Journal of Autism and Developmental Disorders
https://doi.org/10.1007/s10803-023-05936-5

ORIGINAL PAPER

Assessing Autism Knowledge Across the Global Landscape Using the ASK-Q

Ashley J. Harrison[1,12] · Nilofer C. Naqvi[2] · Anne K. Smit[3,4] · Prisha Nanda Kumar[1] · Noor Azimah Muhammad[5] · Sabine Saade[6] · Luodi Yu[7] · Emilie Cappe[8,9] · Hui Min Low[10] · Sarah-Jane Chan[11] · Annelies de Bildt[3,4]

Accepted: 13 February 2023

Abstract

Substantial variability exists with regard to autism service provision around the world. Service disparities observed in many low- and middle-income countries may be driven, in part, by limited autism knowledge; however, measurement limitations have made it difficult to quantify autism knowledge across countries. The current study uses the autism stigma and knowledge questionnaire (ASK-Q) to quantify autism knowledge and stigma between different countries and demographics. The current study compiled data from 6830 participants collected using adapted versions of the ASK-Q administered in 13 different countries, representing four different continents. Structural equation modeling was used to examine how autism knowledge varied across country and individual factors. Results reveal cross country variability with a large, 17-point difference between the countries with the highest knowledge (Canada) and the lowest knowledge (Lebanon). As expected, countries with higher economies had higher levels of knowledge. We also documented differences based on country worldview, participant occupation, gender, age, and education level. These results help to identify specific regions and populations that might most need greater information about autism.

Keywords Autism knowledge · Global variability · Cross-cultural assessment

Early identification of autism spectrum disorder (ASD) or autism has significant implications for positive outcomes (Gabbay-Dizdar et al., 2021; Murza et al., 2016). However, the availability of screening and diagnosis varies greatly across settings and countries (Elsabbagh et al., 2012; Jafarabadi et al., 2021). Global disparities are related to the variability of knowledge about developmental disabilities, including autism (Durkin et al., 2015; Ruparelia et al., 2016; Stahmer et al., 2019) and the stigmas that accompany lower levels of autism knowledge. Research needs to document where low knowledge and high stigmas are particularly concerning to elucidate areas that could benefit from providing

✉ Ashley J. Harrison
Ashley.Harrison@uga.edu

1 Educational Psychology Department, University of Georgia, Athens, GA 30606, USA

2 Department of Psychology, Iona University, New Rochelle, NY 10801, USA

3 Department of Child and Adolescent Psychiatry, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands

4 Accare Child Study Center, Groningen, The Netherlands

5 Department of Family Medicine, Faculty of Medicine, Universiti Kebangsaan Malaysia. Jalan Yaacob Latiff, 56000 Cheras, Kuala Lumpur, Malaysia

6 Psychology Department, American University of Beirut, Beirut 1107 2020, Lebanon

7 Center for Autism Research, School of Education, Guangzhou University, Wenyi Bldg, Guangzhou, China

8 Laboratoire de Psychopathologie et Processus de Santé, Université Paris Cité, 92100 Boulogne-Billancourt, France

9 Institut Universitaire de France (IUF), Paris, France

10 School of Education Studies, Universiti Sains Malaysia, Penang, Malaysia

11 Manggatal Health Clinic, Ministry of Health Malaysia, Putrajaya, Malaysia

12 Department of Educational Psychology, University of Georgia, Aderhold Hall 110 Carlton Street, Athens, GA 30602, USA

Published online: 09 March 2023

more widespread general autism knowledge. Additionally, factors that possibly underlie autism knowledge and stigma need to be investigated.

Global Autism Knowledge Variability

Low autism knowledge has been identified in Indonesia, Laos, Malaysia, and countries in Africa. For example, in Malaysia, there is reported awareness of autism, but many individuals only know the term "Autism" as a category of learning disabilities with little other knowledge (Low & Zailan, 2018). Additionally, less than half (49.6%) of parents, teachers and therapists in Indonesia had adequate knowledge of autism (Handayani & Paramita, 2020) and in Laos only 10–40% of the studied population had adequate knowledge of autism across different domains (i.e. etiology, diagnosis and treatment; Low et al., 2021a). In Saudi Arabia, autism knowledge was shown to be limited among the public, reaching a mean level of just over a third of the maximum possible score (Alyami, 2022). Similarly, knowledge levels remain low in multiple regions of Africa (for reviews see, Bakare et al., 2022; Franz et al., 2017; Wireko-Gyebi & Ashiagbor, 2018). With this preliminary information documenting regions with low knowledge, it is difficult to know how concerning these knowledge levels are without direct comparisons to other regions and it is difficult to know what population variables likely contribute to knowledge deficits.

