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Research paper

Which symptoms of depression and anxiety are most strongly associated with happiness? A network analysis of Indian and Kenyan adolescents

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ABSTRACT

Background: Network analyzes have been applied to understand the relationships between individual symptoms of depression and anxiety. However, little is known about which symptoms are most strongly associated with "positive" indicators of mental health, such as happiness. Furthermore, few studies have examined symptom networks in participants from low- and middle-income countries.

Methods: To address these gaps, we applied network analyzes in a sample of Indian adolescents (Study 1; n=1080) and replicated these analyzes in a pre-registered study with Kenyan adolescents (Study 2; n=2176). Participants from both samples completed the same measures of depressive symptoms, anxiety symptoms, and happiness.

Results: Feeling sad and feeling like a failure had the strongest (negative) associations with happiness items. These two symptoms, as well as worrying and feeling nervous, had the strongest associations with other symptoms of depression and anxiety. Symptoms of depression and anxiety formed a single cluster, which was distinct from a cluster of happiness items. Main findings were consistent across the two samples, suggesting a cross-culturally robust pattern.

Limitations: We used cross-sectional data, and we administered scales assessing a limited subset of symptoms and happiness items.

Conclusions: Our findings support the idea that some symptoms of depression and anxiety are more strongly associated with happiness. These findings contribute to a body of literature emphasizing the advantages of symptom-level analyzes. We discuss how efforts to understand associations between individual symptoms and "positive" mental health indicators, like happiness, could have theoretical and practical implications for clinical psychological science.

1. Introduction

Depression and anxiety are leading causes of disability worldwide (Ferrari et al., 2013; Vigo et al., 2016), and their burden is especially strong among adolescents in low-and middle-income countries (Patel at al., 2007). There is a growing need to better understand these conditions, especially among understudied populations. Furthermore, the World Health Organization has stated that "Mental health is more than just the absence of mental disorders or disabilities" (World Health Organization, 2018). In some ways, this idea is not new for clinical scientists. Happiness, for example, is an important construct to many mental health researchers and clinicians: clients generally want to be happy, and mental health professionals often want to help people become happier. However, with this in mind, researchers and practitioners in clinical psychology have generally focused on studying and treating mental disorders defined by the *Diagnostic and Statistical Manual of Mental Disorders* (APA, 2013) such as depression and anxiety, the two most prevalent categories of disorder (Ferrari et al., 2013). It is often assumed that resolving the symptoms of these disorders will help patients live happier, more fulfilling lives. However, relatively little is

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known about the connections between happiness and specific symptoms of depression and anxiety.

While the scientific study of happiness has not been the focus of clinical psychology, the science of happiness has flourished in recent years. Much of the research on happiness has been spearheaded by the positive psychology movement, which aims to understand the factors that influence well-being (Seligman, 2012). Research on happiness often focuses on subjective well-being—an individual's subjective evaluation of how well they are doing in life (Diener et al., 2003), rather than their emotional state at a given time. The number of studies on happiness has skyrocketed in the last two decades (see Myers and Diener 2018 for a review). Among these are studies about how happiness is influenced by age (Frijters and Beatton, 2012), gender (Diener and Tay, 2015), income (Jebb et al., 2018), and social relationships (Myers and Diener, 2018). Furthermore, several studies have found that happiness is associated with a variety of desirable outcomes, including physical health, life expectancy, and prosocial behaviors (Lathia et al., 2017; see also Myers and Diener 2018). Consistent with much of this growing literature, we operationalize happiness in the present study as a global assessment of one's typical well-being and enjoyment of life.

Recent research on happiness around the globe has revealed striking differences in average levels of self-reported happiness between countries. The most comprehensive data on cross-cultural differences in happiness comes from The United Nations Sustainable Development Goal Network's annual World Happiness Report (Helliwell et al., 2019). The report includes a ranking of countries' happiness, based on respondents' ratings of their lives. Gross Domestic Product (GDP) per capita, social support, life expectancy, freedom to make life choices, generosity, and perceptions of corruption explain variance in national happiness levels (Helliwell et al., 2019). Scandinavian nations reliably rank among the happiest countries in the world, while countries in South Asia and Sub-Saharan Africa report the lowest average levels of happiness (Helliwell et al., 2018, 2019). For example, India and Kenya are two LMICs with particularly low happiness ratings. Out of the 156 countries ranked in the most recent World Happiness Report, Kenya was ranked 121st and India was ranked 140th (Helliwell et al., 2019). It may be especially important to understand the relations between happiness and symptomology in regions of the world with low happiness ratings, as well as whether these relations are consistent across cultures. Such research could identify potential causes and correlates of unhappiness, leading to a better understanding of how to tailor interventions for promoting mental health and happiness. Our study aims to contribute to these goals by understanding cross-cultural patterns of happiness and psychopathology among Indian and Kenyan adolescents.

1.1. Happiness, depression, and anxiety

Surprisingly little work has been done to understand how happiness is related to symptoms of depression and anxiety. Studies in clinical psychology have generally used assessment tools designed to assess for symptoms of mental illnesses. For instance, widely used assessment tools for depression (e.g., Patient Health Questionnaire-9; Kroeneke et al. 2001) and anxiety (e.g., Generalized Anxiety Disorder Screener-7; Spitzer et al. 2006) often screen for the presence or absence of symptoms defined by the Diagnostic and Statistical Manual of Mental Disorders (DSM; American Psychiatric Association (APA), 2013). More recently, psychologists have called for the measurement of "positive" indicators of mental health, noting that the assessment techniques used in clinical psychology are adequate at assessing for mental *illness* yet fail to provide a complete picture of an individual's mental *health*. A comprehensive assessment could also include measures of subjective well-being, life satisfaction, positive emotions, meaning, engagement, relationship quality, achievement, and character strengths (Butler and Kern, 2016; Seligman, 2012). These positive indicators of mental health and well-being may offer useful information that is not redundant with information gathered from clinical assessments. However, relatively little empirical research has examined the relationship between indicators of well-being and indicators of affective disorders.

At first glance, it may seem like depressive symptoms and anxiety symptoms should show strong negative associations with happiness. A few factors complicate this. First, a growing body of biological and neuroscientific research suggests that different physiological and neural pathways underlie positive and negative emotions. This distinction is reflected in the decision by the creators of the Research Domain Criteria (RDoC; Cuthbert, 2014) to separate negative valence systems (e.g., responses to fear, anxiety, and loss) and positive valence systems (e.g., responses to rewards). Second, many clinical disorders are highly heterogeneous—patients with the same disorder often experience different subsets of the criterial symptoms. For instance, one study found over 1000 unique symptom profiles in a sample of 3703 depressed patients (Fried and Nesse, 2015). This heterogeneity, among other findings, has spurred some researchers to advocate for *symptom-level* analyzes. Indeed, such analyzes have shown that depressive symptoms have distinct risk factors, biological markers, and consequences. For example, one study showed that sad mood explained 20% of the variance in depression-related impairment, whereas sleep problems accounted for only 0.7% (Fried and Nesse, 2014).

