The Efficacy of the HCU Online Adaptive Screening System for Assessing Anxiety among Non-Clinical Community Samples of Adolescents

Work-In-Progress Research Series
Report 2

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January, 2022

Acknowledgments: We would like to express our sincere gratitude to the following individuals and organizations whose support has made this report possible. The Children's Mental Health Access Collaborative (funded by CalOptima IGT 6/7) including Children's Cause OC, Western Youth Services, Children's Bureau of Southern California, Child Guidance Center, and MECCA – for funding most of these screenings and providing follow-up services for students in crisis. To the forward-thinking school administrators that saw the need on their campuses: Sandra Preciado-Martin, Principal, Yorba Middle School; Lee Fleming, Head of School, Samueli Academy; and Dr. Adela Cruz, Coordinator School Mental Health, Anaheim Union High School District. A special thanks to Dr. James D'Agostino, Principal, Santiago Charter Middle School for believing in HCU's ability to help save lives on his campus for the past three years.

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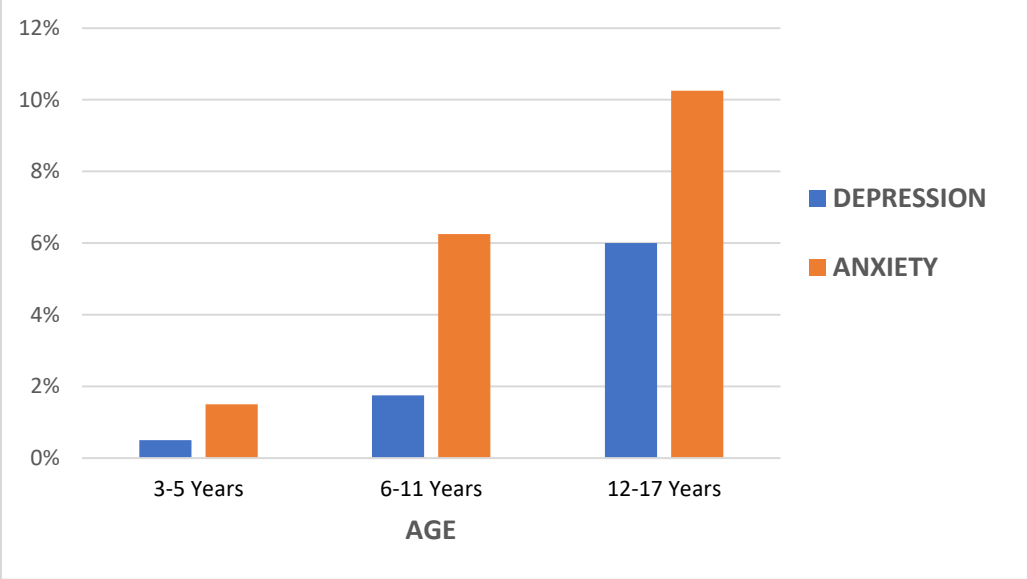
INTRODUCTION

In 2018, a study published in the *Journal of Pediatrics*[1] based on data from the 2016 National Survey of Children's Health (NSCH) estimated that 7.1% of children ages 3-17 years (approximately 4.4 million) had serious anxiety problems and 3.2% of children (approximately 1.9 million) had symptoms of depression. Moreover, whereas behavioral issues were found to be more prevalent among young children, depression and anxiety disorders were found to be more common among adolescents 12-17 years of age (Figure 1).[2] This study also found that about 3 in 4 children (73.8%) aged 3-17 years with depression also had symptoms of anxiety.

Figure 1. Prevalence of Children's Psychological Disorders by Age (NSCH, 2016)



Compared with pre-pandemic prevalence rates for anxiety and depression, data suggest that rates for psychological problems among children and adolescents have dramatically increased worldwide.[3] Specifically, in a meta-analysis containing 29 studies and a total of 80,879 individuals globally, the prevalence estimates of clinically elevated child and adolescent depression and anxiety were 25.2% and 20.5%, respectively, especially among older adolescents and girls. 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.[4] 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. Similarly, a recent Heads Up Checkup (HCU) report[5] containing data

[1] Ghandour RM, Sherman LJ, Vladutiu CJ, Ali MM, Lynch SE, Bitsko RH, Blumberg SJ. Prevalence and treatment of depression, anxiety, and conduct problems in U.S. children. *The Journal of Pediatrics*, 2018. Published online before print October 12, 2018 [Read summaryexternal icon.

[2] https://www.cdc.gov/childrensmentalhealth/data.html

[3] *JAMA Pediatr.* 2021;175(11):1142-1150. doi:10.1001/jamapediatrics.2021.2482

[4] Teen_Mental_Health_PB_FINAL.pdf (ucla.edu)

[5] An Evaluation of the HCU Priority Index (HPI) and Major Depressive Disorder Subscale Among Adolescents: Establishing Reliability and Predictive Validity Criteria (December, 2021), Work-in-Progress Research Series (1).

collected during YRS 2020-2021 from a non-random community sample (N=2244) of adolescents, predominantly drawn from Title I middle schools in Orange County, CA, found the prevalence of high priority cases with elevated depression symptoms to be 50%. As in previous studies, girls were found to be at higher risk than boys, confirming the moderating effect of gender. Further examination of HCU data revealed a strong association between depression and anxiety symptoms. Figure 2 illustrates the percent frequencies in the comorbidity of these two diagnostic categories as well as the moderating effect of gender. For example, among females (n=1150), comorbidity for two or more symptoms for each category occurred in 49% (n=564) of the female sample (n=1150). By contrast, elevated symptoms for these disorders co-occurred in 21% (n=229) of the male sample (n=1094). Figure 3 indicates that of the sample of comorbid high anxiety and depressive symptoms (n=793), females show a consistent pattern of markedly higher levels of social anxiety across grade levels 7-12. This finding remains preliminary due to the limited HCU sample for grades 10-12.

Figure 2. Comorbidity of Social Anxiety and Depression Symptoms by Gender (N=2244)

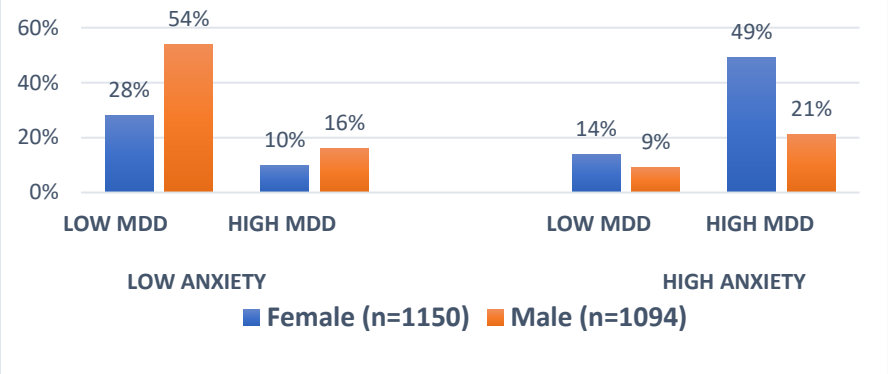
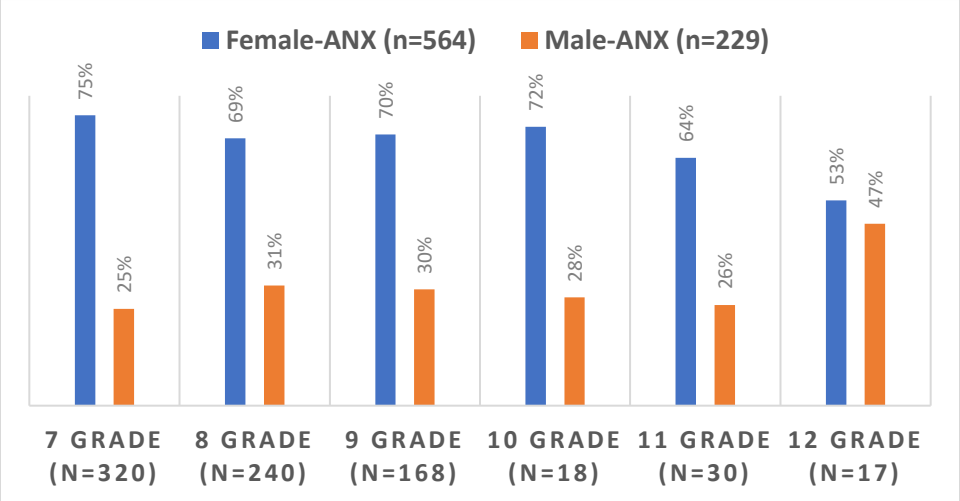


Figure 3. Social Anxiety Symptoms by Gender and Grade for Comorbidity Sample (n=793)



Published epidemiological findings on the prevalence of anxiety and other psychiatric disorders among adolescents affirm the value of efficient methods to assess risk and deliver appropriate interventions. Moreover, the adverse psychological impact among adolescents in the aftermath of the COVID-19

pandemic may even be more consequential than what we currently know. Without early risk detection, therapeutic services, and support resources, the adolescent mental health crisis is likely to grow, further eroding academic performance, diminishing the capacity to cope with challenging situations, and promoting substance abuse as well as other damaging behaviors into adulthood. [6] Although traditional survey methods to assess the presence and severity of psychiatric symptoms among teens have been standard practice for decades, diverse populations in the U.S. are increasingly using on-line screening tools. For example, adolescents and young adults well-versed in the use of social media platforms are likely to utilize this type of technology. In addition, it is advantageous from a health care or school administration standpoint to obtain this type of data cost-effectively and efficiently, especially for adolescents at risk for harming themselves or others.

