General Hospital Psychiatry xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

General Hospital Psychiatry

journal homepage: www.elsevier.com/locate/genhospsych

A novel engagement of suicidality in the emergency department: Virtual Collaborative Assessment and Management of Suicidality

Linda A. Dimeff[a,*], David A. Jobes[b], Samantha A. Chalker[b], Brian M. Piehl[b], Leticia Lobo Duvivier[c], Benjamin C. Lok[d], Mohan S. Zalake[a], Julie Chung[a], Kelly Koerner[a]

[a] Evidence-Based Practice Institute, LLC, 3303 South Irving Street, Seattle, WA 98144, USA
[b] The Catholic University of America, O'Boyle Hall, Room 314, 620 Michigan Ave NE, Washington, DC 20064, USA
[c] Central Arkansas Veterans Healthcare System, 5665 Ponce de Leon Boulevard, Coral Gables, FL 33146, USA
[d] University of Florida, Department of Computer and Information Sciences and Engineering, CSE Room E544, P.O. Box 116120, Gainesville, FL 32611-6120, USA

ARTICLE INFO

Keywords:
Suicide
Emergency department
Virtual
CAMS

ABSTRACT

Objective: A novel avatar system (*Virtual Collaborative Assessment and Management of Suicidality System*; V-CAMS) for suicidal patients and medical personnel in emergency departments (EDs) was developed and evaluated. V-CAMS facilitates the delivery of CAMS and other evidence-based interventions to reduce unnecessary hospitalization, readmissions, and suicide following an ED visit.

Method: Using iterative user-centered design with 24 suicidal patients, an avatar prototype, "Dr. Dave" (based on Dr. Jobes) was created, along with other patient-facing tools; provider-facing tools, including a clinical decision support tool were also designed and tested to aid discharge disposition.

Results: Feasibility tests supported proof of concept. Suicidal patients affirmed the system's overall merit, positive Perception of Care, and acceptability; medical providers (n = 21) viewed the system as an efficient, effective, and safe method of improving care for suicidal ED patients and reducing unnecessary hospitalization.

Conclusions: Technology tools including a patient-facing avatar and e-caring contacts, along with provider-facing tools may offer a powerful method of facilitating best-practice suicide prevention interventions and point-of-care tools for suicidal patients seeking ED services and their medical providers. Future directions include full development of V-CAMS and integration into a health electronic medical record and a rigorous randomized controlled trial to study its effectiveness.

1. Introduction

In 2016, 44,965 people died by suicide in the United States [1], making suicide the tenth leading cause of death overall [2] and the second leading cause of death among those aged 10–44 [3]. In addition, 9.8 million adults contemplate suicide annually. Of these, over one million will make a suicide attempt [4]. Suicide rates in the U.S. increased 24% from 1999 through 2014 for males and females and for all ages 10–44, from 10.5 to 13.0 per 100,000. In 2013, 1.3 million U.S. adults reported making a suicide attempt in the past year; 9.3 million reported having serious thoughts about suicide [5–7]. The U.S. cost of suicides and suicide attempts in 2013 was $58.4 billion—of this 97% was due to lost productivity [8]. When adjusted for underreporting, the figure rises to $94.5 billion or $298 per capita [8].

Emergency department (ED) visits for suicidal ideation and costs associated with these visits has also soared in recent years [8]. Between 2006 and 2013, the rate of ED visits due to suicidal ideation increased by 12% on average annually; by 2013, 1% of all ED visits involved suicidal ideation. In 2012, 483,596 people were treated in EDs for suicide attempts and non-suicidal self-injury, and 332,833 were hospitalized [8]. By 2013, 72% of all ED visits for suicidal ideation resulted in hospital admission. Further, the average length of stay per hospital admission due to suicidal ideation increased from 5.1 days to 5.6 days. During this same period, the percent average annual increase in ED plus inpatient costs for those admitted due to suicidal ideation rose by $1000, from $5000 to $6000 per admission [8]. While it might be hoped that hospitalization may resolve suicide risk, studies show that suicide risk may actually *increase* (up to as much as 200 times) for individuals recently discharged [9–12].

Patients with behavioral health crises pose special challenges for hospital EDs [13]. In the face of increasing utilization, ED "boarding" has unfortunately prolonged the ED waiting experience as inpatient

* Corresponding author.
E-mail addresses: linda@ebpi.org (L.A. Dimeff), jobes@cua.edu (D.A. Jobes), 97chalker@cua.edu (S.A. Chalker), 76piehl@cua.edu (B.M. Piehl), lok@ufl.edu (B.C. Lok), julie@ebpi.org (J. Chung), kelly@ebpi.org (K. Koerner).

https://doi.org/10.1016/j.genhosppsych.2018.05.005
Received 19 February 2018; Received in revised form 17 April 2018; Accepted 17 May 2018

hospital beds may be unavailable and/or transfer to another facility's inpatient unit can often take time [14]. Studies have shown that boarding leads to crowding, poor patient experience and lower quality care [15], delays in treatment, morbidity and mortality [16], and lost revenue [14]. On average, behavioral health patients wait more than three times longer for a bed compared to those with medical emergencies [13,14]. Behavioral health emergencies further deplete ED resources and contributing to crowding as beds that might otherwise be used to treat patients with life-threatening medical conditions [17] are used for those with behavioral health crises. One study found that every behavioral health admission prevented 2.2 beds from turning over and ultimately cost the ED an average of $2264 [14] in lost revenue. Behavioral health patients are routinely held in the ED for days and in some cases weeks. Some studies have found patients with public insurance or who self-pay are significantly more likely to have an ED stay of more than 24 h [13,18]. ED stays, expenses, and care are crucial to the reduction in death by suicide. These issues may lead to less than therapeutic—sometimes even iatrogenic—experiences for some suicidal ED patients who may wait for many hours to even see their ED doctor, let alone realize an optimal clinical disposition.

Effective treatments to reduce death by suicide and suicide attempts exist. In a summary of published suicide randomized controlled trials (RCTs; N = 43), Linehan [19] concluded that outpatient behavioral interventions, including the Collaborative Assessment and Management of Suicidality (CAMS), show considerably more promise than inpatient hospitalization or pharmacotherapy [19–26]. "Caring contacts" via mail or phone were also successful brief interventions that prevent death by suicide [20,21,27–29]. Specifically, those who receive a caring note from the hospital following discharge were nearly 10 times less likely to attempt suicide compared to controls in one study [27]; in others, they were nearly half as likely to attempt or complete suicide in the future [20,21,28,29].

Developed by David Jobes, CAMS is a non-prescriptive, a-theoretical therapeutic framework for patients drawn to suicide as a means of coping. Three published RCTs [30–32] eight non-randomized clinical trials [33–40], and two not yet published RCTs across multiple treatment settings provide ample replicated evidence that CAMS reliably outperforms control conditions in reducing suicidal ideation, overall symptom distress, and depression, while increasing hope, patient satisfaction, and retention to care. A recent RCT provides promising evidence that CAMS reduces self-harm and suicide attempts [31] and that standard CAMS significantly decreases ED visits among suicidal military sub-samples [39,41]. In a community-based RCT [30], CAMS patients had significantly larger and sustained decreases in suicidal ideation and symptom distress with increased hope, clinical retention, and treatment satisfaction. From the superiority RCT in Denmark [31] comparing Dialectical Behavior Therapy (DBT) to CAMS, there were no statistically significant differences in self-harm and suicide attempts among 108 suicide attempters with borderline personality disorder traits despite the fact that CAMS patients received fewer sessions (once weekly for about 10 weeks) compared to those in DBT (twice weekly for 16 weeks). A recent RCT [32] of 148 suicidal U.S. Army Soldiers found that CAMS significantly eliminated suicidal ideation at three months in comparison to enhanced care as usual and sustained that reduction at 6 and 12 months follow-up.

