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Cross-cultural equivalence of the Kessler Psychological Distress Scale (K10) across four African countries in a multi-national study of adults

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ABSTRACT

The Kessler Psychological Distress Scale (K10) has been widely used to screen psychological distress across many countries. However, its performance has not been extensively studied in Africa. The present study sought to evaluate and compare measurement properties of the K10 across four African countries: Ethiopia, Kenya, Uganda, and South Africa. Our hypothesis is that the measure will show equivalence across all.

Data are drawn from a neuropsychiatric genetic study among adult participants ($N = 9179$) from general medical settings in Ethiopia ($n = 1928$), Kenya ($n = 2556$), Uganda ($n = 2104$), and South Africa ($n = 2591$). A unidimensional model with correlated errors was tested for equivalence across study countries using confirmatory factor analyses and the alignment optimization method. Results displayed 30 % noninvariance (i.e., variation) for both intercepts and factor loadings across all countries. Monte Carlo simulations showed a correlation of 0.998, a good replication of population values, indicating minimal noninvariance, or variation. Items "so nervous," "lack of energy/effortful tasks," and "tired" were consistently equivalent for intercepts and factor loadings, respectively. However, items "depressed" and "so depressed" consistently differed across study countries ($R^2 = 0$) for intercepts and factor loadings for both items.

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The K10 scale likely functions equivalently across the four countries for most items, except "depressed" and "so depressed." Differences in K10 items were more common in Kenya and Ethiopia, suggesting cultural context may influence the interpretation of some items and the potential need for cultural adaptations in these countries.

1. Introduction

Common mental health disorders, such as anxiety, depression, and related conditions, are prevalent worldwide affecting one in five individuals annually and one in three during their lifetime (McGrath et al., 2023; Steel et al., 2014). Depression and anxiety disorders alone account for over half of the disability-adjusted life years associated with all mental, neurological, and substance use disorders combined (GBD-2019-Mental Disorders Collaborators, 2022; Rehm and Shield, 2019). In low-and middle-income countries, the adverse impact of untreated common mental health disorders may be even greater given the compounding effects of limited resources, stigma associated with mental illness, and low access to healthcare (Saxena et al., 2007). A crucial first step to effectively prevent and treat common mental health disorders (i.e., anxiety and depressive disorders) in low-and middle-income countries may be to accurately identify and screen them (Mendelson and Eaton, 2018). Yet, several major barriers exist to reliable screening of these conditions in low-resourced settings, including characterizing symptoms of mental distress in culturally, ethnically, and linguistically diverse settings (Patel et al., 2018).

Expression of distress can vary across cultures, countries, and settings both in the types of symptoms endorsed and the language used to describe them (Haroz et al., 2017; Kohrt et al., 2014). However, few studies have examined whether widely used assessment measures for common mental health disorders, including distress, perform similarly across different cultures and settings. The question remains whether psychological constructs, including symptoms first described in "Western settings" (i.e., U.S.A., Canada, Western Europe, Australia), are relevant for individuals from varying cultural, ethnic, and linguistic contexts. If evidence is limited for equivalence of symptom measures, findings from population-based studies may not reflect true differences in prevalence estimates of disorders but may instead reflect an artifact of the instruments used to measure them (Sweetland et al., 2014). Inaccurate and insensitive tools are likely to lead to not only inaccurate prevalence estimates from population-based studies that could influence health policy and resource allocation in the health system, but also to inadequate clinical care due to under-detection of people with these disorders. Thus, investigations across multicultural settings are needed to reliably estimate the true population-level burden of common mental disorders and accurate screenings in clinical settings.

A widely used tool for detecting anxiety and depression symptoms in population-based and clinical settings is the Kessler Psychological Distress Scale (K10; Kessler et al., 2002). Originally developed in the United States for use in the National Health Interview Study, the measure has become widely used globally including in major epidemiological psychiatric survey studies as well as a tool to screen individuals for depression, anxiety, and/or psychological distress across many countries (Kessler et al., 2010; Tran et al., 2019). Initial validation studies demonstrated good psychometric properties among samples in the U.S.A. and Australia (Andrews and Slade, 2001; Kessler et al., 2002). Studies examining the factor structure of the K10 have found both unidimensional and two latent constructs depending on inclusion of mostly community or clinical samples (Sunderland et al., 2012). In addition, evidence suggests the K10 may have cross-cultural validity and good psychometric properties across various settings outside of the U.S.A. (e.g., Puac-Polanco et al., 2023; Tran et al., 2019).