Toward this end, the Heads Up Checkup (HCU) is a comprehensive new generation on-line screening system designed to prioritize risk levels of reported mental health and behavioral problems.[7] The HCU gathers diagnostic information that is consistent with the World Health Organization's standardized ICD-10 criteria for psychiatric disorders.[8] Using a decision-tree approach, the HCU algorithm determines an individual "predictive" priority risk designation, referred to as the HCU Priority Index (HPI), based on the total % symptom criteria endorsed across a comprehensive set of psychiatric categories and behavioral problems. Although not a diagnosis, the HPI narrows the scope of diagnostic information, while simultaneously providing a mechanism to determine the seriousness of reported symptoms. In addition, aggregated HPI group profiles can be compared by various demographic variables for research purposes. To gain a better understanding of how the HCU system functions, this study examines the efficacy of the HCU for assessing anxiety disorder symptoms among non-clinical community samples of adolescents.

SPECIFIC AIMS

Based on the HCU screening data collected among adolescents (N=2244) in Orange County, CA during the 2020-2021 academic years, this report seeks to: a.) document the psychometric properties (i.e., reliability and validity) of three anxiety scales, including social anxiety, generalized anxiety disorder (GAD), and panic disorder; b.) establish the predictive validity of the HCU Priority Index (HPI) in the detection of "true positive" vs "true negative" cases (i.e., sensitivity, specificity, etc.) as well as duration and impact of symptoms; and c.) explore the moderating effect of gender on anxiety by HPI risk designations. Given the uncertainties and excessive isolation due to school disruptions, which have been emblematic of the COVID-19 pandemic for this population, this report also examines the relationships among HCU measures of anxiety, depression, Attention Deficit & Hyperactive Disorder (ADHD), and academic performance. Recommended future research directions, involving the moderating effects of key demographic and psychosocial variables, will be discussed.

METHODOLOGY

PROCEDURE: An Informed Consent was presented on the first page of the screening regarding confidentiality of results (Appendix 1). Students were pre-registered for screening through the HCU administrative dashboard. Individual screening accounts were automatically created for each student using Student ID and a temporary password as login credentials. At the time of screening, students were reminded by a classroom facilitator that participation was voluntary. Students were then directed to a

[6] https://pubmed.ncbi.nlm.nih.gov/30577941/
[7] Heads Up Checkup, Mental Health and Behavioral Risk Screening, https://www.headsupcheckup.com
[8] https://www.who.int/classifications/icd/en/bluebook.pdf

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. All data are analyzed and reported in aggregate form with no identifying personal student information.

SAMPLE: HCU data for this study comprise (N=2244) adolescents, including n=1150 females and n=1094 males, with a total of (n=1688) 7th-8th graders and (n=556) 9th-12th grade students. At the time of screening, all respondents were enrolled in one of four schools (Table 1) in Orange County, California; the HCU was administered in YRS 2020 and 2021 at the middle school coded 112 and 121. Note that two middle schools, which represent 72.3% of the data, are Title I schools. According to Table 2, most students completed the HCU while in grades 7-8 (75.2%), and Table 3 shows that the overwhelming majority (92.3%) completed the screening in English (n=2071). Table 4 and Figure 3 summarize student insurance status by School ID; no insurance data were available for school 112 in YR2020. All duplicate cases or incomplete screenings were excluded from the sample.

Table 1. School ID by Year of Administration (N=2244)

School ID		Grades	Number of Students	Percent	Title I Status
	112_ 2020	7-8	591	26.3	YES
	114_ 2021	7-12	279	12.4	NO
	116 _2021	7-8	254	11.3	YES
	119 _ 2021	9-12	341	15.2	NO
	121 _ 2021	7-8	779	34.7	YES
	Total		2244	100.0	

Table 2. School ID by Grade & Year of Screening (N=2244)

School ID	Grade						Total
	7	8	9	10	11	12	
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 3. School ID by HCU Language (N=2244)

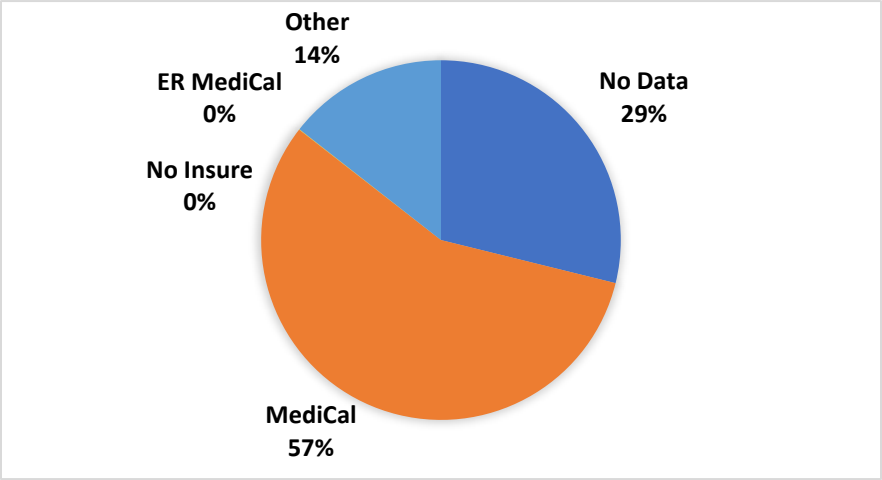
School ID		Language		Total
		English	Spanish	
	112_ 2020	587	4	591
	114_ 2021	279	0	279
	116 _2021	96	158	254
	119 _ 2021	341	0	341
	121 _ 2021	768	11	779

Total	2071	173	2244

Table 4. School ID by Insurance Status (N=2244)

School ID		Insurance Status					
		No Data	MediCAL	ER MediCAL	No Insure	Other, 3rd Pty	Total
	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 4. % Insurance Status (N=2244)



SUMMARY OF HCU ANXIETY VARIABLES

Table 5 summarizes the anxiety symptom variable numbers being evaluated for each HCU anxiety disorder scale. Identifying variable numbers are color coded to show the overlap of key items across the scales. Table 6 includes the description of each numbered variable. All variables are binary and were coded as 0 (NO), 1(YES). For purposes of these analyses, a SUM score was computed totaling the number of symptoms endorsed for each of the three scales.

Table 5. Variable Numbers for Anxiety Disorders

Social Anxiety (F40.1)	Generalized Anxiety Disorder (F41.1)	Panic Disorder without Agoraphobia (F41)
17 items	11 items	13 items
635*	635*	635*
600	611	X
602	612	X
604	X	X
640	X	X
672	X	672
673**	X	673
674	X	674
675	X	675**
676	676	676
677	677	677
678	678	678
697	697	697
680	680	680
681	681	681
682	682	682
683	683	683

Variables with asterisks denote "deal breakers;" these items must be endorsed for membership in a specific anxiety category. Physical symptoms (vars 676-683) are assessed for each diagnostic category. Table 6 includes a description of each of the variables listed numerically in Table 5.

Table 6. Description of Anxiety Variables

635*	Sometimes I feel worried, anxious, or afraid (algorithm requires endorsement of this item to trigger other anxiety-related questions for social anxiety, GAD, and Panic Disorder).
600	I don't like being called on in class or talking in front of others.
602	I'm afraid of being teased or judged
604	It makes me nervous that other kids at school are watching me.
611	I have trouble concentrating or staying focused.
612	It's hard for me to sit still.
640	My self-confidence or self-esteem is low.
672	I avoid being around certain things because they make me feel afraid.
673**	I avoid getting into certain situations that make me feel nervous (Social Anxiety).
674	I sometimes feel afraid even though I know there is no real danger.
675**	I never know when my feelings of fear or panic are going to happen (Panic Disorder).
PHYSICAL SYMPTOMS:	
676	My heart beats very fast.
677	I have a hard time breathing.
678	I feel dizzy.
697	My chest hurts.
680	I get sweaty.
681	My stomach gets upset.

682	I feel like I want to run away.
683	My hands or my body shakes.

For each anxiety category, the severity of the physical symptoms is assessed by how often they occur (i.e., daily, two or three days a week, or about once a week) as well as duration (i.e., 10 minutes or less. several hours, several weeks, or several months). Tables 7-9 summarize the frequency distributions for number of symptoms endorsed for each of the anxiety scales. The prevalence rate reported for high symptoms (2 or more) is summarized below each table.

Table 7. Social Anxiety 17 items w Physical Symptoms

	Frequency	Percent	Cumulative %
0	835	37.2	37.2
1	362	16.1	**MEDIAN = 53**
2	162	7.2	60.6
3	131	5.8	66.4
4	78	3.5	69.9
5	80	3.6	73.4
6	65	2.9	76.3
7	84	3.7	80.1
8	91	4.1	84.1
9	83	3.7	87.8
10	74	3.3	91.1
11	55	2.5	93.6
12	46	2.0	95.6
13	33	1.5	97.1
14	26	1.2	98.3
15	20	.9	99.2
16	12	.5	99.7
17	7	.3	100.0
Total	2244	100.0	

Social Anxiety # Cases with 2–17 (High) total number of symptoms = 1047/2244= 47%

Table 8. (GAD) 11 items w Physical Symptoms

	Frequency	Percent	Cumulative %
0	932	41.5	41.5
1	385	17.2	**MEDIAN=59**
2	203	9.0	67.7
3	116	5.2	72.9
4	137	6.1	79.0
5	133	5.9	84.9
6	111	4.9	89.9
7	87	3.9	93.8
8	63	2.8	96.6
9	44	2.0	98.5
10	22	1.0	99.5
11	11	.5	100.0
Total	2244	100.0	

