An Evaluation of the HCU Priority Index (HPI) and Major Depressive Disorder Subscale Among Adolescents: Establishing Reliability and Predictive Validity Criteria

Work-In-Progress Research Series
Report 1

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INTRODUCTION Educators and policymakers are becoming increasingly aware of the adverse impact of moderate to severe psychological distress among adolescents[1]. Without proper intervention or support services, adolescent mental health issues are likely to undermine academic performance, the ability to cope with social situations, and promote risky behaviors that can have long-term consequences[2]. Although validated measures to assess the presence and severity of psychological symptoms among teens grades 7-12 are available, the need for on-line screening tools to increase accessibility and promote early detection is becoming more critical.

According to the UCLA Center for Health Policy Research, national estimates show that 1 of every 2 adolescents ages 12 to 17 is affected by a mental health disorder[3]. Consistent with this national trend, data from the 2019 California Health Interview Survey (CHIS) show that 45% of California youth in the same age group report struggling with mental health issues, with nearly a third of them experiencing serious psychological distress that could interfere with their development into adulthood. An analysis of demographic factors also found that female adolescents are one-and-a-half times more likely than males to report serious psychological distress (36.6% vs. 22.4%, respectively). Given the social and economic disruptions that have occurred during the COVID-19 pandemic, the trends these data portend most likely represent only the tip of the iceberg. Given the connection between Major Depressive Disorder and suicide, evidence-based efforts to ascertain the extent of depressive symptoms among adolescents, including the identification of relevant follow-up services and clinical interventions, have been strongly recommended by the U.S. Preventive Services Task Force[4].

Toward this end, the Heads Up Checkup (HCU) is a comprehensive new generation on-line mental health and behavioral risk screening system designed to ascertain a respondent's mental health symptom profile, assess symptom severity, and prioritize those in need of supportive resources. The HCU is scored using proprietary algorithms to calculate the percentage of diagnostic criteria endorsed. Additionally, the HCU calculates a priority index (HPI) which is based on the overall mental health screening results. The specific purpose of this report is to evaluate the reliability and predictive validity of the Major Depressive Disorder (MDD) subscale of the Heads Up Checkup (HCU) screen. The following statistical analyses are based on HCU data collected among adolescents in California during the 2020-2021 academic years.

SPECIFIC AIMS This investigation seeks to: a.) document the reliability of the HCU- MDD symptom subscale, b.) establish the relationship between the MDD symptom profile and the HCU Priority Index (HPI); c.) assess the accuracy of HPI to differentiate between high vs. low-risk MDD group classifications; and d.) explore the relationship between gender and MDD by HPI classifications. The HCU-MDD diagnostic items are consistent with the criteria published by World Health Organization for ICD-10 Code F32.9 Major depressive disorder, single episode, unspecified[5]. Table 1 summarizes the eleven symptom items which comprise the HCU-MDD subscale.

[1] https://www.cdc.gov/healthyyouth/data/yrbs/pdf/YRBSDataSummaryTrendsReport2019-508.pdf
[2] https://pubmed.ncbi.nlm.nih.gov/30577941/
[3] Teen_Mental_Health_PB_FINAL.pdf (ucla.edu)
[4] pubmed.ncbi.nlm.nih.gov/26908686/
[5] https://www.icd10data.com/ICD10CM/Codes/F01-F99/F30-F39/F32-/F32.3

METHODOLOGY

SAMPLE**:** Analyses include a total of N=2244 adolescents, including n=1150 females and n=1094 males. All duplicate cases or incomplete screenings were excluded from the sample. At the time of screening, respondents were enrolled in one of four schools (Table 2) in Orange County, California. Note that the HCU was administered in YRS 2020 and 2021 at the Santiago Middle School. In addition, Yorba and Santiago are both Title I middle schools. Table 3 and Figure 1 summarize student insurance status by School ID. Note that insurance information was not available for Santiago Middle School students who were screened in YR2020. According to Table 4, most students completed the HCU while in grades 7-9, and Table 5 shows that the overwhelming majority (92.3%) completed the screening in English (n=2071).

PROCEDURE: Students were pre-registered for screening through the Heads Up Checkup administrative dashboard. Individual screening accounts were automatically created for each student using Student ID and a temporary password as login credentials. At time of screening, classroom facilitators directed students to a URL unique to each school where the student logged in to begin screening. Participating students at each school completed the screening simultaneously during a non-academic period. Students were reminded by classroom facilitator prior to screening that participation was voluntary. See Appendix 1 for a detailed explanation of parent notification, opt-out, and Informed Consent procedures. All data reviewed, analyzed, and reported do not contain any student identifying information.

Table 1. Description of HCU-MDD Symptom Items

1	(v636) I often feel sad, depressed, or hopeless.
2	(v614) I've lost interest in doing things I used to enjoy.
3	(v615) I don't feel like I have enough energy to do anything.
4	(v639) I feel guilty or unworthy.
5	(v589) I don't feel hungry most of the time.
6	(v590) I don't eat enough
7	(v592) Sometimes I eat way too much or eat when I'm not even hungry.
8	(v586) I sleep too much.
9	(v587) I don't get enough sleep.
10	(v611) I have trouble concentrating or staying focused.
11	(v627) Within the past few weeks, I have had thoughts about killing myself.

Table 2. School ID by Year of Administration

		Frequency	Percent	Title I Status
School ID	112_ 2020	591	26.3	YES
	114_ 2021	279	12.4	NO
	116 _2021	254	11.3	YES
	119 _ 2021	341	15.2	NO
	121 _ 2021	779	34.7	YES
	Total	2244	100.0	

Table 3. School ID by Insurance Status (N=2244)

		Insurance Status					
		No Data	MediCAL	ER MediCAL	No Insure	Other, 3rd Pty	Total
School ID	112_ 2020	591	0	0	0	0	591
	114_ 2021	3	210	0	9	57	279
	116 _2021	2	190	7	17	38	254
	119 _ 2021	6	257	1	15	62	341
	121 _ 2021	1	581	5	44	148	779
Total		623	1239	13	85	305	2244

Figure 1. % Insurance Status (N=2244)

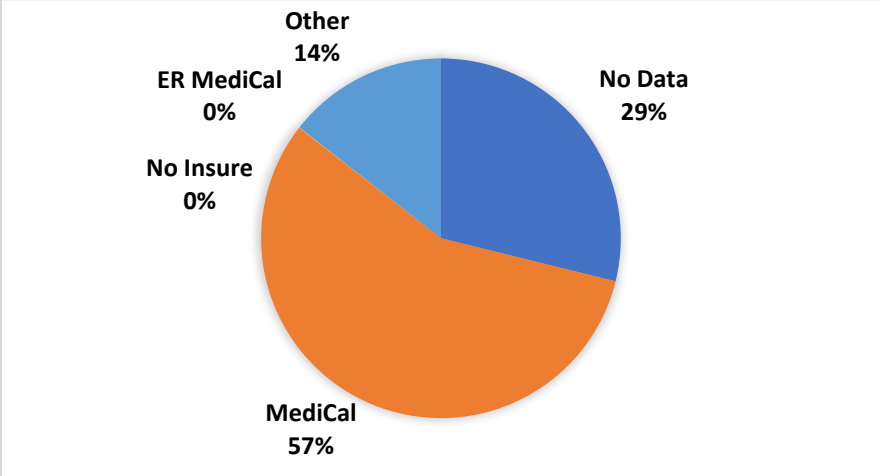


Table 4. School ID by Grade & Year of HCU Screen

		Grade						Total
		7	8	9	10	11	12	
School ID	112_ 2020	310	281	0	0	0	0	591
	114_ 2021	64	0	88	38	58	31	279
	116 _2021	130	124	0	0	0	0	254
	119 _ 2021	0	0	341	0	0	0	341
	121 _ 2021	377	402	0	0	0	0	779
Total		881	807	429	38	58	31	2244

Table 5. School ID by HCU Language

		Language		Total
		English	Spanish	
School ID	112_ 2020	587	4	591
	114_ 2021	279	0	279
	116 _2021	96	158	254
	119 _ 2021	341	0	341
	121 _ 2021	768	11	779
Total		2071	173	2244

Tables 6 and 7 summarize the Cronbach alpha reliability coefficients for the eleven HCU-MDD items. Reliability measures the extent to which the MDD subscale can consistently generate similar results from one screening to the another. As the correlations increase between items, the Cronbach coefficient increases. Reliability coefficients range from ("0") Not at All to ("1.0") Extremely consistent. Ideally, the coefficient should be greater than 0.70 for the HCU-MDD subscale to be considered reliable. Good reliability ensures precision and validity of the statistical analyses[6]. Figure 2 illustrates the conceptual relationship between reliability and validity. Essentially, it suggests that validity is not possible without good reliability.