However, the evidence base in Africa is more limited, where fewer studies have been conducted compared to "Western settings." For example, there have been five studies in South Africa (Andersen et al., 2011; Hoffman et al., 2022; Spies et al., 2009; Spies et al., 2009; van Heyningen et al., 2018), three in Ethiopia (Hanlon et al., 2015; Milkias et al., 2022; Tesfaye et al., 2010), one in Kenya (Ongeri et al., 2022), one in Uganda (Naisanga et al., 2022), one in Tanzania (Vissoci et al., 2018), and one in Burkina Faso (Baggaley et al., 2007; see supplementary Table 1 for more information on these articles). The K10 has shown good psychometric properties and performs as well as, or outperformed, other brief screening instruments in Ethiopia with good criterion validity for depression against the Mini International Neuropsychiatric Interview in primary care patients (Hanlon et al., 2015) and for common mental health disorders against the Comprehensive Psychopathological Rating Scale (CPRS) for postnatal women (Tesfaye et al., 2010). Investigations in South Africa and Burkina Faso also showed good psychometric support for the performance of the K10 in detecting depression and anxiety (Andersen et al., 2011; Baggaley et al., 2007; Patel et al., 2008; Spies et al., 2009; Spies et al., 2009; van Heyningen et al., 2018).

Few studies have examined the factorial validity of the K10 in African countries. Several studies have been published by our group using the same dataset as this study to explore the factor structure of the K10 in: Ethiopia (Milkias et al., 2022), Kenya (Ongeri et al., 2022), Uganda (Naisanga et al., 2022) and South Africa (Hoffman et al., 2022). These investigations provide broad support for the cross-cultural validity of the K10, with a similar factor structure being present in all four (which was a unidimensional model with correlated errors). Aside from our group, only two other studies, to the authors' knowledge, examined the factor structure of the K10 in Africa: one in Ethiopia (Hanlon et al., 2015) and one in Tanzania (Vissoci et al., 2018). In Ethiopia, Hanlon and colleagues found a unidimensional structure through exploratory factor analysis (Hanlon et al., 2015), and in Tanzania, a two-factor structure was noted (Vissoci et al., 2018). In addition, some studies have found that the K10 demonstrated significantly lower discriminating ability among Black South Africans compared to White, "Colored," and Indian/Asian groups in South Africa (Andersen et al., 2011). In summary, existing evidence suggests some validity for applying K10 across cultures and settings in African countries. However, if the measure is to be used for research or clinical purposes across settings, more information is needed on whether the K10 performs similarly across various cultures. While preliminary studies suggest that the K10 is a promising screening instrument, to the authors' knowledge, no study has directly compared its psychometric properties across multi-national settings, comprising linguistically, ethnically, and culturally different settings within Africa.

1.1. Current study

In the present study, we sought to investigate the cultural equivalence of K10 across four countries: Ethiopia, Kenya, Uganda and South Africa. If the K10 measures the same construct across countries with different cultures and languages, few differences would exist across them in how the measure is performing, meaning that individuals across settings interpret and respond to the items on the K10 similarly and the measure has cross-cultural equivalence. We chose to assess cultural equivalence through measurement invariance, which as defined in Brown (2015), as a statistical property that shows if an instrument assesses the same construct (has the same factor structure) and has similar relationships to the construct through equal parameters (e.g., of the confirmatory factor model) across groups. Specifically, we aimed to determine if K10 items assess the same constructs and show equivalent relationships to the psychological distress construct across the four countries. We also aimed to evaluate the generalizability of the psychological distress construct as measured by K10 across the different countries. As such, we hypothesized measurement invariance (i.e.,

equivalence) of K10 across the four countries in Africa using data from a large neuropsychiatric genetic study.

2. Methods

2.1. Study population

This study used data from the Neuropsychiatric Genetics of African Populations-Psychosis (NeuroGAP-Psychosis) study. NeuroGAP-Psychosis is a multi-country, case-control study of psychotic disorders conducted in Ethiopia, Kenya, Uganda, and South Africa. The overarching aims of NeuroGAP-Psychosis are to expand our understanding of the neuropsychiatric and genetic underpinnings of schizophrenia and bipolar disorder through large-scale sample collection and analyses in understudied populations. Methodological details of the study have been previously published (Stevenson et al., 2019). Data is included from participants enrolled from the study's start, February 2018, through March 2020. The sample consists of 9179 participants from Ethiopia ($n = 1928$), Kenya ($n = 2556$), Uganda ($n = 2104$), and South Africa ($n = 2591$), and a common research protocol was used (Stevenson et al., 2019). Participants included in this analysis were controls in the NeuroGAP-Psychosis study.