GAD # Cases with 2 – 11 (High) total number of symptoms = 927=41%

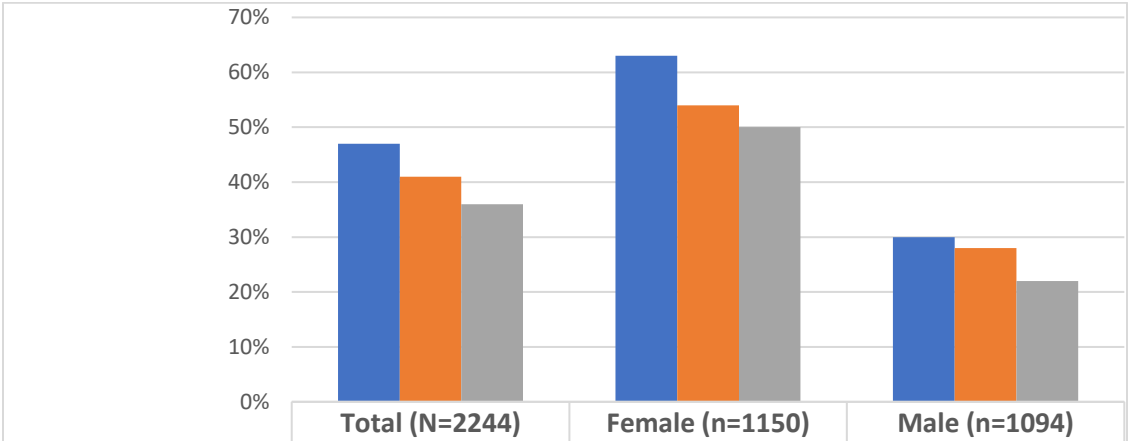
Table 9. Panic Disorder 13 items w Physical Symptoms

	Frequency	Percent	Cumulative %
0	**1390**	**61.9**	**MEDIAN = 62**
1	41	1.8	63.8
2	62	2.8	66.5
3	98	4.4	70.9
4	115	5.1	76.0
5	102	4.5	80.6
6	111	4.9	85.5
7	90	4.0	89.5
8	75	3.3	92.9
9	56	2.5	95.4
10	46	2.0	97.4
11	30	1.3	98.8
12	18	.8	99.6
13	10	.4	100.0
Total	2244	100.0	

PANIC # Cases with 2 – 13 (High) total number of symptoms = 813/2244= 36%

Of the three distributions, Social Anxiety has the highest frequency of 2 or more symptoms (47%) (n=1047). Generalized Anxiety is next with approximately 41% (n=927); the distribution for Panic Disorder was the lowest with 36% (n=813) in the high symptom range. Note that Panic Disorder had the highest number of "0" or NO (n=1390) reported symptoms. Female (n=1150) vs male (n=1094) distributions for 2 or more symptoms endorsed showed markedly higher rates among females across all three anxiety scales. Figure 5 illustrates the % symptom frequency differences for the total sample and by gender:

Figure 5. Differences for Cases with ≥ 2 Anxiety Symptoms for the Total Sample and by Gender



	Total (N=2244)	Female (n=1150)	Male (n=1094)
Social Anxiety	47%	63%	30%
GAD	41%	54%	28%
Panic Disorder	36%	50%	22%

ANXIETY SCALES: RELIABILITY COEFFICIENTS

Reliability is a psychometric property that measures the extent to which a scale generates consistent results from one screening to the another. If scale items "hang together" well, the inter-item correlations increase as does the Cronbach coefficient. Cronbach reliability coefficients, known as alpha (α), can range from (0) "Not at All" to (1.0) "Extremely" consistent. Ideally, the coefficient should be equal to or greater than 0.70. Good reliability ensures greater precision of measurement and validity of the statistical results. Table 10 summarizes the Cronbach alpha reliability coefficients for each of the four anxiety scales for the total sample (N=2244) as well as by gender (females, n= 1150) and (males, n= 1094).

Table 10. Cronbach Alpha Reliability Coefficients

Social Anxiety	α=.91 (Females α=.90; Males α=.88)	17 items
Generalized Anxiety Disorder	α=.86 (Females α=.86; Males α=.80)	11 items
Panic Disorder	α=.91 (Females α=.91; Males α=.89)	13 items

Alpha values are all greater than .70 indicating strong reliability across the four measures of anxiety.

Test-Retest Reliability for YR2020 and YR2021

Sample Distribution by School ID & YR	Frequency	Percent
112_ 2020	591	43
121_ 2021	779	57
Total Sample	1370	100.0

Total Sample by Number of Sessions	Frequency	Percent
One Session	480	35
Two Sessions	**890**	**65**
Total	1370	100.0

The two tables above show the sample breakdown by school ID and year. Approximately 65% (n=890) of the N=1370 students had a screening in YR 2020 and YR 2021. The test-retest reliability coefficients for the anxiety scales were based on the repeat sample of (n=890) respondents.

Table 11. Test-Retest Reliability Cronbach Alphas (N=890)

	December 2020	May 2021	
Social Anxiety	α = .91	α = .92	17 items
Generalized Anxiety	α = .85	α = .87	11 items
Panic Disorder	α = .91	α = .92	13 items

Time 1 and Time 2 alpha values indicate strong test-retest reliability which suggests consistent performance of the HCU Anxiety scales from one screen administration to another.

THE HCU PRIORITY INDEX (HPI)

The HCU screening "predicts" a prioritized risk level among individuals with self-reported mental health concerns across a wide array of possible affective, cognitive, behavioral, and/or developmental factors. Using a decision-tree approach, the algorithm generates a HCU Priority Index (HPI) rating for each respondent based on the total % psychiatric criteria endorsed for one or more diagnoses and/or risk assessments. HPI values range from one to seven as summarized in Table 12. The cumulative percent column indicates that respondents at or below the 50-69% criteria for at least one diagnosis, or Priority Index Level 2, account for 49.5% of the total sample (734+376= 1,110).

For 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 13 summarizes the frequencies by Low HPI Group (Levels 1 & 2) versus High HPI group (Levels 3-7) and sample size for each of these subgroups is n=1112 (Low) vs n=1132 (High). In addition to providing an HPI level for each respondent, this rating provides a "standard" by which to compare how well the HPI differentiates between low vs high priority subgroups. Using 2X2 contingency tables, the "high" vs "low" priority designation is ideal for testing hypotheses regarding the significance and odds of the association between the "predicted" HPI and "observed" symptom levels.

Table 12. 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 13. Distribution of High vs Low HPI by % Diagnostic Criteria Level

Priority Level		Frequency	Percent	Cumulative Percent
	Low Risk Level ≤ 2	1112	49.6	49.9
	High Risk Level ≥3	1132	50.4	100.0
	Total	2244	100.0	

Predictive Validity for the HCU Priority Index (HPI) for Anxiety Scales

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 anxiety symptoms and which are also 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 anxiety symptoms must also be in the predicted low HPI group. Moreover, Positive and Negative Predictive Values (i.e., PPV and NPV) indicate the clinical relevance of the rates of sensitivity and specificity. The prevalence rate of anxiety for each scale is based on the total number of cases classified as having high (2 or more) reported or observed symptoms relative to the total sample (N=2244). Odds Ratios for a determination of the probability of High HPI classification is based on 2 or more reported symptoms. To differentiate between the probability of High HPI membership for "true positive" versus "true negative" cases, Positive and Negative Likelihood Risk Ratios (LRs) for each anxiety scale were also computed.

RESULTS PART I: SOCIAL ANXIETY

To assess the predictive validity of the HPI in its classification of high vs low social anxiety symptoms, a 2X2 contingency frequency analysis was performed (Table 14). These analyses were repeated to assess the moderating effect of gender on the relationship between anxiety symptoms and the HCU Priority Index (Tables 17 & 18).

Table 14. SOCIAL ANXIETY and HPI Predictive Validity Total Sample (N=2244)

	Predicted HPI Classification			
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**	
Observed High SOC ANX Total Symptoms (2-17)	**True Positive 876 (A)**	**False Positive 171 (B)**	**1047 (A+B)**	**PPV=A/(A+B) x 100 876/1047= 84%**
Observed Low SOC ANX Total Symptoms (0-1)	**False Negative 256 (C)**	**True Negative 941 (D)**	**1197 (C+D)**	**NPV= D/(C+D) x 100 941/1197= 79%**
	High HPI Total (A)+ (C) = 1132 HPI Sensitivity A/(A+C)	**Low HPI Total (B)+(D) = 1112 HPI Specificity D/(B+D)**	**TOTAL Sample N= 2244**	

Testing the Association between the HCU Priority Index (HPI) and Social Anxiety Symptoms

A 2 X 2 CHI SQ Test of Independence between the two categorical variables, HPI Risk Level (Low vs High) and Social Anxiety (SOC ANX) symptoms (Low vs High), was performed to assess the strength of their association. For social anxiety, the values at the lowest end of the symptom frequency distribution were used to set the high (2-17) vs low (0,1) symptom cut-off points. A significant association would suggest

that the proportion of "Low vs High" observed SOC ANX cases varies by the "Low vs High" HPI designation.

CHI-SQ TEST OF INDEPENDENCE: Results confirmed a significant association between the "Low vs High" SOC ANX symptoms and the HPI (CHI Sq (1) = 866, p<.001) with a strong effect size (Phi coefficient =0.62). For a 2X2 contingency table, a Phi coefficient is essentially a correlation with a range of (-1 to +1). A correlation value ≥.50 shows a strong relationship between two variables. Another measure of effect size that is useful from a clinical perspective is the odds ratio. In this analysis, the odds ratio estimates the likelihood of a high HPI classification for cases with high SOC ANX symptoms. An odds ratio = 1, signifies no effect or a 50% probability; that is, a high or low HPI classification is equally likely among cases with high SOC ANX symptoms. If the ratio is greater than 1 or 50% probability, the odds for the predicted outcome (i.e., high HPI among high SOC ANX cases) are higher; if less than 1 or 50%, the odds are lower. An odds ratio ≥4 is a strong effect size. In this sample, there is strong evidence for the odds of the predicted outcome. That is, cases with a high level of SOC ANX symptoms are 18.8 times (95% CI 15.2, 23.3) more likely to be classified as high HPI. Note that the odds ratio = 1 (i.e., no effect) does not appear in the confidence interval. The probability of this odds ratio = odd/1+odds = 18.8/19.8= 95%. Therefore, the probability of the predicted outcome is 95%.

