It is illegal to post this copyrighted PDF on any website. Impact of Depression on Anxiety, Well-being, and Suicidality in Mexican Adolescent and Young Adult Students From Mexico City: A Mental Health Screening Using Smartphones

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ABSTRACT

Background: Depression, anxiety, well-being, and suicidality are highly associated during adolescence and greatly predict mental health outcomes during adulthood. This study explored relationships between these variables among students from Mexico City.

Methods: This representative cross-sectional study was carried out in education centers in Mexico City during the 2019–2020 academic year. Using a smartphone app, we implemented validated questionnaires for depression (Patient Health Questionnaire-9), anxiety (Generalized Anxiety Disorder-7), well-being (World Health Organization 5 Well-Being Index), and risk of suicide (Columbia-Suicide Severity Rating Scale). Partial least squares structural equation modeling was performed for the entire sample and after stratifying by gender.

Results: Out of 3,042 students, 1,686 were females; mean age of the sample was 17.3 years. Compared to males, females had higher levels of anxiety, depressive symptoms, and suicidal ideation and lower levels of self-perceived well-being. Structural equation models indicated that depression was the main predictor of the rest of the outcomes in the overall sample. The role of anxiety was heterogeneous across genders and not clearly correlated to suicidal behavior or well-being.

Conclusions: Large-scale mental health screening using an online tool proved feasible, with high response rates. Depression was the most important factor influencing anxiety, suicidal behavior, and well-being in Mexican high school students. The roles of depression and anxiety were heterogeneous across genders.

Trial Registration: ClinicalTrials.gov Identifier: NCT04067076

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*Corresponding author: Enrique Baca-García, MD, PhD, Department of Psychiatry, University Hospital Jimenez Diaz Foundation, Av. de los Reyes Católicos, 2, 28040 Madrid, Spain (ebacgar2@yahoo.es). the global burden of adolescent disease.^{1,2} In particular, depression and anxiety stand out as leading causes of disability among adolescents, and suicide ranks third in causes of death between 15-19 years of age.^{1,2} Moreover, adolescent mental health is considered a major determinant of adult mental health, and 50% of chronic mental health conditions start before 15 years of age.³ Well-being is a measure of an individual's global perception of life satisfaction that encompasses aspects related to mental and physical health as well as of the individual's living conditions.^{4,5} As an outcome, well-being has proved meaningful to the general population⁶ and serves as a holistic assessment of the bio-psycho-social status of the person.⁷ Well-being is thought to contribute notably to and be affected by adolescent mental health conditions: measurements of wellbeing are consistently found to be inversely associated to adolescent depression, anxiety, and suicidal ideation.⁸⁻¹² Because the lack of well-being during adolescence is a key predictor for mental health conditions during adulthood, improving our understanding of adolescent well-being and clarifying the relationships between well-being, mental health conditions, and suicidal behaviors in adolescence is critical not only for improving mental health outcomes among adolescents but also for adult mental health prevention efforts. The well-being of children and adolescents and its relationship to mental health outcomes is a growing area of research interest.¹³

ental health conditions affect nearly 1 in 5 people aged 10–19 years

globally and account for more than 15% of

Even though 90% of adolescents live in low- and middle-income countries, the majority of our understanding of the relationships between mental It is illegal to post this copyrighted PDF on any website, adolescents and young adults; (b) there would be high levels

Clinical Points

- To study mental health among adolescents and young adults from Mexico City, a hard-to-reach population, we used a smartphone-based mental health screening.
- Implementation of this screening was successful, recruiting more than 3,000 participants with high response rates.
- Depression predicted anxiety, suicidality, and (reduced) well-being overall and in gender-specific models.

health conditions, suicide, and loss of well-being among adolescents comes from high income countries.¹⁴ However, the frequency of mental health conditions in adolescents varies greatly across contexts. In Latin America, estimates from the World Health Organization suggest that around 5% of people aged 10-19 years suffer from anxiety, and 4%, from depression. Studies conducted in Mexico reported that up to 30% adolescents live with any anxiety disorder, and around 5.5%, with depression.¹⁵ Further, in a cross-sectional study in high schools in the 32 entities of Mexico, a total of 47% of the students reported at least 1 suicidal ideation symptom, and 9% reported a past suicide attempt.¹⁶