Figure 2. Reliability and Validity

The MDD items used in this analysis are all categorical binary variables; that is, respondents selected from two options (No or Yes). In turn, these responses were converted into the binary numerical values of (0,1).

Table 6. MDD Reliability Coefficient for Total Sample (N=2244)

Cronbach's Alpha	N of Items
.765	11

Alpha = .77 indicates good consistency for the HCU-MDD subscale.

[6] https://explorable.com/statistical-reliability

MDD Test-Retest Reliability for YR2020 and YR2021

Sample Distribution by School ID and YR	Frequency	Percent
112_ 2020	591	43.1
121_ 2021	779	56.9
Total Santiago Sample	1370	100.0

Total Sample by Number of Sessions	Frequency	Percent
One Session	482	35.2
Two Sessions	**888**	**64.8**
Total	1370	100.0

The two tables above show the sample breakdown by YEAR. Approximately 65% (n=888) of students for school codes 112_2020 and 121_2021 participated in two screening sessions. The test-retest reliability coefficients for the 11 MDD items were based on the repeat sample of (n=888) respondents.

Table 7. Test-Retest MDD Reliability Cronbach Alphas (N=888)

Total Sample for Two Sessions (N=888)	**.756** YR 2020 (n=444)	**.773** YR 2021(n=444)	

Time 1 and Time 2 Alpha values (.76, .77) indicate good test-retest reliability which suggests consistency of performance of the HCU MDD subscale over time.

Table 8. For the total sample (N=2244), the Cumulative Percent shows the MEDIAN value of total MDD items endorsed is 1. That is, 51.9% of the total sample had one or fewer MDD reported symptoms.

Table 8. Distribution of MDD # Items for Total Sample (N=2244)

Number of MDD Items Endorsed	Frequency	Percent	Cumulative Percent
0	662	29.5	29.5
1	503	22.4	**MEDIAN=51.9**
2	318	14.2	66.1
3	220	9.8	75.9
4	176	7.8	83.7
5	112	5.0	88.7
6	90	4.0	92.7
7	74	3.3	96.0
8	61	2.7	98.8
9	14	.6	99.4
10	13	.6	100.0
11	1	.0	100.0
Total	2244	100.0	

In addition, these frequencies are indicative of a right tail distribution (See Figure 3). That is, most of the cases are on the low end of the MDD distribution with half the sample endorsing one or no symptoms. This non-normal type of frequency distribution is to be expected in a non-clinical, community sample of respondents.

Figure 3. Non-Normal Frequency Histogram of HCU-MDD Symptoms

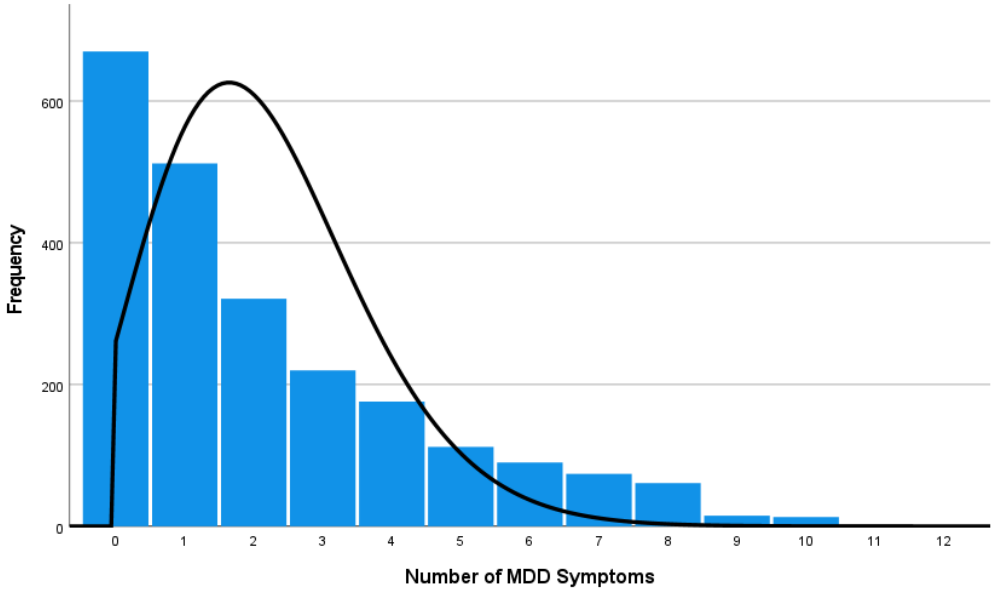


Figure 4 illustrates a possible gender effect for number of reported MDD symptoms. As seen by the placement of the arrow, the number of endorsed items by gender "switches" with a greater number of MDD symptoms (≥3 items) being endorsed by females than males.

Figure 4. Distribution of MDD Items for Females n= 1150 and Males n=1094

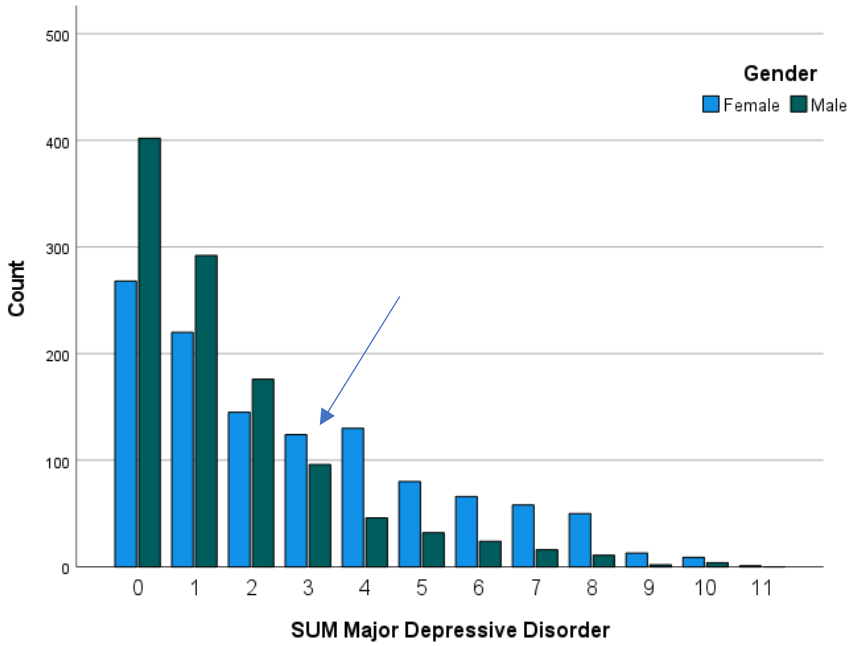


Figure 5. contains data for N=154 female and male respondents who endorsed the variable, "My family is not aware of or does not support my gender and/or sexual orientation." The sample size for males is relatively low in this subgroup (n=128 females, n=26 males). However, the distribution provides preliminary evidence that females, who perceive less support for their sexual orientation, are likely to report more MDD symptoms than males.