Unfortunately, efforts to systematically identify low autism knowledge regions through large scale comparisons have been slowed by measurement concerns in the field. More specifically, a review by Harrison et al. (2017) found that most autism knowledge measures, either had limited psychometric support, or they were developed for a particular study or context, and thus did not meet the criteria for a well established measure (Cohen et al., 2008). Progress has been made in this field with the introduction of more psychometrically sound measurement approaches (e.g., Atun-Einy & Ben-Sasson, 2018; Harrison et al., 2017; McClain et al., 2021). The Autism Stigma and Knowledge Questionnaire (ASK-Q) in particular has documented validity for assessing cross-cultural variability in autism knowledge (Harrison et al., 2017, 2019). The introduction of measures designed with cross-cultural validity in mind can facilitate cross-cultural comparisons without requiring measurement adaptation.

A more comprehensive cross-cultural examination of factors related to autism knowledge and stigma form a starting point for improvement. Until now, most studies examining knowledge in multiple cultural contexts have focused directly on increasing knowledge, as opposed to investigating possible underlying factors. For example, several studies evaluated changes in autism knowledge and stigma after trainings were conducted that aimed to increase autism knowledge and reduce stigma in both the US, as well as, Canada (Saade et al., 2021), Lebanon (Obeid et al., 2015) and Japan (Someki et al., 2018). Cross-cultural comparisons within these intervention studies showed differences in improvement, but did not focus on underlying factors that might result in variable ASD knowledge.

Similarly, the few studies that specifically conduct cross-cultural comparisons show differences between pairs of countries but not a more in depth assessment of factors that might contribute to population level variability in knowledge. More specifically, one comprehensive examination of autism knowledge and stigma directly compared the levels between regions using the ASK-Q in general population samples in China and in the USA (Yu et al., 2020). It showed adequate knowledge in 86–91% of the USA sample on autism diagnosis/symptoms, etiology and treatment, compared to 57–65% in the Chinese sample (Yu et al., 2020). Additionally, 14% of the USA population endorsed autism stigma, compared to 38% in China. In another study, that directly compared teachers from the UK with teachers in China, the latter were found to have lower levels of autism knowledge (Ballantyne et al., 2021). All of these studies provide an introductory snapshot of the global differences in autism knowledge and pave the way for an expansion of this investigation.

Variables Related to Autism Knowledge

Country Level Variables

Country Economy

Specific factors on a country level that may be related to autism knowledge and stigma are country economy and country worldview. Country economy is categorized based on Gross National Income per capita data in US dollars and ranges from low income to high income (World Bank, 2022). Although a commonly studied factor in autism research on diagnosis (Fombonne et al., 2021; Samms-Vaughn et al., 2017), screening (Samadi et al., 2022), universal health coverage (Divan et al., 2021), and service provision (Cardon & Marshall, 2020), country economy has not been studied in relation to autism knowledge. Since the studies mentioned previously documenting regions with low knowledge seem to represent countries with lower income (i.e., Alyami, 2022; Bakare et al., 2022; Franz et al., 2017; Handayani & Paramita, 2020; Low & Zailan, 2018), this relation should be investigated.

Worldview

Another way to categorize countries is according to their worldview (i.e., collectivist or individualist). Country worldview is a factor in perceptions on family quality of life among Korean (collectivistic) and Canadian (individualistic) parents of children with autism in Canada (Fong et al., 2021). It is also related to parental well-being, in that families with an autistic child from an individualistic country reported higher well-being compared to families from a country with a more collectivistic orientation (Smith et al., 2021). In a meta-analysis including data from studies in 64 countries, teachers from countries categorized as individualistic had more positive attitudes towards integrating children with disabilities in mainstream education compared to teachers from other countries (van Steen & Wilson, 2020). This research supports important cultural distinctions in attitudes and experience based on worldview. Research that specifically examines how this concept relates to autism knowledge and stigma is needed.

Individual Level Variables

On the individual level there are also factors that warrant cross-cultural investigation in relation to autism knowledge. Higher autism knowledge and a more positive attitude towards people with autism are consistently seen in women (Gillespie-Lynch et al., 2015; Koyama et al., 2009; Kuzminski et al, 2019; Stronach et al, 2019; Yu et al., 2020), higher socioeconomic groups, and those with higher education levels (Holt & Christensen, 2013; Koyama et al., 2009; Mitchell & Locke, 2015). The relationship between age and autism knowledge and stigma is conflicting; some research showed lower autism understanding among older participants (Koyama et al., 2009; Yu et al., 2020) while other research suggested that age had no impact on autism knowledge (Jensen et al., 2016; Kuzminski et al., 2019).