PREVALENCE of Social Anxiety Symptoms: Relative to the total sample of N=2244 cases, n=1047 cases reported at least two social anxiety symptoms, regardless of HPI membership. Therefore, the prevalence rate for 2 or more social anxiety symptoms is 1047/2244= 47%[9], which is consistent with previous study findings for Major Depressive Disorder prevalence (48%) in this sample.[10]

To quantify the "predictive" characteristics of the HPI for social anxiety, the sensitivity and specificity rates were computed. In addition, to assess the HPI's clinical relevance, the positive (PPV) and negative (NPV) predictive values as well as the likelihood ratios were computed.

SENSITIVITY: Respondents classified as high HPI with high levels of SOC ANX 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 SOC ANX symptoms as being high priority. Of those respondents who reported low SOC ANX 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 SOC ANX symptom frequency and predicted high HPI. Although false negatives are counterintuitive, a high HPI classification can occur among respondents who report one or fewer SOC ANX 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 value, the number of "true positive" cases (n=876) is divided by the total number of respondents with 2 or more SOC ANX symptoms (n=1047). For

[9] See Figure 5.

[10] An Evaluation of the HCU Priority Index (HPI) and Major Depressive Disorder Subscale Among Adolescents: Establishing Reliability and Predictive Validity Criteria (December, 2021), Work-in-Progress Research Series (1).

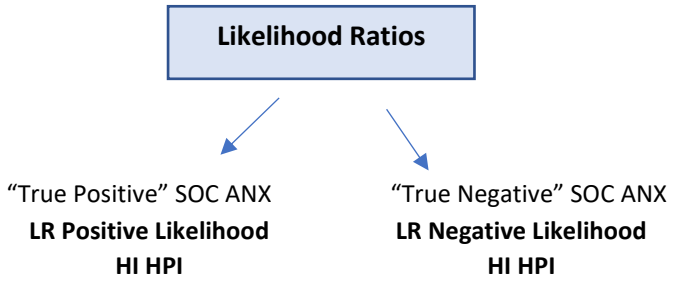
this sample the PPV= 876/1047=84%. This value corresponds to a moderate to strong **Positive Predictive Value (PPV)**. That is, among "true positive" cases, there is an 84% probability that respondents may require follow-up services for social anxiety symptoms.

SPECIFICITY: In this analysis, specificity refers to the HPI's rate of accuracy in predicting "true negative" cases (i.e., Low HPI & Low SOC ANX). To compute specificity, the number of "true negative" cases (n=941) is divided by the total number of cases identified by the HPI as low priority (n=1112). For this sample, the specificity rate is 941/1112=85%. That is, the HPI accurately "predicted" 85% of the cases with a low number of reported SOC ANX symptoms as being low priority. Of those respondents who reported high SOC ANX symptoms (n=171), the HPI falsely identified 15% as low priority cases (171/1112 =15 %). These cases are referred to as "false positives" due to their high frequency of SOC ANX symptoms and predicted low HPI. In this scenario, respondents may have endorsed two or more non-critical SOC ANX 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 probability, the number of "true negative" cases (n=941) is divided by the total number of respondents in the low SOC ANX group (n=1197). For this sample the NPV= 941/1197= 79%. This value corresponds to a moderate to strong **Negative Predictive Value (NPV**). That is, among "true negative" cases, there is a 79% probability that their reported symptoms do not meet the risk threshold for intervention.

Positive and Negative Likelihood Risk (LR) Ratios: Unlike Predictive Values (PPV & NPV), which estimate clinical relevance relative to the total sample of high vs low SOC ANX symptom cases, Likelihood Risk Ratios (Positive and Negative) provide a measure of discrimination between SOC ANX subgroups by HPI risk level. Essentially, a Positive LR tells us the probability of SOC ANX "true positive" cases being classified as high HPI when compared to "true negative" cases. Similarly, a Negative LR provides an estimate of how likely SOC ANX "true negative" cases will be classified in the high HPI group. Therefore, the LRs provide an estimate of how well the high HPI level can differentiate between SOC ANX "true positive" vs "true negative" cases (Figure 6).

Figure 6. Differentiating "true positive" versus "true negative" Social Anxiety cases



The suggested cutoff LR values ≥ 5 or ≤ 0.2 can be applied to the observed likelihood probabilities.[11] An LR close to "1" suggests that the HPI's performance is not useful for categorizing "true positive" vs "true negative" SOC ANX subgroups. An LR >1 would show an increase in the probability of being in the high

[11] https://www.slideshare.net/AbinoDavid/predictive-value-and-likelihood-ratio

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-.85 = 4.8 (95% CI 4.18, 5.54). Cases classified as "true positive" (high HPI, high SOC ANX) are almost 5 times as likely to be in the high HPI risk group. The probability of this odds ratio = odd/1+odds = 4.8/5.8= 83%. Therefore, the probability of the predicted "true positive" outcome is 83%.

Negative LR Ratio = 1-Sensitivity/Specificity =1-.77/ .85 = .27 (95% CI .23, 29). Cases classified as "true negative" (low HPI, low SOC ANX) are approximately one-fourth as likely to be in the high HPI risk group. The probability of the predicted outcome is odd/1+odds = .27/1.27= 21%, which is substantially lower than 50%.

LR Interpretation: The positive and negative LR odds (4.8 vs 0.27) and probabilities (83% vs 21%) indicate strong discrimination between "true positive" vs "true negative" SOC ANX subgroups for the predicted high HPI classification. Moreover, the confidence interval values obtained fall within the recommended cutoff LR values of ≥ 5 and ≤ 0.2.

Table 15. HPI Predictive Validity Estimates for Social Anxiety Total Sample (N=2244)

Prevalence of High SOC ANX Symptoms	Odds Probability	Sensitivity	Positive Predictive Value (PPV)	Specificity	Negative Predictive Value (NPV)	Positive Likelihood Probability	Negative Likelihood Probability
47%	95%	77%	84%	85%	79%	83%	21%

SOCIAL ANXIETY SEVERITY: Duration, Impact, and Physical Symptoms: Social anxiety duration was measured using four variables coded as YES (1) or NO (0): ≤10 min, several hours, several weeks, or several months. The impact on daily functioning included three variables with the same binary coding: interferes daily; 2-3 days per week, and once a week. For the purposes of this analysis, responses for each of the duration variables were summed. The same procedure was followed for the impact variables. The cut-off for a high level of duration responses was set at several hours or more. The impact cut-off was set at symptoms occurring at least once a week. The total number of possible anxiety-related physical symptoms ranged from 1 to 8. The cutoff for assessing severity of physical symptoms was set at 2 or more complaints. Table 16 summarizes the severity results. As expected, cases in the high SOC ANX and high HPI group had the highest levels of duration, impact, and number of anxiety-related physical symptoms. The True Negative and False Negative cases had very low duration and impact levels with no reported complaints of physical symptoms.

Table 16. Duration, Impact, and % Frequency of Social Anxiety Symptoms (N=2244)

	True Positive Hi SOC ANX Hi HPI (n=876)	False Positive Hi SOC ANX Lo HPI (n=171)	True Negative Lo SOC ANX Lo HPI (n=941)	False Negative Lo SOC ANX Hi HPI (n=256)
% Duration ≥ several hrs	30%	3%	0.1%	0%
% Impact ≥ once a week	86%	46%	2%	1.2%
% Frequency Physical Symptoms >2	52%	17.5%	0%	0%

TABLE 17. SOCIAL ANXIETY AND HPI PREDICTIVE VALIDITY: FEMALE SAMPLE (n=1150)

	Predicted HPI Classification		
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**
Observed High SOC ANX Total Symptoms (2-17)	True Positive 624	False Positive 96	720
Observed Low SOC ANX Total Symptoms (0-1)	False Negative 105	True Negative 325	430
	High HPI Total 729	Low HPI Total 421	N= 1150

CHI-SQ TEST OF INDEPENDENCE: For the female sample (n=1150), results confirmed a significant association between the "Low vs High" SOC ANX symptoms and the HPI (CHI Sq (1) = 450, p<.001) with a strong effect size (Phi coefficient =0.63). In this sample, there is strong evidence for the odds of the predicted outcome. That is, cases with a high level of SOC ANX symptoms are 20 times (95% CI 14.8, 27.4) more likely to be classified as high HPI. Note that the odds ratio = 1 (i.e., no effect) does not appear in the confidence interval. The probability of this odds ratio = odd/1+odds = 20/21= 95%. Therefore, the probability of the predicted outcome is 95%.

PREVALENCE of Social Anxiety Symptoms: Relative to the total female sample of N=1150 cases, n=720 cases reported at least two anxiety symptoms, regardless of HPI classification. Therefore, the prevalence rate for social anxiety symptoms is 720/1150= 63%[12], which is consistent with previous study findings for Major Depressive Disorder prevalence for this sample.[13]

- SENSITIVITY: 624/729 = 86% ("true positive" rate): The HPI accurately classified or "predicted" 86% of the female cases with a high number of reported SOC ANX symptoms as being high HPI.
- PPV: 624/720=87% (strong clinical relevance): Among "true positive" cases, there is an 87% probability that respondents may require follow-up services for SOC ANX symptoms.
- SPECIFICITY: 325/421 = 77% ("true negative" rate): The HPI accurately "predicted" 77% of the cases with a low number of reported SOC ANX symptoms as being low priority.
- NPV: 325/430=76% (moderate clinical relevance): Among "true negative" cases, there is a 76% probability that their reported symptoms do not meet the intervention threshold.
- Positive Likelihood Ratio: 5.7 odds (95% CI 4.7,6.9) signify an 85% probability of "true positive" cases being classified as high HPI.
- Negative Likelihood Ratio: .28 odds (95% CI .24,.33) signify a 22% probability of "true negative" cases being classified as high HPI.

[12] See Figure 5.

[13] An Evaluation of the HCU Priority Index (HPI) and Major Depressive Disorder Subscale Among Adolescents: Establishing Reliability and Predictive Validity Criteria (December, 2021), Work-in-Progress Research Series (1).

