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Social media-based professional intervention vs. resource provision for suicidal youth: protocol of a randomized controlled trial

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Abstract

Background: Despite a high prevalence of suicidal ideation and behavior, adolescents and young adults (AYA) often underutilize mental health services due to both structural and personal barriers. At the same time, the massive expansion of social media has introduced new threats to mental health, while also creating vital spaces where AYA can express psychological distress, seek support, and access mental health information. Designed as a bridge to care and a counterbalance to digital risks, the ELIOS project connects suicidal AYA with a team of professional trained web-clinicians (nurses or psychologists supervised by a psychiatrist) through social media platforms. ELIOS is currently being evaluated within the ORIAS trial to assess its efficacy.

Objective: Assess the efficacy of the ELIOS system over simple resource provision for suicidal AYA.

Methods: ORIAS is single-center, open-label, two-arm randomized controlled trial with balanced parallel groups. It will recruit 386 participants aged 18–25 who spontaneously reach out via the Elios Messenger account with recent suicidal ideation. Eligible AYA are randomized to receive either the Elios intervention or conventional mental health resources (control group). The Elios intervention consists of web-clinicians offering initial support, risk evaluation, counseling, and progressive referral to mental health care. The primary outcome is the reduction in suicidal ideation intensity at three months, measured using the Columbia Suicide Severity Rating Scale. Secondary outcomes include suicide attempts, use of healthcare services, psychological distress, attitudes toward help-seeking, participant satisfaction, and usage metrics of the intervention at three months.

Results: No results

Conclusions: Elios is the first suicide prevention system embedded directly within the social media environment and daily digital practices of AYA. By offering easy, personalized, and timely access to professional help, Elios aims to address help-seeking barriers and reduce suicidality. While the ORIAS trial highlights the inherent challenges of conducting traditional interventional research within dynamic social media settings, it is poised to generate high-quality evidence on the feasibility, acceptability, and effectiveness of digital suicide prevention interventions. These findings could inform and support the broader integration of similar models within public health systems. Clinical Trial: ClinicalTrials.gov NCT04642157; https://clinicaltrials.gov/study/NCT04642157?cond=NCT04642157&rank=1

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Abstract

Background. Despite a high prevalence of suicidal ideation and behavior, adolescents and young adults (AYA) often underutilize mental health services due to both structural and personal barriers. At the same time, the massive expansion of social media has introduced new threats to mental health, while also creating vital spaces where AYA can express psychological distress, seek support, and access mental health information. Designed as a bridge to care and a counterbalance to digital risks, the ELIOS project connects suicidal AYA with a team of professional trained web-clinicians (nurses or psychologists supervised by a psychiatrist) through social media platforms. ELIOS is currently being evaluated within the ORIAS trial to assess its efficacy.

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barriers and reduce suicidality. While the ORIAS trial highlights the inherent challenges of conducting traditional interventional research within dynamic social media settings, it is poised to generate high-quality evidence on the feasibility, acceptability, and effectiveness of digital suicide prevention interventions. These findings could inform and support the broader integration of similar models within public health systems.

Trial registration. ClinicalTrials.gov NCT04642157; https://clinicaltrials.gov/study/NCT04642157?cond=NCT04642157&rank=1

Keywords: social media, adolescent, young adult, suicide prevention, digital, web

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Introduction

Globally, suicide is the third leading cause of death among youth aged 15 to 25 (1). Approximately 16,9% of adolescents report experiencing suicidal ideation in the past year, and 6,4% admit having attempted suicide at least once (2). Alarmingly, the situation has significantly worsened over the past five years, with a marked rise in suicide attempt rates – particularly among young women – in several European countries (3,4).

Access to appropriate care is widely acknowledged as a key component of suicide prevention, particularly among young populations (5). However, paradoxically, mental health service utilization remains low among Adolescents and Young Adults (AYA) (6,7). This so-called “service gap”—the discrepancy between a high level of need and limited use of available care (8)—has been attributed to both structural and personal barriers (9). Structural barriers include limited accessibility, high costs, lack of visibility, and inconvenient service delivery (10). Personal barriers among AYA include stigma and self-stigma (11), difficulties in identifying and expressing emotions (12), a self-reliance bias (i.e., the tendency to overestimate one's ability to cope independently) (13), and misbeliefs about care providers (14), all of which can significantly hinder help-seeking behaviors(15). Strikingly, help-seeking has been shown to decrease as psychological distress increases, a phenomenon known as the “help-negation bias”(16).