Distinct relationships might also be found between depressive symptoms and happiness. Research that aims to identify the symptoms with stronger associations with happiness could inform decisions about which symptoms are most important to target. Research on happiness and psychopathology could also facilitate a synthesis of positive psychology and clinical psychology. As noted, research on mental dysfunction has been largely divorced from research on mental well-being, limiting our understanding of both. Integrating research on positive emotions and clinical symptoms has a variety of benefits, such as improving our ability to predict clinical disorders, enhancing our understanding of interactions between positive and negative states, and developing novel interventions (see Wood and Tarrier, 2010).

1.2. Happiness: a developmental and cross-cultural perspective

Ideally, research on the relationship between happiness and psychopathology would be informed by developmental research and cross-cultural research. During adolescence, emotions are theorized to play an important role in the development of psychopathology through their effects on motivation, thoughts, and behavior (Cicchetti et al., 1995). For example, happiness may orient an individual to set goals and seek new social bonds, while sadness may result in withdrawal from goals or peers (Chaplin, 2006). Consequently, happiness may have a reciprocal relationship with developmental competencies, such that happiness results from past success and also promotes future attainment of key developmental competencies (Quinn and Duckworth, 2007). Conversely, negative emotional tendencies may thwart adaptive development. During adolescence, emotional tendencies often stabilize (Larson et al., 2002), and negative tendencies can develop into stable, pathological states of depression and anxiety (Cicchetti et al., 1995). Indeed, adolescents are at particularly high risk for mental illnesses, and most mental illnesses develop during adolescence (Patel et al., 2007). Future research is needed to understand the relations between emotion and psychopathology at this critical juncture in development.

Cultural influences may also play an important role in explaining cross-national differences in subjective well-being (see Diener and Lucas, 2000). For instance, people in different cultures may value or express happiness differently. Some research suggests that some individuals may be averse to strong expressions or experiences of happiness (see Joshanloo and Weijers 2014). Studies have found that, in general, collectivistic cultures value belonging and social cohesion in addition to personal happiness (Biswas-Diener et al., 2012). Furthermore, collectivist cultures have been found to prioritize "low-arousal positive" affective states such as feeling calm, relaxed, and peaceful, while individualistic cultures prioritize "high-arousal positive" states

such as enthusiasm and excitement (Tsai, 2008). Furthermore, collectivists may be more likely to consider both personal experiences and contextual indicators of their social belonging when judging their life satisfaction, while individualists primarily consider personal experiences when judging their overall life satisfaction (Suh et al., 1998).

Despite cross-cultural differences in conceptualizations of happiness, the spread of cultural values through globalization has made the pursuit of happiness an increasingly universal goal (Lyubomirsky et al., 2005; Uchida and Ogihara, 2012). In particular, adolescents and emerging adults are especially sensitive to the values of individualism and self-development that are transmitted through global media and cross-cultural interactions (see Jensen and Arnett 2012). The adoption of happiness as a widespread goal can also be seen in nation-level and international commitments to increase happiness globally. Recently, Bhutan's government introduced the world to the Gross National Happiness index, a nationwide measurement system that puts psychological well-being on par with Gross Domestic Product (GDP; Royal Government of Bhutan, 2011; Sakurai, 2011). Additionally, eliminating the global well-being disparity has been listed as one of the United Nation's 17 Sustainable Development Goals for 2030. What happiness means and how it is expressed may vary by context, but the recognition of happiness and life satisfaction as laudable goals has become nearly universal.

1.3. Happiness and psychopathology: a network analytic approach

Network theories of psychopathology have become popular in recent years (Borsboom and Cramer, 2013; McNally, 2016). Traditional theories assume that a latent disease (e.g., major depression) gives rise to symptoms (e.g., sleep problems, concentration problems, anhedonia). In contrast, network theory focuses on the interactions among symptoms and views disorders as arising from these interactions (e.g., sleep problems lead to concentration problems which lead to anhedonia). Understanding symptom relations has a host of potential benefits; these include identifying symptoms that are ideal treatment targets, identifying symptoms that bridge multiple disorders, identifying unique causes and consequences of different symptoms, predicting the onset of disorders, and understanding comorbidity (Borsboom, 2017; Fried and Nesse, 2015; Fried et al., 2017; McNally, 2016). For example, network analyzes have been used to identify symptoms that may bridge highly comorbid disorders (Cramer et al., 2010). Networks of depression and anxiety have identified sad mood and worry as central symptoms in networks of depression and anxiety (Beard et al., 2016).

One way of examining the relationships between aspects of happiness and individual symptoms of psychopathology is to employ network analysis. In network analysis, associations between "nodes" (such as items of questionnaires measuring happiness, anxiety, and depression) are represented as "edges" (Borsboom and Cramer, 2013). In addition to calculating the associations between nodes, network analysis also produces indices of *centrality* and *bridge centrality*. Symptoms with high centrality are most strongly associated with other symptoms (McNally, 2016). Centrality is not a proxy for variable importance, as many other factors are at play (e.g., Rodebaugh et al. 2018). That said, central symptoms provide a first glimpse at which variables are highly related to others, and can also help to rule out symptoms that are largely unrelated to others (e.g., Elliott et al. 2020). Symptoms with high bridge centrality serve as connections between two communities of nodes, and these symptoms are often highly relevant for studies on comorbidity (e.g., McNally et al. 2017).

Network analysis can also be used to map relations between happiness, depression, and anxiety. If, for example, happiness items form a distinct community from symptoms of depression or anxiety, bridge centrality metrics could be used to point to depressive or anxious symptoms that are most robustly linked to deficits in happiness and well-being. Furthermore, there is a growing need to apply network analysis in non-western settings, particularly to understand how cultural context may affect psychopathology networks. To our knowledge, only one previous study has applied network analysis to examine psychopathology in a non-western sample of adolescents (Wasil et al., 2020).