The recent and steady rise in completed suicides despite numerous effective suicide prevention interventions and billions of public and private research dollars has resulted in considerable debate about why we have failed to "bend the (statistical) curve" with respect to suicide [6]. While numerous factors may account for this fact, expert opinion leads to two clear solutions: First, we have to find ways to "bake (evidence-based practices; EBPs) into healthcare systems so they are used more automatically" [42]. While "bits and pieces" [42] exist, we have yet to put them together in a way that facilitates ease of delivery. Second, smart innovative technologies, including mobile apps and behavioral health platforms, may help "bend the curve" by facilitating the delivery of EBPs, improving access to EBPs, and enabling care coordination [6].

Aligned with the U.S. Surgeon General and the National Action Alliance for Suicide Prevention's "Zero Suicide" (ZS) other policy initiatives [43,44,46–48], we sought to develop a highly innovative, scalable, and effective suicide assessment and intervention for use in EDs. Our goal was to bake suicide prevention EBPs into EDs, to reduce suicides, unnecessary hospitalization, and improve clinical care within large systems of care.

Inspired by "Nurse Louise," a discharge nurse avatar developed by Brian Jack, MD and colleagues at Boston University to reduce hospitalization readmission rates, we wondered whether an avatar [49–51] could be used in EDs to perform a CAMS suicide risk assessment with suicidal ED patients, to teach behavioral skills for reducing imminent distress, and to generate hope by hearing personal stories from persons with lived experience. Studies of "Nurse Louise" had demonstrated its efficacy in reducing ED visits and hospital re-admissions by about 10–30% [52,53]. "Nurse Louise," delivered on a touchscreen attached to a desktop computer and wheeled into the patient's hospital room, "engaged" the patient with patient education and safety information to facilitate a successful discharge from the hospital [54]. Patients "talked" to "Nurse Louise" by answering a series of simple questions about their problems; "Nurse Louise" responded by offering information based on a simple pre-programmed menu of options. The clear majority of patient users were "very satisfied" with "Nurse Louise" (78%) and found "her" "very easy to use" (78%) [54]. Only 11% of patients scored below the midpoint on a scale of therapeutic alliance. In addition, 74% of patients preferred receiving discharge instructions from "Nurse Louise" than from a live doctor or nurse: "*She kept asking if I was tired, or if I wanted to take a break. She cared about me, you know*;" "*Sometimes doctors just talk and assume you understand what they're saying. With a computer you can go slow, go over things again and she checks that you understand.*"; or "*I've had problems with, not this hospital, but other hospitals. I wasn't given the quality time that this lady gave me.*" [56,57]. Engagement with "Nurse Louise" was estimated to save $145 per patient by reducing personnel requirements. Importantly, "Nurse Louise" cut hospital readmissions by half, saving the hospital $412 per patient [55].

Several studies have been conducted to date involving use of virtual agents to address mental health problems. Rizzo and colleagues have developed virtual simulation environments to facilitate training among mental health providers [58–62]. More recently, SimCoach was developed as a virtual healthcare agent to provide veterans and military service members with information about behavioral health problems, assistance in exploring options for care, and to help them connect with live service providers when needed [63]. Lissetti and her colleagues recently developed and tested an avatar to administer a brief motivational intervention for reducing problem drinking; the avatar was deemed both helpful and well-liked by its users [64]. These findings are consistent with other positive findings from avatar studies [65,66].

The current study sought to design, develop, and evaluate the feasibility of "Dr. Dave" and the Virtual CAMS system, including electronic "Caring Contacts," for suicidal patients in EDs, as well as a provider-facing clinical decision support tool to aid in discharge disposition to reduce unnecessary hospitalization.

2. Method

2.1. Process of prototype development and formative evaluation

We applied user-centered design (UCD) principles and methods throughout the formative evaluation as we designed and built the software and content [67–71]. This agile development approach began with understanding the workflow and needs of target end-users, creating and refining preliminary ideas using paper prototypes, progressing to low-fidelity prototypes, and finally building the digitized

software. UCD methods included: contextual inquiry, concurrent think aloud, retrospective think aloud, concurrent probing, and retrospective probing. Semi-structured interviews followed individually administered usability tests to gain further insights into the end-user's experience. We conducted tests in small "batches" (often 4 to 5 users) to understand and verify usability problems. Testing continued until achieving saturation (i.e., no new information was identified by subsequent testers). Changes to address an identified problem were then made, followed by more testing and refinements until no further usability or user-experience problems were identified. Striving for more than ratings of usability, acceptability, and satisfaction, we endeavored for each user to experience a deep sense of feeling cared about and understood.

Virtual CAMS included the following elements: (1) a computer tablet-based avatar ("Dr. Dave") performing a 15-minute segment of the CAMS Suicide Status Interview (SSI); (2) the discharge disposition clinical decision support tool that distills SSI content into an easy-to-review provider report; (3) "Caring Contacts" post-discharge messages; and (4) videos of peer-specialists with lived experience telling their stories for purpose of generating hope. In addition, we developed videos of Dr. Jobes introducing patients to the SSI for later testing of whether suicidal ED patients preferred digital recordings to an avatar.

Throughout the formative evaluation, feedback was solicited from suicidal outpatients at three private outpatient specialty clinics serving suicidal patients (n = 13), psychiatric inpatients (n = 2), and peer advocates with lived experience (n = 5). In addition, feedback was also solicited from medical providers serving these patients (n = 21).

2.1.1. "Dr. Dave" avatar

The avatar was built by Benjamin Lok, PhD and Mohan Zalake at the University of Florida. The 15-minute "Dr. Dave" prototype administered the CAMS SSI. "Dr. Dave" asked the patient questions, and patients typed their responses using a keyboard. "Dr. Dave" then verified "his" understanding (e.g., "This is what I understood is causing you the most emotional pain. Is that right?") before moving to the next question. To ensure accurate numeric ratings, graphic images of scale anchors increase in size (see Fig. 1). For ease of use with acutely distressed users, communication segments were brief and used simple language.

2.1.2. Peer-specialist videos

We created two peer-specialist videos, each approximately 7 min in length (see Fig. 2). Each conveyed a message similar to those provided during in-person meetings with suicidal ED patients: "You are not alone. I have walked in your shoes. It's important to let people know what's troubling you so they can help. There is hope."

2.1.3. Virtual CAMS clinical decision support

A goal of V-CAMS is to provide ED doctors with a report that summarizes various assessment results obtained from "Dr. Dave." This feedback report provides a series of results based on 25 years of "Suicide Status Form" research conducted by Dr. Jobes and his colleagues. These results are intended to supplement a professional clinical interview and decision-making to optimize clinical outcomes for the patient. [49,50]. We conducted two major iterations of the tool with medical providers (see Fig. 3).

2.1.4. Caring contacts

Two waves of testing with suicidal inpatients and outpatients were conducted. Participants were asked to imagine: "*You have been discharged from the ED after a suicide attempt. After a month, you receive a message from your providers*." Querying their preferred form of communication (e.g., letter, email, text), the content of the message, the "sender" of the contact (e.g., their ED providers, "Dr. Dave," the V-CAMS team), as well as the frequency and duration of contact.