Figure 5. Distribution of MDD Items by Support for Gender/ Sexual Orientation

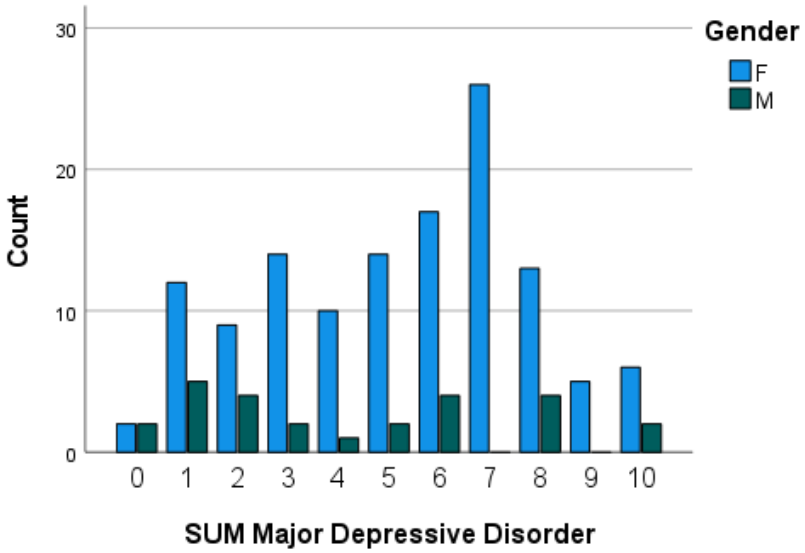


Table 9. Distribution of MDD # Items for Females n= 115 and Males n=1094

Gender			Frequency	Percent	Cumulative Percent
Female		0	263	22.9	22.9
		1	213	18.5	41.4
		2	144	12.5	**MEDIAN = 53.9**
		3	124	10.8	64.7
		4	130	11.3	76.0
		5	80	7.0	83.0
		6	66	5.7	88.7
		7	58	5.0	93.7
		8	50	4.3	98.1
		9	12	1.0	99.1
		10	9	.8	99.9
		11	1	.1	100.0
		Total	1150	100.0	
Male		0	399	36.5	36.5
		1	290	26.5	63.0
		2	174	15.9	78.9
		3	96	8.8	87.7
		4	46	4.2	91.9
		5	32	2.9	94.8
		6	24	2.2	97.0
		7	16	1.5	98.4
		8	11	1.0	99.5
		9	2	.2	99.6
		10	4	.4	100.0
		Total	1094	100.0	

Note that among males, the median number (50%) of MDD endorsed symptoms lies between 0 and 1. By contrast, the median for females is located at 2 MDD symptoms. From a substantive standpoint, evaluation of differences in the number and type of endorsed MDD symptoms by gender variation merits further attention.

HCU Priority Index (HPI)

The Heads Up Checkup (HCU) screening was designed to prioritize individuals with self-reported mental health concerns across a wide array of possible affective, cognitive, behavioral, and/or developmental issues. To flag cases for follow-up services and/or clinical intervention, the HCU's algorithm simultaneously analyzes multiple psychiatric diagnostic categories related to depression, anxiety, behavioral problems, thought disorders, ADHD, ASD/Asperger's, and learning challenges. In addition, the HCU includes risk assessments for suicidal and homicidal ideation, substance use/abuse, relational abuse, and Adverse Childhood Experiences (ACEs).

Using a decision-tree approach, the HCU algorithm determines a "predictive" priority designation for each respondent based on the total % psychiatric criteria and risk factors endorsed across the entire screening. This designation is referred to as the HCU Priority Index (HPI), and its values range from one to seven as summarized in Table 10. The cumulative percent column indicates that respondents at or below the 50-69% criteria for at least one diagnosis, or HPI Level 2, account for 49.5% of the total sample (734+376= 1,110). For the purposes of these analyses, respondents at or below HPI Level 2 (Median) are categorized in the "low" priority group compared to those at or above Level 3. Table 11 summarizes the frequencies by Low HPI Group (Levels 1 & 2) versus High HPI group (Levels 3-7). The sample size for each of these subgroups is n=1,110 (Low) vs n=1134 (High). In addition to providing a priority index level for each respondent, this rating provides a "standard" by which to compare how well the HPI differentiates between low vs high diagnostic subgroups.

Table 10. Distribution of HPI by %Diagnostic Criteria

Percent Diagnostic Criteria Met		Priority Index Level	Frequency	Percent	Cumulative Percent
	<50% crit for =>1 dx	1	734	32.7	32.7
	50-69% crit for =>1 dx	2	376	16.8	**MEDIAN= 49.5**
	70-99% crit for=>1dx	3	438	19.5	69.0
	100% crit for =>1dx	4	556	24.8	93.8
	Suicidal ideation or abuse	5	113	5.0	98.8
	Suicidal, homicidal, hostile, and/or anti-social behavior	6	9	.4	99.2
	Acute suicidal ideation	7	18	.8	100.0
	Total		2244	100.0	

Table 11. Distribution of High vs Low HPI

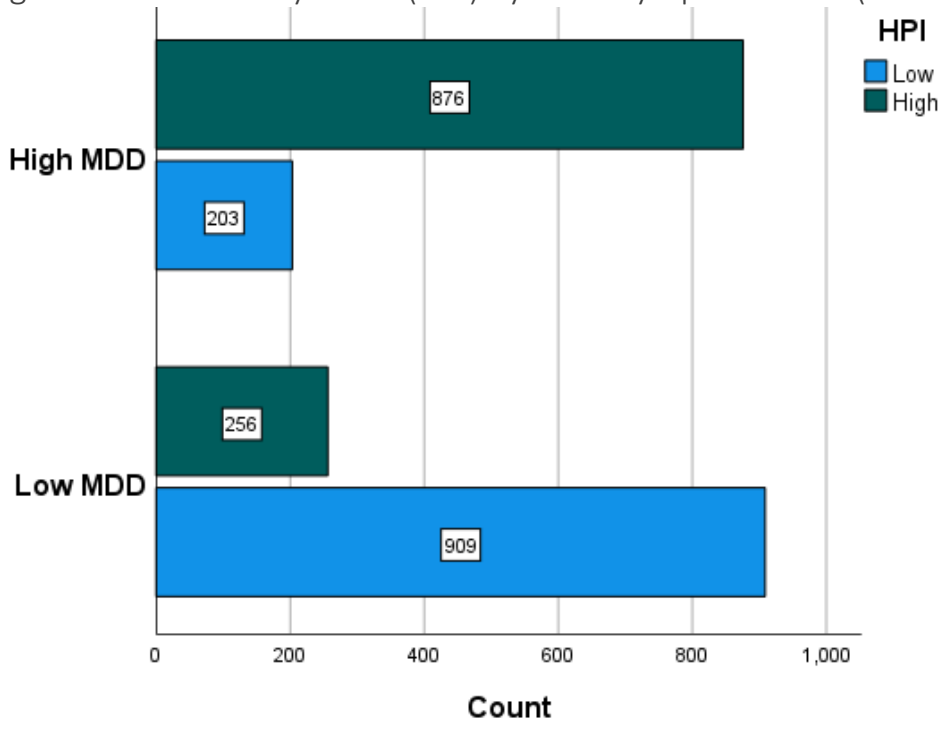
Priority Level		Frequency	Percent	Cumulative Percent
	Low Risk ≤ 2	1110	49.6	49.9
	High Risk ≥3	1134	50.4	100.0
	Total	2244	100.0	

Testing the Association between the HCU Priority Index (HPI) and MDD

A 2 X 2 CHI SQ Test of Independence between the two categorical variables, HPI Risk Level (Low vs High) and MDD Symptoms (Low vs High), was performed to assess the strength of their association. For MDD, the median value (0,1 reported symptoms) for the total sample was used to ascertain the high vs low cut-off point. A significant association would suggest that the proportion of "Low vs High" observed MDD cases varies by the "Low vs High" designation of the HPI.

CHI-SQ TEST OF INDEPENDENCE: Results confirmed a significant association between the "Low vs High" MDD symptoms and the algorithm's HCU Priority Index (CHI Sq (1) = 786, p<.001) with a strong effect size (Phi coefficient = 0.59). For a 2X 2contingency table, a Phi coefficient is essentially a correlation used with a range of (-1 to +1). Another measure of effect size that is useful from a clinical perspective is the odds ratio. An odds ratio = 1, signifies no effect. If the ratio is greater than 1, the odds for a predicted outcome are higher; if less than 1, the odds are lower. In this sample, cases classified as high HPI are 15.3 times more likely to be in the high MDD group (95% CI 12.5, 18.8). An odds ratio >4 is considered a strong effect size. Note that the odds ratio = 1 (i.e., no effect) does not appear in the confidence interval. Figure 6 illustrates the strength of this association; most of the high MDD cases (n=876) fall into the "predicted" high HPI category. Conversely, most of the low MDD cases (n=909) are in the low HPI group. These findings suggest that the HPI may have strong predictive statistical attributes.