A major, contemporary factor influencing access to care is the extensive digitalization of social life. From now on, every AYA younger than 25 are from the generations Z or alpha, which means they were born and grew up with Social Media (SM) (17). In the United States, nearly half of teenagers report being online almost constantly, while in France, 81% connect to a SM platform daily (18). These platforms have created an unprecedented space for AYA to share their struggles and to seek or receive informal support. Searching for mental health information online has become a common practice among AYA, and

distressed youth often turn to SM to access peer support, alleviate feelings of isolation, and seek emotional assistance (20,21). Moreover, a significant number of young SM users disclose suicidal thoughts through public online posts (20,22).

Several characteristics of SM communication suggest that it could serve as a powerful lever to help AYA overcome classical barriers to seeking mental health support : (a) accessibility helps circumvent geographic constraints and limited availability of local services (23,24) ; (b) affordability addresses structural barriers related to cost, facilitating access for financially dependent individuals ; (c) timeliness allows users to access support outside of traditional hours aligning with the fluctuating nature of both suicidal ideation severity and the motivation to seek help (25,26) ; (d) anonymity and privacy may reduce the confrontational aspect of help-seeking interactions, encouraging emotional expression and self-disclosure (25,27) ; (e) the perceived control over interactions provides a sense of safety for individuals who may not be ready for strong interpersonal commitments, as it allows them to disengage from conversations at any time (23).

If the literature acknowledges the original prevention opportunities that the Web has brought out, it also increasingly points out the new or compounded threats to which unregulated interactions or contents can expose (19). This is the second edge of the sword, as qualified by Robert et al. (23) : for instance, SM paved the way for cyber-bullying (28), problematic use, at risk behaviors and increased dissemination of contents with high risk of suicide contagion. Consequently, vulnerable web-users exploring the Internet with ambivalent intentions would more likely be exposed to normalizing, inciting or stigmatizing contents than to helpful resources.

Given the growing consensus on this issue, researchers and suicide prevention organizations have called for a more proactive use of SM. The aim is to shift the balance so that a suicidal web-user is more likely to encounter support, be guided through help-

seeking, and access care than to be pushed toward suicidal behaviors. Yet, digital technologies remain underutilized by prevention efforts. Most current strategies rely on the passive provision of information or emergency contacts. While this increases the availability of help, it does little to overcome the personal barriers that often prevent AYA from seeking care (16,18,22). Simply put, a young person unable to ask for help offline is unlikely to make a call or book an appointment just because a number appears online.

To address the lack of proactive web-based prevention strategies, we developed the ELIOS system (“Équipe en Ligne de Prévention du Suicide” – Online Team for Suicide Prevention). ELIOS is a team of web-clinicians accessible to suicidal AYA via SM. Grounded in the understanding that help-seeking is largely driven by intrapersonal factors (37), ELIOS functions as a gateway provider—offering initial support, reinforcing motivation to seek help, and facilitating referral to appropriate services. Recognizing that, for many AYA, initiating contact online may feel easier than by phone or in person, ELIOS aims to make the Internet a steppingstone toward conventional mental health care.

In this paper, we introduce ORIAS, a randomized controlled trial designed to evaluate the efficacy of the ELIOS system.

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Methods

Aim

The primary objective of ORIAS is to demonstrate the superiority of ELIOS in reducing suicidality at three months, compared to the simple provision of professional resources, among AYA seeking help online for suicidal ideation.

A first set of secondary objectives aims to evaluate the superiority of the ELIOS system over standard professional contact in improving more distal outcomes at three months: (a) reducing the rate of access to conventional healthcare services, including emergency room visits and hospital admissions following a recent suicide attempt or life-threatening behavior; (b) lowering the incidence of suicide attempts; and (c) decreasing all-cause mortality.