Recently, researchers have pointed out important limitations of cross-sectional network research methodology. It is important to point out that—as with any non-experimental methodology—cross-sectional network analysis will suffer from critical inferential problems if important causal variables are omitted (Fried and Cramer, 2017). Some have suggested that cross-sectional networks are inherently unreliable (Forbes et al., 2017; Forbes et al., 2019), although others contend that these concerns are unfounded and based on flawed reasoning and methodology (Borsboom et al., 2017; Jones et al., 2019). While it is true that cross-sectional networks carry important limitations, it would also be unwise to dismiss their utility. Although the leap from cross-sectional networks to causal inference is far from straightforward, cross-sectional network patterns do constrain the possible space of causal maps (e.g., Ryan et al. 2019). Moreover, a cross-sectional network is most informative if it can be replicated—as we aim to do in the present study–or if the contributors to non-replicability can be identified. They are also useful in a predictive sense: central symptoms (i.e., nodes high in expected influence) have been shown to be more predictive of post-treatment outcomes (Elliott et al., 2020). To summarize, cross-sectional networks never provide definitive information about causality, but always provide information that constrains the total space of possible causal patterns.

1.4. The present study

In this paper, we present two empirical studies examining the relationship between depression, anxiety, and happiness in adolescents from two non-western countries. In Study 1, we model a network of depression, anxiety, and happiness in a sample of Indian adolescents. Based on the findings of this study, we pre-registered a set of hypotheses for Study 2. In Study 2, we model a network of depression, anxiety, and happiness (in a separate dataset using the same measurement tools) in a sample of Kenyan adolescents. Through these analyzes, we address the following research questions:

- RQ1: In a network of depressive symptoms and anxiety symptoms, which symptom nodes are most central? (i.e., most strongly connected to other nodes in the network)
- RQ2: In a network of happiness items and symptoms of depression and anxiety, which symptoms are most strongly associated with aspects of happiness?
- RQ3: Do symptoms and happiness items form distinct clusters in a network, or do they blend with each other?

2. Study 1: methodology

2.1. Participants

We used baseline data from a randomized controlled trial of online mental health promotion interventions conducted in Maharashtra, India. Details about the trial are available elsewhere (Wasil, Park, et al., 2020). Briefly, the trial tested the effects of three single-session online mental health programs: one focused on gratitude, one on growth mindsets, and one on behavioral activation. Eligible participants were adolescents (grades 7–12) attending secondary schools in Maharashtra in which the primary language of instruction is English. Study procedures were approved by the Sangath Institutional Review Board; Sangath is a non-governmental organization in India that regularly performs health promotion and mental health promotion research in community settings.

Data for the present analyzes were collected at baseline, prior to the deployment of the interventions. Baseline data were collected from June to August of 2019 in three participating high schools. Students had the

option to fill out the questionnaires online in school computer labs (via a Qualtrics survey link) or via pencil-and-paper.

2.2. Measures

Measures were selected for this study in consultation with collaborators in India. Measures were also reviewed and approved by school officials prior to administration.

2.3. Depressive symptoms (PHQ-9)

The Patient Health Questionnaire-9 (PHQ-9) is a commonly used measure of depressive symptoms. The PHQ-9 has demonstrated adequate reliability (Cronbach's alpha of .86-.89) and validity (Kroenke and Spitzer, 2002), and it has been validated in a sample of Indian adolescents (Ganguly et al., 2013). Example items from the PHQ-9 include "little interest or pleasure in doing things" and "thoughts that you would be better off dead, or of hurting yourself." Participants are asked to rate the frequency of each item over the past two weeks. Items are scored from 0 ("Not at all") to 3 ("Nearly every day"). In our sample, the PHQ-9 demonstrated adequate reliability (Cronbach's alpha = 0.75).

2.4. Anxiety symptoms (GAD-7)

The GAD-7 is a commonly used measure of anxiety symptoms (Spitzer et al., 2006). It shows adequate internal consistency (Cronbach alpha=.92) in samples of youths in North America, as well as strong convergent, divergent, construct, and criterion validity (Spitzer et al., 2006). The GAD-7 has been used extensively in cross-cultural contexts, including with students in India (Leventhal et al., 2015; Jamir et al., 2019). In our sample, the GAD-7 demonstrated adequate reliability (Cronbach's alpha = 0.83).

2.5. EPOCH

The EPOCH is a measure of adolescent well-being (Kern et al., 2016) based on Seligman's (2011) five pillars of well-being. The EPOCH has five subscales measuring engagement, perseverance, optimism, connectedness, and happiness. For the present study, we will only be using the happiness subscale. The happiness subscale has demonstrated adequate internal consistency and test-retest reliability in adolescents (Kern et al., 2016). In our sample, the EPOCH happiness subscale demonstrated adequate reliability (Cronbach's alpha = 0.68). Four items assess different aspects of a person's average happiness levels: "I feel happy", "I love life," "I have a lot of fun," and "I am a cheerful person." These items are rated on a Likert scale from "1 = almost never/not at all like me" to "5 = almost always/very like me."

2.6. Analyzes

2.6.1. Network generation and stability

We estimated network models using the *bootnet* package in R (Epskamp et al., 2018). We used the graphical LASSO method, which estimates regularized partial correlations between nodes. The LASSO method shrinks the edge values estimated in the network, shrinking small edge values to 0. The LASSO adjustment helps address the problem of multiple testing (i.e., reducing false positive errors). We used the EBICglasso procedure, which selects the optimal degree of shrinkage according to an Extended Bayesian Information Criterion (EBIC) and a hyperparameter. We used the default hyperparameter value (*gamma*=0.5).

We tested the stability of the network using both nonparametric bootstrapping and case-dropping bootstrapping in the *bootnet* package (Epskamp et al., 2018). This procedure allows us to test the stability of edge values and centrality values. We created plots displaying confidence intervals and difference plots for edges and centrality values. Bootstrapped difference plots are useful for estimating which edges and centrality values can be meaningfully interpreted as different from one another. In addition to these plots, we used the case-dropping bootstrap to calculate a correlation-stability (CS) coefficient for the network. The CS coefficient indicates the maximum proportion of the original sample that can be dropped while continuing to estimate centrality values that correlate highly (r>0.7) with the network from the full sample. Values of 0.25 and 0.5 indicate benchmarks for adequate and good network stability, respectively (Epskamp et al., 2018).

To measure the centrality of nodes in the network, we used expected influence centrality (Robinaugh et al., 2016). Expected influence centrality represents the sum of all edge weights connected to a given node. Expected influence is related to strength centrality; strength centrality involves the summation of the *absolute value* of edge weights. A high expected influence value suggests that a node is positively associated with other nodes in the network (i.e., increases in the value of that node are associated with increases in the value of other nodes). Centrality estimations can be affected by restricted ranges of variance. To test for this problem, we tested the correlation between strength values and node variances. A positive correlation would indicate that differential variance may be inflating centrality estimates. We used strength centrality for this estimation because any problem with inflated variance should increase both positive and negative edges, rather than only positive edges.