With regard to professional background, the relation with autism knowledge is not as clear. The majority of autism knowledge research focuses on knowledge among individuals who are responsible for diagnostic referrals or evaluations, such as caregivers, health professionals (e.g., pediatricians or psychologists) or service providers (e.g., teachers). Although these groups would be anticipated to have higher levels of knowledge as compared to the general public, research shows that there is variability in knowledge within different community settings (Johnson et al., 2012), between types of medical professionals (McCormack et al., 2020) and types of teachers (Sanz-Cervera et al., 2017), and among knowledge domains (McCormack et al., 2020; van't Hof et al., 2020b). Globally low levels of autism knowledge are seen among health professionals around the world such as in Turkey (Altay, 2019), Pakistan (Rahbar et al., 2011), Iraq (Muhammad et al., 2013), Sri Lanka (Rohanachandra et al., 2017), and Indonesia (Handayani & Paramita, 2020). Although research shows similarly low knowledge among teachers globally (Gómez-Marí et al., 2021), it seems that internationally, access to training seems to moderate autism knowledge among teachers (Naqvi et al., 2020; Sanz-Cervera et al., 2017).

Past research has emphasized smaller scale studies that typically examine autism knowledge patterns within one, or at most two, distinct cultural contexts. Measurement advances that specifically emphasized the development of a measure for cross-cultural study allows for the expansion of this research to large, diverse samples that can examine a wider range of participant characteristics in relation to autism knowledge to understand variable patterns across regions. Large datasets obtained through coordinated, high-quality measurement allow for the use of more complex models that can control for a range of specific variables to answer more detailed questions about population variability.

Current Study

The current study examines the results of the ASK-Q across 13 different countries and with a variety of respondents, including teachers, health professionals, and the general population. Comparing autism knowledge across country contexts allows for an examination of knowledge differences in multiple areas. First, we investigated differences across individual countries and then in terms of groupings, by worldview and income. Second, we examined differences in autism knowledge between the different populations in relation to autism that comprised the samples. Third, we examined how different sociodemographic factors related to autism knowledge.

Based on the literature review, the first hypothesis was that higher income countries would have higher amounts of autism knowledge compared to low and middle income countries. A second hypothesis would be that countries classified as individualist using the Hofstede Model (Hofstede, 2011) would have higher knowledge compared to countries considered collectivist using the general assumption that there is tendency towards countries that are higher income to be more individualistic in orientation than lower income countries (Ball, 2001). The third hypothesis was that female gender identification and higher levels of education would be related to more autism knowledge and lower stigma.

Method

Procedure

A data repository was created using Qualtrics software. All researchers (n = 66) that had requested to use the ASK-Q before 2021 were sent an email asking if they would be

willing to share data to examine the cross-cultural psychometrics (as will be discussed in another paper), as well as to examine cross-cultural differences as discussed here. See the guidelines sent to researchers in Appendix. In order to create the data repository, each researcher who had utilized the ASK-Q submitted an anonymized data file containing individual item-level ASK-Q responses and demographic data with an accompanying code. Each researcher who submitted data ($n = 21$) was assigned a unique study ID code. Data were recoded as necessary to ensure all studies used the same responses for correct and incorrect ASK-Q responses and to convert all sociodemographic data to a common metric (see sociodemographic section below). All were merged into one final file used for data analysis. The compilation of data collection occurred after collection at the individual sites. Autistic community members were not involved in this study but would be an excellent addition to the team to determine next steps for how to address areas/groups with low autism knowledge.

Measures

Autism Stigma and Knowledge Questionnaire (ASK-Q)

The ASK-Q is a 49-item questionnaire, with dichotomous (agree/disagree) response options. In the original development study conducted in the United States of America (Harrison et al., 2017), the ASK-Q was administered to participants representing the general public and produced high internal consistency (Cronbach's Alpha = 0.88) and construct validity, as well as high test-retest reliability (> 0.933) in a follow-up study (Harrison et al., 2019). Subsequent USA studies have replicated the good psychometric properties with expanded samples from the general public (Yu et al., 2020), college students (Harrison et al., 2019; Kitchin et al., 2022; Obeid et al., 2020), and police officers (Love et al., 2021). The ASK-Q has also demonstrated strong psychometric performance in distinct cultural and linguistic settings (Harrison et al., 2019; Low et al., 2021a, 2021b; Yu et al., 2020). Recently, cross-cultural validity of ASK-Q has been attested through direct comparison between data collected in China and in the USA using rigorous computational procedures (Yu et al., 2020). So far, cross-cultural application of ASK-Q is frequent and has yielded meaningful results about diverse populations around the globe including parents in Mongolia (Harrison et al., 2019), college students and teachers in China (Lu et al., 2020, 2022), and teachers in Laos (Low et al., 2021a, 2021b).