Figure 6. HCU Priority Index (HPI) by MDD Symptom Level (N=2244)



Assessing Predictive Validity for the HCU Priority Index (HPI)

The validity of an assessment tells us the extent to which it accurately measures the domains being evaluated. In the case of predictive validity, one can estimate how accurately a measure "predicts" certain outcomes, such as being able to differentiate between cases requiring clinical intervention or not. The following analyses will evaluate the HPI's sensitivity, which is the rate of "true positives" or the proportion of cases with reported high MDD symptoms which are determined to be in the high HPI group. In addition, the rate of specificity or the extent to which the HPI can detect "true negative" cases will be ascertained. To be in this group, cases with reported low MDD symptoms must also be in the predicted low HPI group. Moreover, the positive and negative predictive values indicate the clinical relevance of the rates of sensitivity and specificity. The prevalence rate of MDD for this sample depends on the total number of cases classified as high priority. Positive and negative Likelihood Risk Ratios (LRs) were computed for the total sample. Odds ratios for different subgroup analyses were also assessed.

To assess the predictive validity of the HPI, the prevalence, sensitivity (% true positive cases), specificity (% true negative cases), and the percent positive and negative predictive values (PPV & NPV) were computed based on a 2X2 contingency frequency table (Table 12). Although values for these measures depend on the prevalence of disease (in this case, MDD symptoms), rates typically range from .70 to .90. These analyses were repeated to assess the impact of gender on the relationship between MDD symptoms and the HCU Priority Index (Tables 15 & 16).

Table 12. MDD and HPI Predictive Validity Total Sample (N=2244)

	Predicted HPI Classification			
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**	
Observed High MDD # Total Symptoms (2-11)	**True + 876 (A)**	**False + 203 (B)**	**1079 (A+B)**	**PPV=A/(A+B) x 100 876/1079= 81%**
Observed Low MDD # Total Symptoms (0,1)	**False - 256 (C)**	**True - 909 (D)**	**1165 (C+D)**	**NPV= D/(C+D) x 100 909/1165= 78%**
	High HPI Total (A)+ (C) = 1132 HPI Sensitivity A/(A+C)	**Low HPI Total (B)+(D) = 1112 HPI Specificity D/(B+D)**	**MDD TOTAL Sample N= 2244**	

TOTAL SAMPLE PREVALENCE of High HPI for MDD: A total of n=1079 cases reported at least two MDD symptoms. Relative to the total sample of N=2244 cases, the prevalence rate for MDD symptoms is 1079/2244= 48%, which is consistent with findings recently published by the UCLA Center for Health Policy Research for psychological distress among adolescents.

Based on the cross-tabulated frequencies, the HPI identified n=876 "true positives" (i.e., High MDD and High HPI) and n=909 "true negatives" (i.e., Low MDD and Low HPI). These cases are important because they validate the predicted HPI classifications and affirm recommendations for intervention services. To quantify the predictive characteristics of the HPI, its sensitivity and specificity rates were computed. In addition, to assess the HPI's clinical relevance, the positive (PPV) and negative (NPV) predictive values were computed.

SENSITIVITY: Respondents classified as high HPI with high levels of MDD symptoms are referred to as "true positive" cases. In this analysis, sensitivity refers to the HPI's rate of accuracy in predicting "true positive" cases. To compute sensitivity, the number of "true positive" cases (n=876) is divided by the total number of cases identified by the HPI as being high priority (n=1132). For this sample, the sensitivity rate is 876/1132 = 77%. That is, the HPI accurately "predicted" 77% of the cases with a high number of reported MDD symptoms as being high priority. Of those respondents who reported low MDD symptoms (n=256), the HPI falsely identified 23% as being high priority (256/1132 = 23%). These cases are referred to as "false negatives" due to their low MDD symptom profile and predicted high HPI. Although false negatives are counterintuitive, a high HPI classification can occur among respondents who report one or fewer MDD symptoms because the HPI utilizes a range of diagnostic considerations and risk factors to determine the overall priority level of the complete screening.

POSITIVE PREDICTIVE VALUE (PPV): Among the "true positive" cases, what is the probability that the HPI classification has clinical relevance? To compute this percentage, the number of "true positive" cases (n=876) is divided by the total number of respondents in the high MDD group (n=1083). For this sample the PPV= 876/1079 = 81%. This value corresponds to a moderate to strong **Positive Predictive Value (PPV)**. That is, among "true positive" cases, there is an 81% probability that respondents may require follow-up services for MDD symptoms.

SPECIFICITY: Respondents classified as low HPI and low MDD symptoms are categorized as "true negative" cases. In this analysis, specificity refers to the HPI's rate of accuracy in predicting "true negative" cases. To compute specificity, the number of "true negative" cases (n=909) is divided by the total number of cases identified by the HPI as low priority (n=1112). For this sample, the specificity rate is 909/1112=82%. That is, the HPI accurately "predicted" 82% of the cases with a low number of reported MDD symptoms as being low priority. Of those respondents who reported high MDD symptoms (n=203), the HPI falsely identified 18% as low priority cases (203/1112 = 18%). These cases are referred to as "false positives" due to their high MDD symptom profile and predicted low HPI. In this scenario, respondents may have endorsed two or more non-critical MDD symptoms or may not have reached the threshold number of critical symptoms necessary to generate a high priority designation.

NEGATIVE PREDICTIVE VALUE (NPV): Among the "true negative" cases, what is the probability that this HPI classification has clinical relevance? To compute this percentage, the number of "true negative" cases (n=909) is divided by the total number of respondents in the low MDD group (n=1165). For this sample the NPV= 909/1165 = 78%. This value corresponds to a moderate to strong **Negative Predictive Value (NPV**). That is, among "true negative" cases, there is a 78% probability that their reported symptoms do not meet the intervention threshold.

Table 13. Summary of HPI Predictive Validity for Total Sample (N=2244)

Prevalence of High MDD	Sensitivity	Positive Predictive Value (PPV)	Specificity	Negative Predictive Value (NPV)
48%	77%	81%	82%	78%

Positive and Negative Likelihood Risk (LR) Ratios: Unlike Predictive Values (PPV & NPV), which indicate clinical relevance relative to the total sample of high or low MDD cases, Likelihood Risk Ratios (Positive and Negative) provide a measure of discrimination between HPI risk classifications. Essentially, a Positive LR tells us the likelihood of "true positives" being classified as high HPI when compared to "true negative" cases. Similarly, a Negative LR provides the likelihood of "true negatives" being classified in the high HPI group. Unlike predictive values (PPV and NPV), LRs are less affected by fluctuations in the prevalence of MDD[7]. The suggested cutoff LR values > 5 or < 0.2 can be applied to the observed likelihood probabilities[8]. An LR close to one would suggest that the HPI's performance is not useful for categorizing MDD subgroups. An LR >1 would show an increase in the probability of being in the high HPI group, whereas a ratio <1 would suggest a decrease. The LRs and 95% Confidence Intervals summarized below were generated by SPSS using the Crosstabulation Risk command.

Positive LR Ratio = Sensitivity/ 1 - Specificity =.77/ 1-.82 = 4.2 (95% CI 3.646, 4.698). Cases classified as True Positives (high HPI, high MDD symptoms) are approximately four times as likely to be in the high HPI risk group, compared to True Negative cases (low HPI, low MDD symptoms).

Negative LR Ratio = 1-Sensitivity/Specificity = 1-.77/ .82 = .27 (95% CI .239, 299). Cases classified as True Negatives (low HPI, low MDD symptoms) are approximately one-fourth as likely to be in the high HPI risk group. Note that this ratio = .27 is markedly less than 1 which signifies a substantial decrease in the probability of the predicted high risk HPI outcome.

Interpretation: The LRs (4.2, 0.27) and confidence interval values obtained closely approximate recommended cutoff LR values of > 5 and < 0.2, which suggests good HI PRIORITY discrimination between "true positive" vs "true negative" MDD subgroups. (See Appendix 3 for review of Odds Ratio and LRs as effect sizes).

SEVERITY: Duration of MDD Symptoms and Impact on Daily Functioning

The severity of symptoms across the four HPI group classifications was assessed using the HCU duration and impact of depressive symptoms variables. The duration of symptoms variable included four categories: Less than a week; 2-3 weeks; a month or more; or 6 months or more. The impact on daily functioning included four levels as well: No impact; interferes daily; serious daily interference; barely functioning. Responses for both variables were coded as 0 or 1. Table 14 summarizes the results for duration and impact. As expected, cases in the high MDD and high HPI group had the highest levels of severity. The True Negative and False Negative cases had no duration or impact data because according

[7] https://acutecaretesting.org/en/articles/diagnostic-accuracy--part-2brpredictive-value-and-likelihood-ratio
[8] https://www.slideshare.net/AbinoDavid/predictive-value-and-likelihood-ratio

to the HCU algorithm, these respondents did not meet the threshold of ≥2 critical MDD items to proceed to the qualifying items regarding duration and impact of depressive symptoms.