A second set of secondary objectives focuses on exploring potential mediating mechanisms underlying the ELIOS system's effects. This includes assessing its superiority in (d) reducing psychological pain at three months; (e) increasing access to mental healthcare, emergency services, or hospital admissions unrelated to suicide attempts or life-threatening behaviors; and (f) decreasing negative attitudes toward mental health care at three months.

Finally, a third set of secondary objectives explores the acceptability and utilization of the ELIOS system. This involves (g) comparing participant satisfaction at three months between the ELIOS intervention and simple professional contact, and (h) measuring platform usage throughout the study period.

ELIOS intervention

The ELIOS system consists of "web-clinicians" who provide direct intervention to suicidal AYA via SM channels. These web-clinicians are nurses or psychologists placed under the supervision of a psychiatrist. They are specially trained to clinical care for suicidal

AYA, including crisis intervention, counseling, motivational guidance, SM engagement, and online textual and iconographic communication.

The goal of the ELIOS intervention is twofold: to reduce users' distress and suicidality, and to ensure an effective referral to mental health services. To achieve this, web-clinicians: (a) provide first-line mental health care, including clinical evaluation and counseling tailored to the participant's estimated suicide risk; and (b) gradually motivate the participant to engage more deeply in care by addressing barriers to help-seeking. Depending on the quality of the therapeutic alliance and the participant's specific needs, this may involve transitioning to phone-based interactions to increase the likelihood of successful referral to in-person healthcare services.

Web-clinicians operate through a specially designed platform to which several SM channels can converge through their APIs. The ELIOS platform was co-designed with a group of AYA. As shown in **Figure 2**, it consists in a secured webspace with three main components: (a) a chat space where web-clinicians can interact with participants and decide which SM channel to use for communication. Within this space, they can easily access conversation history, switch between channels, or change the participant they are engaging with ; (b) a schedule of participants to contact, organized by a hierarchical prioritization algorithm based on simple rules (e.g., prioritizing users with high suicidality scores) ; (c) a digital clinical record that automatically compiles relevant data collected in line with the research protocol (e.g., inclusion scale results), while also allowing web-clinicians to manually and ergonomically add any additional information gathered during their interactions with users. Unfortunately, at the time of writing, the platform could only be connected to Facebook Messenger due to technical and financial constraints (see **Discussion**).

Please insert figure 2 here

Design

ORIAS is a randomized, controlled, single-center, open-label, two-arm, superiority trial with balanced parallel groups. The participant pathway through the study is illustrated in **Figure 1**.

The ELIOS system is promoted through organic and paid SM campaigns, enabling distressed AYA to initiate contact spontaneously via its Messenger account. Upon receiving a first-contact private message, an algorithm-driven smartbot automatically responds through the same channel to begin the interaction. The smartbot verifies whether this is the users' initial contact, acknowledges their effort in seeking help, and invites them to click a hyperlink to access the ELIOS website. Importantly, the smartbot's pre-registered messages were developed based on input from a focus group of adolescents and young adults (AYA).

Once on the website, users are guided through a sequence of pages where they: (a) receive comprehensive information about the program and research study; (b) complete an online eligibility assessment form; and (c) if eligible, are invited to provide electronic informed consent. Upon consenting, users proceed to complete online questionnaires for the study's baseline assessment (M0). Finally, participants are randomly assigned to one of two study groups. The randomization procedure involves block randomization stratified by sex, with randomly generated blocks of size 4. A random selection among the possible block compositions is then used to generate the final allocation list.

Participants assigned to the control group are directed to a final webpage containing a list of first-line, specialized, and emergency mental health resources, including general practitioners, psychiatric outpatient clinics, emergency services, and the national suicide prevention helpline. The resources are tailored to the participant's level of suicidality, as assessed through the inclusion forms. This comparator was selected to minimize

intervention effects while still providing access to the most reliable mental health resources available online.

Participants assigned to the ELIOS intervention group are also redirected to a final separate page informing them that a web-clinician will contact them as soon as possible via Messenger to initiate the intervention. If the request is made outside of working hours, the clinician makes initial contact at the beginning of the next working period.