The ASK-Q generates a total knowledge score that is derived from three knowledge subdomains (Etiology, Diagnosis, Treatment). A third Stigma subscale can also be calculated but this subscale is comprised entirely of items that also load onto one of the knowledge domains. The current study opted to focus on the total ASK-Q score as the outcome variable in all analyses instead of a subscale level examination for several reasons. First, as is common when using self-report measures across cultural contexts, there is likely some variable measure performance across countries that is more likely to arise at the item or subscale level in the form of factorial invariance (Cheung & Rensvold, 1999). This is evidenced by research that shows that there is greater variability in the internal consistency among the subscales (i.e., Saade et al., 2021), although the ASK-Q total score has demonstrated strong psychometrics across multiple cultural contexts (i.e., Harrison et al., 2019; Low et al., 2021a, 2021b; Lu et al., 2020). Second, this approach allowed for the simplification of already complex analyses that still provides a meaningful gauge of regions/populations with particularly concerning knowledge levels. The reported internal consistency values of the total ASK-Q in this international research ranges from 0.72 to 0.87 (Harrison et al., 2019; Low et al., 2021a, 2021b; Lu et al., 2020).

Sociodemographic Data

Participating research sites uploaded demographic data collected for their particular study about participants, including gender, role in participating in study, occupation, age, and education level. A master data code was then created to develop numeric values for all the demographic variables that were applicable across all datasets to ensure a shared demographic nomenclature for comparable analysis. Coding for each sociodemographic variable was reviewed and then the option choices for each variable that had the highest generalizability was selected and used in the overall data set. Additional coding such as worldview and country economy was based on the country participants resided in at the time of the study.

Individual Level Variables We included age, gender, level of education and the population or relation to autism of the participants. For age, some sites used discrete numbers and some used ranges, thus for the combined dataset a composite choice was selected that aligned with all of the datasets: age categories utilized included, (1) college age (18–25 years), (2) young adult (26–35 years), (3) middle aged (36–50 years), (4) older adult (51–64 years), and (5) elderly (65 years or older). The population variable was consolidated into (1) general public, (2) teachers or teachers in training (students in education-specific programs), (3) family members of autistic persons, and (4) health professionals (physicians, psychologists, and/or other clinicians). The education variable aligned with the range of reported education from all of the datasets and was designed to be inclusive of different international educational conceptualizations. The resulting educational categories were (1) some high school/sec-

ondary school, (2) high school/secondary school diploma or equivalent (3) Associate's or other two-year degree (4) some college, no degree (5) Bachelor's or other four-year degree or (6) graduate or professional degree. Gender was categorized into 4 indications: (1) Male, (2) Female, (3) Other, (4) Missing. In addition to the variables stated above, there were other demographic variables that were requested from individual research sites but multiple were not included in the final data analysis due to substantial missing data. The variables excluded for large amounts of missing data were birth country (missing 46.6%), occupation (missing 24.4%), and race or ethnicity (missing 66.4%).

Country Level Variables Country economy was determined by the GDP (gross domestic product) of the country (see Table 1). For our study, all countries fell into one of three country economy categories: high income (United States, United Kingdom, France, Canada, the Netherlands, and Romania), upper middle (Malaysia, China, and Lithuania), and lower middle (Lebanon, Indonesia, Tanzania, and Laos; The World Bank, 2022).

The Hofstede Model was used to designate countries into collectivist and individualist countries (Hofstede, 2011). The individualist/collectivist dichotomy mirrors the higher/lower income dichotomy in countries, where the USA, the UK, Romania, Canada, the Netherlands, France and Lithuania have populations with an individualistic orientation (Darwish & Huber, 2003), while historically low to middle income countries like Malaysia, Indonesia, Laos, Lebanon, China, and Tanzania have populations with a more collectivistic orientation (Darwish & Huber, 2003).

Participants

In the 21 datasets submitted, 13 different countries were represented. The total n of the current study is 6830 participants. The largest numbers of participants were from China (27.5%), Indonesia (15.4%), Romania (14.3%), the Netherlands (9.0%), and the USA (8.0%). Of the 6830 participants, more than half were recruited from the general public (52.0%). The other participants were from studies on specific populations, leading to inclusion of teachers/teachers in training (43.1%), family members of autistic people (0.67%), or physicians, psychologists, or clinicians (3.79%). The majority of the participants were from countries that had an upper middle class economy (45.7%) and had a collectivist worldview (67.1%). The majority of the participants identified as female (75.4%) and had some college experience (26.9%) or had obtained a bachelor's degree (29.9%). There was a wide distribution of age but approximately a third of the sample were part of the 18–25 age range (30.0%; Table 1).