Only controls were administered the K10 measure as part of the study. Eligibility for control participants included that they were at least 18 years old and spoke one of the consent languages. Exclusion criteria included a current or previous clinical diagnosis of psychotic disorders (i.e., schizophrenia, bipolar disorders with psychotic features), alcohol and substance misuse as demonstrated by inpatient or in acute medical care for the condition, or the inability to consent to the study, as determined by the University of California, San Diego Brief Assessment of Capacity to Consent (UBACC; Jeste et al., 2007). Participants were recruited from general medical facilities and where they were seeking healthcare, were caregivers for individuals seeking care, or were students or staff members working at the clinics. In Ethiopia, control participants were recruited at the Black Lion Hospital, also known as the Tikur Anbessa Specialized Hospital, which is a referral hospital in Addis Ababa, the capital city, where patients can be referred from throughout the country. In Kenya, control participants were enrolled from medical facilities serving both urban and rural residents from the western region from Moi Teaching and Referral Hospital in Eldoret and affiliated sites in Webuye, Kapenguria, Kitale, Kapsabet, Iten, and Kakamega, and from the coastal region from the Kenya Medical Research Institute (KEMRI) Wellcome Trust Research Programme with recruiting sites in Kilifi County, Malindi sub-County, Port Reitz, and Coast General Provincial Hospitals. In Uganda, control study participants were recruited from Butabika National Mental Health Referral Hospital and four regional referral hospitals in Uganda: Naguru, Arua, Mbarara, and Gulu Hospitals. Ugandan study sites were located within urban centers but served both urban and rural populations as primary and secondary referral health facilities. In South Africa, participants were enrolled from a mix of urban and rural sites from the Eastern and Western Cape Provinces: Fort England Psychiatric Hospital and satellite clinics (Makhanda, Eastern Cape), Nelson Mandela Academic Hospital, Mthatha General Hospital and satellite clinics (Mthatha, Eastern Cape), Dora Nginza Hospital and satellite clinics (Gqeberha, Eastern Cape), Cecilia Makiwane Hospital and satellite clinics (East London, Eastern Cape), Komani Hospital and satellite clinics (Komani, Eastern Cape), Valkenberg Hospital (Cape Town, Western Cape), and several community clinics in the Cape Town Metropolitan Area.

2.2. Demographic characteristics

Study participants provided information on demographic variables, including age, level of education, marital status, current living situation, and sex at birth. Information on these variables was collected using encrypted tablets and uploaded to a secure cloud-based server.

2.3. Kessler 10

The Kessler Psychological Distress Scale is a 10-item questionnaire assessing general psychological distress experienced in the past 30 days (Kessler et al., 2002, 2003). Items assess commonly associated symptoms of depressive and anxiety disorders on a 5-point Likert scale from 0 to 4, with higher values corresponding to greater distress. A total score is derived by summing all items, ranging from 0 to 40. The K10 has excellent psychometric performance, including good concordance with blinded clinical diagnoses in the U.S.A. and other "Western" (i.e., Canada, Australia, New Zealand, and Western Europe) countries (Andrews and Slade, 2001; Furukawa et al., 2003; Kessler et al., 2002).

2.4. Study procedures

The self-report version of the K10 items and responses were read to participants to avoid challenges with literacy and unfamiliarity with the format of questionnaires. Research staff across all study sites received structured training on the administration of the K10, including role-plays, item-by-item description of questionnaires, and on-site supervision and support.

K10 was translated into local languages in each country. A thorough translation and back-translation by independent mental health experts was conducted, and these two versions were then compared by the study team to arrive at a consensus. Local languages included: Acholi-Luo, Afrikaans, Amharic, Kiswahili, Luganda, Lugbara, Afaan Oromoo, Runyankole and Xhosa (see supplemental materials for translated K10 versions). Of note, in Kenya, Uganda and South Africa, the K10 was also administered in English to those who spoke it as their preferred language.

2.4.1. Ethical considerations

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees. Informed consent was obtained from all participants, and all procedures involving human subjects were approved prior to the commencement of data collection procedures. The Institutional Review Board at Harvard T.H. Chan School of Public Health (#IRB17-0822) in the U.S.A reviewed the study as did local sites throughout the African sites (see Stevenson et al., 2019 for details of local ethics boards).

2.5. Statistical analysis

We first explored frequency distributions of sociodemographic and lifestyle characteristics of participants by country. Participants' characteristics were summarized using means (± standard deviation [*SD*]) for continuous variables with normal distributions and counts and percentages for categorical variables. For continuous variables with non-normal distribution as assessed using the Shapiro–Wilk test, we report median values (interquartile ranges [*IQR*]). In addition, means, SDs, and Cronbach's alpha were calculated for K10 items for each country (see Supplemental Table 2). Descriptive analyses were performed using SPSS v.25, and psychometric analyses were conducted using MPlus 8.5 (Muthen and Muthen, 1998-2017).

