BMJ Open

Universal mental health screening with a focus on suicidal behaviour using smartphones in a Mexican rural community: protocol for the SMART-SCREEN population-based survey

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ABSTRACT

Introduction Mental disorders represent the second cause of years lived with disability worldwide. Suicide mortality has been targeted as a key public health concern by the WHO. Smartphone technology provides a huge potential to develop massive and fast surveys. Given the vast cultural diversity of Mexico and its abrupt orography, smartphone-based resources are invaluable in order to adequately manage resources, services and preventive measures in the population. The objective of this study is to conduct a universal suicide risk screening in a rural area of Mexico, measuring also other mental health outcomes such as depression, anxiety and alcohol and substance use disorders.

Methods and analysis A population-based cross-sectional study with a temporary sampling space of 9 months will be performed between September 2019 and June 2020. We expect to recruit a large percentage of the target population (at least 70%) in a short-term survey of Milpa Alta Delegation, which accounts for 137 927 inhabitants in a territorial extension of 288 km^2.
They will be recruited via an institutional call and a massive public campaign to fill in an online questionnaire through mobile-assisted or computer-assisted web app. This questionnaire will include data on general health, validated questionnaires including Well-being Index 5, Patient Health Questionnaire-9, Generalized Anxiety Disorder Scale 2, Alcohol Use Disorders Identification Test, selected questions of the Drug Abuse Screening Test and Columbia-Suicide Severity Rating Scales and Diagnostic and statistical manual of mental disorders (DSM-5) questions about self-harm.
We will take into account information regarding time to mobile app response and geo-spatial location, and aggregated data on social, demographic and environmental variables. Traditional regression modelling, multilevel mixed methods and data-driven machine learning approaches will be used to test hypotheses regarding suicide risk factors at the individual and the population level.

Ethics and dissemination Ethical approval (002/2019) was granted by the Ethics Review Board of the Hospital Psiquiátrico Yucatán, Yucatán (Mexico). This protocol has been registered in ClinicalTrials.gov. The starting date

Strengths and limitations of this study

► Smartphone-screening (SMART-SCREEN) a population's mental health provides a novel approach to public health screening campaigns.
► Innovative methods using smartphone-based technology are an easy, cost-effective means to studying suicidal ideation, depression and other mental health outcomes and risk factors.
► Mental health data will be explored along with other health-related questionnaires in a built-in smartphone app that will enhance data collection; however, a web-based version is already functional and access points located in educational and municipal facilities will be made available.
► SMART-SCREEN expects to recruit a large percentage of the target population (at least 70%) in a short-term cross-sectional survey. It will be powered by a local massive health campaign.
► This study has some limitations: access of people who do not own a smartphone is particularly concerning. Probabilistic models will be used to handle data losses without biasing nor decreasing the validity of our results.

of the study is 3 September 2019. Results will serve for the planning and healthcare of groups with greater mental health needs and will be disseminated via publications in peer-reviewed journal and presented at relevant mental health conferences.

Trial registration number NCT04067063.

INTRODUCTION

According to the 2017 Global Burden of Disease (GBD) study, mental disorders represent the second cause of years living with disability (YLDs) worldwide.[1] In particular, depression is the third leading cause of YLDs right after low back pain and headache disorders.[2] Substance use disorders are also a leading cause of disability.[1] The impact of depression and substance use disorders is similar in high-income and Latin American and Caribbean countries.[3]

Furthermore, mental disorders underlie most of cases of suicidal behaviour.[4 5] Suicide is considered a key public health concern by the WHO[4] and a sustainable development indicator by the United Nations.[5] Notably, deaths due to self-harm are irregularly distributed across the globe, with 79% of global suicides happening in low/middle-income countries (LMICs).[6 7] Suicide mortality is driven by a complex combination of risk and protective factors at the individual and the population levels, such as mental health and substance use disorders, access to lethal means or availability of proper healthcare and social welfare programmes and evidence-based interventions. The prevalence of such factors, as well as their relative impact on suicide rates, varies over time and across populations. For example, while over 90% of suicides in western countries are related to mental health disorders, this proportion does not exceed 50% in China[8]; and while many high income countries have experienced a recent increase in suicide mortality among middle-aged men, this phenomenon has not been detected in Southern Europe.[9] Notwithstanding the need to account for regional variations in suicide risk factors and suicide mortality in order to appropriately impact suicide risk globally, most suicide research is conducted in high-income countries, where suicide risk is lowest.[4]