Table 1 Country- and individual-level frequencies

Variable	Frequency	Percent
Country of residence		
USA	547	8.0
China	1876	27.5
Canada	117	1.7
Tanzania	231	3.4
UK	180	2.6
France	324	4.7
Malaysia	372	5.4
Lithuania	90	1.3
Laos	180	2.6
Netherlands	615	9.0
Romania	974	14.3
Lebanon	274	4.0
Indonesia	1050	15.4
Country economy		
High income	2245	32.9
Upper middle	3124	45.7
Lower middle	1461	21.4
Worldview		
Individualistic	2245	32.9
Collectivistic	4585	67.1
Population		
General public	3554	52.0
Teachers/teachers in training	2941	43.1
Family member of someone with ASD	46	0.7
Physician, psychologist, or other clinician	259	3.8
Missing	30	0.4
Gender		
Male	1333	19.5
Female	5151	75.4
Other	78	1.1
Missing	257	3.9
Age		
18–25	2066	30.1
26–35	1667	24.4
36–50	1795	26.3
51–64	841	12.3
65 +	87	1.3
Missing	374	5.5
Education level		
Some primary or elementary school	9	0.2
Secondary school	612	10.3
High school diploma or equivalent	1267	21.3
Associate's degree	742	12.5
Some college, no degree	1080	18.2
Bachelor's degree	1555	26.2
Graduate or professional degree	682	10.0
Missing	915	13.5

Analysis Plan

We conducted Structural Equation Modeling to assess which factors were associated with autism knowledge on three levels, using Mplus Version 8.1. We compared total autism knowledge as assessed by the ASK-Q on global variability (level 3; including three models based on differences in country, world economy, and worldview), population that participants identify with as related to presumed familiarity with autism (level 2), and individual sociodemographic differences (level 1). We opted to use a sequential model of analysis to allow for the examination of some variables both as predicators and as controls, and to account for a high level of correlation between some factors that had limited variability in different contexts (e.g., some countries only had one type of respondent thus limited variability in population). Further, in alignment with literature that suggests the introduction of greater degrees of freedom in a model might result in overfitting or less reliable predictions (Garrido et al., 2022), this sequential model allowed for a simpler way to examine the research questions with greater model fit.

Missing data were handled with Maximum Likelihood Method (MLM) estimation (Muthén & Muthén et al., 2012). The MLM estimation used in these analyses because of the robustness to violations of normality (Bollen, 1989; Diamantopoulous et al., 2000), as was the case with this sample and is common with much social science research (Barnes et al., 2001). MLM helps adjust the Chi squared statistic for the observed non-normality. As a result of this estimation model traditional fit statistics were not appropriate. Instead we report LogLikelihood (LL) and the Akaike (AIC) and Bayesian (BIC) information criteria to demonstrate how the model fit changed with increased model control (McCoach et al., 2022; McNabb & Murayama, 2021; Miller, 1977). We also used the AIC and the BIC to examine measurement equivalence across groups (countries). This approach aligns with theorists that indicate that cross-cultural factorial non-invariance may be an intangible goal, thus emphasizing the importance of total measurement equivalence instead (Byrne et al., 1989; Marsh & Hocevar, 1985).

For global variability (level 3) we investigated three models. In model a, country differences were assessed by comparing 12 other countries to the USA (reference country) by regressing dummy-coded countries onto total autism knowledge and controlling for population because samples varied on the target population recruited. In model b we grouped countries into three world economy categories: high income, upper middle income, and lower middle income countries, and investigated differences in autism knowledge in relation to these groups by regressing world economy group membership onto total autism knowledge and controlling for country and population. In model c we grouped countries into collectivistic or individualistic countries and investigated differences in autism knowledge between these groups and controlling for both country of residence and population. For each model, study population was dummy coded, with the general public as the reference group.

Within level 2, differences between populations in terms of autism knowledge were investigated. We assessed whether the different roles that participants fulfilled when recruited for individual studies related to autism knowledge, using the general public as the reference group. Within level 1, we investigated whether individuals' sociodemographic characteristics, including their age, gender and level of education, related to autism knowledge. In this model we controlled for both study population, as well as country of residence following the same dummy coding as the level 3 and 2 analyses on total ASK-Q.