Likewise, child and adolescent well-being estimates indicate substantial heterogeneity across countries. Mexico, despite having the Organization for Economic Cooperation Development's highest adolescent fertility rate and the second highest proportion of adolescents not in employment or education, shows the highest share of adolescents reporting high levels of life satisfaction,¹⁷ a domain that captures cognitive aspects of (and is considered closely related to) well-being.18-21 Qualitative and ethnographic work has looked into the particularities of psychological well-being among Mexican adolescents,^{22,23} and there are concerns that Mexican girls may experience substantial loss of psychological well-being when transitioning to adolescence²⁴ and that the proportion of Mexican adolescents reporting lack of well-being increases with age.²⁵

The association between all these variables—depression, anxiety, suicidality, and well-being-is complex, and data on these associations are even scarcer among youth. Use of smartphone apps could play a key role in enhancing access to youth for research and intervention purposes, especially given the role of smartphones as the centerpiece of this population's communication strategies²⁶ and the limitations in face-to-face assessments brought about by the COVID-19 pandemic. However, the extent to which smartphone-based assessments of youth mental health are feasible in locations outside of high-income countries remains unstudied.

This study used a broad sample of young students from Mexico City to (1) describe the prevalence of 4 mental health variables (depression, anxiety, suicidal behavior, and wellbeing) and compare their distribution across gender and (2) explore the relationship between these 4 variables by means of partial least squares structural equation modeling (PLS-SEM). We hypothesized that (*a*) smartphone-based mental health screening would be feasible and appropriate to study depression, anxiety, suicidal behavior and well-being among of mental health problems in Mexican students; and (c) general well-being would interact with suicide behavior in its relationship with depression and anxiety.

Mexico, with its improving economy, very large youth population, and solid private telecommunications sector, is slightly over the Latin American average in terms of smartphone penetration.

METHODS

Study Design

This study is a population-based cross-sectional survey study. It follows the STROBE guidelines for its reporting,²⁷ and the study protocol was registered in ClinicalTrials.gov (NCT04067076).

Setting

Study sites were educational centers belonging to the Instituto de Educación Media Superior (IEMS) of Mexico City, which are accountable for high school education (ie, upper-secondary school curricula), with students usually ranging from 15 to 22 years old.

The survey had an open-ended recruitment period along the 2019-2020 academic year. Official recruitment started in late August 2019; students were invited via an institutional call to fill in an online questionnaire through a smartphone app. At that time, parents were also invited to participate by downloading the same app. Involvement was enhanced by local educational institutions, encouraging the student community to participate via motivational talks at the beginning of the academic year.

Study Population and Sampling Design

The study population encompassed a total of 2,835 young students from IEMS (1,278 males and 1,557 females) who agreed to participate in the survey until December 2019 (a 3-month recruitment period). A consecutive sampling approach was adopted, with the intent to reach as many students as possible.

Our inclusion criteria were (1) being at least 15 years of age; (2) being enrolled in the IEMS educational services; (3) being able to use a smartphone or computer equipment, using either their own smartphone or computer terminals enabled by local education services; (4) being able to understand the nature, purpose, and methodology of the study; and (5) accepting participation in the study and checking the corresponding box in the app to verify that the informed consent has been expressly given. Exclusion criteria were (1) being deprived of liberty (by judicial or administrative decision) and (2) being protected by law (guardianship or conservatorship).

Variables

Outcomes. Our main outcomes were (a) suicidal behavior, (b) depression, (c) anxiety, and (d) subjective wellbeing. Each of these variables were latent variables measured

website.

It is illegal to post this convrighted PDE Table 1. Study Population Characteristics^a