In Mexico, mental health issues represent a considerable proportion of the burden of disability, with depression and anxiety disorders ranking as the fifth and ninth leading causes of disability, respectively.[10] In addition, suicide is the 15th leading cause of death in Mexico,[11] with particularly concerning rates among young men, and suicide mortality has increased alarmingly over the recent years. In a report based on the GBD estimates, Naghavi *et al* estimated that age-standardised suicide mortality of men and women combined have increased over a 20% between 1990 and 2016 in Mexico,[12] and data from the National Institute of Statistics and Geography suggest that the steepest increases have taken place over the last decade—from 4.3 suicides per 100 000 in 2008 to 5.2 in 2016.[13] This is in contrast with global decreasing trends, driven by marked reductions in suicide mortality in China and India, but in line with recent increases in the USA.[14]

In Mexico, suicide attempts have an annual prevalence of 0.7%[15] for a total of over 900 000 annual suicide attempts that entail a substantial burden for the Mexican Health System.[16] Despite these large numbers, insufficient mental health services are available and large gaps exists in mental healthcare[17]; less than 30% of people who die by suicide in Mexico have received mental health treatment over the previous year and less than 20% of individuals with depression seek help from mental healthcare providers.[18]

In the current moment of emergence of e-health and m-health,[19] smartphones serve as a readily available tool for data collection[20 21] and universal screening and intervention.[22–28] Mobile technology entails huge potential for the development of massive fast surveys, allowing for the collection of even more information than is explicitly asked, such as geographic location via global positioning system.[29 30] Thus, smartphones could be useful in epidemiological surveys, which are the base for healthcare planning and resource allocation. Recently, a nation-wide survey protocol was published that included smartphone-collected data from all residents of the Netherlands and looked at their exposure to environmental factors that could affect mental health outcomes such as depression and suicide risk.[20] However, this survey relies on stratified representative sampling, and therefore it cannot be considered a universal community screening. Additionally, also in the Netherlands, a national crowdsourcing study investigated multiple mental health dimensions in a sample from the general population (n=12 503).[31] In rural Guatemala similar smartphone-based methods have been used to estimate the burden of acute gastroenteritis and norovirus, using a sample of around 400 children covering an area of $200 \, km^2$ over 6 months.[32] It should be noted that, to date, no study has tried to cover an entire community in a systematic way.

Given the vast cultural diversity of Mexico and its numerous communities and abrupt orography, smartphone-based assessments are invaluable in order to manage healthcare resources and administer preventive measures. Furthermore, practically the entire Mexican population owns a mobile phone and 83.8% of mobile phone owners have a smartphone, representing 69,9 million people.[33] Regarding mental health, smartphones can be useful for the development of epidemiological or screening surveys and also to optimise existent resources. Of note, most countries, including Mexico, have less than two psychiatrists per 100 000 people.[34]

The objective of this study is to conduct a universal screening of suicidal ideation, depression, anxiety and alcohol and substance use in a large rural area of Mexico. Our working hypothesis is that that this universal screening based on a smartphone app can identify people at risk across the whole community. Data from this screening should serve to depict a map of the mental health and related needs of the population that can inform local healthcare planning. This map will be useful to improve assistance to groups and individuals at greatest
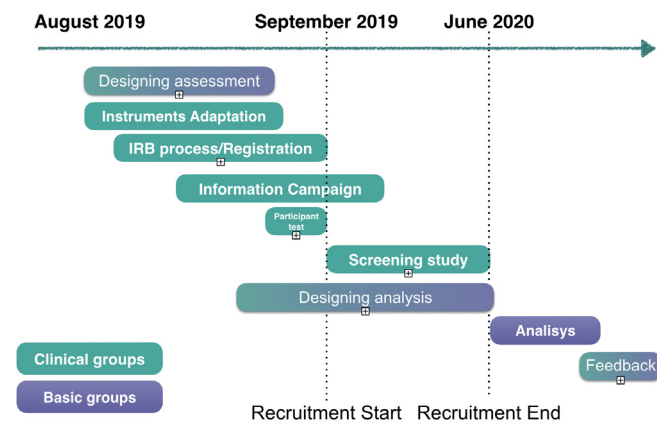
August 2019   September 2019   June 2020