Table 14. Duration and Impact of MDD Symptoms

	True Positives (n=876)	False Positives (n=205)	True Negatives (n=909)	False Negatives (n=256)
% Duration	42%	4%	0	0
% Impact	27%	2%	0	0

CORRELATIONS: Using the total sample (N=2244), the variables for MDD, Duration, and Impact were transformed into two levels (High vs. Low) to compute correlations. Results revealed significant positive moderate correlations between level of MDD symptoms, Duration (r=0.46, p<.001) and Impact (r=0.36, p<.001). In addition, as expected, Duration and Impact were strongly correlated with each other (r=0.70, p<.0001).

GENDER EFFECT ANALYSES

Table 15. MDD and HPI Predictive Validity Female Sample Only (N=1150)

	Predicted HPI Classification			
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**	
Observed High MDD # Total Symptoms (2-11)	**True + 591 (A)**	**False + 83 (B)**	**674 (A+B)**	**PPV=A/(A+B) x 100 591/674=88%**
Observed Low MDD # Total Symptoms (0,1)	**False - 138 (C)**	**True - 338 (D)**	**476 (C+D)**	**NPV= D/(C+D) x 100 338/476=71%**
	High HPI Total (A)+ (C) = 729	**Low HPI Total (B)+(D) = 421**	**MDD TOTAL Female Sample N= 1150**	

CHI SQ (1) = 414, p<.001, PHI = .60 (Strong Association), Odds Ratio = 17 (95% CI 12.8, 23.6). In the female sample (N=1150), cases classified as High HPI are 17 times more likely to be in the High MDD group.

FEMALE PREVALENCE of High HPI for MDD

High Priority Column Total / Total Female Sample = 674/1150 = 59%. This rate is higher than the prevalence for the total sample, which suggests that females may be experiencing greater levels of MDD symptoms than males. Alternatively, females may simply be willing to reveal more MDD symptoms compared to their male counterparts. In either case, it has been long established that females experience higher levels of depression than males[9],[10].

- SENSITIVITY: 591/729 = 81% ("true positive" rate): The HPI accurately classified or "predicted" 81% of the female cases with a high number of reported MDD symptoms as being high priority.
- PPV: 591/674=88% (strong clinical relevance): Among "true positive" cases, there is an 88% probability that respondents may require follow-up services for MDD symptoms.
- SPECIFICITY: 338/421 = 80% ("true negative" rate): The HPI accurately "predicted" 80% of the cases with a low number of reported MDD symptoms as being low priority.
- NPV: 338/476=71% (moderate clinical relevance): Among "true negative" cases, there is a 71% probability that their reported symptoms do not meet the intervention threshold.

Table 16. MDD and HPI Predictive Validity Male Sample Only (N=1094)

	Predicted HPI Classification			
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**	
Observed High MDD # Total Symptoms (2-11)	**True + 285 (A)**	**False + 120 (B)**	**405 (A+B)**	**PPV=A/(A+B) x 100 285/405 = 70%**
Observed Low MDD # Total Symptoms (0,1)	**False - 118 (C)**	**True - 571 (D)**	**689 (C+D)**	**NPV= D/(C+D) x 100 571/689= 83%**
	High HPI Total (A)+ (C) = 403	**Low HPI Total (B)+(D) = 691**	**MDD TOTAL Male Sample N= 1094**	

CHI SQ (1) = 311, p<.001, PHI = .53 (Strong Association), Odds Ratio = 11.5 (95% CI 8.6, 15.4). In the male sample (N=1110, cases classified as High HPI are 11.5 times more likely to be in the High MDD group.

[9] https://doi.org/10.1111/1467-8721.00142

[10] doi: 10.3928/02793695-20121107-04

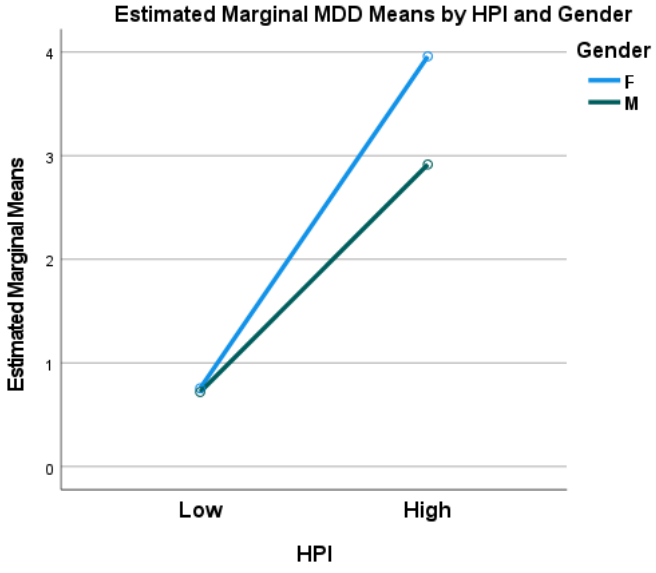
MALE PREVALENCE of MDD Symptoms: Of the n=1094 males in the sample, n=405 reported at least two MDD symptoms. Therefore, the prevalence rate for this group is 405/1094 = 37%. The MDD prevalence rate difference between females and males is 60% (.59 -.37 = .22/.37= .60).

- SENSITIVITY: 285/403 = 71% ("true positive" rate): The HPI accurately classified or "predicted" 71% of the male cases with a high number of reported MDD symptoms as being high priority.
- PPV: 285/405= 70% (moderate clinical relevance): Among "true positive" cases, there is a 70% probability that respondents may require follow-up services for MDD symptoms.
- SPECIFICITY: 571/691 = 83% ("true negative" rate): The HPI accurately "predicted" 83% of the cases with a low number of reported MDD symptoms as being low priority.
- NPV: 571/689 = 83%: Among "true negative" cases, there is an 83% probability that their reported symptoms do not meet the intervention threshold.

The difference in sensitivity rates between females and males (81% vs 71%, respectively) may be attributable to the marked difference in MDD prevalence rates between females and males (59% vs 37%).

A Two-Way ANOVA was performed to assess the moderating effect of gender on the mean number of MDD symptoms by HPI level. Based on the pattern of gender differences observed in the frequencies of MDD symptoms, an interaction between gender and HPI level for MDD was expected. A significant interaction was supported, $F(1, 2240) = 40.8$, $p<.001$, $\eta_p^2 = .018$. That is, although the mean number of MDD symptoms does not differ between females(n=421) and males (n=691) in the Low HPI category (.755, .719, respectively), there is a marked difference between females (n=729) and males (n=403) for High HPI (3.96, 2.92, respectively). Figure 7 illustrates that for Low HPI, the MDD means do not differ by gender. In the High HPI group, however, females have a higher MDD mean level compared to males. Therefore, the relationship between HPI level and MDD appears to be moderated by gender. Although $\eta_p^2 = .018$ suggests the interaction effect is weak, an increase in the male sample size may improve detection of this effect.

Figure 7. Interaction Effect between Gender and HPI on MDD Level



REPEATED HCU SCREEN ANALYSES

Tables 17 and 18 are based on data for years 2020 and 2021 only. A cross-tabulation of the predictive validity data from YR2020 to YR2021 can tell us if there was a marked change in the prevalence rate of the HCU Priority Index for MDD cases. In addition, any notable changes in prevalence of MDD symptoms as well as the identification of true positives (sensitivity) and/or true negatives (specificity) are documented in Table 19.

Table 17. MDD and HPI Predictive Validity YR2020 Sample (N=591)

	Predicted HPI Classification			
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**	
Observed High MDD # Total Symptoms (2-11)	**True + 181 (A)**	**False + 54 (B)**	**235 (A+B)**	**PPV=A/(A+B) x 100 181/235 = 77%**
Observed Low MDD # Total Symptoms (0,1)	**False - 73 (C)**	**True - 283 (D)**	**356 (C+D)**	**NPV= D/(C+D) x 100 283/356 = 80%**
	High HPI Total (A)+ (C) =254	**Low HPI Total (B)+(D) = 337**	**MDD TOTAL Female Sample N= 591**	

CHI SQ (1) = 184.5, p<.001, PHI = .56 (Strong Association), Odds Ratio = 13 (95% CI 8.7,19.9). In the Santiago YR2020 sample (N=591), cases classified as High HPI are 13 times more likely to be in the High MDD group.