Females	Males	Р	Study populatior
(n=1,557)	(n=1,278)	value	(n=2,835)
17.2 (2.06)	17.3 (2.05)	.82	17.3 (2.06)
1,349 (86.9)	1,149 (89.9)	.00	2,498 (88.1)
208 (12.9)	129 (10.1)		337 (11.8)
564 (36.2)	572 (44.6)	<.01	1,136 (40)
817 (52.5)	618 (48.2)		1,435 (50.5)
176 (11.3)	92 (7.2)		268 (9.4)
1,001 (64.4)	915 (71.5)	<.01	1,916 (67.6)
89 (5.7)	55 (4.3)		144 (5.1)
125 (8)	85 (6.6)		210 (7.4)
340 (21.9)	225 (17.6)		565 (19.9)
738 (47.4)	516 (40.3)	<.01	1,171 (41.3)
819 (52.6)	762 (59.6)		1,664 (58.7)
	Females (n = 1,557) 17.2 (2.06) 1,349 (86.9) 208 (12.9) 564 (36.2) 817 (52.5) 176 (11.3) 1,001 (64.4) 89 (5.7) 125 (8) 340 (21.9) 738 (47.4) 819 (52.6)	$\begin{array}{c c} Females \\ (n=1,557) & (n=1,278) \\ \hline 17.2 (2.06) & 17.3 (2.05) \\ \hline 1,349 (86.9) & 1,149 (89.9) \\ 208 (12.9) & 129 (10.1) \\ \hline 564 (36.2) & 572 (44.6) \\ 817 (52.5) & 618 (48.2) \\ 176 (11.3) & 92 (7.2) \\ \hline 1,001 (64.4) & 915 (71.5) \\ 89 (5.7) & 55 (4.3) \\ 125 (8) & 85 (6.6) \\ 340 (21.9) & 225 (17.6) \\ \hline 738 (47.4) & 516 (40.3) \\ 819 (52.6) & 762 (59.6) \\ \hline \end{array}$	$\begin{array}{c c} Females \\ (n=1,557) \\ (n=1,278) \\ (n=1,278) \\ (n=1,278) \\ value \\ \hline \end{array} \\ \hline \end{array} \\ \begin{array}{c} 17.2 (2.06) \\ 17.3 (2.05) \\ 17.3 (2.05) \\ .82 \\ \hline \end{array} \\ \hline \end{array} \\ \begin{array}{c} 1,349 (86.9) \\ 129 (10.1) \\ 129 (10.1) \\ \hline \end{array} \\ \begin{array}{c} .00 \\ 208 (12.9) \\ 129 (10.1) \\ \hline \end{array} \\ \begin{array}{c} .00 \\ .00 \\ 208 (12.9) \\ 129 (10.1) \\ \hline \end{array} \\ \begin{array}{c} .00 \\ .00 \\ .00 \\ .00 \\ .00 \\ 129 (10.1) \\ \hline \end{array} \\ \begin{array}{c} .00 \\$

^aValues expressed as n (%) unless otherwise noted.

Abbreviations: C-SSRS = Columbia-Suicide Severity Rating Scale, GAD-2 = abbreviated version of Generalized Anxiety Disorder-7, PHQ-9 = Patient Health Questionnaire-9, WHO-5 = World Health Organization Well-being Index.

throughout specific instruments. Individual questions in each questionnaire were used as observed variables of the latent one.

Data Sources and Measurement

Smartphone app. Assessment was carried out through a smartphone app, called MeMind and described elsewhere,²⁸ that also has a supporting web-based platform in case participants cannot access it otherwise. MeMind databases do not contain personal identification data of any individual, with all data being registered anonymously under encrypted security protocols.

Assessment of mental health conditions and associated risk factors. To assess mental health conditions and associated risk factors. To assess mental health conditions and associated risk factors, we used several psychometric instruments previously adapted to Spanish and used in Mexico.^{29–32} These instruments, used as built-in questionnaires in the MeMind app, are as follows: (*a*) Columbia-Suicide Severity Rating Scale (C-SSRS)³³ as a useful tool to identify suicidal behavior³⁴; (*b*) Patient Health Questionnaire-9 (PHQ-9) as a self-administered questionnaire for depression screening³⁵; (*c*) the abbreviated version of the Generalized Anxiety Disorder-7 (GAD-7),³⁶ which uses only 2 questions from the latter (ie, GAD-2)^{37,38} as an anxiety screening instrument; and (*d*) the World Health Organization Well-being Index (WHO-5) as a measure of the self-perception of well-being.³⁹

For all of these questionnaires, we used specific cutoff points. C-SSRS measures a range of suicidal behaviors (from the wish to be dead to preparatory acts) using yes/ no questions and classifies suicide risk in low, moderate, or high.³³ For PHQ-9, scores below 4 were considered to indicate not suffering depression, scores between 4 and 14 as being in need of screening for depression, and scores above 14 as being in need of depression treatment.³⁰ For GAD-2 total, scores over 3 were considered as indicative of the presence of an anxiety disorder.³⁷ For WHO-5, scores under 50 points were considered as indicative of low well-being.³⁹

Statistical Analyses

Descriptive analysis. Descriptive and exploratory analyses were performed in order to depict participant characteristics. Subgroup analyses were performed by gender, assuming gender differences in the predictors. Thus, bivariate analyses were also performed to identify differences among subgroup characteristics.

SEM modeling. A PLS-SEM was performed to establish causal relationships between latent variables, specifically, between risk factors (suicidal behavior, depression, and anxiety) and well-being.