2.2. Formative evaluation procedures

During the first phase of development, input was solicited from a variety of end-users, beginning with hospital administrators, medical providers, and peer specialists, and progressing to suicidal patients. The

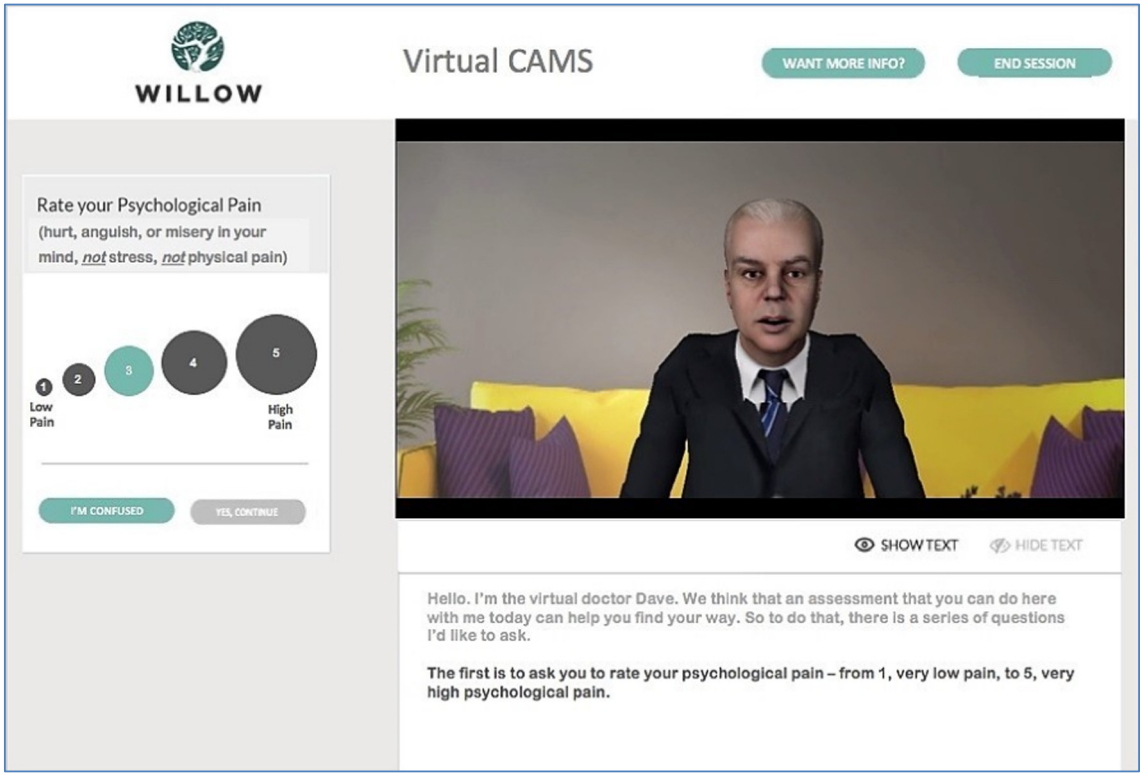

Fig. 1. "Dr. Dave" avatar—graphic representation of scale anchors.

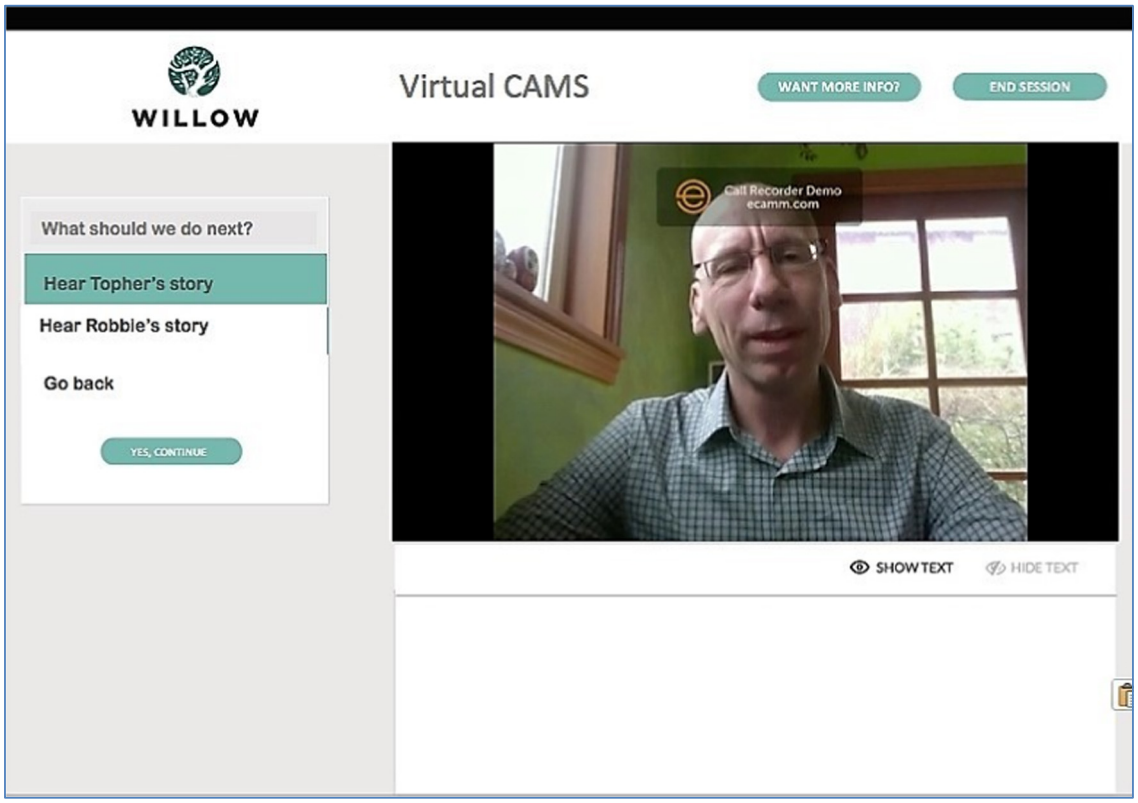

Fig. 2. Peer specialist video.

intent was to better understand provider workflow in EDs and use case scenarios for suicidal ED patients to ensure that the eventual avatar would be well-tolerated, and add significant value for healthcare systems, patients, and providers. A total of 12 meetings with administrators and medical providers were completed across several hospital services, including two inpatient psychiatry units, one psychiatric liaison service in a hospital, and three EDs to collect critical feedback and input.

Next, testing was conducted with 15 suicidal outpatients and two inpatients. These convenience samples were used as proxies for ED patients, as our early testing required easy access to suicidal patients and an ability to advance-schedule testing sessions. Potential participants were told about the research by their provider based on the study inclusion criteria: English-speaking, 18 years and older, currently suicidal and/or had made a suicide attempt in the past six months and deemed sufficiently stable to participate in the research. No exclusion criteria were set. Those interested directly contacted the research team who then conducted screening and informed consent procedures—either online, via the telephone, or in person. Test sessions were conducted in person in the ED or virtually using a combination of an online screen sharing tool and telephone for suicidal outpatients. Two researchers conducted each interview: one facilitated the user-test session; the other took notes. A semi-structured interview was conducted after each test session to better understand users' comments and preferences. Measures included: a demographics questionnaire, and the Usability, Satisfaction and Acceptability Questionnaire (USAQ), a brief face-valid self-report measure using a five-point Likert scale (1 = poor; 3 = good; 5 = excellent) adapted from the System Usability Scale (SUS) [71,72]. When testing occurred remotely, participants were interviewed while at their clinics and in the presence of staff for safety. New ideas generated by participants were treated as hypotheses to verify through further testing. Interviews ranged in length from 60 to 90 min.