Network analyzes are problematic if multiple nodes measure the same underlying construct. To test for this possibility, we used *goldbricker* function in the *networktools* package (Jones, 2018; Levinson et al., 2018). The *goldbricker* function operates by comparing nodes by their correlation with each other and additionally by comparing their correlation *patterns* (i.e., topological overlap) with other variables in the dataset. If two nodes indeed have measurement overlap, we would expect them to have similar correlations with other variables in the dataset. In contrast, if nodes represent independent constructs, we would expect their correlation patterns with other variables to differ. The *goldbricker* function formalizes this process. We tested for any pair of nodes sharing a topological overlap of greater than 75% (i.e., less than 25% of significantly divergent dependent correlations, p < 0.001).

2.6.2. Estimated network

We generated two networks. The first network model included only the symptoms of depression and anxiety: the nine depressive symptoms present in the PHQ-9 and the seven anxiety symptoms present in the GAD-7. The second network model included these symptoms of depression and anxiety as well as the four happiness items on the happiness subscale of the EPOCH.

3. Study 1: results

3.1. Sample characteristics and descriptive statistics

Our sample consisted of 1,082 adolescents (47.7% female; M_{age}=14.19, SD_{age}= 1.52) attending secondary schools in Maharashtra, India. The mean score on the PHQ-9 was 8.13 (SD = 5.05), and the mean score on the GAD-7 was 7.50 (SD = 4.78). Table S1 and Table S2 present the item means and frequencies for PHQ-9 items (Table S1) and GAD-7 items (Table S2). In this sample, anhedonia and low energy were the most commonly endorsed depression symptoms, as well as the symptoms with the highest mean scores. Irritability, worrying, and difficulty controlling worries were the most commonly endorsed anxiety symptoms, as well as the anxiety symptoms with the highest mean scores.

3.2. Network generation and stability (study 1)

We tested for problematic topological overlap using the *goldbricker* function. Results indicated that there were several pairs of items in our dataset that were potentially overlapping. Because PHQ item 9

(thoughts about suicide) is theoretically distinct from other symptoms, we maintained PHQ item 9 as a separate node even in the case of topological overlap. Apart from the suicide item, we combined items that evidenced topological overlap. On the PHQ-9, items 2 and 6 (feeling sad; feeling like a failure) were combined (this node is hereafter referred to as "negative feelings"). On the GAD-7, items 2 and 3 (worrying; inability to control worries) were combined. On the EPOCH, Happiness Item 1 and Happiness Item 3 (feeling happy; loving life) were combined.

The networks had high stability. Edge values were estimated with narrow confidence intervals for the symptom network (Fig. S1) as well as the network of symptoms and happiness (Fig. S2). For both networks, the CS coefficients were at the tested ceiling of 0.75, indicating that at least 75% of the sample could be dropped before the correlation with original centrality values dropped below r=0.7. Also, for both networks, variance was negatively correlated with strength centrality values (r = -0.64, -0.47).

Network plot layouts were generated using multidimensional scaling (MDS; see Jones et al. 2018 for a tutorial). Using the MDS layout, nodes with stronger similarities (i.e., positive edge values) are close together. In other words, the distance between nodes is indicative of the relationship between them. The MDS layout does not correspond perfectly to the edge weights because it is constrained to two dimensions; the reported *stress-1* value of the MDS fit is used to guide interpretations (see Mair et al. 2016).

3.3. Network of depression and anxiety in Indian adolescents

Fig. 1a depicts the network of depressive symptoms and anxiety symptoms in Indian adolescents. The MDS solution had a *stress-1* value of 0.22.

Overall, depression and anxiety symptoms correlated positively with one another. The strongest edges were observed between: worry (worrying and inability to control worrying, combined) and feeling nervous; worry and feeling afraid; and suicidal thoughts and negative feelings (feeling sad and feeling like a failure, combined). Fig. 1b shows expected influence values with confidence intervals. Most expected influence values were estimated to be different from each other in a difference test (Fig. S3). Negative feelings, worry, and feeling nervous had the highest expected influence values.

3.4. Network of depression, anxiety, and happiness in Indian adolescents

Fig. 2a depicts the network of depressive symptoms, anxiety symptoms, and happiness items in Indian adolescents. The MDS solution had a *stress*-1 value of 0.15.

In general, depression and anxiety symptoms correlated positively with one another and negatively with happiness items. Across several iterations of *walktrap* and *spinglass* community analyzes, the happiness items consistently formed a community distinct from the anxiety and depression symptoms. Fig. 2b shows bridge expected influence values with confidence intervals. Because happiness and psychopathology are negatively correlated, the importance of a node is indicated by strong negative bridge expected influence values (i.e., farther to the left in Fig. 4). Most bridge expected influence values were estimated to be different from each other in a difference test (Fig. S4). Of the symptoms in the symptom community, negative feelings demonstrated the most robust bridge expected influence value, indicating that negative feelings were most highly associated with the community of happiness items. Of the items in the happiness community, feeling cheerful demonstrated the most robust bridge expected influence value, indicating that feeling cheerful was the item most highly associated with the community of symptoms.

4. Study 1 discussion

We created a network of depressive symptoms, anxiety symptoms, and happiness items on a sample of Indian adolescents. As expected, symptoms of depression and anxiety generally correlated negatively with happiness items. Furthermore, we identified nodes with strong centrality values (negative feelings, worry, and feeling nervous) in the symptom network and strong bridge centrality values (negative feelings and cheerful) in the symptom/happiness network.