2.5.1. Measurement invariance

Measurement invariance has been examined through a series of multiple-group confirmatory factor analyses in the past (CFAs; Brown, 2015; Jöreskog, 1971). Traditionally, to evaluate instrument performance across groups, increasing constraints on models have been placed at each step starting with configural, then metric, and lastly scalar invariance. However, there are many disadvantages to traditional multiple-group CFAs, including that factor means cannot be used to compare models. Also, scalar invariance is typically rejected given its stringency, and to arrive at partial invariance with a scalar model, items are removed individually, which is both cumbersome and may lead to

incorrect solutions (Asparouhov and Muthén, 2014; Muthén & Asparouhov, 2018).

2.5.1.1. Alignment optimization method. Recent advancements in measurement invariance methodology have pointed to new procedures for identifying invariance across several countries, or groups, including the alignment optimization method (Asparouhov and Muthén, 2014; Muthén & Asparouhov, 2018). For these analyses, we utilized CFAs for the comparison of group-specific means and variances through approximate instead of exact invariance, which allows flexibility in determining optimal model fit. First, a configural model was used to establish factor means (see Fig. 1). The configural model was based on prior work with weighted least squares estimation a unidimensional factor structure with correlated errors (Sunderland et al., 2012) for the following items pairs: nervous, so nervous, restless, so restless, and depressed so depressed (see Fig. 1). This model was chosen because it was found to be most appropriate for community samples (instead of clinical samples) and research from this dataset on the country-specific performance of K10 found that the unidimensional model with correlated errors was the best fitting for Ethiopia (Milkias et al., 2022), Kenya (Ongeri et al., 2022), Uganda (Naisanga et al., 2022) and South Africa (Hoffman et al., 2022).

Then, an aligned optimization model was estimated with the same fit as the configural model while minimizing the amount of noninvariance through a simplicity function, similar to rotation criteria utilized in exploratory factor analyses (Asparouhov and Muthén, 2014). We used a *fixed* approach where the factor mean was fixed to 0, with Uganda serving as the reference group given that its factor mean was closest to 0. This approach was selected because a *free* alignment approach where all factor means were freely estimated resulted in standard errors that indicated that type of model might be poorly identified (Asparouhov and Muthén, 2014).

The alignment optimization method allowed comparison of parameters such as item intercepts (i.e., item mean value) and factor loadings from all groups, with smaller contributions to the simplicity function suggesting invariant variables. A recommended 25 % threshold is used for establishing invariance. If more than 25 % of the intercepts or more than 25 % of the factor loadings make small contributions to simplicity function, then noninvariance, or differences, are likely across groups (Muthén and Asparouhov, 2014). Lastly, we conducted Monte Carlo simulation studies to check the quality of the alignment solution by examining the stability of the findings across groups, or countries in our case (Muthén and Asparouhov, 2018). A recommended correlation of 0.980 or greater has been made for groups' ordering for factors to be trustworthy (Muthén and Asparouhov, 2013).

3. Results

3.1. Descriptive statistics

Demographic information for participants across all four countries is reported in Table 1. Kenyan and South African participants were equally represented across female and male sex at birth, whereas the Ugandan group had slightly more female than male participants (56.3 %), and the Ethiopian group had more male participants (60 %). Median participant age across all four countries ranged between 33 and 35 years old. South African participants differed somewhat from participants in other countries with comparatively higher rates of single marital status and completion of at least some secondary education. In terms of living arrangements for study participants, most lived with a spouse or partner across all countries. Ethiopia and South Africa were the only countries where the second most common option was people who lived in the parental home. Lastly, Supplementary Table 2 includes information on K10 means, SDs, and Cronbach's alphas for each country that ranged from 0.83 to 0.86 (for a full discussion of these please refer to Hoffman et al., 2022; Milkias et al., 2022; Naisanga et al., 2022; Ongeri et al., 2022).

Table 1
Participant demographics by African country, $N = 9179$.