Providers were told about the study by the research site contact at each organization. Procedures were identical to those used with patients with one exception: testing focused primarily on provider tools and workflow integration. All participants were compensated $50 for their time. All procedures used in this effort were approved by EBPI's and The Catholic University of America's Institutional Review Boards (IRB).

2.3. Summative evaluation procedures

Our final test of feasibility involved evaluating the completed Virtual CAMS prototype with suicidal ED patients. Participants were 18 years or older, English-speaking, currently admitted to the ED due to an acute suicidal crisis and deemed by staff as sufficiently stable to provide consent and participate. Patients were approached about the study by their medical provider. Those interested were screened and provided a brief study overview by EBPI staff. All ten patients approached wished to participate; three, however, declined because of the perceived arduous nature of the informed consent process. Following consent, participants (n = 7) completed a demographics questionnaire, were provided a tablet containing V-CAMS, and used it as they wished. All patients completed the SSI. Once done (typically 20–25 min), participants completed the USAQ and a brief semi-structured interview. Participants were paid $50 for their effort. Demographic data are described in Table 1.

Open-ended qualitative data from all suicidal patients (n = 24) gleaned from the semi-structured interviews that followed engagement with “Dr. Dave” were analyzed by two graduate students under the direction of Dr. Jobes using a modified version of Consensual Qualitative Research (CQR) methodology [73,74]. Verbatim responses to the primary interview question (“*What are your overall impressions of “Dr. Dave*?”) were categorized using a four-level CQR coding strategy (0 = not applicable, 1 = low, 2 = medium, 3 = high) for each coding domain. Coding domains included: 1) Overall Merit (i.e., *is this process worth doing, would you want to use Dr. Dave or avatar/technology while waiting for medical attention in the future; would it be helpful to others*?); 2)

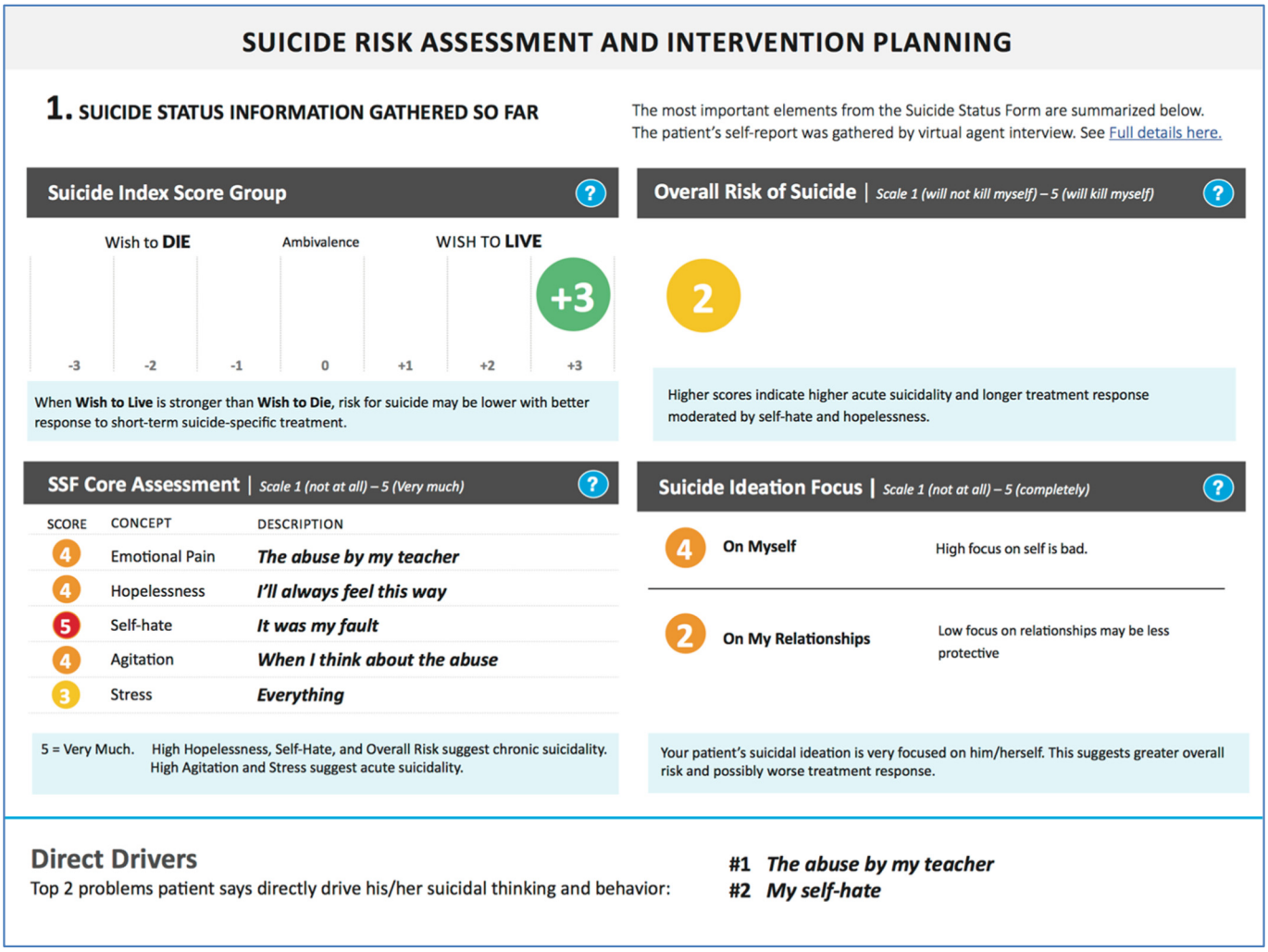

Fig. 3. V-CAMS SSI template.

Perception of Care (i.e., *feeling or belief that one is being supported and cared for in time of need*); and 3) "Acceptability of Technology" (i.e., *like/dislike of technology for risk assessment, particularly in a medical setting*). Taken together, the resulting interview responses were overwhelming supportive of the V-CAMS Dr. Dave experience.

3. Results

Overall, four important findings emerged through our initial 80+ hours of testing and interviews. First, administrators and providers universally viewed tablets as acceptable technology to deliver V-CAMS as patients are always under observation—either directly monitored in open-spaces or with cameras when in a closed room. They excluded only psychotic and/or severely agitated patients as inappropriate to use CAMS. Second, all participants liked the hope-instilling videos by peer-specialists and viewed them as a nice counterbalance to the "Dr. Dave" SSI. Finally, patient participants preferred a simple avatar (like "Nurse Louise") using a computer-generated voice instead of recorded delivery of CAMS or use of Dr. Jobes' actual voice for "Dr. Dave." Stated plainly by one participant, "It's clear that the avatar is a computer and not a person trying to get into my head." While not all suicidal patients felt strongly in their preference, all found the simple avatar acceptable and valuable to use.