Designing assessment

Instruments Adaptation

IRB process/Registration

Information Campaign

Participant test

Screening study

Designing analysis

Analisys

Feedback

Clinical groups

Basic groups

Recruitment Start   Recruitment End

Figure 1 Gantt chart smartphone-screening study.

risk enhancing their identification and early reference to mental healthcare providers.

METHODS AND ANALYSIS
Study design
We will implement a population-based cross-sectional study with a temporary sampling space of 9 months. The study design will follow the Strengthening the Reporting of Observational Studies in Epidemiology statement.[35] Figure 1 depicts the study phases as a Gantt diagram.

Study population and sampling design
The Milpa Alta Delegation is located at the southern end of Mexico City. It has a territorial extension of 288 km², divided in nine municipalities. Its estimated population is 137 927 inhabitants, according to the 2015 intercensal survey, with roughly 92 000 individuals aged between 15 and 69 years old.[36] Table 1 depicts the distribution of population aged ≥18 years in each of the nine municipalities that form the Milpa Alta Delegation. Importantly,

Table 1 Population aged 18 years and over living in each of the Milpa Alta Delegation municipalities according to the electoral roll and the nominal list by electoral section (June 2019)

Municipality	Population
Tecomitl	23 731
Xicomulcco	4363
Tlacoyucan	6409
Oztotepec	14 588
Cuauhtenco	11 779
Tlacotenco	9505
Atocpan	10 192
Villa Milpa Alta	12 556
San Francisco Tecoxpa San Jeronimo Miacatlan San Agustin Ohtenco	13 213
Total	106 336

the Milpa Alta Delegation has one regional hospital with a sole psychiatrist (PEAC). The nearest psychiatric hospital and mental health department are 3 hours away by car.

As we aimed at recruiting the whole population in a single survey study in less than 1 year, no sampling procedure was established.

Our inclusion criteria are as follows: (1) being between 15 and 70 years old; (2) being able to use a smartphone or a computer, either using their own smartphone or computers enabled by local government at the Milpa Alta Delegation or by local education services at educational centres; (3) being able to understand the nature, purpose and methodology of the study; (4) accepting participation in the study and checking the corresponding box in the app that verifies that informed consent has been expressly given.

Exclusion criteria are: (1) being deprived of liberty (by judicial or administrative decision) and (2) being protected by law (eg, being under guardianship).

The rationale behind including the entire population is based on the main objective of the study: performing a population screening. We expect a response rate of, at least, 70% of the population between 15 and 70 years old; primarily, from their own smartphone. To achieve higher rates and avoid discrimination based on age or access to technology[37] web access devices will be enabled for public use in educational and municipal facilities.

Survey
Starting September 2019, all Milpa Alta inhabitants are being invited via an institutional call and a massive public campaign to fill in an online questionnaire through mobile-assisted or computer-assisted web apps.

The survey will be carried out in three sequential phases:
1. Preparation phase, prior to any recruitment. A few citizens will be asked for pilot-testing of the survey's cultural competence.
2. A first official recruitment period aimed at young population (aged 15–24 years) conducted within the educational institutions of Milpa Alta.
3. A second official recruitment period aimed at adult population (aged more than 18 years) of the Milpa Alta Delegation.

After fulfilling the questionnaire, each participant will receive a report including a global assessment of their responses unless they did not authorise it previously. Together with the report they will be sent a brief questionnaire to retrieve their opinion regarding their overall experience with the study procedure. In the event that the participant has a high risk of psychopathology, suicide and/or addiction, a priority appointment at a mental healthcare centre will be recommended and facilitated via an app message or e-mail, ensuring anonymity at all times.
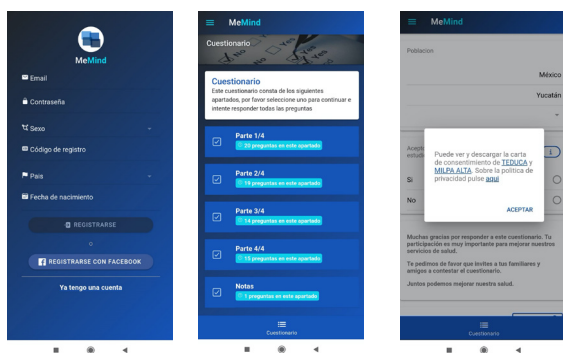
Figure 2 MeMind screenshots.