YR2020 PREVALENCE for MDD Symptoms:
Total Cases reporting 2or more MDD symptoms/ Total Santiago YR2020 Sample =235/591 = 40%.

- SENSITIVITY: 181/254 = 71% ("true positive" rate): The HPI accurately classified or "predicted" 71% of the YR2020 cases with a high number of reported MDD symptoms as being high priority.
- PPV: 181/235 = 77% (strong clinical relevance): Among "true positive" cases, there is an 77% probability that respondents may require follow-up services for MDD symptoms.
- SPECIFICITY: 283/337 = 84% ("true negative" rate): The HPI accurately "predicted" 84% of the cases with a low number of reported MDD symptoms as being low priority.
- NPV: 283/356 = 80% (moderate clinical relevance): Among "true negative" cases, there is an 80% probability that their reported symptoms do not meet the intervention threshold.

Table 18. MDD and HPI Predictive Validity YR2021 Sample (N=779)

	Predicted HPI Classification			
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**	
Observed High MDD # Total Symptoms (2-11)	**True + 291 (A)**	**False + 64 (B)**	**355 (A+B)**	**PPV=A/(A+B) x 100 291/355 = 82%**
Observed Low MDD # Total Symptoms (0,1)	**False - 103 (C)**	**True - 321 (D)**	**424 (C+D)**	**NPV= D/(C+D) x 100 321/424 = 76%**
	High HPI Total (A)+ (C) = 394	**Low HPI Total (B)+(D) = 385**	**MDD TOTAL Female Sample N= 779**	

CHI SQ (1) = 257, p<.001, PHI = .58 (Strong Association), Odds Ratio = 14 (95% CI 9.9,20.1). In the Santiago YR2021 sample (N=779), cases classified as High HPI are 14 times more likely to be in the High MDD group. For all practical purposes, there is no difference in the odds ratios for YRS 2020 and 2021.

YR2021 PREVALENCE of High HPI for MDD:
Total Cases Reporting two or more MDD Symptoms / Total YR2021 Sample = 355/779 = 46%. This represents a prevalence rate increase of 15% from YR2020 to YR2021.

- SENSITIVITY: 291/394 = 74% ("true positive" rate): The HPI accurately classified or "predicted" 74% of the YR2021 cases with a high number of reported MDD symptoms as being high priority.
- PPV: 291/355 = 82% (strong clinical relevance): Among "true positive" cases, there is an 82% probability that respondents may require follow-up services for MDD symptoms.
- SPECIFICITY: 321/385 = 83% ("true negative" rate): The HPI accurately "predicted" 83% of the cases with a low number of reported MDD symptoms as being low priority.
- NPV: 321/424 = 76% (moderate clinical relevance): Among "true negative" cases, there is a 76% probability that their reported symptoms do not meet the intervention threshold

Table 19 provides a summary of the predictive validity values from YR2020 to YR2021 as well as the % change in these values. Most notable is the % increase in the prevalence of High MDD cases. This change may account for the increase in the HPI sensitivity and positive predictive value for MDD.

Table 19. % Relative Change of Predictive Validity Measures for YR2020 vs YR2021 (N=1370)

	YEAR 2020 (n=591)	YEAR 2021 (n=779)	% Relative Change
Prevalence ≥ 2 MDD Symptoms	40%	46%	+ 15%
Sensitivity	71%	74%	+ 4%
Positive Predictive Value	77%	82%	+ 6.5%
Specificity	84%	83%	1% decrease
Negative Predictive Value	80%	76%	5% decrease

REPEATED HCU SCREEN ANALYSES BY GENDER

Figure 8 disaggregates the MDD frequencies by gender. The increase in high HPI cases from YR 2020 to YR 2021 is predominantly among females. The variable School ID along the x axis refers to the school with data for YRS 2020 and 2021.

Figure 8. MDD Frequencies by HPI, Gender, & HCU Year (N=1370)

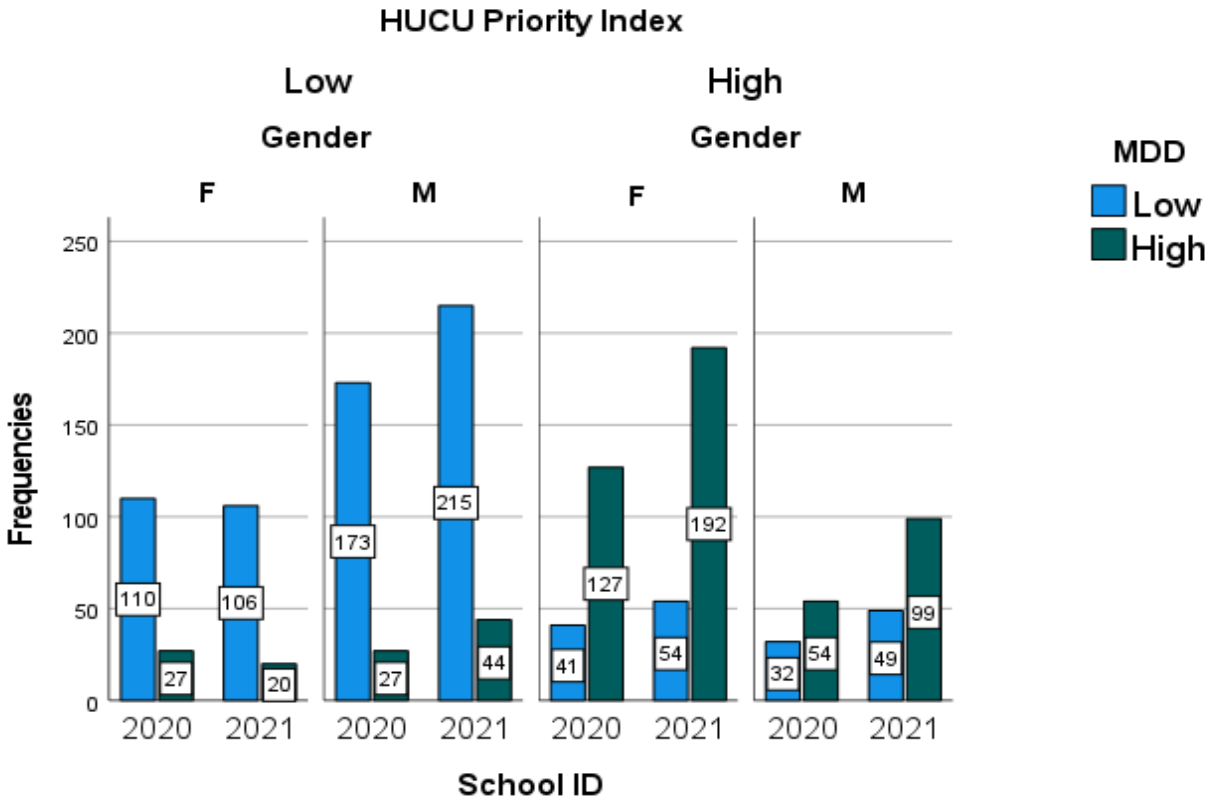


Table 20 provides a breakdown of the total sample by the number of HCU screening sessions. Currently, respondents have participated in either one or two sessions.

Table 20. Sample by Gender Number of Sessions

Gender			Frequency	Percent
Female		One Session	204	30.1
		Two Sessions	473	69.9
		Sub-Total	677	100.0
Male		One Session	276	39.8
		Two Sessions	417	60.2
		Sub-Total	693	100.0
		Grand Total	1370	

Figures 9 and 10 illustrate the number of respondents in the high vs low MDD categories by HPI, Gender, and Number of HCU screening sessions for years 2020 and 2021. It is evident from these graphs that regardless of number of HCU sessions, females classified as high HPI report a higher level of MDD symptoms compared to their male counterparts across years 2020 and 2021.