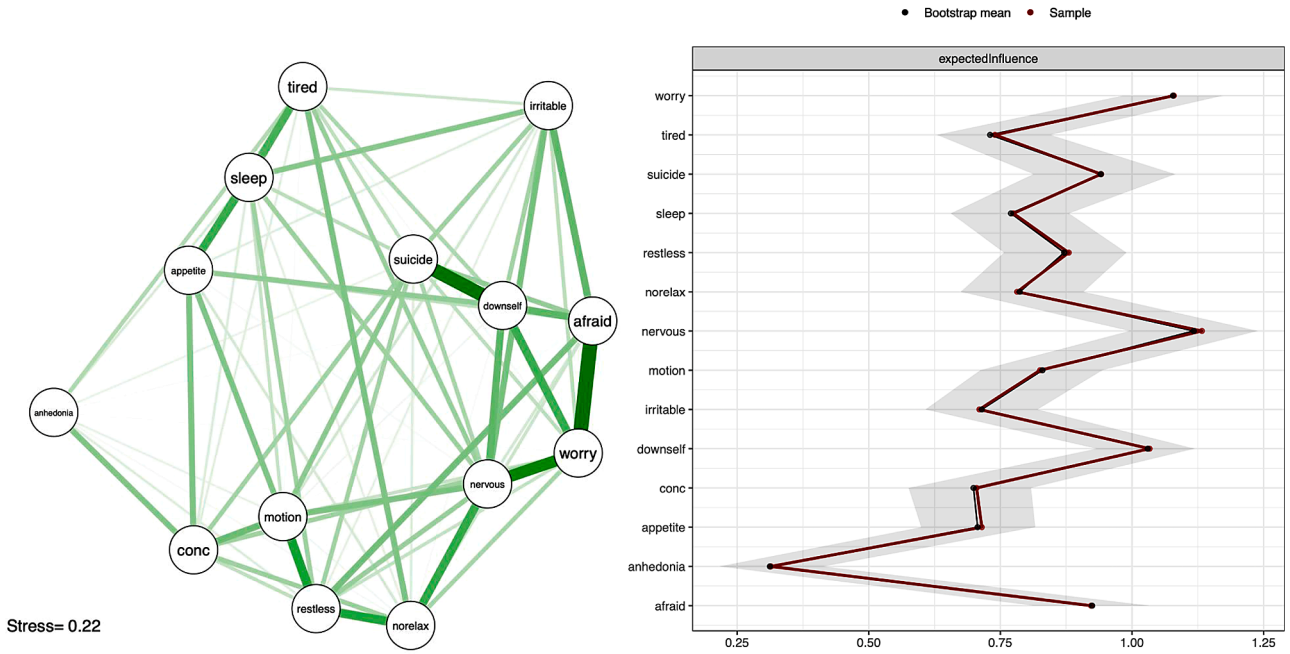

Fig. 1. Network of Internalizing Symptoms in Indian Adolescents with Expected Influence. a (left) shows the network of internalizing symptoms. Edge thickness indicates the strength of the partial correlation between nodes. Green lines represent positive associations and red lines represent negative associations. b (right) shows the centrality (expected influence) of each symptom of the internalizing network. A high expected influence value suggests that a node is positively associated with other nodes in the network (i.e., increases in the value of that node are associated with increases in the value of other nodes). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

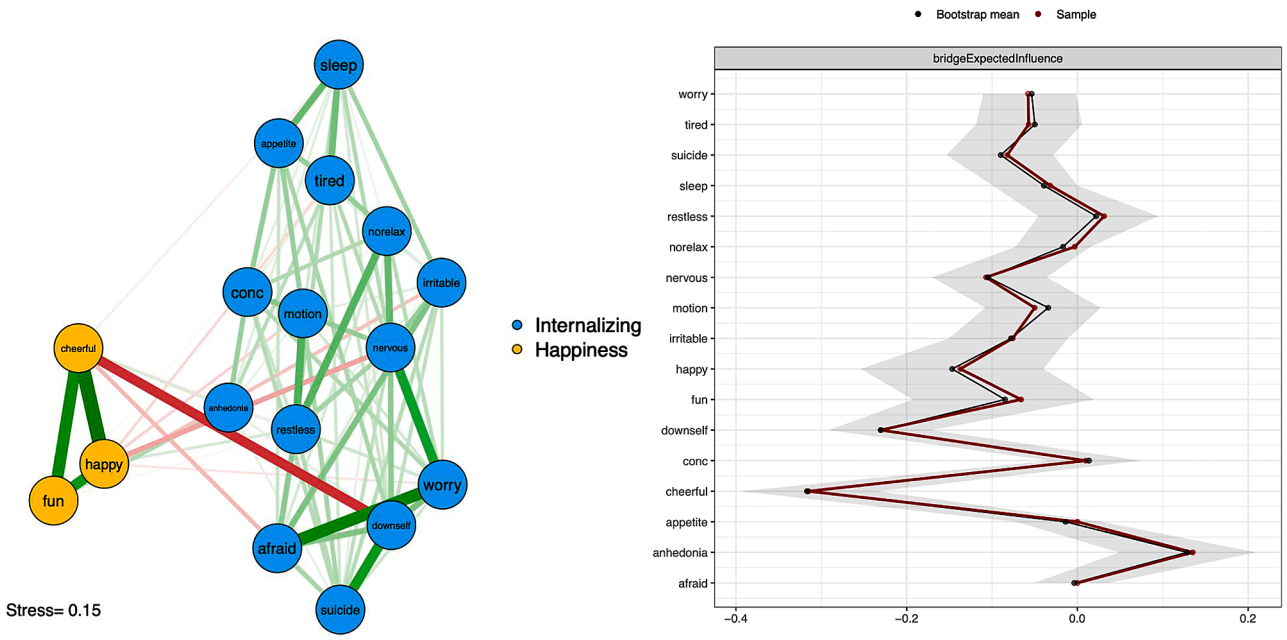

Fig. 2. Network of Internalizing Symptoms and Happiness in Indian Adolescents with Bridge Expected Influence. a (left) shows the network of internalizing symptoms and happiness items. Edge thickness indicates the strength of the partial correlation between nodes. Green lines represent positive associations and red lines represent negative associations. b (right) shows the centrality (bridge expected influence) of each symptom of the network. Because happiness and psychopathology are negatively correlated, the importance of a node is indicated by strong negative bridge expected influence values (i.e., nodes farther to the left in the figure have a stronger influence). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

These findings allowed us to set hypotheses for study 2, a network analysis with the same measurement tools from a sample of adolescents in Kenya. Based on the findings of study 1, we pre-registered the following hypotheses (https://osf.io/8ub4m):

- H1: Among anxiety and depression symptoms, the nodes for "feeling down about oneself," (i.e., negative feelings) "worry", and "feeling nervous" will have expected influence values within the top third of nodes in the symptom community.
- H2: Among bridge symptoms, "feeling down about oneself" (from the symptom community) and "cheerful" (from the happiness community) will have negative bridge expected influence values within the bottom third of all nodes. That is, "feeling down about oneself" and "cheerful" will bridge the symptom community and the happiness community.
- H3: The majority of partial correlations, or "edges" between mental health symptoms and well-being items will be negative.

Findings consistent with these hypotheses would suggest a successful replication of our main findings in a distinct sample from a different cultural context. Findings inconsistent with these hypotheses could suggest that there are differences in network structure cross-culturally.

5. Study 2: methodology

5.1. Participants

We used baseline data collected in Nairobi, Kenya over the summer of 2019, the same time period during which the data from study 1 was collected (see Osborn et al. 2020). These data were collected as part of a randomized controlled trial of *Shamiri*, a four-week lay counselor intervention. Details about the intervention (Osborn et al., 2019) and the randomized controlled trial (Osborn et al., 2020) are available elsewhere. Eligible participants were high school students between the ages of 13 and 18 (grades 9 to 12). Study procedures were approved by the Maseno University Ethics Review Committee, the local institutional review board.