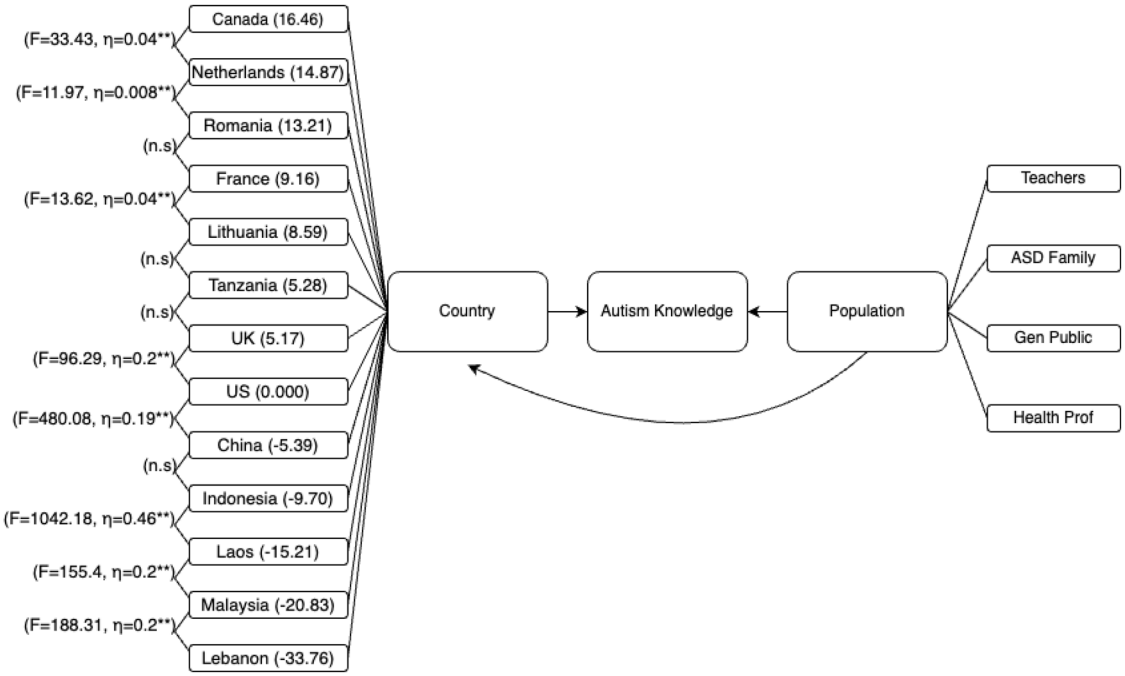
Following significant findings within the SEM model between predictors of interest and total ASK-Q scores, Post Hoc analyses were conducted to determine the amount of variability between specific groups on each level in SPSS version 28.0.1.0 using Univariate ANOVAs. For example, groups within a broader category (e.g., country within the global comparison) were ordered from lowest to highest amounts of knowledge based on the standardized SEM parameter estimates. Then pairwise comparisons were made between countries in order. The same variables added as controls in each SEM model, were also included in the corresponding ANOVA post hoc analyses. The significance level was set at $p < 0.01$ for all analyses (SEM parameters, Post Hoc ANOVA and pairwise analyses).

Results

Research Question 1: Global Variability

Model 1a: Country Differences

Model 1, on country differences, identified that autism knowledge in all countries significantly differed from autism knowledge in the USA (all p's < 0.001; see Fig. 1). Model fit statistics included LL = − 18,606.07, AIC = 37,246.14, and BIC = 37,361.61. The parameter estimates representing the amount of difference from the USA reference were used to order countries from most to least total autism knowledge. After controlling for study population, participants from Canada demonstrated the highest autism knowledge with a total mean score of 42.27 and Lebanon the lowest score with a mean of 24.86. Post Hoc analyses were conducted to examine whether the difference between ordered pairs was significant. A meaningful stepwise pattern of significant differences was revealed for each compared pair, except for



Note: The comparisons between the UK/US, Indonesia/Laos, and Laos/Malaysia do not include population as a control variable because there was insufficient variability in the distribution.

Fig. 1 Model 1a: Country SEM and post hoc comparison

between Romania/France, Lithuania/Tanzania, Tanzania/UK, and China/Indonesia (see Fig. 1 for more details).

Additionally, to examine measurement equivalence across groups, we compared the AIC/BIC for this model including all of the examined countries, with individual models for each of the five countries with samples greater than 500 (China, US, Indonesia, Netherlands, & Romania). Fit statistics across all of these individuals models were comparable to the full country model indicating conceptual equivalence of the total ASK-Q score across countries (China: AIC = 40,817.57, BIC = 40,858.33; US: AIC = 40,882.42, BIC = 40,923.17; Indonesia: AIC = 41,048.57, BIC = 41,089.32; Netherlands: AIC = 40,817.57, BIC = 40,858.33; Romania: AIC = 40,817.57; BIC = 40,858.33).