PLS-SEM maximizes the explained variance of the latent constructions under analysis, instead of reproducing a theoretical covariance matrix, as traditional covariance matrix SEM (CB-SEM). The mathematical notation for the general case of a PLS-SEM model can be expressed as follows:

$Y' = YB + \varepsilon$

In the previous formula, *Y* denotes matrix of latent variables, *B* represents coefficients of the matrix, and ε is the random error associated to the model. The group of observed variables, ie, individual questions, that are related to a single latent variable—with each questionnaire representing a latent variable—is called block (*g*). In this way, a PLS-SEM model might be composed of as many blocks as number of latent variables analyzed. Before building a PLS-SEM model, all observed variables should be scaled with parameters $\mu = 0$ and $\sigma = 1$. The mathematical relationship between latent variables and the observed ones is shown below, for a block *g*, in the following formulation:

$$X = y_g w_g^{\mathrm{T}} + F_g$$

In the previous formula, w_g^{T} represents the weight matrix of the multivariate regression, which is estimated using the partial least squares algorithm, in addition

Figure 1. The SEM Model Structure to Be Explored^a



^aRectangles represent observed variables, circles represent latent variables, and arrows represent the paths. Abbreviations: C-SSRS = Columbia-Suicide Severity Rating Scale, GAD-2 = abbreviated version of Generalized Anxiety Disorder-7, PHQ-9 = Patient Health Questionnaire-9, SEM = structural equation modeling, WHO-5 = World Health Organization Well-being Index.

 $E[F_g | y_g] = 0$. In this way, for the block X_g , which corresponds to the latent variable y_g , it is measured by $X_1, ..., X_n$ observed variables with their respective $w_1, ..., w_n$ individual weights.

Finally, values for observed variables, path coefficients for the blocks, and their respective nonparametric hypothesis tests were reported. Root mean square error of approximation (RMSEA; < 0.08 with lower 90% confidence interval below 0.05 and upper value up to 0.08), comparative fit index (CFI; > 0.95), Tucker-Lewis index (TLI; > 0.9), and the normed fit index (NFI; > 0.9) were used to evaluate model fit in both main and subgroup data analyses.^{40–42} However, we also described the models' predictive capabilities, ie, how well observed variables predict the latent variables, as a better approach to the global model's assessment.⁴³ R statistical software⁴⁴ and SEMinR software package⁴⁵ were employed for all analyses.

Ethical Issues

Ethical approval (001/2019) was obtained from the Ethics Review Board of the Hospital Psiquiátrico Yucatán, Mérida, State of Yucatán (Mexico). Participants 18 years or older gave informed consent through the app. For any participant under 18 years old, parental informed consent was obtained.

Table 2. Goodness-of-Fit Statistics for All Models						
Statistic	Main model	Females	Males			
RMSEA	0.054	0.057	0.053			
(95% CI)	(0.052-0.056)	(0.054-0.060)	(0.049-0.056)			
CFI	0.919	0.915	0.914			
TLI	0.906	0.901	0.901			
NFI	0.91	0.90	0.893			

Abbreviations: CFI = comparative fit index, NFI = normed fit index, RMSEA = root mean square error of approximation, TLI = Tucker-Lewis index.

RESULTS

We recruited a total of 2,835 students. The descriptive statistics are reported in Table 1. Mean age of our participants was 17.3 years (SD 2.06). They had mean values that did not represent any mental disorder in the main analysis. However, results indicate worse mental health outcomes for the female subgroup, and stratified analyses by cutoff points showed up to 21.9% of female students at high risk of suicide (17.6% in males) and nearly half of our female population reporting low quality of life (Table 1).

The distribution of age was similar across genders. Comparisons of students aged $< vs \ge 18$ years yielded no

SEM model path	Mean	Standard deviation	T statistic	P value
Main model				
Depression → Suicidal behavior	0.740	0.015	47.90	<.001
Depression → Anxiety	0.705	0.021	33.22	<.001
Depression \rightarrow Well-being	-0.710	0.015	-48.65	<.001
Suicidal behavior → Well-being	0.046	0.039	1.179	.113
Anxiety → Well-being	0.111	0.032	3.410	.048
Anxiety → Suicidal behavior	-0.087	0.051	-1.716	.101
Males				
Depression → Suicidal behavior	0.688	0.034	20.47	<.001
Depression \rightarrow Anxiety	0.678	0.030	22.80	<.001
Depression \rightarrow Well-being	-0.687	0.028	-24.43	<.001
Suicidal behavior \rightarrow Well-being	0.012	0.070	0.172	.689
Anxiety → Well-being	0.143	0.048	2.99	.049
Anxiety → Suicidal behavior	-0.056	0.064	-0.879	.304
Females				
Depression → Suicidal behavior	0.769	0.016	47.51	<.001
Depression \rightarrow Anxiety	0.714	0.028	25.60	<.001
Depression \rightarrow Well-being	-0.720	0.028	-33.66	<.001
Suicidal behavior \rightarrow Well-being	0.079	0.061	1.308	.168
Anxiety → Well-being	0.104	0.060	1.703	.203
Anxiety \rightarrow Suicidal behavior	-0.118	0.048	-2.473	.050