Figure 9. Frequencies by HPI & Gender: One Session Only

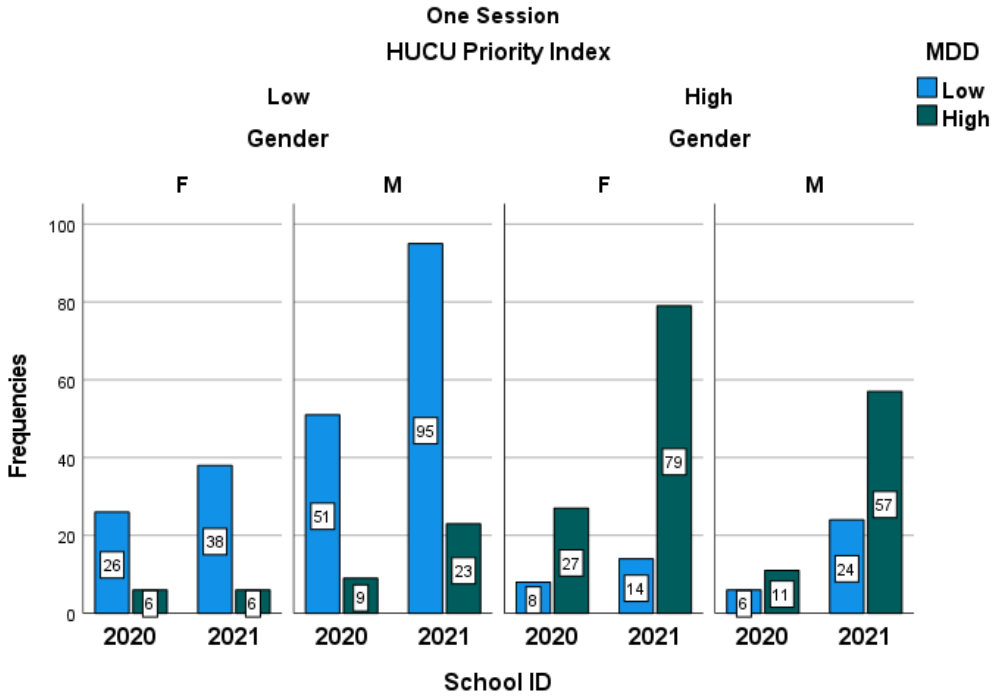
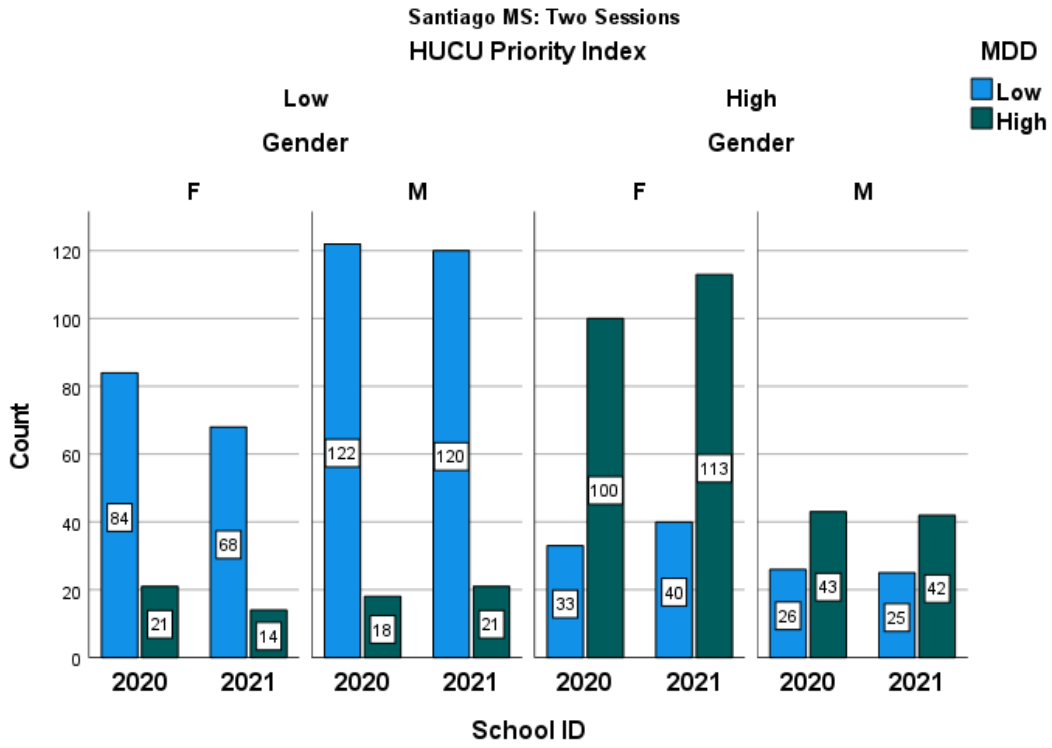


Figure 10. Frequencies by HPI & Gender: Two Sessions



CONCLUSION

An efficient, precise, and secure method for detecting psychological distress among adolescents is critical to the delivery of appropriate and timely support services. Overall, data for the HCU-MDD subscale suggest that the Heads Up Checkup (HCU) on-line screening system can accurately differentiate among groups by establishing risk priority levels according to level of self-reported symptoms. In this study, MDD symptom level and severity data (i.e., duration of symptoms and impact on daily living), were found to be consistent with the "predicted" HPI risk subgroups. Moreover, the HPI predictive validity ratios provide evidenced-based support for its clinical and practical relevance. Data regarding the prevalence of MDD symptoms among adolescents, and especially among females, also suggests that the HCU screen can generate findings that are consistent with published statewide and national survey results on adolescent mental health. Furthermore, the data comparing YR2020 and YR2021 indicate that the HCU screen may be able to detect changes over time in prevalence, sensitivity, and positive predictive values.

Additional validity analyses to examine the relationships among the HCU-MDD subscale and other subscales, including anxiety, post-traumatic stress disorder, sleep disorders, and attention deficit hyperactive disorder, are needed to determine the efficacy of the HPI in detecting risk. In addition, understanding how various HPI risk scenarios differ by risk factors, such as negative early childhood experiences, alcohol and/or drug abuse, low social support, and sexual orientation will inform efforts for more focused interventions and support resources. Additional demographic data will also provide information about the ways in which differences in age, race, ethnic origin, acculturation, U.S. region, and family socioeconomic status may have harmful or protective effects on risk groups identified by the HCU-HPI. Triangulating HCU findings with follow-up intervention outcomes as well as corroborating independent data from schools regarding academic and behavioral functioning would also reinforce the positive psychometric properties of the HCU-HPI.

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Appendix 1: Mental Health Consent Procedure

- Minor consent laws in the State of California allow young people aged 12 and over to consent to certain services without parent or guardian involvement. Minors may consent to certain services related to sexual and reproductive health, mental health, and drug and alcohol treatment. For details, please see the National Center for Youth Law's California Minor Consent and Confidentiality Laws grid. When a young person accesses services under minor consent laws, those services are to be maintained confidentially – meaning that providers are bound by law to not share this information, including with parents/guardians.
- In all cases, parents were notified by the schools in advance about the intention to provide a school-wide screening to students. Parents were provided with an opportunity to opt their child out of the screening. Students opted out of screening by parents were blocked from accessing the screening during the school-wide launch.
- At the end of the screening, students were provided with an opportunity to consent to share results. If a student consented to share and provided a parent's email at the end of the screening, results were automatically sent to parent.
- Immediately prior to beginning the screening, students were provided with the following information via email to their student email account. These instructions were also read aloud to the students in the classroom prior to beginning screening:

  We will be using this class period to complete a mental health screening. The screening takes anywhere from 3 to 10 minutes to complete and is voluntary. If you choose not to take the screening, please study, read, or sit quietly.

  As soon as you login, you will be asked to reset your password. This will keep your results confidential. Your results will not be shared with anyone unless it is required by law.

  During the screening, you will be asked to choose symptoms you may be experiencing or concerns you may have about your moods, thoughts, feelings, and activities. Answer the questions based on what is true for you MOST OF THE TIME.

  ***YOU MAY CHOOSE MORE THAN ONE ANSWER FOR EACH QUESTION**.*

  As soon as you complete the screening, your results will be available to review. Just follow the prompts on your screen.

  If you want to find out about free and low-cost resources and get your questions about mental health answered and/or talk to someone – click on the Get Support link in your account.

  This account belongs to you, and you can access your results anytime you wish. The Get Support tab in your account gives you links to mental health resources that are available for your use including chat, talk, and text crisis lines.

- Upon logging in to begin the screening, the following Consent is presented to each student:

Based on the information submitted in your registration, you have been directed to the Adolescent Self-Report.

The information you share in this screening will generally be kept confidential. Your responses and results are protected and will only be shared with your consent. However, the law requires disclosure in some situations even without your permission.

Confidentiality cannot be maintained when:

- You share that you may seriously harm yourself or others
- You share that you are being abused-physically, sexually or emotionally-or that you have been abused in the past.
- You are involved in a court case and a formal request is made for information about your screening.