Three themes emerged for providers. First, about 30% of the sample wanted the clinical decision support tool to provide a definitive recommendation about whether to hospitalize or release a patient. Second, providers universally wanted the capacity to "drill deeper" into the clinical support content as needed and have ability to access as-needed and "Just-in-Time Training" materials about how to do specific CAMS and other EBP therapeutic tasks (e.g., how specifically to talk with a suicidal patient about removing lethal means and effectively tolerating their distress). Providers also wanted the ability to "prescribe" skills modules and see what skills patients learned while waiting in the ED. Finally, providers viewed Virtual CAMS integration into their electronic health records as essential requirement going forward.

Patients too responded favorably to Virtual CAMS. Suicidal ED patients experienced "Dr. Dave" as easy to use, helpful, and in some cases, even an entertaining therapeutic distraction while they waited in the ED. They described "Dr. Dave" in adjectives similar to those used to describe "Nurse Louise" on which our avatar was based: "He's kind and asks me really practical, helpful questions;" "He speaks to me directly in a compassionate way—he is kind and invested." While the peer specialist videos were also well-received, several consistent recommendations emerged: 1) shorten videos to a max of 5 min; 2) increase diversity of stories and peer specialists (both were Caucasian and similar in age); and 3) avoid language that could trigger patient distress (e.g., avoid talk about lethal means). With respect to the "Caring Contacts," fewer than 10% of the total sample preferred to receive text messages from "Dr. Dave." The majority preferred that they be delivered by their ED provider. Feasibility was also reflected in the quantitative ratings: USAQ ratings across all user categories were higher than our original 3.5 a priori cut-off score. Specifically, non-ED suicidal patients

Table 1
Patient demographics.

		N (24)	%
Setting	Outpatient	15	62.5
	Inpatient	2	8.3
	ED	7	29.2
Gender	Male	6	25
	Female	17	70.8
	Other	1	4.2
Age	18–29	6	25
	30–39	6	25
	40–49	5	20.8
	50–59	7	29.2
Race[a]	American Indian/Alaskan Native	2	8.3
	Asian	3	12.5
	Black/African American	4	16.7
	White	15	62.5
	Hispanic	2	8.3
	Other	1	4.2
Education	High School	8	33.3
	2-Year college	1	4.2
	4-Year college	8	33.3
	Master's	0	0
	Doctorate	1	4.2
	Other	6	25
Depression	Yes	23	95.8
	No	1	4.2
Anxiety	Yes	23	95.8
	No	1	4.2
Trauma	Yes	16	66.7
	No	8	33.3
Substance Ab.	Yes	10	41.7
	No	14	58.3

[a] Some patients identified as bi-racial.

produced a mean score of 4.4 (SD = 0.30) during the formative evaluation phase; suicidal ED patients averaged a score of 4.5 (SD = 0.41) during the summative phase.

To gain greater insights into the preferences and opinions of suicidal patients, a thorough analysis of qualitative data from the semi-structured interviews further supported feasibility. For the Overall Merit domain, 13 of 18 endorsed the experience at a medium to high level (with four not applicable responses; inter-rater reliability Kappa = 0.906; $p < .0001$). One participant noted: "*It's great! You can learn a lot from it… It hit everything as far as emotions, I can't stress that enough. It explained everything right down to a tee: What you're going through; what you're going to go through. It made me feel like I wasn't alone - that there are people going through the same thing that I am.*" Another patient observed: "*Something to do in the emergency room…there is certainly going to be a lot waiting. Something to focus on instead of all the sights and sounds of the ER. "Dr. Dave" is paying attention specifically to you.*" Similarly, Perception of Care domain responses were also positive, with 12 of 18 endorsing this domain at a medium to high level (with six "not applicable responses;" inter-rater reliability Kappa = 0.900; $p < .0001$). Verbatim responses include: "*The caring face and the warm gesture that someone cares.*" From another patient: "*I think that it was the fact that people care, that people seemed to really care and if I'm there getting help, I will want those people who are supportive and not just talking about it. It was a very caring thing to happen, and a good idea for that time waiting in the waiting room.*" Finally, Acceptability of Technology domain responses were also supportive, with 12 of 18 patients endorsing this notion at a medium to high level (with six "not applicable" responses; inter-rater reliability Kappa = 0.832; $p < .0001$). One patient described: "*I think the interaction…it's this avatar, which is hilarious because he blinks, I like the videos, it's engaging and it serves its purpose - it provides a connection, and using healing language to get you to stop thinking about whatever angle you are looking at, and focus on a road to recovery*."

4. Discussion

Death by suicide and other suicidal behaviors (suicide attempts, suicidal ideation, and non-suicidal self-injury) remain a significant public health problem. Despite considerable suicide prevention initiatives and numerous efficacious suicide prevention interventions like CAMS, suicide rates in the United States have continued to rise [1,2,5] and efforts to date have failed to "bend the (statistical) curve" away from suicide [6]. This project, with its innovative platform-based avatar system, seeks to help bend the curve by "baking" EBPs directly into large healthcare organizations and leveraging innovative technologies both at and beyond the point of care to reduce suicide, avert unnecessary hospitalization, and decrease hospital readmissions. Virtual CAMS, with its avatar, "Dr. Dave," was inspired by another efficacious hospital-based avatar ("Nurse Louise") that successfully sought to reduce medical-surgical hospital readmissions by facilitating discharge planning. We thus sought to determine its feasibility for use with suicidal ED patients in acute distress and with their treatment providers.

Several findings are particularly noteworthy. First, medical personnel and administrators were overwhelmingly positive in their view that such a tool could have a positive impact in the ED. There was consistent consensus across sites about the benefits of such a system (namely, the ease and efficiency of delivering a suicide prevention EBP while suicidal patients waited in the ED, and one that standardizes care). Use of clinical decision support tools and "Just-in-Time Training" to aid in the discharge disposition efforts was well received. We also found consensus with respect to patients who would be excluded from its use (i.e., psychotic and/or highly agitated, aggressive patients). Second, when provided a choice between use of traditional online video methods and an avatar to perform the SSI, suicidal patients preferred a hybrid approach that included a brief introduction by Dr. Jobes, with the bulk of the modified CAMS assessment performed by a simple avatar. This was particularly important for patients with paranoid cognitions who were better able to tolerate the avatar. Finally, use of an avatar to perform a suicide risk assessment was broadly acceptable to suicidal ED patients that we interviewed. Indeed, suicidal ED patients described "Dr. Dave" similarly to how medical-surgical patients described "Nurse Louise."

Several study limitations are important to note. First, while Virtual CAMS was developed with extensive target end-user feedback during the formative evaluation, the sample size of suicidal ED patients who interacted with the completed prototype was small (n = 7) and limited to a single teaching hospital in an urban environment. The complexity of conducting this type research with a vulnerable population in fast-moving EDs as well as the intended scope of the project limited our ability to test our hypotheses and findings in other geographic regions and with more suicidal ED patients – thus compromising the ability to generalize from our findings presented here. Future research is required with more participants and in more varied hospital settings to determine whether the findings indeed generalize. Second, because not all components of Virtual CAMS were programmed into the platform due to the project scope, it is impossible to know for certain how the components (beyond "Dr. Dave") will be used once seamlessly integrated into a delivery platform and deployed. Finally, by virtue of the feasibility focus, we do not know whether such a system will actually produce the intended outcomes we seek: namely, decreases in suicides, unnecessary hospital admissions, and readmissions. Give the promising nature of Virtual CAMS, more research is needed to fully develop Virtual CAMS with additional input from more suicidal ED patients from a range of hospital EDs and providers, to integrate its varies components, and ultimately submit the intervention to a rigorous clinical test to determine its efficacy.