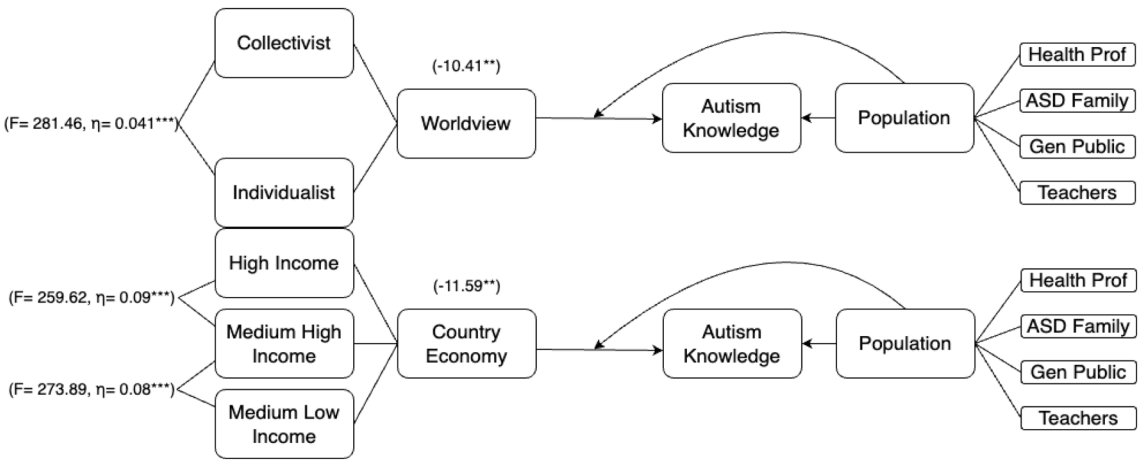


Fig. 2 Models 1b and 1c: Country economy and worldview SEM and post hoc comparison, controlled for study population

Model 1b: World Economy

Model 1b (Fig. 2), on world economy, showed that world income was significantly associated with autism knowledge, such that countries with lower incomes had lower amounts of autism knowledge ($p < 0.001$). Similar to the country comparison, we present the following fit statistics, LL = -27,263.15, AIC = 54,548.30, and BIC = 54,623.02. Post hoc analyses revealed significant differences between High Income and Upper Medium Income ($p < 0.001$), as well as between the Upper Medium Income and Lower Medium Income ($p < 0.001$).

Model 1c: Worldview

Our model 1c (Fig. 2), on worldview, showed that participants from individualistic countries had significantly higher levels of autism knowledge (M = 37.4, SD = 5.81, $p < 0.001$) compared to participants residing in countries labeled as collectivistic. Model fit statistics were as follows, LL = -24,380.42, AIC = 48,782.84, and BIC = 48,857.55.

Research Question 2: Participant Population

We observed that family members of autistic persons had significantly more autism knowledge compared to the general public ($p < 0.001$) but that health professionals (including medical doctors and psychologists) and teachers had significantly less knowledge than the general public (both p's < 0.001). In terms of model fit, LL = − 18,606.07, AIC = 37,246.14, and BIC = 37,361.61. In this model, the amount of autism knowledge increased in a significant stepwise fashion from teachers, to health professionals, to the lay public, and then family members with the highest total knowledge (all p's < 0.001). See Fig. 3 for follow up post hoc details.

Research Question 3: Sociodemographic Variability

The third, sociodemographic cluster of analyses, controlled for study population and country, examined differences in autism knowledge for gender, age and education. Model fit statistics indicated this model had the best fit of all examined, LL = − 15,946.82, AIC = 30,139.64, and BIC = 30,291.60. SEM analyses revealed gender was significantly related to total ASK-Q scores ($p < 0.0001$), such that women had more autism knowledge than men, and more education was significantly related to more autism knowledge ($p < 0.001$).

With regard to age, we hypothesized a non-linear trend, in that older adults would not necessarily have the highest or lowest amount of knowledge. As such, we dummy coded the data and compared the middle age group (reference group) to all of the age brackets above and below: (1) college age, (2) young adult, (3) older adult and (4) elderly. Our results confirmed the non-linear nature of the data but in a different pattern than expected. Our SEM model revealed that middle aged, elderly and young adults all had comparable autism knowledge after controlling for country and study population, but that older adults ($p = 0.006$) and college age students ($p < 0.001$) had significantly lower knowledge (see Fig. 4). Age groups were placed in order from most to least autism knowledge (i.e., middle aged, elderly, young adults, older adults, and college age) and post hoc pairwise comparisons were conducted to examine if stepwise differences were significant (see Fig. 4). Since the top three groups (i.e., middle aged, elderly, young adults) were not significantly different in the SEM model, Post hoc analysis examined only differences between those significantly different from the reference groups. Post Hoc tests on significant findings from the SEM analyses revealed no significant differences between the amount of autism knowledge between younger and older adults, but that the autism knowledge held by college age participants was significantly lower than older adults ($F = 20, 28$; $p < 0.001$).

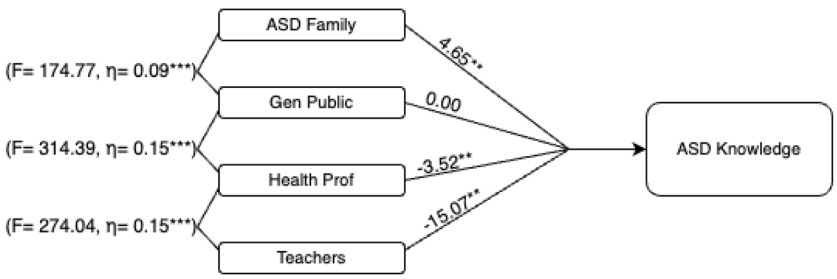


Fig. 3 Model 2: Study population ASD knowledge variability with post hoc comparison

Note: The comparison of the general population to both health professionals and family members does not include country of residence as a control variable because these groups were sampled from a very narrow range of countries.