Participants who do not meet the inclusion criteria are also provided with reliable and appropriate resources tailored to their specific situation.

Three months after inclusion, the ELIOS smartbot automatically reaches out to all participants via Messenger and send them a hyperlink to the follow-up assessment (M3) through an online form. If the participant does not complete the questionnaire within one week, two automatic reminders are sent at one-week intervals.

Please insert figure 1 here

Participants

To be included, users spontaneously contacting the ELIOS Messenger account have (a) to be aged 18 to 25 inclusive, (b) to have been experiencing suicidal ideations in the week prior the contact, (c) to live in France and speak French and (d) to provide informed consent.

According to the results from Nam et al. (29), we assume that the 3-months mean score at the C-SSRS lol-subscale will be 9.8 +/- 5.4 in the control arm. In the ELIOS intervention arm, we expect this value to be decreased by 20%, corresponding to a mean difference of 2 points at 3 months. With a standard deviation of 5.4 points, a type I error of 5% and a power of 90%, we calculated that 154 patients per arm will be required to detect a difference of 2 points in the primary endpoint with a 2-sided t test. To account for an anticipated loss to follow-up rate of 20%, we will enroll 193 participants per groups, which

means a total of 386 participants.

Inclusion have started on the 13th of October 2022.

Outcomes

The intensity of suicidal ideation is measured at baseline (M0) and at three months (M3). It is assessed using the *Intensity of Ideation (IoI)* subscale of the *Columbia Suicide Severity Rating Scale (C-SSRS)* (30). This subscale comprises five items, each rated on a 0 or 1-to-5 Likert scale. Participants evaluate different dimensions of their most severe suicidal thoughts during a given period: frequency, duration, controllability, deterrents, and reason for ideation. Scores are summed to yield a total ranging from 2 to 25, with higher scores indicating greater intensity of suicidal ideation. The IoI subscale has demonstrated good internal consistency (Cronbach's α between 0.73 and 0.95) (30). The French version used in this study has undergone linguistic validation (31).

All secondary endpoints are measured at M3. Participants are asked: (a) whether and when they consulted a general practitioner, psychiatrist, psychologist, or nurse, or whether they were admitted to a hospital or emergency department for psychological, psychiatric, or substance use-related reasons; (b) whether the consultation or admission was preceded by a suicide attempt or life-threatening behavior ; (c) whether and when they attempted suicide without seeking care from conventional mental health services or visiting an emergency department.

Vital status will be determined after the end of the study by querying the Registers of Civil Status, using participants' identity and place of birth.

Attitudes toward mental health care are assessed using a French version of the Attitudes Toward Seeking Professional Psychological Help–Short Form (ATSPPH-SF) (32). The ATSPPH-SF is one of the most widely used tools for evaluating attitudes related to help-seeking. It consists of 10 items rated on a 4-point Likert scale, from 0 (disagree) to 3

(agree). Five items are reverse scored, so that higher overall scores reflect more positive attitudes toward seeking professional psychological help.

Satisfaction of the participants is measured with the CSQ-8. The CSQ-8 is validated and frequently used in relation to mental health services (33). It consists in 8 items to which the participants respond via Likert scales ranging from 1 (low satisfaction) to 4 (high satisfaction). Higher scores indicate greater satisfaction with the services.

Finally, we collect usage metadata from the platform, including the total number of logins, number of spontaneous contacts initiated by participants, mean duration of each interaction, average number of participants contacted per day, and the rate of successful recontacts (i.e., recontacts that received a response).

Statistical analysis

The primary endpoint (change in the C-SSRS IoI-subscale score between baseline and 3 months) will be compared between the two arms using the constrained Longitudinal Data Analysis model (cLDA) proposed by Liang and Zeger (34). In the cLDA, both the baseline and post-baseline values are modeled as dependent variables using a linear mixed model, and the true baseline means are constrained to be the same for the two treatment arms. Hence, the cLDA provides an adjustment for the baseline values in estimating the treatment effects. The treatment effect will be estimated by the time-by-arm interaction, including gender as covariate.