Given the magnitude of the suicide public health problem and the universal acknowledgment of challenges for suicidal patients—and their providers—in hospital emergency departments, the need for innovation for more effective ED-based assessment and intervention is

clear. The promise of Virtual-CAMS described in the present investigation is encouraging but more research and development is needed to fully realize the potential of the Virtual-CAMS intervention. As we pursue more input from suicidal ED patients (and their providers) from a range of hospital EDs, we will endeavor to further integrate its varied components and ultimately test the impact of V-CAMS within well-powered rigorous randomized controlled trial research. Within this pursuit, we aim to provide compassionate patient-centered care, while meaningfully assisting busy ED providers, through an innovative, cost-effective, and clinically-efficacious approach to help avert the tragedy of suicide.

Acknowledgements

This work was supported by the National Institute of Mental Health (1 R43 MH108222-01A1). We are also very grateful to NIMH Program Officer, Adam Haim, PhD, for his enduring support of our research and this project, and NIMH Suicide Research Consortium Chair Jane Pearson, PhD for her early recommendation to include the voices and feedback from people with lived experience, including peer advocates. Their feedback and encouragement throughout this project was invaluable in designing V-CAMS.

We are grateful to our V-CAMS team of advisors who helped shape V-CAMS' potential and provided us access to research participants (medical personnel and/or suicidal patients) in their settings: Katherine Anne Comtois, PhD, MPH, University of Washington, Harborview Medical Center (HMC); J.J. Rasimas, MD, MPH, HealthPartners Hospital; Heidi Combs, MD, Chief, Inpatient Psychiatry, HMC; Sabrina Citos, RN, Nurse Manager, Inpatient Psychiatry, HMC; Jagoda Pasic, MD, Chief, Psychiatric Emergency Services (PES), HMC; Brian Palmer, MD, MPH, Co-Chair for Education, Department of Psychiatry and Psychology, Mayo Clinic; Joy Mead-Meucci, MS, Senior Director, Research, Innovation, Technology, and Partnerships, Behavioral Health, Aurora Health Care; and Topher Jerome, Peer Support Specialist Supervisor, HMC. We wish to thank Josh Smith, LMSW, DBT Institute of Michigan, Nancy Gordon, LCSW, Tampa Bay CBT/DBT, and Andrew White, PhD, Portland DBT Institute, Inc. for their support and assistance in gathering data from suicidal outpatients at their respective clinics. Data Safety Monitoring Board members (Greg Brown, PhD, Jeff Sung, MD, Bryan Craig, PsyD) were very helpful in our efforts to develop a more efficient, creative method of conducting informed consent with suicidal ED patients who were in acute distress. Travis Osborne, PhD, Chair, Behavioral Health Research Collaborative was consistently at the ready providing timely and meticulous review of modifications as adjustments in the research procedure were required to accommodate the needs of suicidal ED patients. A special thank you to Dave Luxton, PhD who generously shared his insights and recommendations about how to maximize the impact of Caring Contacts based on his own research and his extensive review of the research literature.

Since conducting this preliminary research, a number of dear colleagues from other healthcare organizations have provided rich insights into the challenges of EDs along with access to providers and administrators to aid in our future efforts to strengthen V-CAMS. We are particularly grateful to: Suzanne Witterholt, MD, Medical Director of Consultation and Complex Care, and Paul Goering, MD, Vice President, Mental Health, Allina Health; and Patricia Adams, MHA, Senior Strategy Consultant, Carle Foundation Hospital.

Disclosures

Drs. Dimeff and Koerner co-own Evidence-Based Practice Institute, LLC and will derive profits from Virtual CAMS once it is complete and made commercially available. They both derive royalties from published books. Both provide professional workshops, lectures, and other trainings and are compensated for these activities. Dr. Dimeff co-owns Portland DBT Institute, Inc. and derives profit from this organization.

Dr. Jobes receives book royalties from American Psychological Association Press and Guilford Press. He is also a co-owner of CAMS-care, LLC which provides professional training and consultation in the CAMS approach.

References

[1] Centers for Disease Control and Prevention (CDC). Web-based Injury Statistics Query and Reporting System (WISQARS) [online]. National Center for Injury Prevention and Control, CDC (producer); 2017, 2016. Retrieved from: http://www.cdc.gov/injury/wisqars/index.html.

[2] Centers for Disease Control and Prevention. 10 leading causes of death by age group, United States – 2014. National Center for Injury Prevention and Control, CDC using WISQARS; 2014 Retrieved from: https://www.cdc.gov/injury/wisqars/pdf/leadingcausesofdeathbyagegroup2014-a.pdf, Accessed date: 5 October 2016.

[3] Center for Behavioral Health Statistics and Quality. 2015 national survey on drug use and health. Rockville, MD: Substance Abuse and Mental Health Services Administration; 2016.

[4] Shepard DS, Gurewich D, Aung KL, Reed GA, Silverman MM. Suicide and suicidal attempts in the United States: costs and policy implications. Suicide Life Threat Behav 2015;46(3):352–62. http://dx.doi.org/10.1111/sltb.12225.

[5] Centers for Disease Control and Prevention (CDC). Web-based injury statistics query reporting system (WISQARS) [online]. National Center for Injury Prevention and Control, CDC (producer); 2013, 2011. Retrieved from: http://www.cdc.gove/injurywisqars/index.html.

[6] Insel TR. Proceedings from The Leadership Institute: will technology transform mental health care? 2017.

[7] Curtin SC, Warner M, Hedegaard H. Increase in suicide in the United States, 1999–2014. Hyattsville, MD: National Center for Health Statistics; 2016. Retrieved from https://www.cdc.gov/nchs/products/databriefs/db241.html.

[8] Owens PL, Fingar KR, Heslin KC, Mutter R, Booth CL. Emergency department visits related to suicidal ideation, 2006–2013: statistical brief #220. Healthcare cost and utilization project (HCUP) statistical briefs [internet]. Rockville, MD: Agency for Healthcare Research and Quality (US); 2017 (Available from https://www.ncbi.nlm.nih.gov/books/NBK442036/).

[9] The National Confidential Inquiry into Suicide and Homicide by People with Mental Illness. Annual report 2014: England, Northern Ireland, Scotland and Wales. Manchester: University of Manchester; 2014. [July 2014].

[10] Bickey H, Hunt IM, Windfuhr K, Shaw J, Appleby L, Kapur N. Suicide within two weeks of discharge from psychiatric inpatient care: a case control study. Psychiatr Serv 2013;64(7):653–9. http://dx.doi.org/10.1176/appi.ps.201200026.

[11] Crawford MJ. Suicide following discharge from inpatient psychiatric care. Adv Psychiatr Treat 2004;10:434–8. http://dx.doi.org/10.1192/apt.10.6.434.

[12] Appleby L, Dennehy JA, Thomas CS, Faragher EB, Lewis G. Aftercare and clinical characteristics of people with mental illness who commit suicide: a case-control study. Lancet 1999;353:1397–400. http://dx.doi.org/10.1016/S0140-6736(98)10014-4.

[13] Pearlmutter MD, Dwyer KH, Burke LG, Rathlev N, Maranda L, Volturo G. Analysis of emergency department length of stay for mental health patients at ten Massachusetts emergency departments. Ann Emerg Med 2017;70(2):193–202. http://dx.doi.org/10.1016/j.annemergmed.2016.10.005.

[14] Nicks BA, Manthey DM. The impact of psychiatric patient boarding emergency departments. Emerg Med Int 2012;2012:360308.