5.2. Measures

Measures were selected for this study in consultation with collaborators in Kenya. We administered the PHQ-8, GAD-7, and EPOCH happiness subscale to the Kenyan adolescents. The measurements were identical to those of study 1, except we administered the PHQ-8 rather than the PHQ-9.

The PHQ-8 is simply the PHQ-9 with the suicide item removed (Kroenke and Spitzer, 2002). Our Kenyan colleagues advised us to remove this item due to the stigma associated with suicide in Kenya. PHQ-8 and PHQ-9 scores are highly correlated, and the same cut-offs are typically used to assess severity of depressive symptoms (Kroenke and Spitzer, 2002). The PHQ-8 has been shown to have adequate internal consistency ($\alpha = 0.89$), test-retest reliability and discriminant validity within North American samples (Kroenke et al., 2001). The PHQ-8 has also demonstrated adequate internal consistency ($\alpha = 0.73$) with Kenyan adolescents (Osborn et al., 2019).

The PHQ-8 (Cronbach's alpha = 0.78), GAD-7 (Cronbach's alpha = 0.82), and EPOCH happiness subscale (Cronbach's alpha = 0.79) each demonstrated adequate internal consistency in this present sample of Kenyan adolescents.

5.3. Analyzes

The analyzes performed were identical to those of study 1 (see "Study 1 Methodology" section above).

6. Study 2: results

6.1. Sample characteristics and descriptive statistics

Our sample consisted of 2176 Kenyan adolescents (58.3% female; $M_{age} = 15.21$, $SD_{age} = 1.14$). The mean score on the PHQ-8 was 7.92 ($SD = 5.20$), and the mean score on the GAD-7 was 7.42 ($SD = 5.10$).

Table S1 and Table S2 present the item means and frequencies for PHQ-8 items (Table S1) and GAD-7 items (Table S2). In this sample, feeling like a failure, concentration problems, and anhedonia were the most commonly endorsed depression symptoms, as well as the symptoms with the highest mean scores. Worrying, inability to control worries, and feeling nervous were the most commonly endorsed anxiety symptoms, as well as the symptoms with the highest mean scores.

6.2. Network generation and stability (study 2)

We tested for problematic topological overlap using the *goldbricker* function. Results indicated that there were a few pairs of items in our dataset that were better explained as multiple measurements of the same construct. Specifically, for these pairs, less than 25% of topologically overlapping correlations were significantly different from one another ($p < 0.001$). On the GAD-7, items 2 and 3 (inability to control worries; worrying) were combined. On the EPOCH, items 1 and 3 (feeling happy; loving life) were combined. This is consistent with study 1, except that we did not need to combine PHQ items 2 and 6 (feeling sad; feeling like a failure) for the Kenya analyzes.

The networks had high stability. Edge values were estimated with narrow confidence intervals for the symptom network (Fig. S5) and the symptom/happiness network (Fig. S6). For both depression network and the symptom/happiness network, the CS coefficients were at the tested ceiling of 0.75, indicating that at least 75% of the sample could be dropped before the correlation with original centrality values dropped below r=0.7. Variance was negatively correlated with strength centrality values for both the symptom network and symptom/happiness network (r = -0.08; r = -0.18).

6.3. Network of depression and anxiety in Kenyan adolescents

Fig. 3a depicts the network of depressive symptoms and anxiety symptoms in Kenyan adolescents. As in study 1, network plot layouts were generated using MDS (see Jones et al. 2018 for a tutorial). The MDS solution had a *stress-1* value of 0.23.

Consistent with study 1, depression and anxiety symptoms correlated positively with each other. The strongest edges were observed between feeling down and feeling like a failure, feeling tired and sleep problems, worrying and feeling nervous, and feeling restless and not being able to relax. Fig. 3b shows expected influence values with confidence intervals. Most expected influence values were estimated to be different than each other in a difference test (Fig. S7). Worrying, feeling nervous, feeling restless, feeling like a failure, and feeling down had the highest expected influence values. These findings are largely consistent with study 1, in which negative feelings (feeling like a failure and feeling down), worrying, and feeling nervous had the highest expected influence values. One difference is that feeling restless was a central symptom in the Kenya network but not in the India network.

6.4. Network of depression, anxiety, and happiness in Kenyan adolescents

Fig. 4a depicts the network of depressive symptoms, anxiety symptoms, and happiness items in Kenyan adolescents. The MDS solution had a *stress-1* value of 0.17.

Consistent with study 1, depression and anxiety symptoms correlated positively with one another and negatively with happiness items. Additionally, across several iterations of *walktrap* and *spinglass* community analyzes, the happiness items consistently formed a community distinct from the anxiety and depression symptoms. Fig. 4b shows bridge expected influence values with confidence intervals. Most expected influence values were estimated to be different than each other in a difference test (Fig. S8). Item 2 (feeling down) demonstrated the strongest bridge expected influence value (i.e., most strongly negative) among the items in the symptom community. In Study 1, negative feelings (item 2 combined with item 6, feeling like a failure) demonstrated the strongest bridge expected influence value. As in Study 1, feeling cheerful demonstrated the strongest bridge expected influence value among the items in the happiness community.