	South Africa n = 2591	Kenya n = 2556	Uganda n = 2104	Ethiopia n = 1928
	Count (%)	Count (%)	Count (%)	Count (%)
Sex				
Female	1337 (51.6)	1239 (48.5)	1185 (56.3)	767 (39.8)
Male	1254 (48.4)	1317 (51.5)	919 (43.7)	1161 (60.2)
Age (median, IQR)	33.0 (17.0)	34.0 (18.0)	33.0 (18.0)	35.0 (15.0)
18–29	955 (36.9)	809 (31.7)	750 (35.6)	487 (25.3)
30–44	1056 (40.8)	1101 (43.1)	840 (39.9)	1001 (51.9)
45–59	493 (19.0)	518 (20.3)	387 (18.4)	388 (20.1)
60+	87 (3.4)	128 (5.0)	127 (6.0)	52 (2.7)
Marital status				
Single	1436 (55.4)	841 (32.9)	600 (28.5)	751 (39.0)
Married or cohabitating	880 (34.0)	1367 (53.5)	1110 (52.8)	900 (46.7)
Widowed	64 (2.5)	112 (4.4)	135 (6.4)	80 (4.1)
Divorced or separated	204 (7.9)	235 (9.2)	258 (12.3)	197 (10.2)
Level of education				
No formal	8 (0.3)	44 (1.7)	114 (5.4)	52 (2.7)
Primary	218 (8.4)	602 (23.6)	663 (31.5)	449 (23.3)
Secondary	1877 (72.4)	753 (29.5)	890 (42.3)	567 (29.4)
University	486 (18.8)	1156 (45.2)	435 (20.7)	860 (44.6)
Living arrangements				
Alone	610 (23.5)	532 (20.8)	324 (15.4)	280 (14.5)
Parental family	630 (24.3)	447 (17.5)	357 (17.0)	655 (34.0)
Spouse or partner	875 (33.8)	1194 (46.7)	994 (47.2)	872 (45.2)
Friends or other relatives	453 (17.5)	381 (14.9)	423 (20.2)	113 (5.8)

Note: Counts may may not add up to the total sample size due to missing information for some categories from some participants. IQR = interquartile range. Methods: frequencies by count and percentages.

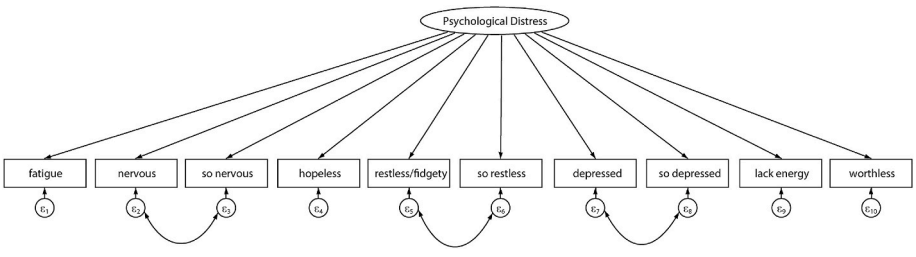

Fig. 1. Unidimensional model with correlated errors for configural model for K10 for alignment optimization method. *Note:* See individual country papers (Hoffman et al., 2022; Milkias et al., 2022; Naisanga et al., 2022; Ongeri et al., 2022) for estimates for each model for each country.

3.2. Measurement invariance

3.2.1. Alignment optimization method

The comparison of CFA models across countries with the alignment optimization method yielded several congruent results when comparing across countries and K10 items. Table 2 displays direct results from the alignment optimization model parameters (i.e., item intercepts [or means] and factor loadings), with countries that differed or were non-invariant, presented in bold and parenthesis. The total amount of non-invariance (i.e., bolded countries) when comparing the four countries for both item intercepts and factor loadings was 30 %, slightly higher than the recommended 25 % threshold for establishing invariance (Muthén and Asparouhov, 2014). Noninvariance, or difference, was equally spread across intercepts and factor loadings for all items on the K10 with 30 % noninvariance across intercepts and 30 % noninvariance across loadings. Kenya was the country with the most noninvariance, meaning it differed the most from all others across both intercepts and factor loadings with 40 % total noninvariance. Ethiopia was a close second with 35 % noninvariance mostly from factor loadings. Uganda was the country with the least noninvariance with 20 % for both intercepts and loadings, meaning it differed the least, and South Africa had 25 % overall noninvariance (see Table 2).

When examining similarities at the item level, most items performed equivalently across parameters for all four countries, though a few differed by country. Table 3 represents invariance for loadings and intercepts by item across all countries. The fit function and R^2 are measures of invariance with higher values indicating invariance. R^2 values closer to 0 suggest noninvariance, and items with values closer to 1 are invariant across groups. Most items on the K10 appeared invariant based on the results from Table 3, meaning they were equivalent across countries. Based on both fit function contribution and R^2, "so nervous," "lack of energy" (i.e., feeling that tasks and activities were effortful) and "tired" were the most invariant items for intercepts and loadings respectively. These findings were consistent with those seen in Table 2, where the items "so nervous" was invariant across intercepts and "tired" was invariant across factor loadings for all countries. Thus, the items "so nervous," "lack of energy, and "tired" performed *most* similarly across samples from the four countries in representing the construct of distress.