Strategies to enhanced participation

Participation will be enhanced by several multilevel strategies before starting recruitment periods:

1. The mayor's office will disseminate the survey through posters in public places and health institutions, and advertisements will be placed in regional media websites (press conference prior to start the recruitment).
2. Local educational institutions will encourage participation of the student community through talks held annually at the beginning of the official school year.
3. Members of the suicide prevention programme of Milpa Alta will coordinate procedures for local dissemination in each Milpa Alta Delegation municipality in collaboration with local representatives and community leaders.
4. During the recruitment period, data on study participation will be collected in real time. If participation is observed to be lower than expected in specific municipalities or sociodemographic groups, additional informative measures will be adopted.

Smartphone app

All assessments will be carried out using the MeMind smartphone app (Android and iOS) (figure 2) or the MeMind web app (https://frontend.memind.net). This app is in use since 2014 and was developed to enhance access to clinical information for mental healthcare professionals and patients, with both clinical management and research purposes.[38 39] The MeMind app is programmed to send anonymous reports to participants, via the app or registration through e-mail, in an automatic procedure that requires no active intervention by professionals and is compliant with the recommendations of mental healthcare professionals.

Participants will complete a built-in questionnaire composed of three generals question about health (body mass index, diabetes mellitus and prescribed treatment) and several psychometric instruments:

► The Well-being Index (WHO-5) scale is widely implemented both in mental health and general health surveys. It has demonstrated adequate validity as a screening tool for depression and as a measure of clinical response to interventions in various clinical trials in several countries including Mexico.[40]

► The Patient Health Questionnaire-9 is a self-administered questionnaire used to screen depression. It consists of nine items based on the Diagnostic and statistical manual of mental disorders (DSM-IV) diagnostic criteria for depression. In the Mexican population, the questionnaire was tested in 55 000 women from the Mexican Teachers' Cohort, showing high internal consistency with a Cronbach's alpha of 0.89.[41]

► The Generalized Anxiety Disorder Scale (GAD)-2 is an abbreviated version of GAD-7 which is a widely used anxiety screening instrument.[42–44]

► A short version of the Alcohol Use Disorders Identification Test (AUDIT-C) will be used to assess alcohol use.[45 46] This version will consist of the three first items of the AUDIT.[46] We will seek to identify risk use patterns (alcohol misuse), using as threshold a score greater or equal to 5 in men and 4 in women.

► Three questions selected from the Drug Abuse Screening Test questionnaire will be used to assess the use of substances and their impact. These questions correspond with the screening part of the questionnaire.[47]

► The Columbia-Suicide Severity Rating Scale (C-SSRS)[48] is widely used for the study of suicidal behaviours and has demonstrated good sensitivity and specificity identifying the highest risk states for suicide.[49] It has been translated and culturally adapted for the Mexican population.

► Two additional questions about self-harm adapted from DMS 5.[50]

Outcomes

Our main outcomes will be participation rate (eg, sampling coverage with respect to the population), rate of evaluations completed correctly and, if participation rate is lower than 80%, level of representativeness of the sample.

Secondary outcomes will include the following: (1) estimated prevalence of suicidal behaviours as measured by C-SSRS, depression, anxiety and alcohol and substance use disorders; (2) intensity of suicidal ideation and severity of self-injurious and/or suicidal behaviours; (3) quality of life of the population measured as measured by the WHO-5 scale and (4) profiles and clustering of comorbid mental-health problems within the population.

Statistical analyses and result summaries for stakeholders

The statistical analysis has been designed considering four periods (table 2). During the recruitment phase, we will collect and process data in order to run real-time analyses and obtain key performance metrics that include the following domains: recruitment rate, representativeness, access and quality of data. Estimating the screening representativeness and coverage is key, as this study aims at universally screening all the population of Milpa Alta. Our hypothesis is that representativeness will be high, especially among youth.