[15] Bender D, Pande N, Ludwig M. Psychiatric boarding interviews. Washington, DC: U.S. Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation; 2009.

[16] Bernstein SL, Aronsky D, Duseja R, et al. The effect of emergency department crowding on clinically oriented outcomes. Acad Emerg Med 2009;16:1–10.

[17] Abid Z, Melter A, Lazar D, et al. Psychiatric boarding in the US EDs: a multifactorial problem that requires multidisciplinary solutions. Policy brief. Urgent Matters 2014;1:1–6.

[18] Chang G, Weiss A, Kosowsky JM, et al. Characteristics of adult psychiatric patients with stays of 24 hours or more in emergency department. vol. 63. 2012. p. 283–6.

[19] Linehan MM. Suicide intervention research: a field in desperate need of development. Suicide Life Threat Behav 2008;38(5):483–5. http://dx.doi.org/10.1521/suli.2008.38.5.483.

[20] Fleischmann A, Bertolote JM, Wasserman D, De Leo D, Bolhari J, Botega NJ, et al. Effectiveness of brief intervention and contact for suicide attempters: a randomized controlled trial in five countries. Bull World Health Organ 2008;86(9):703–9. http://dx.doi.org/10.2471/blt.07.046995.

[21] Motto JA, Bostrom AG. A randomized controlled trial of post-crisis suicide prevention. Psychiatr Serv 2001;52(6):828–33. http://dx.doi.org/10.1176/appi.ps.52.6.828.

[22] Comtois KA, Linehan MM. Psychosocial treatments of suicidal behaviors: a practice-friendly review. J Clin Psychol 2006;62(2):161–70. http://dx.doi.org/10.1002/jclp.20220.

[23] Hawton K, Townsend E, Arensman E, Gunnell D, Hazell P, House A, et al. Psychosocial versus pharmacological treatments for deliberate self harm. Cochrane Database Syst Rev 2000;2:CD001764http://dx.doi.org/10.1002/14651858.CD001764.

[24] Gonzales NA, Pitts SC, Hill NE, Roosa MW. A meditational model of the impact of interparental conflict on child adjustment in a multiethnic, low-income sample. J Fam Psychol 2000;14(3):365–79. http://dx.doi.org/10.1037/0893-3200.14.3.365.

[25] Brown GK, Ten Have T, Henriques GR, Xie SX, Hollander JE, Beck AT. Cognitive