TABLE 18. SOCIAL ANXIETY AND HPI PREDICTIVE VALIDITY MALE SAMPLE (n=1094)

	Predicted HPI Classification		
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**
Observed High SOC ANX Total Symptoms (2-17)	True Positive 252	False Positive 75	327
Observed Low SOC ANX Total Symptoms (0-1)	False Negative 151	True Negative 616	767
	High HPI Total 403	Low HPI Total 691	N= 1094

CHI-SQ TEST OF INDEPENDENCE: For the male sample (n=1094), results confirmed a significant association between the "Low vs High" SOC ANX symptoms and the HPI (CHI Sq (1) = 324, p<.001) with a strong effect size (Phi coefficient= 0.55). In this sample, there is strong evidence for the odds of the predicted outcome. That is, cases with a high level of SOC ANX symptoms are 13.7 times (95% CI 10.02, 18.8) more likely to be classified as high HPI. Note that the odds ratio = 1 (i.e., no effect) does not appear in the confidence interval. The probability of this odds ratio = odd/1+odds = 13.7/14.7= 93%. Therefore, the probability of the predicted outcome is 93%.

PREVALENCE of Social Anxiety Symptoms: Relative to the total male sample of N=1094 cases, n=327 cases reported two or more social anxiety symptoms, regardless of HPI classification. Therefore, the prevalence rate for social anxiety symptoms is 327/1094= 30%[14], which is markedly lower than the 63% prevalence rate for females.

- SENSITIVITY: 252/403= 63% ("true positive" rate): The HPI accurately classified or "predicted" 63% of the male cases with a high number of reported SOC ANX symptoms as being high HPI.
- PPV: 252/327=77% (moderate clinical relevance): Among "true positive" cases, there is a 77% probability that respondents may require follow-up services for SOC ANX symptoms.
- SPECIFICITY: 616/691 = 89% ("true negative" rate): The HPI accurately "predicted" 89% of the cases with a low number of reported SOC ANX symptoms as being low priority.
- NPV: 616/767= 80% (moderate clinical relevance): Among "true negative" cases, there is an 80% probability that their reported symptoms do not meet the intervention threshold.
- Positive Likelihood Ratio: 3.5 odds (95% CI 2.9, 4.3) signify a 78% probability of "true positive" cases being classified as high HPI.
- Negative Likelihood Ratio: .26 odds (95% CI .22, .30) signify a 21% probability of "true negative" cases being classified as high HPI.

[14] See Figure 5.

Table 19. HPI Predictive Validity Estimates for Social Anxiety Total Sample (N=2244) and Gender

	Prevalence of High SOC ANX Symptoms	Odds Probability	Sensitivity	Positive Predictive Value (PPV)	Specificity	Negative Predictive Value (NPV)	Positive Likelihood Probability	Negative Likelihood Probability
N=2244	47%	95%	77%	84%	85%	79%	83%	21%
Female	63%	95%	86%	87%	77%	76%	85%	22%
Male	30%	93%	63%	77%	89%	80%	78%	21%

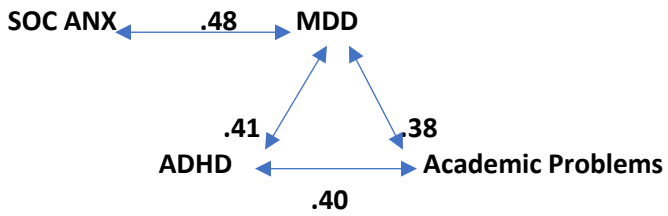
Severity comparisons showed marked differences for number of anxiety-related physical symptoms between females and males (59% v 33%, respectively). As expected, severity differed by HPI and symptom levels (Table 20).

TABLE 20. Duration, Impact, and % Frequency of Social Anxiety Symptoms by Gender

	True Positive Hi SOC ANX Hi HPI		False Positive Hi SOC ANX Lo HPI		True Negative Lo SOC ANX Lo HPI		False Negative Lo SOC ANX Hi HPI	
	Female (n=624)	Male (n=252)	Female (n=96)	Male (n=75)	Female (n=325)	Male (n=616)	Female (n=105)	Male (n=151)
% Duration ≥ several hours	32%	27%	4.2%	1.3%	0%	0.2%	0%	0%
% Impact ≥ once a week	87%	83%	40%	55%	1.5%	2.3%	1%	1.3%
% Physical Symptoms >2	59%	33%	5.3%	2.7%	0%	0%	0%	0%

CORRELATIONS FOR SOCIAL ANXIETY, MDD, ADHD, and ACADEMIC PROBLEMS: A description of the MDD, ADHD, and academic problems scales can be found in Addendum 2. Correlation coefficients were compared for the "true positive" versus "true negative" samples. A moderate correlation cutoff of r=0.35 was used to reduce the data to moderate and strong relationships. Figure 7 Illustrates the correlational structure for **"TRUE POSITIVE"** cases (n=876). The graph shows that two interconnected clusters emerged. The first is between Social Anxiety and MDD (r=0.48), and the second is between MDD and ADHD (r=0.41) as well as academic problems and MDD (r=0.38). ADHD and academic problems were also correlated (r=0.40). A similar structure emerged for "true positive" cases by gender.

Figure 7. CORRELATIONS FOR TRUE POSITIVE SOCIAL ANXIETY CASES (n= 876)



Among **"TRUE NEGATIVE"** cases (n= 941), there were one moderate correlation between social anxiety and academic problems (r=0.46). There was a weak correlation between social anxiety and MDD (r=0.21). There was no difference by gender.

The two correlational configurations demonstrate that a combination of HPI level and disorder symptoms may yield better predictive models than HPI or symptom counts alone. For example, among "true positive" cases, the relationship between social anxiety and academic problems may be mediated by depression and behavioral problems, regardless of gender. This would be an interesting model to test further, especially since males typically report significantly fewer depression and social anxiety symptoms than females.

RESULTS PART II: GENERALIZED ANXIETY DISORDER (GAD)

TABLE 21. GAD AND HPI PREDICTIVE VALIDITY (N=2244)

	Predicted HPI Classification		
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**
Observed High GAD Total Symptoms (2-11)	True Positive 830	False Positive 97	927
Observed Low GAD Total Symptoms (0-1)	False Negative 302	True Negative 1015	1317
	High HPI Total 1132	Low HPI Total 1112	N= 2244

CHI-SQ TEST OF INDEPENDENCE: For the total sample (N=2244), results confirmed a significant association between the "Low vs High" GAD symptoms and the HPI (CHI Sq (1) = 965.5, p<.001) with a strong effect size (Phi coefficient =0.66). In this sample, there is strong evidence for the odds of the predicted outcome. That is, cases with a high level of GAD symptoms are 29 times (95% CI 22.5, 36.8) more likely to be classified as high HPI. Note that the odds ratio = 1 (i.e., no effect) does not appear in the confidence interval. The probability of this odds ratio = odd/1+odds = 29/30= 97%. Therefore, the probability of the predicted outcome is 97%.

PREVALENCE of GAD Symptoms: Relative to the total sample of N=2244 cases, n=927 cases, reported two or more GAD symptoms, regardless of HPI classification. Therefore, the prevalence rate for GAD symptoms is 927/2244= 41%[15].

- SENSITIVITY: 830/1132 = 73% ("true positive" rate): The HPI accurately classified or "predicted" 73% of the female cases with a high number of reported GAD symptoms as being high HPI.
- PPV: 830/927 = 90% (strong clinical relevance): Among "true positive" cases, there is a 90% probability that respondents may require follow-up services for GAD symptoms.

[15] See Figure 5.

- SPECIFICITY: 1015/1112 = 91% ("true negative" rate): The HPI accurately "predicted" 91% of the cases with a low number of reported GAD symptoms as being low priority.
- NPV: 1015/1317 = 77% (moderate clinical relevance): Among "true negative" cases, there is a 77% probability that their reported symptoms do not meet the intervention threshold.
- Positive Likelihood Ratio: 7.4 odds (95% CI 6.1, 8.9) signify an 88% probability of "true positive" cases being classified as high HPI.
- Negative Likelihood Ratio: .26 odds (95% CI .23, .28) signify a 21% probability of "true negative" cases being classified as high HPI.

Table 22. HPI Predictive Validity Estimates for GAD Total Sample (N=2244)

Prevalence of High GAD Symptoms	Odds Probability	Sensitivity	Positive Predictive Value (PPV)	Specificity	Negative Predictive Value (NPV)	Positive Likelihood Probability	Negative Likelihood Probability
41%	97%	73%	90%	91%	77%	88%	21%

GAD SEVERITY: Duration, Impact, and Physical Symptoms: GAD duration was measured using four variables coded as YES (1) or NO (0): ≤10 min, several hours, several weeks, or several months. The impact on daily functioning included three variables with the same binary coding: interferes daily; 2-3 days per week, and once a week. Based on the HCU algorithm requirements for severity, the cut-off for high GAD level of duration responses was set at "several weeks or more."[16] The impact cut-off was set at symptoms occurring "at least 2-3 days per week."[17] The total number of possible anxiety-related physical symptoms ranged from 1 to 8. The cutoff for assessing severity of physical symptoms was set at 2 or more complaints. Table 23 summarizes the GAD severity results. As expected, cases in the high GAD and high HPI group had the highest levels of duration, impact, and number of anxiety-related physical symptoms. The True Negative and False Negative cases had very low duration and impact levels with no reported complaints of physical symptoms.

TABLE 23. Duration, Impact, and % Frequency of GAD Symptoms (N=2244)

	True Positive Hi GAD Hi HPI (n=830)	False Positive Hi GAD Lo HPI (n=97)	True Negative Lo GAD Lo HPI (n=1015)	False Negative Lo GAD Hi HPI (n=302)
% Duration ≥ several weeks	4.3%	0%	0%	0%
% Impact ≥ 2-3 days per week	51%	13.4%	.4%	2.3%
% Physical Symptoms >2	54%	14%	0%	0%

[16] SOC ANX duration cutoff = "several hours or more" versus GAD duration cutoff = "at least several weeks or more."
[17] SOC ANX impact cutoff = "at least once a week" versus GAD impact cutoff = "at least 2-3 days per week."