The secondary binary outcomes at 3 months will be compared between the two arms using logistic regression models adjusted for gender. Odds ratios and theirs 95% confidence intervals will be derived from logistic regression models as effect sizes (experimental vs. control). The secondary quantitative outcomes will be compared between the two arms using analysis of covariance (ANCOVA) to adjust for baseline score and gender. Standardized mean differences and theirs 95% confidence intervals will be

calculated as effect size. If the model residuals are not distributed normally (despite the log-transformation of the data), ANCOVA will be performed on the rank-transformed data (non-parametric analysis).

Finally, the variables related to the use of the platform will be described in the intervention group. These quantitative variables will be expressed as means (standard deviations), medians (interquartile ranges) and ranges.

Statistical tests will be performed with a 2-tailed alpha risk of 0.05. No adjustment for multiple testing will be applied; and thus, all secondary objectives will be considered exploratory. All analyses will be performed in all randomized patients based on their original group of randomizations, according to the intention-to-treat, after handling missing values.

Ethical and Regulatory Considerations

Participation in the ORIAS study was contingent upon the signing of informed consent by all participants.

The ORIAS study was approved by the Sud-Ouest and Outre-Mer IV Committee for the Protection of Persons (CPP; IORG0009855, France) and authorized by the French Data Protection Authority (Commission Nationale de l’Informatique et des Libertés, CNIL).

The trial was registered on ClinicalTrials.gov under the identifier NCT04642157.

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Discussion

Originality and Contribution of the ORIAS Protocol

To our knowledge, ELIOS is the first suicide prevention helpline fully tailored to the SM environment and the digital behaviors of AYA. By harnessing the interactive features of SM platforms, ELIOS aims to overcome the help-seeking barriers that often prevent distressed AYA from accessing traditional support. Given that randomized controlled trials of SM–based interventions remain scarce and challenging to conduct, the ORIAS study will generate novel, high-quality evidence not only regarding ELIOS but also for the wider field.

Comparison with previous or ongoing work

The potential of SM as a tool for suicide prevention, particularly among AYA, have been envisaged for a decade (35–37), with several systematic reviews suggesting promising effectiveness (20,38,39). However, progress in this area has lagged research on the risks associated with SM. Most efforts have primarily focused on risk detection via data mining, psychoeducational dissemination, peer-to-peer support, online training, or efforts to improve mental health literacy (20,40). Evidence-based, professionally led applications remain scarce (41), with only a few notable exceptions. These include the REFRAME-IT program (42) which delivers cognitive behavioral therapy to at-risk secondary school students via a secure digital platform; the Rebound project (43), which integrates positive psychology, peer support, and psychosocial interventions for AYA recovering from a severe depression; and the Safe Conversations program (44) which facilitates supervised discussions within a closed Facebook group for secondary school students in communities recently affected by youth suicides. All three programs complement traditional therapy by offering remote, evidence-based interventions to pre-identified at-risk AYA who opt to engage in dedicated digital spaces. In contrast, ELIOS adopts a universal prevention model. As recommended by Montague et al. (45), it leverages both the technological and

socio-interactional affordances of SM platforms to fill gaps in mental health service accessibility.

Expected results

Seamlessly integrated into the everyday digital environments of AYA, ELIOS aligns with their habitual online behaviors, enabling them to reach out easily and spontaneously. This design facilitates the delivery of timely, context-sensitive support by trained web-clinicians, which we anticipate will reduce the intensity of suicidal ideation among distressed users (46). Beyond providing immediate relief, ELIOS is also structured to engage AYA through minimal initial interaction, creating opportunities to enhance motivation, and ultimately increase the likelihood of accessing professional support. Through these proximal outcomes, we expect ELIOS to contribute to a reduction in suicide attempts and deaths among participants.

Methodological and ethical challenges

Despite some initiatives, a clear gap remains in best-practice guidelines and standardized frameworks for both digital interventions and research in this domain (36). As a result, like many pioneering teams, we encountered significant early-stage challenges in implementing the ORIAS study, often navigating uncharted territory.