differences in gender or in any of the clinical assessments. There were differences in terms of marital status, number of people living together, and employment situation (older students were more frequently married, lived in smaller households, and were more frequently employed).

SEM Models

Figure 1 describes the general structure for our SEM model, which was implemented for the entire sample (main model) and after stratifying by gender. Models did not fit well considering CFI but had acceptable fit in TLI and NFI— except for the males model in the case of NFI (Table 2); conversely, overall RMSEA was good for all models, although 90% CI only supported the males model having good fit. On the other hand, observed variables (questionnaire items) were statistically significant in all models, except for (1) question 1 of PHQ-9 ("little interest or pleasure in doing things") in main and subgroup models and (2) question 4 of C-SSRS (suicidal ideation with intent to die but without a specific plan; 0.57, P = .14), only among men. Results of individual item coefficients for all models are available in Supplementary Appendix 1.

Results from SEM models (Table 3) show that depression was associated with anxiety, suicidal behavior, and wellbeing (all *P* values \leq .01) in every model. Furthermore, no association was found between anxiety and suicidal behavior, nor any of the variables and depression. However, although depression was the main predictor of well-being, a marginally significant path was also found between anxiety and well-being. Final statistically significant paths of the main SEM model are shown in Figure 2.

Subgroup analyses by gender showed overall similar results to the main model, as described in Table 3, with slightly different statistical significance values for the paths connecting anxiety and well-being (P=.049 for men)

Figure 2. Significant Paths of the Main SEM Model^a



^aThe numbers indicate the path coefficients. Nonsignificant paths as well as items of the scales used to measure the latent variables (all significant, except for question 1 of PHQ-9) are omitted for the sake of clarity. Abbreviations: PHQ-9=Patient Health Questionnaire-9, SEM=structural equation modeling.





^aThe numbers indicate the path coefficients in males (part A) and females (part B). Nonsignificant paths in either males or females as well as items of the scales used to measure the latent variables (all significant, except for question 1 of PHQ-9 in either model and questions 3 and 4 of C-SSRS in males) are omitted for the sake of clarity. Abbreviations: C-SSRS = Columbia-Suicide Severity Rating Scale, PHQ-9 = Patient Health Questionnaire-9, SEM = structural equation modeling.

and anxiety and suicidal behavior (P=.05 for women). Statistically significant paths and their coefficients are depicted in Figure 3.

DISCUSSION

In this study using a universal mental health screening among students living in Mexico City, we detected high prevalences of depression, anxiety, and suicide risk, especially among female students.⁴⁶ In addition, using a PLS-SEM model, we found that depression was the strongest predictor of the rest of variables under study, including wellbeing. Our study demonstrates the feasibility of an online tool to screen for mental health problems among Mexican youth. Respondents showed high adherence to use of the online tool, indicating high levels of acceptability. This experience should be helpful for researchers as well as health system decision makers from comparable contexts where adolescents and young adults experience barriers in access to mental health care. Digital screening tools may provide an efficient, inexpensive alternative to enhance knowledge of the population's burden of mental health problems, potentially improving mental health care planning and delivery.

Our screening indicated clinically relevant levels of anxiety and depression in around 10% of our sample. Anxiety and depression are common in adolescents and young adults. Our results show that the prevalences of these conditions among our study population were roughly in line with previous estimates from Mexico,¹⁵ markedly below prevalence in other Northern American countries such as the United States,⁴⁷ and slightly above the bounds estimated worldwide for children and adolescents, namely, 6.5% (95% CI, 4.7-9.1) for any anxiety disorder and 2.6% (95% CI, 1.7-3.9) for any depressive disorder.⁴⁸ Notably, in line with evidence from representative studies from other locations,⁴⁹ both depressive and anxiety symptoms were more frequent among females than males. Furthermore, we found that up to 26.8% of our participants had moderate or high risk of suicide, which is also above any estimation of suicide ideation in youth from other locales in the Americas (with data ranging from 10.2% in Costa Rica to 23.2 in Guyana)⁵⁰ and that females were at greater risk of suicide than males. Specifically in Mexico, nationwide lifetime risk of suicide attempt in adolescents is around 2.7%,⁵¹ with slightly higher prevalence in Mexico City, where the prevalence of depression and anxiety may be, respectively, as high as 4.8% (95% CI, 3.9%–5.7%) and 29.8% (95% CI, 28.2%–31.5%).¹⁵ Surprisingly, despite high rates of depression, anxiety, and suicide, almost 60% of the students assessed reported a high level of well-being, a finding in line with previous reports.¹⁷