Alternatively, several items functioned differently both across most countries and for some countries specifically. The items "depressed" and "so depressed" functioned differently across countries by displaying noninvariance for both intercepts and loadings (see Table 2), meaning that these two items did not appear to function similarly across the four countries. As shown in Table 2, "depressed" and "so depressed" differed most consistently in South Africa and Ethiopia. In addition, items that functioned differently in Kenya (the country with the most differences) for both the intercept of factor loading levels were nervous/so nervous, lack of energy, and worthless (see Table 2). This was in contrast with how consistently similar these items performed across the other three other countries (Tables 2 and 3).

Table 4 displays factor means derived from the alignment optimization model where Uganda served as the reference group. Study countries are ordered from highest to lowest based on factor means, with South Africa as the country with the highest levels of distress and Ethiopia with the lowest. Results suggest that study participants in Kenya and South Africa endorsed higher levels of distress as measured by K10 compared to participants in Ethiopia and Uganda.

We also conducted a recommended Monte Carlo simulation study given that 30 % of our measurement parameters were noninvariant, meaning above the 25 % cut off (Muthén and Asparouhov, 2014). In the Monte Carlo simulations study, replications were used to generate factor means, which were then compared to the factor means for the four countries from the alignment method. Muthén and Asparouhov (2013) recommend a correlation of at least 0.980 for the ordering of groups for factors to be trustworthy. We found a correlation of 0.998 that indicates the Monte Carlo simulation based on the data from our study were successful in recovering population values and that noninvariance is not large in our data.

Table 2
Approximate measurement noninvariance for intercepts and loadings by African country for K10.

	Intercepts				Total
1. Tired	SA	KE	**(UG)**	**(ETH)**	
2. Nervous	SA	**(KE)**	UG	ETH	
3. So nervous	SA	KE	UG	ETH	
4. Hopeless	**(SA)**	KE	UG	ETH	
5. Restless	SA	KE	**(UG)**	ETH	
6. So restless	SA	KE	UG	**(ETH)**	
7. Depressed	**(SA)**	KE	**(UG)**	ETH	
8. So depressed	**(SA)**	**(KE)**	UG	ETH	
9. Lack of energy	SA	**(KE)**	UG	ETH	
10. Worthless	SA	**(KE)**	UG	ETH	
% Noninvariance	30 %	40 %	30 %	20 %	30 %
	Loadings				
1. Tired	SA	KE	UG	ETH	
2. Nervous	SA	KE	UG	**(ETH)**	
3. So nervous	SA	**(KE)**	UG	ETH	
4. Hopeless	SA	KE	UG	**(ETH)**	
5. Restless	SA	KE	**(UG)**	ETH	
6. So restless	SA	**(KE)**	UG	ETH	
7. Depressed	**(SA)**	KE	UG	**(ETH)**	
8. So depressed	**(SA)**	KE	UG	**(ETH)**	
9. Lack of energy	SA	**(KE)**	UG	ETH	
10. Worthless	SA	**(KE)**	UG	**(ETH)**	
% Noninvariance	20 %	40 %	10 %	50 %	30 %
% Total noninvariance	25 %	40 %	20 %	35 %	30 %

Note. Countries that are deemed to have a significantly noninvariant measurement parameter are shown in boldface within parentheses. SA= South Africa; KE= Kenya; UG= Uganda; ETH = Ethiopia.
Method: alignment-optimization with confirmatory factor analyses (maximum likelihood) with fixed approach with Uganda as the reference country.

Table 3
Alignment fit statistics for all countries for K10.

	Intercepts		Loadings	
Items	Fit function contribution	R^2	Fit function contribution	R^2
1. Tired	−3.113	0.875	−2.189	0.947
2. Nervous	−2.514	0.939	−2.478	0.690
3. So nervous	−2.068	0.952	−2.768	0.734
4. Hopeless	−2.882	0.884	−2.401	0.933
5. Restless	−2.429	0.942	−2.506	0.797
6. So restless	−2.359	0.890	−2.702	0.770
7. Depressed	−3.596	0.000	−3.244	0.000
8. So depressed	−3.202	0.000	−2.897	0.356
9. Lack of energy	−2.359	0.978	−2.499	0.872
10. Worthless	−2.337	0.924	−2.760	0.854

4. Discussion

The aim of this study was to examine psychometric equivalence of the K10 measure across four African countries, including Ethiopia,

Table 4
Factor means comparison for all four countries.