TABLE 24. GAD AND HPI PREDICTIVE VALIDITY FEMALE SAMPLE (n=1150)

	Predicted HPI Classification		
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**
Observed High GAD Total Symptoms (2-11)	True Positive 579	False Positive 40	619
Observed Low GAD Total Symptoms (0-1)	False Negative 150	True Negative 381	531
	High HPI Total 729	Low HPI Total 421	N= 1150

CHI-SQ TEST OF INDEPENDENCE: For the female sample (n=1150), results confirmed a significant association between the "Low vs High" GAD symptoms and the HPI (CHI Sq (1) = 525, p<.001) with a strong effect size (Phi coefficient =0.68). In this sample, there is strong evidence for the odds of the predicted outcome. That is, cases with a high level of GAD symptoms are 37 times (95% CI 25.3, 53.4) more likely to be classified as high HPI. Note that the odds ratio = 1 (i.e., no effect) does not appear in the confidence interval. The probability of this odds ratio = odd/1+odds = 37/38= 97%. Therefore, the probability of the predicted outcome is 97%.

PREVALENCE of GAD Symptoms: Relative to the total female sample of N=1150 cases, n=619 cases reported two or more GAD symptoms, regardless of HPI classification. Therefore, the prevalence rate for GAD symptoms is 619/1150= 54%[18].

- SENSITIVITY: 579/729 = 79% ("true positive" rate): The HPI accurately classified or "predicted" 79% of the female cases with a high number of reported GAD symptoms as being high HPI.
- PPV: 579/619= 94% (strong clinical relevance): Among "true positive" cases, there is a 94% probability that respondents may require follow-up services for GAD symptoms.
- SPECIFICITY: 381/421 = 90% ("true negative" rate): The HPI accurately "predicted" 90% of the cases with a low number of reported GAD symptoms as being low priority.
- NPV: 381/531= 72% (moderate clinical relevance): Among "true negative" cases, there is a 72% probability that their reported symptoms do not meet the intervention threshold.
- Positive Likelihood Ratio: 11 odds (95% CI 8.2,15) signify an 92% probability of "true positive" cases being classified as high HPI.
- Negative Likelihood Ratio: .30 odds (95% CI .26,.35) signify a 23% probability of "true negative" cases being classified as high HPI.

[18] See Figure 5.

TABLE 25. GAD AND HPI PREDICTIVE VALIDITY MALE SAMPLE (n=1094)

	Predicted HPI Classification		
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**
Observed High GAD Total Symptoms (2-11)	True Positive 251	False Positive 97	308
Observed Low GAD Total Symptoms (0-1)	False Negative 152	True Negative 634	786
	High HPI Total 403	Low HPI Total 691	N= 1094

CHI-SQ TEST OF INDEPENDENCE: For the male sample (n=1094), results confirmed a significant association between the "Low vs High" GAD symptoms and the HPI (CHI Sq (1) = 367, p<.001) with a strong effect size (Phi coefficient= 0.58). In this sample, there is strong evidence for the odds of the predicted outcome. That is, cases with a high level of GAD symptoms are 18 times (95% CI 17.1, 25.7) more likely to be classified as high HPI. Note that the odds ratio = 1 (i.e., no effect) does not appear in the confidence interval. The probability of this odds ratio = odd/1+odds = 18/19= 95%. Therefore, the probability of the predicted outcome is 95%.

PREVALENCE of GAD Symptoms: Relative to the total male sample of N=1094 cases, n=308 cases reported two or more GAD symptoms, regardless of HPI classification. Therefore, the prevalence rate for GAD symptoms is 308/1094= 28%, which is markedly lower than the 54% prevalence rate for females[19].

- SENSITIVITY: 251/403= 62% ("true positive" rate): The HPI accurately classified or "predicted" 62% of the male cases with a high number of reported GAD symptoms as being high HPI.
- PPV: 251/308= 82% (moderate clinical relevance): Among "true positive" cases, there is an 82% probability that respondents may require follow-up services for GAD symptoms.
- SPECIFICITY: 634/691 = 92% ("true negative" rate): The HPI accurately "predicted" 92% of the cases with a low number of reported GAD symptoms as being low priority.
- NPV: 634/786= 81% (moderate clinical relevance): Among "true negative" cases, there is an 81% probability that their reported symptoms do not meet the intervention threshold.
- Positive Likelihood Ratio: 4.4 odds (95% CI 3.4, 5.5) signify an 81% probability of "true positive" cases being classified as high HPI.
- Negative Likelihood Ratio: .24 odds (95% CI .20, .28) signify a 19% probability of "true negative" cases being classified as high HPI.

[19] See Figure 5.

Table 26. HPI Predictive Validity Estimates for GAD Total Sample (N=2244) and Gender

	Prevalence of High GAD Symptoms	Odds Probability	Sensitivity	Positive Predictive Value (PPV)	Specificity	Negative Predictive Value (NPV)	Positive Likelihood Probability	Negative Likelihood Probability
N=2244	41%	97%	73%	90%	91%	77%	88%	21%
Female	54%	91%	79%	94%	90%	72%	92%	23%
Male	28%	95%	62%	82%	92%	81%	81%	19%

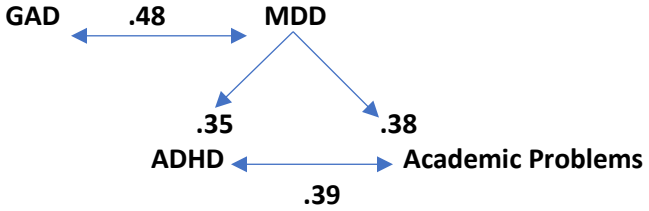
TABLE 27. Duration, Impact, and % Frequency of GAD Symptoms by Gender

	True Positive Hi GAD Hi HPI		False Positive Hi GAD Lo HPI		True Negative Lo GAD Lo HPI		False Negative Lo GAD Hi HPI	
	Female (n=579)	Male (n=251)	Female (n=40)	Male (n=57)	Female (n=421)	Male (n=634)	Female (n=150)	Male (n=152)
% Duration ≥ several weeks	5%	2.8%	0%	0%	0%	0%	0%	0%
% Impact ≥ 2-3 days per week	58%	34%	15%	12.3%	.5%	.3%	2.7%	2%
% Physical Symptoms >2	63%	33%	25%	7%	0%	0%	0%	0%

Severity comparisons by gender showed a marked difference between true and false positive females and males (63% v 33% and 25%v 7%, respectively) for number of physical symptoms and impact.

CORRELATIONS FOR GAD, MDD, ADHD, and ACADEMIC PROBLEMS: Correlation coefficients were compared for "true positive" versus "true negative" cases. A moderate correlation cutoff of r= 0.35 was used to reduce the data to moderate and strong relationships only. Figure 8 Illustrates the correlational structure for **"TRUE POSITIVE"** cases (n=830). This configuration, like social anxiety, shows two interconnected clusters. The first is between GAD and MDD (r=0.48), and the second is between MDD and ADHD (r=0.35) as well as academic problems (r=0.38). ADHD and academic problems were also correlated (r=0.39). A similar structure emerged for "true positive" cases by gender, with one exception being that females (n=579) had a moderate correlation between GAD and ADHD (r=0.40). For the "true positive" GAD and social anxiety cases, the correlations appear to be similar in magnitude.

Figure 8. CORRELATIONS FOR TRUE POSITIVE GAD CASES (n= 830)



Among **"TRUE NEGATIVE"** cases (n= 1015) a single strong correlation emerged centered around the GAD and ADHD (r=0.65) which suggests a greater relevancy of ADHD symptoms in this group.

RESULTS PART III: PANIC DISORDER

TABLE 28. PANIC DISORDER AND HPI PREDICTIVE VALIDITY (N=2244)

	Predicted HPI Classification		
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**
Observed High PA Total Symptoms (2-11)	True Positive 740	False Positive 73	813
Observed Low PA Total Symptoms (0-1)	False Negative 392	True Negative 1039	1431
	High HPI Total 1132	Low HPI Total 1112	N= 2244

CHI-SQ TEST OF INDEPENDENCE: For the total sample (N=2244), results confirmed a significant association between the "Low vs High" PA symptoms and the HPI (CHI Sq (1) = 840, p<.001) with a strong effect size (Phi coefficient =0.62). In this sample, there is strong evidence for the odds of the predicted outcome. That is, cases with a high level of PA symptoms are 30 times (95% CI 20.6, 35) more likely to be classified as high HPI. Note that the odds ratio = 1 (i.e., no effect) does not appear in the confidence interval. The probability of this odds ratio = odd/1+odds = 30/31= 97%. Therefore, the probability of the predicted outcome is 97%.

PREVALENCE of PA Symptoms: Relative to the total sample of N=2244 cases, n=813 cases reported two or more PA symptoms, regardless of HPI classification. Therefore, the prevalence rate for PA symptoms is 813/2244= 36%[20].

- SENSITIVITY: 740/1132 = 65% ("true positive" rate): The HPI accurately classified or "predicted" 65% of the female cases with a high number of reported PA symptoms as being high HPI.
- PPV: 740/813 = 91% (strong clinical relevance): Among "true positive" cases, there is a 91% probability that respondents may require follow-up services for GAD symptoms.
- SPECIFICITY: 1039/1112 = 92% ("true negative" rate): The HPI accurately "predicted" 92% of the cases with a low number of reported PA symptoms as being low priority.
- NPV: 1039/1431 = 73% (moderate clinical relevance): Among "true negative" cases, there is a 77% probability that their reported symptoms do not meet the intervention threshold.
- Positive Likelihood Ratio: 8.1 odds (95% CI 6.5, 10) signify an 88% probability of "true positive" cases being classified as high HPI.
- Negative Likelihood Ratio: .30 odds (95% CI .28, .33) signify a 23% probability of "true negative" cases being classified as high HPI.

[20] See Figure 5.