In this study, we also explored the relationship between depression, anxiety, suicide risk, and well-being. Somewhat similar studies have been previously conducted on the relationships between depression, anxiety, and suicidal behavior,^{52–54} but studies analyzing their relationship with

It is illegal to post this copy well-being are scarce, especially in adolescents. For instance, while the roles of hopelessness, depression, stress, negative coping strategies, and perceived meaning in life in suicide risk were analyzed in a sample of 2,000 Chinese university students, between-factor relationships were not assessed.⁵⁵ These relationships also were not assessed in the study of Lew et al, also in Chinese students, although they identified meaning in life as a protective factor against suicide.⁵⁶

Evidence shows the complex relationship between anxiety and depression and how both interact synergistically,^{52,53} especially in the presence of anxiety and irritability.^{57,58} Our results also show a paradoxical relationship, with anxiety levels being related to an increase in well-being levels in both main and male models. These results may be due to a partial effect of depression on well-being mediated through anxiety in a competitive partial mediation, a suppressing effect of depression on anxiety, an inconsistent mediation, or a lack of goodness-of-fit.⁵⁹ In any case, depression-anxiety comorbidity is a more salient risk factor for suicidal behavior than the two conditions alone and than other diagnoses and well-known risk factors such as family history of suicidal behavior, not having children, or being less than 35 years old.^{42,57}

Our results also suggest that depression is the critical factor driving increases in suicide risk and anxiety levels and decreases in self-perceived well-being. Our results support the findings from a previous study on individual and social risk factors on suicidality performed in 7,000 Korean adults using SEM that found that strain due to individual risk factors was related to depression and suicidality,⁶⁰ and they are roughly in line with findings from the Christchurch birth cohort reporting associations between life satisfaction and mental health problems (ie, major depression, anxiety disorder, suicidality, and substance dependence).⁶¹ Somewhat different to our results, however, SEM estimates from the Christchurch cohort suggest that the associations between life satisfaction and mental health problems are bidirectional. Importantly, study sample selection and variable definitions varied across ours and the Christchurch cohort study. In addition, cross-country comparisons of studies ascertaining prevalence of and associations between well-being, depression, anxiety, and suicidality are difficult to interpret, largely due to social and cultural differences across contexts (eg, different roles of country-specific protective factors, such as meaning of life, social connectedness, and family, faith, and religion, etc). Of note, in line with the Christchurch cohort study, associations between the different mental health outcomes under study did not vary markedly across gender-with similar effect estimates for all the paths being considered.

The use of structural equation models allowed us to better explore the complex interrelationship of several suicide risk factors and form hypotheses about the directionality of the causal relationships between depression, anxiety, well-being, and suicidal behavior. Although the RMSEA index revealed a marginal lack of fit for main and female models, both are supported by the TLI and NFI indices and, more importantly, **pheed PDF on any website** by an assessment of models' predictive capabilities. Notably, while goodness of fit indices can help elucidate fit issues in CB-SEM models, there is evidence that these indices should be used cautiously in PLS-SEM models.⁴³

Moreover, PLS-SEM technique is also useful for exploratory as well as predictive models. This versatility could be combined with the use of smartphones for a massive screening of a population,⁶² which in turn could be an invaluable tool for planning and decision-making. Notably, in the current context of the coronavirus disease 2019 (COVID-19) pandemic, where restrictions to in-person contact are continuously being put in place and technology can provide a safe method for collecting information at the community level, these tools are clear game changers for public health monitoring.

Also, it is well-known that there is an urgent, global need for research aimed at child and adolescent mental health promotion.¹⁴ Findings from the current study emphasize the necessity of early detection campaigns to prevent suicide and improve well-being in Mexico. Based on the above data, a plan should be designed to address the needs of youth from Mexico City, while a greater focus should also be put on mental health monitoring in the rest of the nation.