One key challenge, shared by most researchers in this field (47) involved securing and maintaining the necessary ethical and regulatory approvals. Both the ELIOS intervention and the ORIAS study raise complex ethical considerations. For example, when a web-clinician initiates contact, the participant is anonymous. This anonymity, coupled with the inherent limitations of online interactions, complicates risk assessment, and constrains the ability to implement emergency interventions (36). Nevertheless, ELIOS is built on the premise that it provides a critical preventive touchpoint for individuals who might otherwise never seek help. To mitigate the risks of missed intervention opportunities, ELIOS is

explicitly designed not as a stand-alone solution but as a gateway to traditional healthcare. Accordingly, web-clinicians focus on fostering participant engagement with the aim of gradually reducing anonymity and facilitating direct access to professional support. Secondly, confidentiality concerns are frequently raised in relation to SM–based interventions. Within the ELIOS system, several safeguards have been implemented to address these issues: all conversations are conducted exclusively through Facebook's private messaging feature, a dedicated data protection officer ensures that data collection and storage processes are fully compliant with European data protection regulations, and web-clinicians operate under strict ethical protocols. Nonetheless, ELIOS remains exposed to a particular vulnerability regarding data confidentiality: under European legislation, data shared on SM platforms are co-owned by both the user and the platform provider. As a result, we have no oversight or control over how Meta may access, process, or retain the data exchanged during interactions. Considering this unavoidable limitation—and in recognition of the need to balance potential confidentiality risks against the urgent imperative to reduce life-threatening risk—the French Data Protection Authority (CNIL – Commission Nationale de l'Informatique et des Libertés) still granted authorization to proceed with the study.

Another limitation of the ELIOS system is that it is accessible solely via Messenger, a platform less frequently used by AYA. This arose primarily from technical and economic constraints. The more widely adopted platforms among Generation Z in France (48)—TikTok, Instagram, and Snapchat—either lack compatible communication interfaces, automatically reject integration attempts, or permit access only through paid services beyond our financial capacity. Nevertheless, our recruitment rate remains promising, likely since nearly 40% of individuals aged 18-25 still use Facebook (48) and because we promoted ELIOS via Instagram.

Likewise, due to research regulations, we were required to exclude minor participants from the ORIAS study. This exclusion represents a significant missed opportunity for both prevention and research, as younger adolescents are among the most affected by suicidal ideation and attempts, and simultaneously among the heaviest users of SM (49).

Implications for research and prevention practices

Most of ORIAS's limitations stem from a mismatch between SM interventions and the rigor and demands of randomized controlled trials. Additionally, these limitations arise from the lack of acculturation of academic stakeholders to digital fields, including their codes and norms, which sometimes results in overly stringent positions. Despite these challenges, we remained committed to complying with ORIAS's requirements to determine whether ELIOS or similar innovations merit inclusion in the current prevention arsenal. Specifically, generating high-level evidence would provide a compelling argument to persuade decision-makers to implement ELIOS as the SM channel for the French national suicide prevention helpline (3114), to encourage SM platforms to grant broad access to ELIOS, and to convince regulatory authorities to authorize ELIOS's use by minors.

Conclusion and future perspectives

The regulation of SM access, particularly for minors, is a topic of global discussion. If proven effective, ELIOS could offer a complementary preventive approach by providing innovative access to professional support. If combined with data-mining techniques used to identify at-risk users, it could also serve as a practical tool for developing a proactive suicide prevention outreach system. However, this would require a more in-depth examination of specific ethical challenges.

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Figures caption

Figure 1. Overview of participant pathway through the ORIAS protocol

Figure 2. Screenshot of the ELIOS digital platform. A. Menu allowing the web-clinicians to access the agenda, chat space, list of included participants, and platform setting;.B. Waiting list, prioritized based on waiting time and level of suicidality; C. Chat space where the web-clinicians can leave a note, schedule a follow-up, initiate a call, or close the conversation; D. Digital clinical record where the web-clinician can enter or review information about the participant's situation, inclusion form results, personal and family medical history, current medications, suicidal ideation, and clinical status.

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Declarations

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The sponsors had no role in study design; collection, management, analysis, and interpretation of data; writing of the report; and decision to submit the report for publication.

Conflicts of interest

The authors declare that they have no conflicts of interests.

Data Availability

Only the promotor and investigators will access the final trial dataset.