Table 29. HPI Predictive Validity Estimates for Panic Total Sample (N=2244)

Prevalence of High Panic Symptoms	Odds Probability	Sensitivity	Positive Predictive Value (PPV)	Specificity	Negative Predictive Value (NPV)	Positive Likelihood Probability	Negative Likelihood Probability
41%	97%	73%	90%	91%	77%	88%	21%

PANIC DISORDER (PA) SEVERITY: Duration, Impact, and Physical Symptoms: PA duration was measured using four variables coded as YES (1) or NO (0): ≤10 min, several hours, several weeks, or several months, with a duration of ≤10 minutes being a key feature. The impact on daily functioning included three variables with the same binary coding: interferes daily; 2-3 days per week, and once a week. Based on the HCU algorithm requirements for severity, the cut-off for high GAD level of duration responses was set at "several weeks or more."[21] The impact cut-off was set at symptoms occurring "at least 2-3 days per week."[22] The total number of possible anxiety-related physical symptoms ranged from 1 to 8. The cutoff for assessing severity of physical symptoms was set at 2 or more complaints. Table 30 summarizes the PA severity results. As expected, cases in the high GAD and high HPI group had the highest levels of duration, impact, and number of anxiety-related physical symptoms. The True Negative and False Negative cases had very low duration and impact levels with no reported complaints of physical symptoms.

TABLE 30. Duration, Impact, and % Frequency of PA Symptoms (N=2244)

	True Positive Hi PA Hi HPI (n=740)	False Positive Hi PA Lo HPI (n=73)	True Negative Lo PA Lo HPI (n=1039)	False Negative Lo PA Hi HPI (n=392)
% Duration ≤ 10 minutes	65%	93%	2.3%	2.3%
% Impact > 2-3 days per week	51%	13.4%	.4%	2.3%
% Physical Symptoms >2	54%	14%	0%	0%

TABLE 31. PANIC DISORDER AND HPI PREDICTIVE VALIDITY FEMALE SAMPLE (n=1150)

	Predicted HPI Classification		
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**
Observed High PA Total Symptoms (2-11)	True Positive 539	False Positive 33	572
Observed Low PA Total Symptoms (0-1)	False Negative 190	True Negative 388	578
	High HPI Total 729	Low HPI Total 421	N= 1150

[21] SOC ANX duration cutoff = "several hours or more" versus GAD duration cutoff = "at least several weeks or more."
[22] SOC ANX impact cutoff = "at least once a week" versus GAD impact cutoff = "at least 2-3 days per week."

CHI-SQ TEST OF INDEPENDENCE: For the female sample (n=1150), results confirmed a significant association between the "Low vs High" PA symptoms and the HPI (CHI Sq (1) = 466, p<.001) with a strong effect size (Phi coefficient =0.64). In this sample, there is strong evidence for the odds of the predicted outcome. That is, cases with a high level of PA symptoms are 33 times (95% CI 22.5, 49.4) more likely to be classified as high HPI. Note that the odds ratio = 1 (i.e., no effect) does not appear in the confidence interval. The probability of this odds ratio = odd/1+odds = 33/34= 97%. Therefore, the probability of the predicted outcome is 97%.

PREVALENCE of PA Symptoms: Relative to the total female sample of N=1150 cases, n=572 cases reported two or more PA symptoms, regardless of HPI classification. Therefore, the prevalence rate for PA symptoms is 572/1150= 49.7%.

- SENSITIVITY: 539/729 = 74% ("true positive" rate): The HPI accurately classified or "predicted" 74% of the female cases with a high number of reported PA symptoms as being high HPI.
- PPV: 539/572= 94% (strong clinical relevance): Among "true positive" cases, there is a 94% probability that respondents may require follow-up services for PA symptoms.
- SPECIFICITY: 388/421 = 92% ("true negative" rate): The HPI accurately "predicted" 92% of the cases with a low number of reported PA symptoms as being low priority.
- NPV: 388/578= 67% (moderate clinical relevance): Among "true negative" cases, there is a 67% probability that their reported symptoms do not meet the intervention threshold.
- Positive Likelihood Ratio: 11.6 odds (95% CI 8.3,16.3) signify an 92% probability of "true positive" cases being classified as high HPI.
- Negative Likelihood Ratio: .35 odds (95% CI .31,.39) signify a 26% probability of "true negative" cases being classified as high HPI.

TABLE 32. PANIC DISORDER AND HPI PREDICTIVE VALIDITY MALE SAMPLE (n=1094)

	Predicted HPI Classification		
	High HPI Group (3-7)	**Low HPI Group (1-2)**	**TOTAL**
Observed High PA Total Symptoms (2-11)	True Positive 201	False Positive 40	241
Observed Low PA Total Symptoms (0-1)	False Negative 202	True Negative 651	853
	High HPI Total 403	Low HPI Total 691	N= 1094

CHI-SQ TEST OF INDEPENDENCE: For the male sample (n=1094), results confirmed a significant association between the "Low vs High" PA symptoms and the HPI (CHI Sq (1) = 288, p<.001) with a strong effect size (Phi coefficient= 0.51). In this sample, there is strong evidence for the odds of the

predicted outcome. That is, cases with a high level of PA symptoms are 16 times (95% CI 11, 23.5) more likely to be classified as high HPI. Note that the odds ratio = 1 (i.e., no effect) does not appear in the confidence interval. The probability of this odds ratio = odd/1+odds = 16/17= 94%. Therefore, the probability of the predicted outcome is 94%.

PREVALENCE of PA Symptoms: Relative to the total male sample of N=1094 cases, n=241 cases reported two or more PA symptoms, regardless of HPI classification. Therefore, the prevalence rate for PA symptoms is 241/1094= 22%, which is markedly lower than the 49.7% prevalence rate for females.

- SENSITIVITY: 201/403= 49.9% ("true positive" rate): The HPI accurately classified or "predicted" 49.9% of the male cases with a high number of reported PA symptoms as being high HPI.
- PPV: 201/241= 83% (moderate clinical relevance): Among "true positive" cases, there is an 83% probability that respondents may require follow-up services for PA symptoms.
- SPECIFICITY: 651/691 = 94% ("true negative" rate): The HPI accurately "predicted" 94% of the cases with a low number of reported PA symptoms as being low priority.
- NPV: 651/853= 76% (moderate clinical relevance): Among "true negative" cases, there is a 76% probability that their reported symptoms do not meet the intervention threshold.
- Positive Likelihood Ratio: 4.6 odds (95% CI 3.5, 6.1) signify an 82% probability of "true positive" cases being classified as high HPI.
- Negative Likelihood Ratio: .28 odds (95% CI .25, .32) signify a 22% probability of "true negative" cases being classified as high HPI.

Table 33. HPI Predictive Validity Estimates for Panic Total Sample (N=2244) and Gender

	Prevalence of High PA Symptoms	Odds Probability	Sensitivity	Positive Predictive Value (PPV)	Specificity	Negative Predictive Value (NPV)	Positive Likelihood Probability	Negative Likelihood Probability
N=2244	36%	97%	65%	91%	92%	773%	88%	23%
Female	49.7%	97%	74%	94%	92%	67%	92%	26%
Male	22%	94%	50%	83%	94%	76%	82%	22%

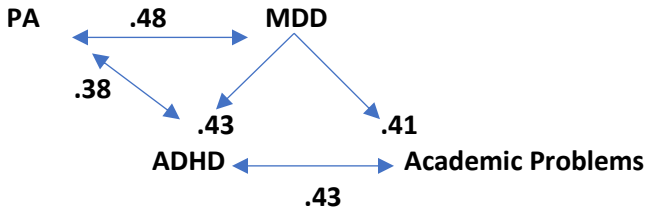
TABLE 34. Comparison of Duration, Impact, and % Frequency of Panic Symptoms by Gender

	True Positive Hi PA Hi HPI		False Positive Hi PA Lo HPI		True Negative Lo PA Lo HPI		False Negative Lo PA Hi HPI	
	Female (n=539)	Male (n=201)	Female (n=33)	Male (n=40)	Female (n=388)	Male (n=651)	Female (n=190)	Male (n=202)
% Duration ≤10 minutes	63.4%	68%	91%	95%	2.3%	2.3%	2%	3%
% Impact At least 2-3 days per week	63%	43%	24%	18%	0%	0%	1%	.5%
% Frequency Physical Symptoms >2	68%	42%	30%	5%	0%	.3	0%	0%

The severity measures for PA indicate that females identified as “true positive” cases have the highest levels of physical symptoms. Regarding symptom duration, a higher percentage of cases classified as “true” or “false” positive indicated the duration of their symptoms to be 10 minutes or less. The high endorsement of this duration level among “false positive” cases (high PA symptoms but low HPI) was not sufficient to categorize them as “true positives.”

CORRELATIONS FOR PA, MDD, ADHD, and ACADEMIC PROBLEMS: Correlation coefficients were compared for the “true positive” and “true negative samples. A moderate correlation cutoff of r=0.35 was used to reduce the data to moderate and strong relationships. Figure 9 Illustrates the correlational structure for **“TRUE POSITIVE”** cases (n=740). This configuration shows one interconnected cluster between PA and MDD (r=0.48), PA and ADHD (r=0.38), MDD and ADHD (r=0.43), academic problems and MDD (r=0.41), and ADHD and academic problems (r=0.43). There were no gender differences among “true positive” cases.

Figure 9. CORRELATIONS FOR TRUE POSITIVE PA CASES (n= 740)



Among **“TRUE NEGATIVE”** cases (n= 1039) there were no significant correlations equal to or greater than the r=0.35 cutoff. There we no gender differences. Although these correlations do not definitively determine the relationships among these variables, they suggest the relevancy of ADHD and MDD in the identification of cases at risk for panic disorder. Additional diagnostic indices may be needed to clarify the differences between these groups.