Nevertheless, certain limitations of this study should be noted. First, not having a smartphone might lead to some degree of attrition in our study sample. However, in our sample most students owned a smartphone, and, in addition, there was an approximate 60% of smartphone penetration in 2019 for the whole Mexican population.⁶³ Furthermore, to ensure enough recruitment, access to computer devices in educative centers was provided. We cannot rule out that population groups with reduced schooling rates or internet access, such as lower-income students, racial/ethnic minorities, and females, may be somewhat underrepresented in our sample. In fact, we did recruit a larger number of males than females. This limitation also hinders interpretability of prevalence estimates, as some degree of self-selection may drive the high rates of mental health problems and especially suicide risk that were detected. Second, for this screening, only a range of mental health conditions were assessed, and suicide risk is the result of the interaction of many risk factors that are not represented in this analysis.⁶⁴ More complex models should be built to better understand the network of factors underlying suicide risk. Eventually, these models could solve the relative lack of fit presented here, or the lack of association of the 2 questions from PHQ-9 and C-SSRS. Third, models did not include important variables that may enhance understanding of the described associations as well as transportability of results (ie, potential protective factors); ascertaining and including these variables in subsequent modeling efforts is a natural next step to this study.

In conclusion, a massive mental health screening was conducted among students from Mexico City. Results obtained from this evaluation emphasize the relevance of depression as a predictor of anxiety, suicidal risk, and loss of well-being, but also the high prevalence of mental health disorders—and particularly of suicide risk—in the studied

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population. We used an accessible, efficient, and evidence satisfaction: the full life versus the empty life. Happiness Stud.

based screening system that can be well accepted by young people and allows a quick screening. This technology could be employed in coordination and integration with readily available health system resources and research organisms to monitor mental health in the community, especially in the post-COVID-19 era, where these resources have become essential.

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Availability of data and material: Data and additional material are available upon request

Code availability: The smartphone app used in this study is available in the Android market and online at: https://frontend.memind.net.

Supplementary material: Available at PSYCHIATRIST.COM

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See supplementary material for this article at PSYCHIATRIST.COM.



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Supplementary Material

- Article Title: Impact of Depression on Anxiety, Well-Being, and Suicidality in Mexican Adolescent and Young Adult Students From Mexico City: A Mental Health Screening Using Smartphones
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- **DOI Number:** 10.4088/JCP.20m13806

List of Supplementary Material for the article

1. <u>Appendix 1</u> Coefficients and Statistical Significance, by SEM Model

Disclaimer

This Supplementary Material has been provided by the author(s) as an enhancement to the published article. It has been approved by peer review; however, it has undergone neither editing nor formatting by in-house editorial staff. The material is presented in the manner supplied by the author.

Appendix 1. Coefficients and statistical significance, by SEM model.

Descriptive statistics for ITEMS – Latent variables and hypothesis testing (N	ain model)
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Item - Latent variable	Mean	Standard Deviation	T-Statistics	p-value
WHO-5 (question 1) <-> Well-being	0.83	0.04	27.10	0.00
WHO-5 (question 2) <-> Well-being	0.74	0.05	12.91	0.00
WHO-5 (question 3) <-> Well-being	0.73	0.08	16.40	0.00
WHO-5 (question 4) <-> Well-being	0.74	0.06	21.50	0.00
WHO-5 (question 5) <-> Well-being	0.74	0.05	15.14	0.00
PHQ-9 (question 1) <-> Depression	0.17	0.30	0.89	0.48
PHQ-9 (question 2) <-> Depression	0.77	0.03	16.53	0.00
PHQ-9 (question 3) <-> Depression	0.50	0.09	5.61	0.00
PHQ-9 (question 4) <-> Depression	0.60	0.09	8.75	0.00
PHQ-9 (question 5) <-> Depression	0.60	0.11	5.44	0.00
PHQ-9 (question 6) <-> Depression	0.79	0.08	13.32	0.00
PHQ-9 (question 7) <-> Depression	0.50	0.09	5.31	0.00
PHQ-9 (question 8) <-> Depression	0.59	0.13	11.38	0.00
PHQ-9 (question 9) <-> Depression	0.70	0.10	14.88	0.00
GAD-2 (question 1) <-> Anxiety	0.75	0.09	31.26	0.00
GAD-2 (question 2) <-> Anxiety	0.70	0.03	18.88	0.00
C-SSRS (question 1) <-> Suicidal behavior	0.83	0.04	15.21	0.00
C-SSRS (question 2) <-> Suicidal behavior	0.65	0.08	18.22	0.00
C-SSRS (question 3) <-> Suicidal behavior	0.55	0.11	8.21	0.00
C-SSRS (question 4) <-> Suicidal behavior	0.60	0.13	5.21	0.00