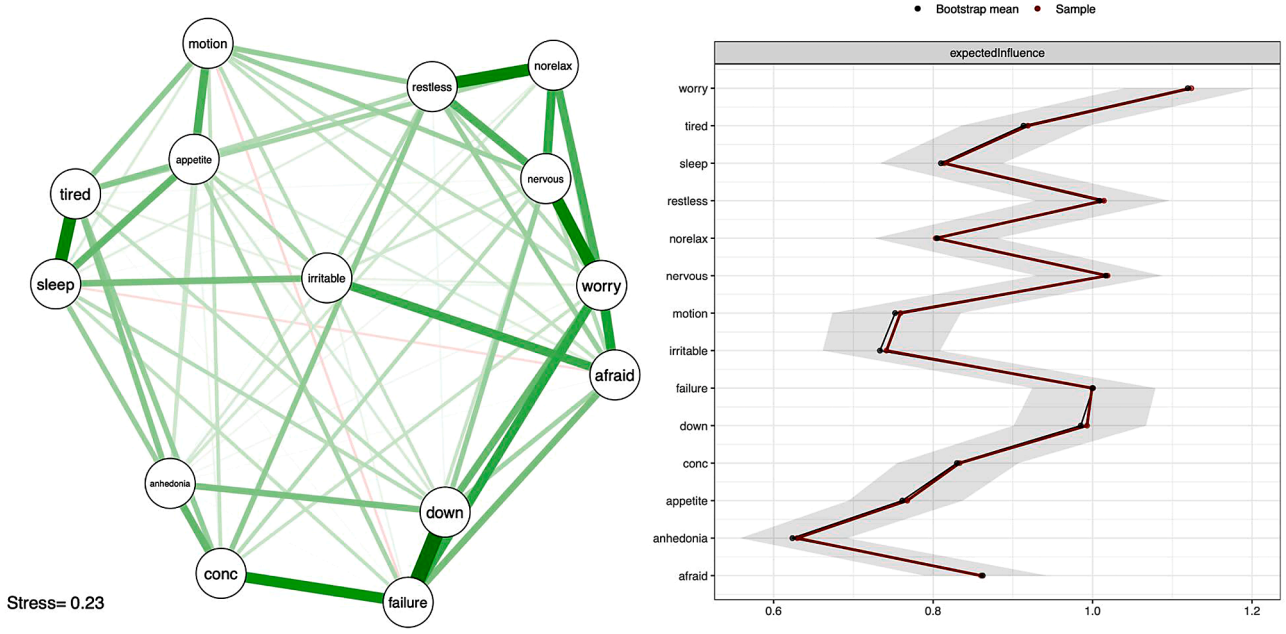

Fig. 3. Network of Internalizing Symptoms in Kenyan Adolescents with Expected Influence. a (left) shows the network of internalizing symptoms. Edge thickness indicates the strength of the partial correlation between nodes. Green lines represent positive associations and red lines represent negative associations. b (right) shows the centrality (expected influence) of each symptom of the internalizing network. A high expected influence value suggests that a node is positively associated with other nodes in the network (i.e., increases in the value of that node are associated with increases in the value of other nodes). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

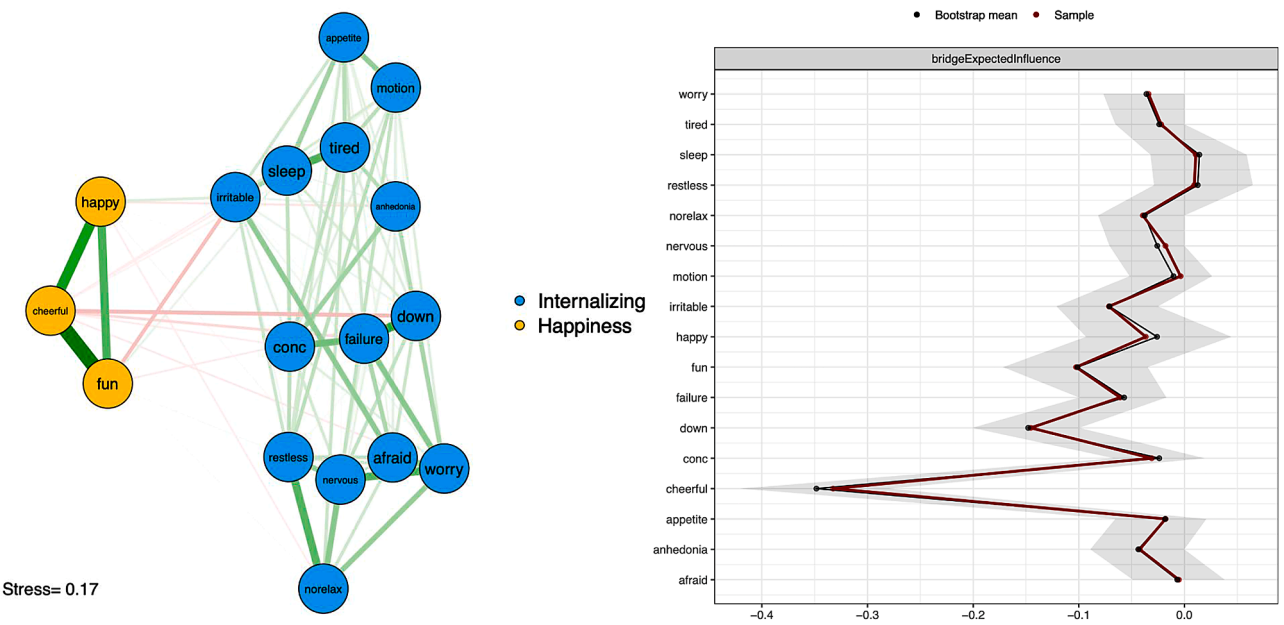

Fig. 4. Network of Internalizing Symptoms and Happiness in Kenyan Adolescents with Expected Influence. a (left) shows the network of internalizing symptoms and happiness items. Edge thickness indicates the strength of the partial correlation between nodes. Green lines represent positive associations and red lines represent negative associations. b (right) shows the centrality (bridge expected influence) of each symptom of the network. Because happiness and psychopathology are negatively correlated, the importance of a node is indicated by strong negative bridge expected influence values (i.e., nodes farther to the left in the figure have a stronger influence). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

7. General discussion

We created a network of depressive symptoms, anxiety symptoms, and happiness items using responses from a sample of Indian adolescents (study 1) and Kenyan adolescents (study 2). Based on the results of study 1, we pre-registered three hypotheses (https://osf.io/8ub4m) for study 2. Each of our three hypotheses was confirmed. First, in the depression and anxiety networks, the same symptoms emerged within the top third of expected influence values (worrying, feeling nervous, feeling down about oneself/feeling like a failure). Second, in the symptom/happiness networks, the same items emerged within the top third of bridge expected influence values (feeling down about oneself/feeling sad in the symptom community, and feeling cheerful in the happiness community). Third, the majority of the edges between symptoms and well-being items were negative. One notable difference between the networks generated in the two samples is that the network items "feeling sad" and "feeling like a failure" demonstrated considerable topological overlap in study 1 but not in study 2. Therefore, these items were combined into a single node ("negative feelings") in study 1 but left as two separate nodes in study 2. Even considering this difference, the hypotheses remained supported (e.g., both items that constituted "negative feelings" – "feeling sad" and "feeling like a failure" – fell within the top third of bridge expected influence values in Study 2).