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

MM: Contributed to the protocol design, led the development of the ELIOS platform, managed the project, and co-drafted the manuscript.

ML: Assisted in project management and the design of the ELIOS platform, and revised the manuscript.

ACL: Carried out the ELIOS interventions.

LR, NR, VJ: Supervised the ELIOS interventions.

MW: Contributed to protocol design, statistical plan development, and manuscript revision.

ALD, KD: Participated in project management as representants of the trial sponsor

AD: Contributed to the design of the protocol and the statistical plan, and revised the manuscript.

TD. Oversaw the communication regarding the protocol.

PG: Participated in protocol design and project management, supervised the ELIOS interventions, and revised the manuscript.

CEN: Designed the protocol, assisted in project management and the design of the ELIOS platform, managed the project, and co-drafted the manuscript.

Abbreviations

AYA. Adolescents and Young Adults

SM. Social Media

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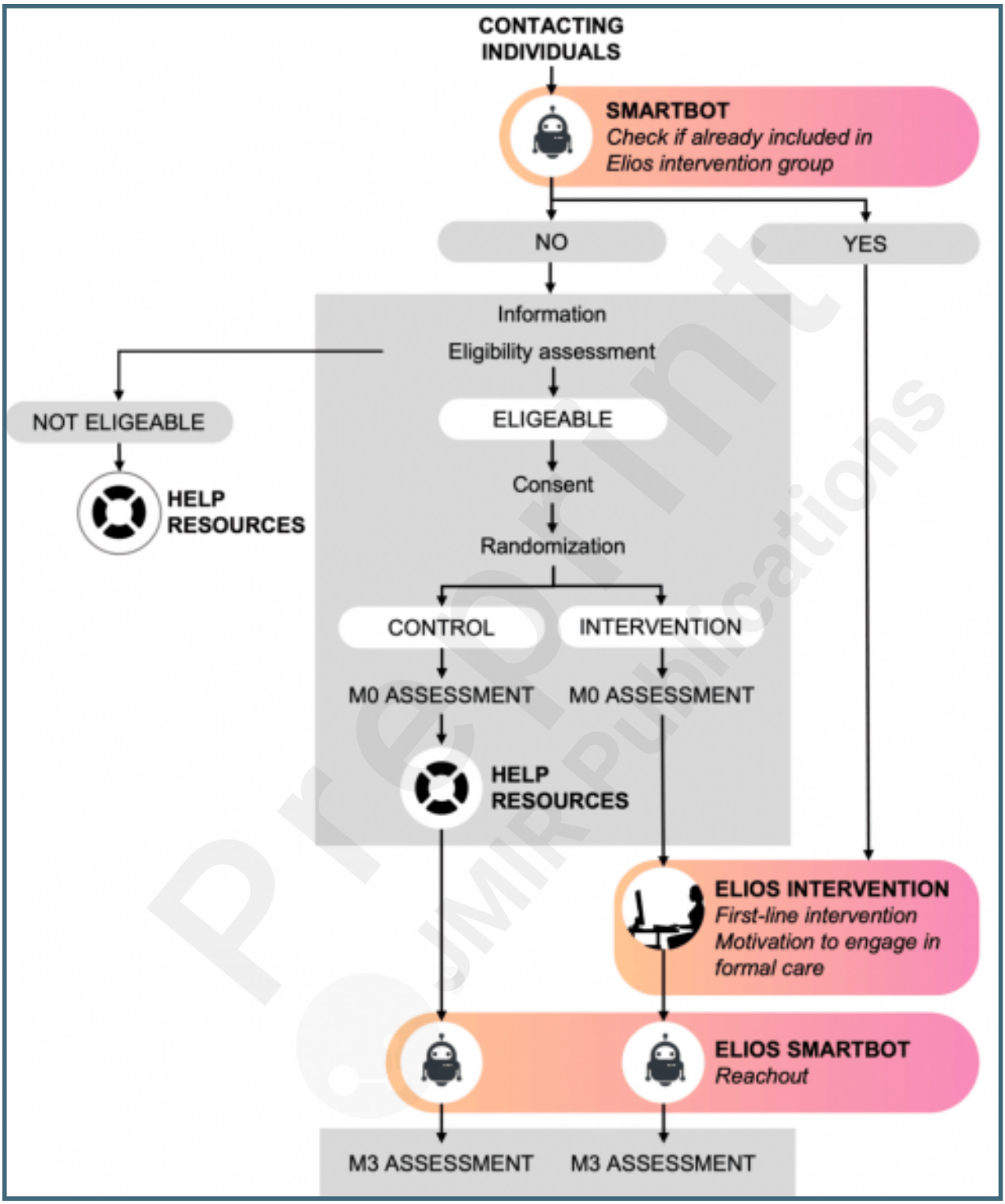
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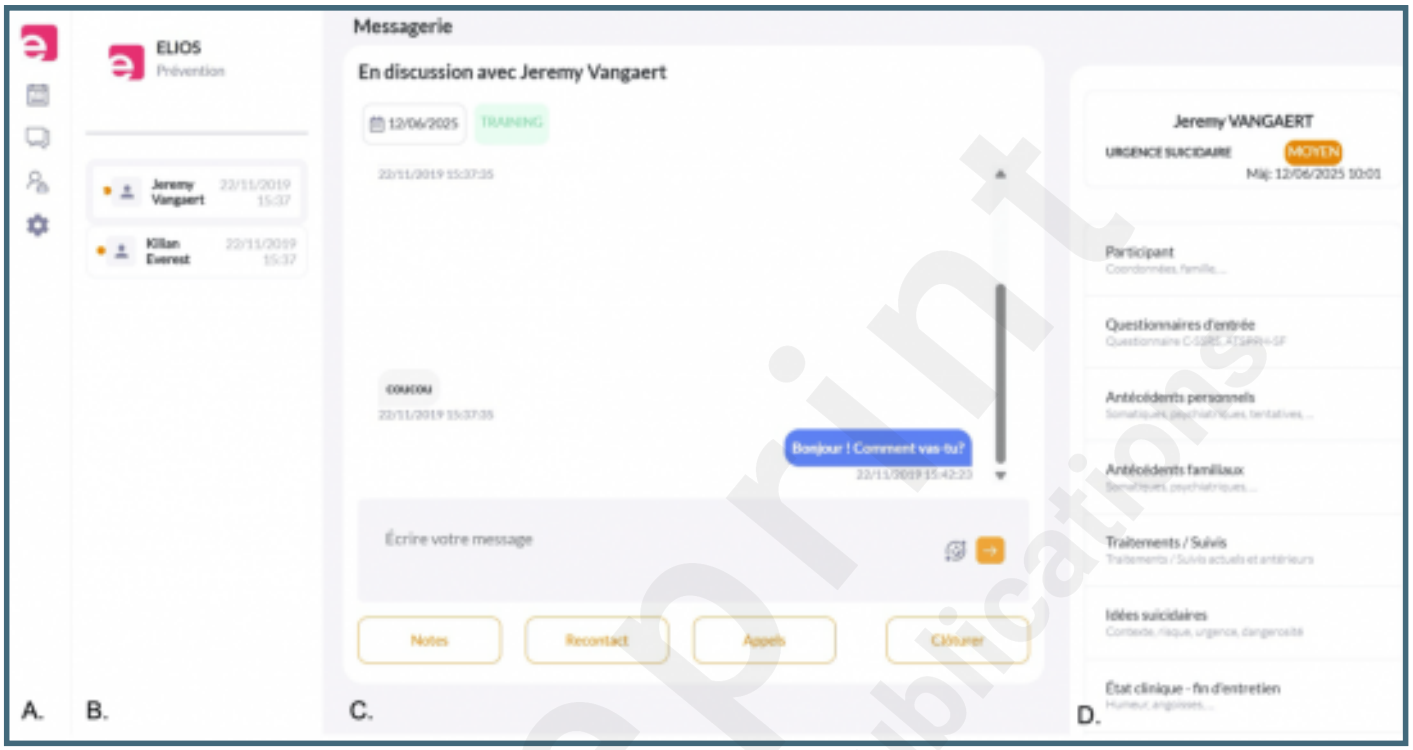
Figures

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