Table 2 Analysis, products and dissemination strategy

Period	Recruitment	End of recruitment	One week after	Two weeks after
Agent	Research team	Health planners	Municipalities Educational system Local leaders	Participants
Task	▶ Monitoring ▶ Determination of relevant key performance indicators (KPIs) ▶ Use KPIs for increase recruitment	▶ Mapping of disorders ▶ Description procedures	▶ Cut-off point determination ▶ Pattern analysis ▶ Cluster analysis	▶ Design of participant-friendly reports ▶ Explain outliers ▶ Estimate degree of honesty
Indicator/ domain measures	▶ Recruitment rate ▶ Representativeness ▶ Access ▶ Data quality assessment	▶ Representativeness ▶ Disease rates ▶ Feasibility ▶ Cost ▶ Limitations	▶ Representativeness ▶ Inaccessible population ▶ Ranking of health problems	▶ Reliability ▶ Validity ▶ Rate of referral to mental healthcare providers
Products	▶ Key performance metrics (KPM)	▶ Recommendations for the extension of this kind of surveys to other communities	▶ Reports for different community stakeholders	▶ Personal report for participants
Final results	KPM for an extended survey	Information for the design of rapid surveys in communities using smartphones	Information for the design of preventive measures in the community	Detect untreated severe cases and refer them to the healthcare system

The use of questionnaires via smartphone allows for recording response times. This measure can be useful to estimate the degree of honesty of the participants' honesty.

We will conduct descriptive analyses based on demographical and clinical data, including responses to questionnaires, in order to estimate the prevalence of positive screenings for each of the studied conditions. In addition, building on these data as well as on information regarding time to mobile app response and geo-spatial localisation, and aggregated data on social, demographical and environmental variables from the included locations, we will combine traditional regression methods with multilevel mixed methods and data-driven, machine learning approaches to test hypotheses regarding suicide risk factors at the individual and the population level. This will allow us to conduct a series of studies nested within the main research proposal that will greatly increase our understanding of suicide risk in Mexico.

Patient and public involvement

The study includes support by an advisory group comprised by a sample of people from the source population, which met with the research team during the earlier stages of the study. This advisory group provided input to the programme of research, giving feedback on questionnaire content and length and reflecting on their overall experience with the screening process under study. In addition, members of the advisory group contributed informally and on their own initiative to the dissemination plan.

ETHICS, DATA MANAGEMENT AND DISSEMINATION
Ethical review

The project will be conducted in accordance with the Declaration of Helsinki of the World Medical Association on ethical principles for medical research in humans, as well as with all requirements established in Mexico's laws on data protection.[51] Ethical approval (002/2019) was granted by the Ethics Review Board of the Hospital Psiquiátrico Yucatán, Yucatán (Mexico).

All personal data necessary for the development of the study are subject to the Mexican legislation. Each patient participating in the study will be anonymised and identified with a code. No data that may lead to the identification of the participants in the study will be published in any of the works derived from this research.

There is no cost or financial compensation for participating in this study: all interviews and tests will be conducted at no cost, and participants will not obtain any financial compensation, except for the benefits that derive from obtaining personal mental health reports and the overall improvement of healthcare planning that may stem from the study.

The only risk that may derive from the study is related the clinical evaluation. However, ecological momentary assessments are commonly used for the evaluation of patients and do not represent significant risks for subjects. Previous studies have shown that repeated patient questioning, including questions regarding suicidal ideation, does not lead to an increased risk of suicide.[52] If a participant is rated as being at high risk of suicide, MeMind will send him/her information regarding the nearest

psychiatric facility, as well as an emergency telephone number. To ensure anonymity, this is an automatised procedure.

Before accessing the questionnaire, each participant will have to provide consent to participate in the study after reading the study's information and consent form. For people under 18 years old, parents' informed consent will be obtained.

Data management
Databases
Data will be processed within a secure information technology environment, as stated above. Strategies for data security and protection are in compliance with Mexican law and European regulations. Participants will take the survey voluntarily and will grant their permissions before any data are gathered.