These findings support the idea that individual symptoms of depression and anxiety share different associations with happiness. Specifically, it appears that PHQ item 2 (feeling down, depressed, or hopeless) and PHQ item 6 (feeling like a failure) shared the strongest associations with happiness items. In contrast, we found that some symptoms (e.g., concentration problems, feeling afraid, appetite problems, trouble relaxing) were only weakly associated with happiness items. Interestingly, feeling down and feeling like a failure also showed strong associations with other symptoms. Such findings suggest that these "emotional" symptoms of depression—feeling down and feeling like a failure—are especially strongly tied to both symptomatology and happiness. One possibility is that these symptoms are universally central—that is, feeling down and feeling like a failure might be strongly tied to other symptoms in western samples as well. Alternatively, there may be cultural and developmental features of our samples that contributed to the high centrality of these symptoms. For example, in both Kenya and India, adolescents face immense pressure to succeed (Bhasin et al., 2010; Yara and Wanjohi, 2011), and this can be particularly salient for students who feel that their families' future prospects depend on their academic achievement (Deb et al., 2015). Feeling like a failure could be especially important in these contexts, where failing to perform one's academic or economic responsibilities could have major consequences. Future research should examine if "feeling like a failure" is as central in adult samples, while acknowledging that "feeling like a failure" may have different definitions at different developmental stages (e.g., school success in adolescence vs. career success in adults). Furthermore, stigma toward mental illnesses is common in both Kenya (see Mutiso et al. 2017, Ndetei et al., 2011 and Ndetei et al. 2016) and India (Venkatesh et al., 2015; Böge et al., 2018; Wasil et al., 2020), and this may influence the centrality of feeling down, depressed, or hopeless. For these reasons, it is possible that studies in other cultures—especially those with less pressure to perform and where stigma toward emotional problems is less pervasive— may yield different centrality estimates.

Additionally, similar symptoms emerged as the most commonly endorsed across the two samples. Anhedonia, difficulty controlling worries, and worrying were highly common, endorsed by over 70% of participants in each sample. We also found relatively consistent rates of depression and anxiety across the two samples. Applying scoring guidelines for the PHQ-9 and GAD-7, similar rates were found for mild depression (64% of the sample in study 1, 63% in study 2), moderate depression (30, 27%), severe depression (1, 1%), mild anxiety (62, 60%), moderate anxiety (25, 25%), and severe anxiety (7, 8%). These rates are consistent with rates reported in previous studies of school-attending Indian adolescents (Wasil et al., 2020; Deb et al., 2015) and Kenyan adolescents (Osborn et al., 2019), highlighting the burden of mental health problems among these groups.

We also wondered if happiness items and symptoms of depression and anxiety would emerge as a single community or as two distinct communities. Our findings suggest the latter: in both samples, we found that the happiness items formed a community separate from the symptoms. This pattern of findings is consistent with the idea that, "mental

health is more than just the absence of mental disorders or disabilities" (World Health Organization, 2018). Furthermore, in both samples, two of the four happiness items (feeling happy and loving life) demonstrated considerable topological overlap. However, this still left three distinct happiness nodes from the EPOCH: feeling happy, feeling cheerful, and having fun. Network theory has challenged how we typically view depression; for instance, network theorists have argued that "depression" is too heterogenous to be conceptualized as one discrete construct. Rather, depression may be better understood as a constellation of distinct symptoms, each with their own etiologies, consequences, and treatments (Fried and Nesse, 2015). Our analyzes suggest that "happiness" may be best conceptualized similarly. Among the four happiness items in the EPOCH, we found three distinct nodes with unique patterns of correlations with mental health symptoms. An important avenue of future research could involve understanding different "sub-constructs" that underly happiness, incorporating the idea that different components of happiness may be associated with distinct causes and outcomes. The fact that happiness items showed distinct patterns of correlations with symptoms is also noteworthy and could guide future work in positive psychology. In some contexts, happiness or subjective well-being may be composed of multiple distinct constructs. For instance, we found that even seemingly similar items like "I have a lot of fun", "I feel happy", and "I am a cheerful person" can demonstrate distinct patterns of association with psychopathology. These findings suggest that it may be promising to develop models that attempt to break down happiness or subjective well-being into constituent parts (see Seligman 2018).

Our study offers several avenues and implications for future research. For instance, interventions focused specifically on addressing commonly endorsed symptoms (e.g., anhedonia, worrying, and the ability to control worrying), highly central symptoms (e.g., feeling sad, feeling like a failure, worrying, feeling nervous), or symptoms most strongly associated with happiness (e.g., feeling like a failure, feeling sad) may be especially helpful to reduce the burden of mental illnesses in these contexts. Several scholars have argued that it may be important to target specific symptoms (e.g., McNally 2016) or use symptom-level data to enhance personalized medicine approaches (e.g., Fried and Nesse 2015). While our cross-sectional findings cannot substitute for longitudinal work, our findings offer one step toward identifying certain symptoms that could represent ideal treatment targets. Importantly, research is needed to understand which interventions and which intervention components are most effective at treating specific symptoms for youths. Although this approach is rare in developmental psychopathology, promising research is emerging on the treatment of anhedonia in the context of adult schizophrenia (Favrod et al., 2010; Strauss, 2013) and adult depression (e.g., Cao et al. 2019). Such research could offer a useful template for a line of research aimed at treating anhedonia, and other common or central symptoms, among youth and adolescents. Furthermore, future work could use different kinds of methods to attempt to understand symptoms and concerns that are most strongly impacting participants' wellbeing. Such work could involve open-ended qualitative approaches designed to solicit individuals' top concerns (e.g., Weisz et al. 2011 and Wasil et al. 2021) or approaches that prompt participants to rate the degree to which individual symptoms are concerning and impairing (Wasil et al., 2021).

Our findings should be interpreted in light of certain strengths and limitations. Strengths of the study include data from multiple samples, consistent measurement tools across studies, large sample sizes, and preregistration of key hypotheses in a replication study. Limitations of the study include the use of cross-sectional data and the use of scales assessing a limited subset of symptoms and happiness items. Future research using more exhaustive measurement tools could be useful to further understand the relationships between depressive symptoms, anxiety symptoms, and happiness in non-western samples.

Overall, we hope that this line of research leads to additional work on how symptoms of psychopathology are differentially associated with happiness. If one goal of clinical psychology interventions is to promote happiness, a better understanding of the symptoms that most influence happiness will be critical. Furthermore, we hope this line of research is extended to inform our understanding of happiness and psychopathology among youth in non-western contexts. Such research will contribute to a diverse evidence base necessary to make meaningful cross-cultural comparisons relating to the relationships between symptoms and their impact on happiness. Most importantly, such research will be crucial to develop the most effective and culturally relevant interventions for youths in LMICs, who bear a considerable share of the burden of mental health problems around the world.

CRediT authorship contribution statement

Akash R. Wasil: Conceptualization, Data curation, Supervision, Formal analysis, Writing – original draft, Writing – review & editing. **Sarah Gillespie:** Data curation, Supervision, Writing – original draft, Writing – review & editing. **Suh Jung Park:** Data curation, Supervision, Writing – original draft, Writing – review & editing. **Katherine E. Venturo-Conerly:** Data curation, Writing – review & editing. **Tom L. Osborn:** Data curation, Writing – review & editing. **Robert J. DeRubeis:** Data curation, Writing – review & editing. **John R. Weisz:** Formal analysis, Writing – review & editing. **Payton J. Jones:** Data curation, Supervision, Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare no conflict of interest.

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Supplementary materials

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