Ranking	Group	Factor Mean Value	Groups with Significantly Smaller Factor Mean (5 % significance level)
1	SA	0.611	KE UG ETH
2	KE	0.220	UG ETH
3	UG	0.000	ETH
4	ETH	−0.314	

Kenya, Uganda, and South Africa. Overall, the K10 seems to be mostly invariant (i.e., equivalent) across the four countries that were tested, particularly based on Monte Carlo simulation studies for which alignment method results were well replicated. However, certain countries and several items showed some variation that merits further exploration. For example, results in the Kenyan group suggested a high percentage of noninvariance, or difference, compared to the other countries. Data from Ethiopia also demonstrated noninvariance, in particular, with factor loadings, or how items represented the psychological distress construct. These findings for Kenya and Ethiopia likely mean that cultural influences are shaping how participants in these settings interpret and respond to certain K10 items with those in Kenya consistently ratings items higher and those in Ethiopia consistently rating items lower given differences in each country's factor means. One explanation for differences in Kenya could include that data was collected from two different regions, a western and eastern one with differences in culture, ethnicity, language and socioeconomic status. In addition, much variability existed within the western Kenyan clinics with diverse cultures and settings (see Ongeri et al., 2022 from our group for more information). Diversity in these variables in Kenya may have contributed to the differences found there by impacting how participants understand and assign meaning to items on the K10. In addition, it should be noted that Ethiopia was the only setting where the English version of the K10 was not administered since it is not a spoken language there like the other three countries. As such, differences for Ethiopia could be driven from not having an English version K10 (linguistic artifact) rather than true cultural differences.

Items that assessed depression, including "depressed" and "so depressed," did not function uniformly across settings, suggesting that participants in each country likely understand these items differently. These two items differed for Ethiopia and South Africa in particular, which was similar to prior research on K10 and depression measures in Ethiopia and South Africa. This finding is aligned with studies on postpartum depression among mothers in Ethiopia, noting lack of content validity for the item "depressed" on the K10, suggesting that a better term for the setting may be "feeling unhappy" (Tesfaye et al., 2010). The study by Tesfaye and colleagues (2010) also found that the item "worthless" on K10 was not understood by most participants and had to be altered to "no value," which was consistent with our evidence that the item "worthless" functioned differently for Ethiopia at the factor loading level. Similarly, a study of depression screening measures that included the K10 in primary care in Ethiopia found that endorsing "feeling depressed" was not prevalent among all depressed patients compared to other presenting symptoms, such as irritability, hypothesized by the authors to be due to cultural difference in societal acceptance of sadness, but not anger (Hanlon et al., 2015). In addition, the K10 scale showed mixed results in South Africa for detecting depressed and anxious individuals (Andersen et al., 2011; Peltzer et al., 2012; Spies et al., 2009; Spies, Stein et al., 2009; van Heyningen et al., 2018), with poor detection rates particularly for Black South Africans (Andersen et al., 2011). Prior work has suggested that items assessing mood using the words "depression" may at times perform less well in African countries compared to "Western settings" (Bolton, 2001; Kaaya et al., 2008) though a published review of qualitative literature showed that depressed mood was frequently endorsed in studies in African countries (Haroz et al., 2017). Our findings on items "depressed" and "so depressed" combined with the mixed literature in this area suggest that future work is warranted, including qualitative and mixed methods approaches, to clarify how participants in various cultural groups interpret these items from their perspectives. In addition, measures that are transdiagnostic and/or that group symptoms based on mechanism of development and maintenance of disorders (i.e., how emotion avoidance is showing up in that particular culture) may be more helpful than DMS based symptoms that may be culturally bound to "Western" settings.

The differences in intercepts and factor loadings in Kenya for items nervous/so nervous, lack of energy, and worthlessness contrasted with the rest of the data for the other three countries, where the items may apply consistently. Item level data for depression in Kenya is limited despite research conducted on depression measures (e.g., Otiende et al., 2017), making it difficult to interpret the present finding. A recent publication that focused on a culturally informed depression scale among Luo people in Kenya, the Luo Depression Questionnaire, includes three items related to lack of energy: "Feeling that your heart is tired to the extent that you have trouble doing things," "feeling tired even when you haven't done anything," and "Feeling weak but you can't find what causes weakness," suggesting that "lack of energy" may have a more nuanced meaning in Kenya relative to other settings (Osborn et al., 2021). Similarly, when Osborn et al. (2021) compared worthlessness to an equivalent term for the Luo, they found a complex construct that involved self, social relationships, and societal expectations. More research may be needed to understand how the K10 may function differently in Kenya, though prior findings from our group (Ongeri et al., 2022) showed that the measures for Kenya fit well with prior literature. Research in depressive symptoms in eastern Kenya has shown they are under-detected in Kilifi resulting in poor health seeking behavior for depression in some outpatient clinics (Bitta et al., 2017).