The database will not contain any identification data; hence, preserving responders' complete privacy. The consumer web database is hosted on Amazon Web Services and all communications are encrypted using Hypertext Transfer Protocol Secure protocols and protected by security systems. There will be a summary record of all maintenance work performed (who/when/why/actions taken) as well as a record of all accesses to maintenance consoles (log files).

Dissemination
We hope to achieve a scalable procedure throughout Mexico to generate a map of the mental health and needs of the population in local communities, which will serve for the planning and healthcare of groups with greater mental health needs.

In addition, results will be disseminated via publications in peer-reviewed journal and presented at relevant mental health conferences.

DISCUSSION
SMART-SCREEN is an innovative tool for mental health screening that has been specifically designed to explore and further understand the distribution of suicidal behaviours in the general population. This strategy enhances access to previously neglected rural communities and virtually does not need financial investment, as it builds on smartphone technology, currently of widespread use in the population. This strategy is cheaper and faster than traditional epidemiological surveys and can be useful to fill the gap regarding suicide behaviours, especially in understudied populations such as LMICs. Of note, although many LMIC have usually less health resources than upper-middle income countries, smartphone penetrance is increasing rapidly worldwide. At the moment, the number of smartphone users have surpassed 2 billion globally in 2016 and it is expected that there will be around 3 billion users by 2021.[53]

This project is a local initiative, with local stakeholders (municipalities government, educational institutions and mental health caregivers) directly involved in its implementation. Information provided by the survey will be useful in addition to the Psychiatric Epidemiologic National Survey that is conducted every year[54] for mental healthcare planning and resource allocation. In addition, SMART-SCREEN will detect and refer people at risk to current mental health facilities with no need for increases in available resources and, in fact, will optimise access to mental healthcare among underserved people with mental health needs. If the project is successfully developed, and we achieve our participation goals, the epidemiological information yielded will be representative and of incredible value. Furthermore, this methodology can be transported to others settings and used to screen a variety of health conditions. Finally, SMART-SCREEN can be a critical tool for the redefinition of mental healthcare policies.

SMART-SCREEN is intended to not only be a screening system but also to integrate personalised preventive actions. Participants who screen positive for mental health risk can receive individual-level healthcare recommendations, referral vouchers for local mental healthcare facilities and so on. For instance, two of the most successful preventive strategies for suicide behaviours, the WHO's brief intervention and contact intervention,[55] and the safety planning intervention,[56] can be easily incorporated to SMART-SCREEN.

SMART-SCREEN will be the first smartphone-based epidemiological survey covering an entire population, as most traditional surveys and even current smartphone-based projects instead use population samples.[20 32] The whole population will be assessed using easy to understand and validated instruments, real-time analyses will be conducted and quick feedback information will be reported to local health stakeholders and also to participants.

The main strength of this project is its innovative nature and its feasibility: the technology we will use in the SMART-SCREEN initiative has been previously used with success in clinical populations with mental disorders, achieving large sample sizes.[57–60] We are concerned that difficulties in access to SMART-SCREEN among people who do not have a smartphone, as well as among the elderly, may somewhat undermine our study. We hope to overcome this limitation with the involvement of local administrations and community leaders, who will disseminate the project and provide assisted computer stations in educational and municipal facilities. Other potential limitations include difficulties to achieve population representativeness, especially in the event that we achieve low participation rates, and the possibility of collecting low-quality, untruthful or missing data; to overcome these potential limitations we have selected widely demonstrated usefulness self-reported questionnaires and we will also use probabilistic models that allow us to handle data losses without introducing bias or lowering the validity of our analyses. Finally, we have chosen short forms of all questionnaires to avoid overwhelming participants:

notably, we have successfully used questionnaires with a similar length in similar, previous studies.[58]

The SMART-SCREEN project pushes the boundaries of psychiatric scientific knowledge by allowing for massive population detection of suicide risk and mental health disorders using current state of the art technologies. Furthermore, SMART-SCREEN is a cost-effective tool for mental healthcare planning that enhances the inter-action between mental health systems and underserved customers by making use of common, inexpensive and widespread technology. Our study will serve as an example for other large, comprehensive health assessments, especially if they are deployed within large public healthcare systems from rural communities and/or LMIC.

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