therapy for the prevention of suicide attempt: a randomized controlled trial. JAMA 2005;294(5):563–70. http://dx.doi.org/10.1001/jama.294.5.563.
[26] Linehan MM, Comtois KA, Murray AM, Brown MZ, Gallop RJ, Heard HL, et al. Two-year randomized controlled trial and follow-up of Dialectical Behavior Therapy vs therapy by experts for suicidal behaviors and borderline personality disorder. Arch Gen Psychiatry 2006;63(7):757–66. http://dx.doi.org/10.1001/archpsyc.63.7.757.
[27] Luxton DD, June JD, Comtois KA. Can post-discharge follow-up contacts prevent suicide and suicidal behavior? A review of evidence. Crisis 2013;34(1):32–41. http://dx.doi.org/10.1027/0227-5910/a000158.
[28] Carter GL, Clover K, Whyte IM, Dawson AH, Este CC. Postcards from the edge project: randomized controlled trial of an intervention using postcards to reduce repetition of hospital deliberate self poisoning. Br Med J 2005;331(7520):805. http://dx.doi.org/10.1136/bmj.38579.455266.e0.
[29] Vaiva G, Durcrocq F, Meyer P, Mathieu D, Philippe A, Libersa C, et al. Effect of telephone contact on further suicide attempts in patients discharged from an emergency department: randomised controlled study. Br Med J 2006;332:1241–5. http://dx.doi.org/10.1136/bmj.332.7552.1241.
[30] Comtois KA, Jobes DA, O'Connor SS, Atkins DC, Janis K, Chessen CE, et al. Collaborative Assessment and Management of Suicidality (CAMS): feasibility trial for next-day appointment services. Depress Anxiety 2011;28(11):963–72. http://dx.doi.org/10.1002/da.20895.
[31] Andreasson K, Krogh J, Wenneberg C, Jessen HK, Krakauer K, Gluud C, et al. Effectiveness of Dialectical Behavior Therapy versus Collaborative Assessment and Management of Suicidality treatment for reduction of self-harm in adults with borderline: a randomize observer-blinded clinical trial. Depress Anxiety 2016;33:520–30. http://dx.doi.org/10.1002/da.22472.
[32] Jobes DA, Comtois KA, Gutierrez PM, Brenner LA, Huh D, Chalker SA, Ruhe G, Kerbrat AH, Atkins DC, Jennings K, Crumlish J, Corona CD, O'Connor S, Hendricks KE, Schembari B, Singer B, Crow B. A randomized controlled trial of the collaborative assessment and management of suicidality versus enhanced care as usual with suicidal soldiers. *Psychiatry: Interpersonal and Biological Processes* 2017;*80*:339–56. http://dx.doi.org/10.1080/00332747.2017.1354607.
[33] Jobes DA, Jacoby AM, Cimbolic P, Hustead LAT. Assessment and treatment of suicidal clients in a university counseling center. J Couns Psychol 1997;44(4):368–77. http://dx.doi.org/10.1037//0022-0167.44.4368.
[34] Elis TE, Rufino KA, Allen JG, Fowler JC, Jobes DA. Impact of a suicide-specific intervention within inpatient psychiatric care: the Collaborative Assessment and Management of Suicidality (CAMS). Suicide Life Threat Behav 2015;45(5):556–66. http://dx.doi.org/10.1111/sltb.12151.
[35] Ellis TE, Green KL, Alen JG, Jobes DA, Nadorff MR. Collaborative Assessment and Management of Suicidality in an inpatient setting: results of a pilot study. Psychotherapy 2012;49(1):72–80. http://dx.doi.org/10.1037/a0026746.
[36] Arkov K, Rosenbaum B, Christansen L, Jonsson H, Muchow M. Treatment of suicidal patients: the Collaborative Assessment and Management of Suicidality (CAMS). Ugeskr Laeger 2008;170(3):149–52. [PMID: 18208732].
[37] Jobes DA, Kahn-Greene E, Greene J, Goeke-Morey M. Clinical improvements of suicidal outpatients: examining suicide status from responses as predictors and moderators. Arch Suicide Res 2009;13(2):147–59. http://dx.doi.org/10.1080/13811110902835080.
[38] Nielsen AC, Alberdi IF, Rosenbaum B. Collaborative Assessment and Management of Suicidality method shows effect. Dan Med Bull 2011;58(8):A4300. [PMID: 21827722].
[39] Jobes DA, Wong SA, Conrad AK, Drozd JF, Neal-Walden T. The Collaborative Assessment and Management of Suicidality (CAMS) versus treatment as usual: a retrospective study with suicidal outpatients. Suicide Life Threat Behav 2005;35(5):483–97. http://dx.doi.org/10.1521/suli.2005.35.5.483.
[40] Ellis TE, Rufino KA, Allen JG. A controlled comparison trial of the Collaborative Assessment and Management of Suicidality (CAMS) in an inpatient setting: outcomes at discharge and six months follow up. Psychiatry Res 2017;249:252–60. http://dx.doi.org/10.1016/j.psychres.2017.01.032.
[41] Huh D, Jobes DA, Comtois KA, Kerbrat A, Chalker S, Guitierrez P. The Collaborative Assessment and Management of Suicidality (CAMS) versus Enhanced Care as Usual (E-CAU) with suicidal soldiers: moderator analyses from a randomized controlled trial. 2018. [Manuscript under review].
[42] Waltz J, Dimeff LA, Koerner K, Linehan MM, Taylor L, Miller C. Feasibility of using video to teach a Dialectical Behavior Therapy skill to clients with borderline personality disorder. Cogn Behav Pract 2009;16(2):214–22. http://dx.doi.org/10.1016/j.cbpra.2008.08.004.
[43] U.S. Department of Health and Human Services (HHS) Office of the Surgeon General, National Action Alliance for Suicide Prevention. National strategy for suicide prevention: goals and objectives for action. Washington, DC: HHS; 2012. [September 2012].
[44] Education Development Center. About zero suicide Retrieved from: http://zerosuicide.sprc.org/about; 2015, Accessed date: 23 August 2017.
[46] Hogan MF, Goldstein J. Suicide prevention: an emerging priority for health care. Health Aff 2016;35:1084–90. http://dx.doi.org/10.1377/hlthaff.2015.1672.
[47] National Action Alliance for Suicide Prevention: Transforming Health Systems Initiative Work Group. Recommended standard care for people with suicide risk: making health care suicide safe. Washington, DC: Education Development Center, Inc.; 2018.
[48] Comtois KA, Kerbrat A, Atkins DC, Roy-Byrne P, Katon WJ. Self-reported usual care for self-directed violence during the six months prior to emergency department admission. Med Care 2015;53(1):45–53. http://dx.doi.org/10.1097/MLR.0000000000000252.
[49] Jobes DA. The collaborative assessment and management of suicidality (CAMS): an evolving evidence-based clinical approach to suicidal risk. Suicide Life Threat Behav 2012;42:640–53.
[50] Jobes DA. Managing suicidal risk: a collaborative approach. 2nd ed. New York: Guilford Press; 2016.
[51] Jobes, D. A., Gregorian, M. J., & Colborn, V. A. (in press). A stepped care approach to clinical suicide prevention. Psychological Services.
[52] Jack BW, Chetty VK, Anthony D, Greenwald JL, Sanchez GM. The re-engineered hospital discharge program to decrease rehospitalization: a randomized trial. Ann Intern Med 2009;150(3):178–87. http://dx.doi.org/10.7326/0003-4819-150-3-200902030-00007.
[53] Berkowitz RE, Fang Z, Helfand BKI, Jones RN, Schreiber R, Paasche-Orlow MK. Project reengineered discharge (RED) lowers hospital readmissions of patients discharged from a skilled nursing facility. J Am Med Dir Assoc 2013;14(10):736–40. http://dx.doi.org/10.1016/j.jamda.2013.03.004.
[54] Bickmore TW, Pfeifer LM, Byron D, Forsythe S, Henault LE, Jack BW, et al. Usability of conversational agents by patients with inadequate health literacy: evidence from two clinical trials. J Health Commun 2010;15(1):197–210.
[55] Jack B, Bickmore T. Louise: saving lives, cutting costs in healthcare Retrieved from https://www.bu.edu/fammed/projectred/publications/VirtualPatientAdvocateWebsiteInfo2.pdf; 2007.
[56] Jack B, Bickmore T. The re-engineered hospital discharge program to decrease re-hospitalization Retrieved from https://www.bu.edu/fammed/projectred/publications/RED%20Fact%20Sheet%202-7-09%20v2.pdf; 2009.
[57] Gratch J, Wang N, Okhmatovskaia A, Lamothe F, Marsella S, Morales M, et al. Can virtual humans be more engaging than real ones? Proceedings of the 12th international conference on human-computer interaction: intelligent multimodal interaction environments (HCI'07). Lecture notes in computer science. vol. 4552. Berlin Heidelberg: Springer-Verlag; 2007. p. 286–97.
[58] Kenny P, Rizzo AA, Parsons T, Gratch J, Swartout W. A virtual human agent for training clinical interviewing skills to novice therapists. Annu Rev Cyberther Telemed 2007;5:81–9.
[59] Lok B, Ferdig RE, Raij A, Johnson K, Dickerson R, Coutts J, et al. Applying virtual reality in medical communication education: current findings and potential teaching and learning benefits of immersive virtual patients. 2007.
[60] Lok B, Rick F, Andrew R, Kyle J, Dickerson R, Coutts J, et al. Applying virtual reality in medical communication education: current findings and potential teaching and learning benefits of immersive virtual patients. J Virtual Real 2006;1(3–4):185–95.
[61] Parsons TD, Kenny P, Ntuen CA, Pataki CS, Pato MT, Rizzo AA, et al. Objective structured clinical interview training using a virtual human patient. Stud Health Technol Inform 2008;132:357–62.
[62] Rizzo Albert, Parsons Thomas D, Buckwalter John Galen, Kenny Patrick G. A new generation of intelligent virtual patients for clinical training. Proceedings of IEEE virtual reality conference. 2010.
[63] Rizzo A, Forbell E, Lange B, Buckwatlter JG, Williams J, Sagae K, et al. SimCoach: an online intelligent virtual human agent system for breaking down barriers to care for service members and veterans. In: Scurfield RS, Platoni KT, editors. Healing war trauma: a handbook of creative approaches. Routledge; 2012. p. 238–50.
[64] Lisetti CL, Amini R, Yasavur U, Rishe N. I can help you change! An empathic virtual agent delivers behavior change health interventions. ACM Trans Manag Inf Syst 2013;4(4):19:1–19:28.
[65] Bickmore TW, Picard RW. Establishing and maintaining long-term human-computer relationships. ACM Trans Comput Hum Interact 2005;12(2):617–38.
[66] Bickmore TW, Pfeifer LM, Jack BW. Taking the time to care: empowering low health literacy hospital patients with virtual nurse agents. Proceedings of the 27th international ACM conference on human factors in computing systems (CHI'09). New York: ACM; 2009. p. 1265–74.
[67] Kushniruk AW, Patel VL. Cognitive and usability engineering methods for the evaluation of clinical information systems. J Biomed Inform 2004;37(1):56–76. http://dx.doi.org/10.106/j.jbi.2004.01.003.
[68] Tullis T, Albert B. Measuring the user experience: collecting, analyzing, and presenting usability metrics. Second ed. Waltham, MA: Elsevier, Inc.; 2013.
[69] Norman DA, Draper SW. User centered design: new perspectives on human-computer interaction. Hillsdale, NJ: L. Erlbaum Associates, Inc.; 1986.
[70] Nielsen J. Usability engineering. San Diego, CA: Academic Press; 1993.
[71] Bangor A, Kortum P, Miller JA. Determining what individual SUS scores mean: adding an adjective rating scale. J Usability Stud 2009;4:114–23.
[72] Broke J. SUS: a "quick and dirty" usability scale. In: Jordan PW, Thomas B, Weerdmeester BA, McClelland IL, editors. Usability evaluation in industry. London: Taylor and Francis; 1996. p. 189–94.
[73] Hill CE, Knox S, Thompson BJ, Williams EN, Hess SA. Consensual qualitative research: an update. J Couns Psychol 2005;52:196–205.
[74] Jobes DA, Nelson KN, Peterson EM, Pentiuc D, Downing V, Francini K, et al. Describing suicidality: an investigation of qualitative SSF responses. Suicide Life Threat Behav 2004;34:99–112.