Sharing with others:

- Except for the situations described above, your responses to the screening questions will not be disclosed to others.
- We encourage you to share the results with your healthcare professional.

Agreement to Participate: I have read the information above and voluntarily consent to participate. I understand that I may stop the screening at any point before I finish. If I choose not to complete the screening, any previous responses will not be recorded. **PROCEEDING TO THE NEXT SCREEN CONSTITUTES YOUR AGREEMENT TO PARTICIPATE.**

Appendix 2: Review of Effect Sizes for Odds Based on Binary Data

Measures of Effect Size: If a CHI SQ test result shows a p value <.05, you can reject the null hypothesis that the two binary variables, MDD & HPI (i.e., each having two levels such as, high vs low) being evaluated are not independent of each other. However, a p value doesn't tell you the magnitude of the association between two variables. In other words, we need a metric that tells us the "practical relevance" of the test result. For a 2 X 2 contingency table, we turn to the CHI SQ effect size measures, PHI or Cramer's V, which are typically interpreted like a Pearson "r" correlation. These effect size values can range from 0 to 1, with a strong effect size being ≥ 0.50. Another useful method for assessing effect size is the ratio of the odds of the outcome being predicted or "odds ratio." In this example, we'd like to know: How likely will cases classified as HI Priority (HPI) be in the HI MDD group? Note that the variable HPI (priority level) has an important connotation in healthcare when identifying patients at higher risk and in need of intervention.

ODDS Ratio Criteria: If the odds ratio = 1, there is no effect or both outcomes have the same chance of occurring; if > 1 there is an increase in the probability of the predicted outcome; if < 1 the probability of the outcome decreases. An odds ratio ≥ 4 is a strong effect size.

PROCEDURE: TABLE 1 (2 X 2 Contingency Table) shows that the outcome variable HPI has two levels, HI vs LO, and the predictor variable, Major Depressive Disorder (MDD) SYMPTOMS, also has two levels, HI vs LO. Each cell corresponds to four possible outcomes (a,b,c,d) as well as the row, column, and grand totals. In this case, we'd like to know: How likely will an individual with HI MDD (≥2 symptoms) be classified as a HI HPI case (vs LO HPI)? To compute the odds ratio for this predicted outcome, there are 3 formulas. Each formula, predicts to the numerator:

TABLE 1			
	HI HPI	**LO HPI**	**TOTALS**
HI MDD SYMPTOMS	a	b	a+b
LO MDD SYMPTOMS	c	d	c+d
TOTALS	a+c	b+d	(a+c) + (b+d)

FORMULAS:

1. **Odds$_1$** of HI PRIORITY & HI MDD = a/c = Number of HI HPI & HI MDD (a) / Number of HI HPI & LO MDD (c)
   (HI PRIORITY Condition with HI vs LO MDD)

2. **Odds$_2$** of LO PRIORITY & HI MDD =b/d = Number of LO HPI & HI MDD (b) / Number of LO HPI & LO MDD (d)
   (LO PRIORITY Condition with HI vs LO MDD)

3. ***RATIO of the Odds**, **divide Odds$_1$ by Odds$_2$** = (a/c) / (b/d) = Odds$_1$ of HI HPI & HI MDD (a/c) / Odds$_2$ of LO HPI & HI MDD (b/d)
   (HI vs LO Priority with HI MDD only)

*Remember, the ODDS RATIO predicts to the numerator→ Odds$_1$ of HI HPI & HI MDD

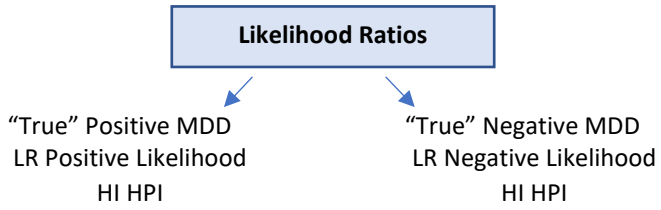
TABLE 2	**HI HPI**	**LO HPI**	**TOTALS**
HI MDD ≥2 SYMPTOMS	876 (a)	203 (b)	1079 (a+b)
LO MDD SYMPTOMS	256 (c)	909 (d)	1165 (c+d)
TOTALS	1132 (a+c)	1112 (b+d)	2244 (a+c) + (b+d)

1. Odds$_1$ = a/c = 876/256 = 3.421875
2. Odds$_2$ = b/d = 203/909 = 0.22332
3. Odds Ratio= Odds$_1$ / Odds$_2$ = 3.421875/0.2530253 = 15.32

ODDS RATIO INTERPRETATION: Cases classified as HI PRIORITY are 15 times more likely to be in the HI MDD group! Based on the magnitude of this Odds Ratio, we can conclude that this prediction has strong practical and clinical importance.

LIKELIHOOD RATIO is another type of effect size which can be obtained from a 2 X 2 Contingency Table. For our purposes, the LR prediction involves how well the outcome variable, HPI, can accurately discriminate between MDD subgroups. Specifically, using the LRs we'd like to know: How likely will the "true positive" and "true negative" MDD subgroups be classified as HI HPI? (See Figure 1). Recall, that for the odds ratio we asked: How likely will cases in the HI MDD group be identified as being HI HPI? These two questions are not the same. The LR question has to do with the HPI variable's ability to distinguish between two types of MDD cases ("true positives" vs "true negatives") in assigning a HI HPI level. By contrast, the Odds Ratio focuses on the likelihood of the HI HPI classification for HI MDD cases only.

Figure 1. How likely are the "true positive" and "true negative" cases HI HPI?



To answer the LR question, we will compute two LRs. The first will predict to the likelihood of "true" HI MDD cases being classified as HI HPI. This is known as the Positive Risk Ratio. The other LR will predict the likelihood of "true" LO MDD cases being classified as HI HPI. This is known as the Negative Risk Ratio. An LR close to one suggests that the HPI variable's performance is not useful for categorizing MDD subgroups. An LR >1 shows an increase in the probability of being in the HI HPI group, whereas a ratio <1 suggests a decrease. The LR computations are shown below. LRs and their respective 95% Confidence Intervals can be generated by SPSS using the Crosstabulation Risk command. It is expected that the LR+ value will be greater than the LR- value ("true negatives" are not expected to be classified as high priority cases).

To compute the Positive and Negative Likelihood Ratios, we will need the estimates for sensitivity (i.e., true positive MDD cases = a/a+c) and specificity (i.e., true negative MDD cases = d/ b+d). Refer to HCU Priority Index (HPI)-MDD, Work-in-Progress, Report 1 (https://headsupcheckup.com/MDD) for explanations of sensitivity and specificity as measures of predictive validity. To compute sensitivity, the number of "HI MDD", "HI HPI" cases (n=876) is divided by the total number of cases identified as being high HPI (n=1132). For this sample, the sensitivity or "true positive" rate is 876/1132 = 77%. To compute specificity, the number of "LO MDD" by "LO HPI" cases (n=909) is divided by the total number of cases identified as low HPI (n=1112). For this sample, the specificity or "true negative" rate is 909/1112 = 82%.

TABLE 2	HI HPI	LO HPI	TOTALS
HI MDD ≥2 SYMPTOMS	876 (a)	203 (b)	1079 (a+b)
LO MDD SYMPTOMS	256 (c)	909 (d)	1165 (c+d)
TOTALS	1132 (a+c)	1112 (b+d)	2244 (a+c) + (b+d)

LR Formulas & Computations:

Positive LR Ratio = Sensitivity/ 1 - Specificity =.77/ 1-.82 = 4.139 (95% CI 3.646, 4.698). Cases classified as True Positives (high PRIORITY, high MDD symptoms) are approximately four times as likely to be in the high PRIORITY group, compared to True Negative cases (low HPI, low MDD symptoms).

Negative LR Ratio = 1-Sensitivity/Specificity = 1-.77/ .82 = .267 (95% CI .239, 299). Cases classified as True Negatives (low PRIORITY, low MDD symptoms) are approximately one-fourth as likely to be in the high PRIORITY risk group. Note that this ratio = .267 is markedly less than 1 which signifies a substantial decrease in the probability of the predicted high priority outcome.

INTERPRETATION: The positive and negative LRs (4.139 and 0.267, respectively) closely approximate the recommended cutoff LR values of > 5 and < 0.2, which suggests good HPI discrimination between “true positive” vs “true negative” MDD subgroups.