Descriptive statistics for ITEMS – Latent variables and hypothesis testing (Males)

Descriptive statistics for ITEMS – Latent variables and hypothesis testing (Females)

ltem - Latent variable	Mean	Standard Deviation	T-Statistics	p-value	II
WHO-5 (question 1) <-> Well-being	0.86	0.10	9.50	0.00	WHO-
WHO-5 (question 2) <-> Well-being	0.73	0.16	5.51	0.00	WHO-
WHO-5 (question 3) <-> Well-being	0.71	0.09	7.05	0.00	WHO-
WHO-5 (question 4) <-> Well-being	0.72	0.09	14.87	0.00	WHO-
WHO-5 (question 5) <-> Well-being	0.72	0.11	6.97	0.00	WHO-
PHQ-9 (question 1) <-> Depression	0.13	0.23	1.49	0.10	PHQ-9
PHQ-9 (question 2) <-> Depression	0.77	0.08	21.34	0.00	PHQ-9
PHQ-9 (question 3) <-> Depression	0.46	0.17	2.90	0.00	PHQ-9
PHQ-9 (question 4) <-> Depression	0.58	0.13	5.90		PHQ-9
PHQ-9 (question 5) <-> Depression	0.57	0.16	3.80	0.00	PHQ-9
PHQ-9 (question 6) <-> Depression	0.80	0.12	5.97	0.00	PHQ-9
PHQ-9 (question 7) <-> Depression	0.49	0.16	3.46	0.00	PHQ-9
PHQ-9 (question 8) <-> Depression	0.61	0.10	6.01	0.00	PHQ-9
PHQ-9 (question 9) <-> Depression	0.69	0.09	8.62	0.00	PHQ-9
GAD-2 (question 1) <-> Anxiety	0.79	0.08	15.30	0.00	GAD
GAD-2 (question 2) <-> Anxiety	0.65	0.11	6.71	0.00	GAD
C-SSRS (question 1) <-> Suicidal behavior	0.80	0.19	3.78	0.00	C-SSRS (q
C-SSRS (question 2) <-> Suicidal behavior	0.64	0.22	6.48	0.00	C-SSRS (q
C-SSRS (question 3) <-> Suicidal behavior	0.48	0.10	2.01	0.04	C-SSRS (q
C-SSRS (question 4) <-> Suicidal behavior	0.57	0.26	1.21	0.14	C-SSRS (q

ltem - Latent variable	Mean	Standard Deviation	T- Statistics	p-value
WHO-5 (question 1) <-> Well-being	0.80	0.09	10.21	0.00
WHO-5 (question 2) <-> Well-being	0.73	0.13	5.14	0.00
WHO-5 (question 3) <-> Well-being	0.73	0.08	11.88	0.00
WHO-5 (question 4) <-> Well-being	0.74	0.10	4.45	0.00
WHO-5 (question 5) <-> Well-being	0.75	0.09	6.78	0.00
PHQ-9 (question 1) <-> Depression	0.21	0.23	0.80	0.31
PHQ-9 (question 2) <-> Depression	0.77	0.05	11.40	0.00
PHQ-9 (question 3) <-> Depression	0.52	0.11	5.62	0.00
PHQ-9 (question 4) <-> Depression	0.62	0.09	7.47	0.00
PHQ-9 (question 5) <-> Depression	0.59	0.14	3.16	0.00
PHQ-9 (question 6) <-> Depression	0.78	0.03	16.20	0.00
PHQ-9 (question 7) <-> Depression	0.51	0.16	3.50	0.00
PHQ-9 (question 8) <-> Depression	0.58	0.05	9.21	0.00
PHQ-9 (question 9) <-> Depression	0.73	0.04	11.20	0.00
GAD-2 (question 1) <-> Anxiety	0.73	0.08	9.85	0.00
GAD-2 (question 2) <-> Anxiety	0.72	0.09	10.02	0.00
C-SSRS (question 1) <-> Suicidal behavior	0.84	0.03	14.20	0.00
C-SSRS (question 2) <-> Suicidal behavior	0.66	0.09	6.89	0.00
C-SSRS (question 3) <-> Suicidal behavior	0.59	0.11	8.96	0.00
C-SSRS (question 4) <-> Suicidal behavior	0.61	0.13	4.85	0.00