Overall, the K10 seemed to function equivalently across countries and is likely measuring psychological distress, anxiety, and depression symptoms similarly. Several items, especially "depressed," may need to be culturally adapted. Understanding invariance can help with further cultural adaptations in each country (e.g., Ametaj et al., 2021) so that measures are more sensitive and equivalent across settings. For example, tools that screen for somatic symptoms, irritability, sleep disturbances and thoughts of death have been found to perform better in screening for distress in Ethiopia (Hanlon et al., 2008; Tomlinson et al., 2007). Qualitative and mixed methods approaches, such as cognitive interviewing, may help in identifying appropriate cultural adaptations to improve psychometric properties of measures like the K10. Overall, this study's strengths include a large sample size within each country that helps identify items and settings for further exploration.

4.1. Limitations and future directions

Findings from the present study should be understood within their limitations. First, our study sample was drawn from a general hospital population and caretakers of individuals seeking healthcare, which may limit some of the generalizability of our findings to the broader populations in each setting. This limitation is partially offset by the large study sample size. Second, measurement invariance is aimed at determining cultural equivalence of symptoms but lacks information on symptom prevalence and sensitivity to capturing clinical diagnoses of depression or anxiety. For example, an item like "tired" may function similarly across all four countries but may be less predictive of true cases of depression. Future studies that are focused on criterion validity in each of the four countries can shed light on prevalence and sensitivity of specific items. Third, we compared K10 across four African countries but not against a U.S.A. population, where the measure was developed. Future studies that include a control or reference population (e.g., U.S.A. based sample) may be useful in determining the degree of variability from the original items as others have done (e.g., Heuvelman et al., 2018). Lastly, findings are limited due to cultural variations within each country (e.g., two distinct regions in Kenya for recruitment) or various K10 language versions within each country from different spoken languages. We did not have sample sizes that were equal or large enough to examine invariance by language or study center.

4.2. Conclusion

The K10 scale performed mostly equivalently across Ethiopia, Kenya, Uganda, and South Africa. Findings suggest that the measure might be interpreted similarly and may be generalizable across these four

countries. Items "so nervous," "lack of energy/effortful tasks" and "tired" were consistently equivalent, but the items "depressed" and "so depressed" are likely interpreted differently across settings. Compared to other countries, Kenya and Ethiopia were two settings where comparative differences appeared on the K10, suggesting that participants in these countries likely interpret some items differently. Future research that includes a comparison reference population from a "Western" country may shed light on variations with respect to an original validation sample. Also, future work using mixed methods research would add to understanding local variation in item meanings across the four countries examined in the present report.

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Contribution

All authors have materially participated in the research and/or article preparation for this study. AAA, CAD, and BG participated in the design of research questions and study for this manuscript. AAA conducted data analyses and interpretation of results. AAA, CAD, and JH drafted the manuscript. DA, EKK, LA, ST, ZZ, DJS, CRJCN and SMK, KCK, and BG obtained funding for the NeuroGAP-Psychosis study. AS, RES, JK, SG, MA, AP, and RMM contributed to data acquisition. All authors reviewed the results, edited and critically revised the manuscript, and approved the final version of the manuscript.

CRediT authorship contribution statement

Amantia A. Ametaj: Formal analysis, Writing – original draft, Writing – review & editing. **Christy A. Denckla:** Conceptualization, Writing – original draft, Writing – review & editing. **Anne Stevenson:** Project administration, Writing – review & editing. **Rocky E. Stroud:** Project administration, Writing – review & editing. **Jasmine Hall:** Writing – original draft. **Linnet Ongeri:** Writing – original draft, Writing – review & editing. **Barkot Milkias:** Writing – original draft, Writing – review & editing. **Jacob Hoffman:** Writing – original draft, Writing – review & editing. **Molly Naisanga:** Writing – original draft, Writing – review & editing. **Dickens Akena:** Funding acquisition, Resources, Supervision, Writing – review & editing. **Joseph Kyebuzibwa:** Project administration, Writing – review & editing. **Edith K. Kwobah:** Investigation, Resources, Supervision, Writing – review & editing. **Lukoye Atwoli:** Funding acquisition, Investigation, Supervision, Writing – review & editing. **Stella Gichuru:** Project administration, Writing – review & editing. **Solomon Teferra:** Funding acquisition, Investigation, Supervision, Writing – review & editing. **Melkam Alemayehu:** Project administration, Writing – review & editing. **Zukiswa Zingela:** Investigation, Supervision, Writing – review & editing. **Dan J. Stein:** Funding acquisition, Investigation, Supervision, Writing – review & editing. **Adele Pretorius:** Project administration, Writing – review & editing. **Charles R.J.C. Newton:** Funding acquisition, Investigation, Resources, Supervision, Writing – review & editing. **Rehema M. Mwema:** Project administration, Writing – review & editing. **Symon M. Kariuki:** Investigation, Supervision, Writing – review & editing. **Karestan C. Koenen:** Conceptualization, Funding acquisition, Writing – review & editing. **Bizu Gelaye:** Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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