RESULTS PART IV: "True Positive" Prevalence Rates Across Anxiety Scales

Figure 10 demonstrates the prevalence rate of symptoms among "true positive" cases across the three anxiety scales varies. That is, although a third of the total sample reported 2 or more anxiety and were classified as High HPI, the moderating effect of gender appears to be strong across the three types of anxiety. Half of the female sample versus a third of males reported 2 or more symptoms and were identified by the HPI as being high priority. Exploring the moderating effects of age and other key demographic factors may help to clarify further the "true positive" profiles for anxiety.

Figure 10. "True Positive" Prevalence Rates for Social Anxiety, GAD, and PA

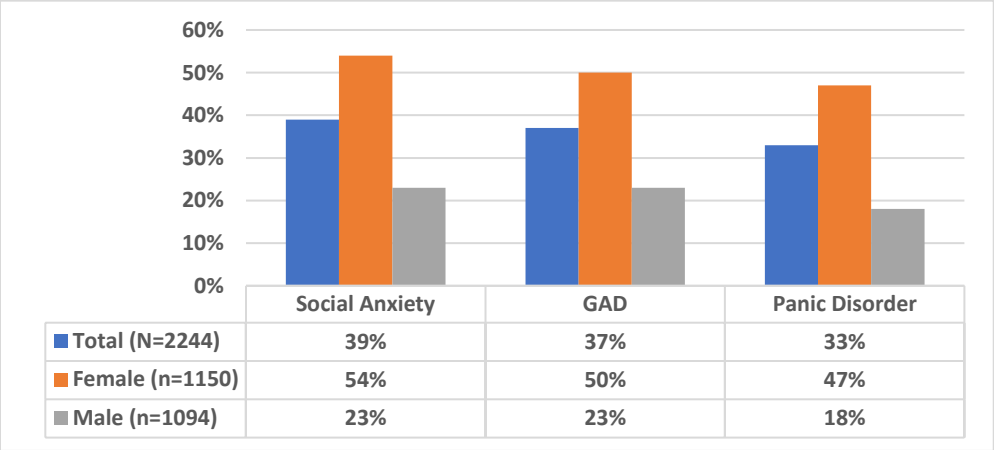


Table 35 shows the prevalence rate computations for the "true positive" cases (High Symptom, High HPI) by sample size:

Table 35. Prevalence Rate Computations for "True Positive" Cases Across Anxiety Scales

	Social Anxiety	GAD	Panic
Total Sample (N=2244)	876/2244=39%	830/2244=37%	740/2244=33%
Female (n=1150)	624/1150=54%	579/1150=50%	539/1150=47%
Male (n=1094)	252/1094=23%	251/1094=23%	201/1094=18%

RESULTS PART V: HCU Repeated School Data YR2020 and YR2021

Figure 11 is based on prevalence rates for a sample of students (N=890) who participated in two consecutive screenings, one in May, 2020 and the other in December, 2021. This graph demonstrates that the prevalence rate among cases with "high" (two or more) symptoms for each anxiety diagnostic category and high HPI, varies by year and gender. Overall, the prevalence among females is higher than males across the three anxiety scales, with an uptick from YR2020 to YR2021. Among males, prevalence rates hover around 20% across the anxiety scales. However, an increase in social anxiety is evident from YR2020 to YR2021 (19% v 32%, respectively). The increase in social anxiety represents a change of 68% among males. These timepoints are relevant because the first screening coincides with the beginning of the COVID-19 pandemic in the U.S. By the second screening students had already experienced school closures and other disruptions due to the pandemic. Unfortunately, causal inferences regarding the negative effects of the pandemic on anxiety prevalence rates among students in this sample remain speculative.

Figure 11. Anxiety "True Positive" Prevalence Rates for REPE Sample (n=890) by Gender & Year

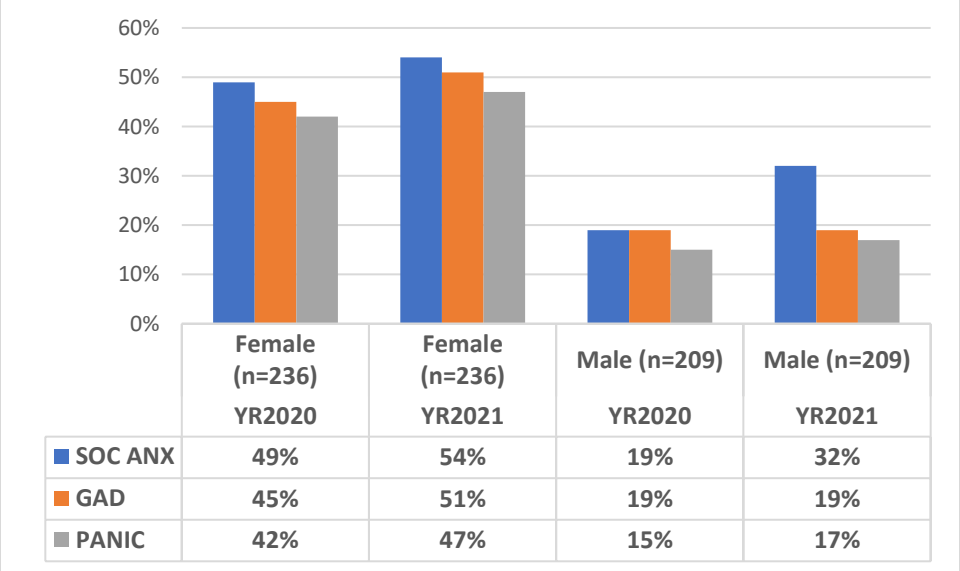


Table 36. Prevalence Rate Computations for "True Positive" REPE Cases by Gender & Year

Total (N= 890)	Female YR2020 (n=236)	Female YR2021 (n=236)	Male YR2020 (n=209)	Male YR2021 (n=209)
SOCIAL ANXIETY	115/236=49%	128/236=54%	40/209=19%	67/209=32%
GAD	107/236=45%	122/236=51%	39/209=19%	40/209=19%
PANIC	99/236=42%	112/236=47%	31/209=15%	36/209=17%

CONCLUSION

As a new generation on-line screening system for the early detection of psychological and behavioral problems among adolescents, the Heads Up Checkup (HCU) appears to be efficacious in identifying low versus high risk levels of social anxiety, generalized anxiety disorder, and panic disorder. For establishing the predictive validity for each diagnostic category, the strategy for differentiating risk status involves group classification by number of self-reported symptoms in conjunction with a priority index (HPI) or percent diagnostic criteria met. As an initial step, based on a total sample (N=2244) of middle-and high school students from Orange County, CA, strong reliability for the social anxiety, generalized anxiety disorder, and panic disorder scales was established. In the next phase, the predictive validity analyses for each of the anxiety scales yielded sensitivity, specificity, positive and negative predictive values in the moderate to high range. In addition, the Likelihood Ratios suggest that the odds for discriminating between "true positive" versus "true negative" cases when predicting to high HPI met acceptable criteria. Not surprisingly, the prevalence rates for high symptoms were similar across the different forms of anxiety, with social anxiety being slightly higher, especially among females.

Effect sizes were estimated using odds ratios for the prediction of high priority cases. These estimates were strong and provided additional evidence for the clinical relevance of the HCU screen. Moreover, severity data (i.e., duration of symptoms and impact on daily living), were found to be consistent with the "predicted" HPI risk subgroups. Data regarding the prevalence of anxiety symptoms among adolescents in this sample, and especially among females, also suggest that the HCU screen can generate findings that are consistent with published statewide and national survey results on adolescent mental health. Furthermore, the repeated middle school data for YR2020 and YR2021 indicate that the HCU screen may be able to detect changes over time in the prevalence rate of anxiety symptoms among females and males.

Additional validity analyses to examine the convergence among the HCU anxiety scales and other diagnostic measures of depression, suicidal ideation, attention deficit disorders as well as academic and behavioral problems, are needed to determine the mediating effects of these variables in differentiating among specific forms of anxiety. In addition, understanding how various HPI risk scenarios differ by risk factors, including negative early childhood experiences, alcohol and/or drug abuse, social stressors, low social support, coping capacity, sexual orientation, and social media influences may inform efforts for appropriate therapeutic interventions and support resources. Moreover, demographic data will also provide information regarding the effects that age, race, ethnicity & language preference, and family socioeconomic status may have on risk profiles and behavioral outcomes. 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 screen.

The correlational configurations which emerged among "true positive" cases, point to promising future multivariate research directions. For example, what is the significance of the comorbidity between various anxiety disorders and depression? Is the relationship between anxiety and depression likely to result in more adverse outcomes than each of these disorders alone? How would psychological risk factors, such as alcohol and/or drug abuse, and key demographic variables impact diagnostic comorbidities? Delving into these questions may provide more evidence-based and compelling arguments for the utility of the HCU as an early detection system for psychological problems among adolescents.

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Appendix 1: Mental Health Informed 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 mental health consent details, please see the National Center for Youth Law's California Minor Consent and Confidentiality Laws grid (Family Code §6924 and Health & Safety Code §124260).[23] 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.

[23] © 2014 National Center for Youth Law, revised: Oct. 2014. Available at www.teenhealthlaw.org.

- 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: HCU Items and Reliability for MDD & ADHD and List of Academic Problems

Table 1. HCU-MDD Symptom Items (Cronbach alpha =.74, strong)

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.
11	(v627) Within the past few weeks, I have had thoughts about killing myself.

Table 2. HCU-ADHD Items (Cronbach alpha =.90, strong)

1	(v652) I'm easily distracted.
2	(v653) I have a hard time sticking with an activity or task to the end.
3	(v654) I avoid tasks where I must concentrate, like homework or studying.
4	(v655) I have trouble staying organized.
5	(v656) I'm always losing things.
6	(v611) I have trouble concentrating or staying focused.

Table 3. HCU- Selected List of Common Academic Problems

1	(v595) I have always struggled with certain subjects in school.
2	(v596) I haven't always struggled with grades but I'm struggling now.
3	(v597) Reading and/or writing is a challenge for me.
4	(v598) Math is the most difficult subject for me.
5	(v600) I don't like being called on in class or talking in front of others.
6	(v628) I have trouble remembering things.