 95% of adolescents using

smartphones and 70% of adolescents expressing interest in using applications to help with their mental health, a digital safety plan is a rational approach to supporting suicidal adolescents. Similar applications have been shown to be widely adopted and feasible in research studies conducted internationally. Our group seeks to conduct a feasibility study of an English language, evidence-based application to ensure that adolescents have access to a high-quality safety plan at a time of crisis.

Future Studies

While our proposed feasibility study focuses on the digital implementation of a validated intervention, the application platform can easily be expanded for future studies. One area of interest is using an application to tie patients into integrated care models. Integrated care models describe a web of services, including national crisis centers, hotlines, emergency departments, and community health centers. Several published papers have shown that, when used appropriately, integrated care models can provide effect outreach to at-risk adolescents.[3] Many of these interventions are simple: for example, one study evaluated the impact of 'provider contact' with a patient by simply randomizing patients to receive form letters inquiring about how they were doing with an addressed, stamped envelope to allow patients to respond if they so choose. This intervention led to a statistically significant difference in suicide in the first two years of the study.[3] This study was completed in the 1960's-1990's but could be easily adapted to a virtual platform with automated reminders sent to patients following discharge. Further, with the widespread use of electronic medical records, applications could also integrate with healthcare data, tracking hospital readmissions, appointment adherence, and even medication adherence. This type of platform has the potential to have wide-reaching implications for both patients and

healthcare professionals. Even more important, if designed and implemented carefully, this technology could help interrupt the cycle of repeated presentation to the ED for mental health crises.

The ED is currently asked to serve as both a mental health crisis center, a community mental health center, and a medical emergency center but has neither the resources, space, or personnel to meet these needs. It is therefore paramount that ED physicians focus on connecting patients to available outpatient resources and provide them coping skills.

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