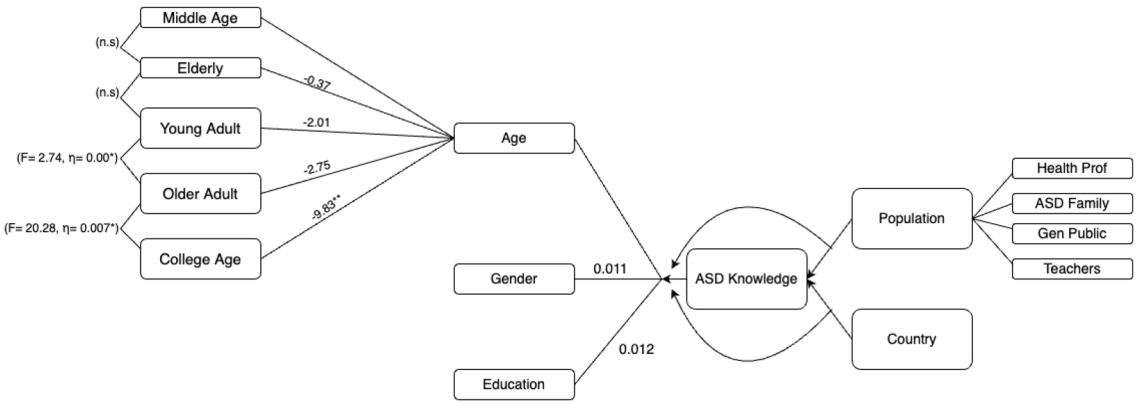


Fig. 4 Model 3. Sociodemographic autism knowledge variability with post hoc comparison

Discussion

This study represents an international coordination among a group of researchers from around the world to comprehensively examine how autism knowledge varies across the global landscape using one common measurement tool. The use of a large sample collected from 13 different countries allowed for an examination of how global, country and individual level factors relate to autism knowledge. This study revealed that participants from higher income countries and those that had an individualistic designation, had more autism knowledge than those from middle income countries and those classified as collectivistic. We also looked at specific cross-country differences, which were relatively large in terms of their effect sizes. When controlling for differences in study populations, the highest knowledge existed among participants from Canada and the Netherlands, while the lowest was observed in participants from Lebanon and Malaysia. This large-scale, cross-country investigation aligns with previous studies showing low autism knowledge in lower resourced countries and regions (e.g., Alyami, 2022; Bakare et al., 2022; Franz et al., 2017; Handayani & Paramita, 2020; Low & Zailan, 2018), and extends this by documenting the extent of these global differences.

This study also addressed the questions of how autism knowledge varied globally based on participant characteristics such as participant role in relation to autistic persons (population) and sociodemographic factors. We found that in this sample, across the global landscape, family members of autistic persons had greater knowledge than the general public, whereas teachers and health professionals had less knowledge. Research has shown variability with regard to the autism knowledge among health professionals and has revealed that knowledge levels are largely different among specific groups of health professionals and specific subdomains of knowledge (van 't Hof et al., 2020). However, from a global perspective autism knowledge among healthcare providers is consistently lower than would be expected or preferred to ensure equitable provision of services (e.g., Altay, 2019; Handayani & Paramita, 2020; Muhammad et al., 2013; Rahbar et al., 2011; Rohanachandra et al., 2017). Teachers in our study also demonstrated significantly less autism knowledge compared to the general public. This aligns with a recent review of teacher knowledge documenting systematically low knowledge among this population around the globe (Gómez-Marí et al., 2021). Of note, there were multiple variables that could not be controlled for in this collaboratively collected sample. For example, much of the earlier work in this area has focused on how autism knowledge varies across teacher or school level variables. Global research in this area has revealed that autism knowledge varies based on type/amount of training (Gómez-Marí et al., 2021; Mavropoulou & Padeliadu, 2000; Ravet, 2018), the grade level taught in Cuba (Hernández-González et al., 2022), and the amount of school resources in Tanzania (Naqvi et al., 2020). Future research should also consider examining these types of factors to aid in developing intervention programs to more successfully and universally increase autism knowledge across professionals responsible for identifying and educating autistic individuals. That said, in alignment with much of the global literature, this study looked at knowledge broadly among a heterogeneous group of health professionals and teachers and revealed that both groups could benefit from increased knowledge.

In alignment with much of the other published research (Gillespie-Lynch et al., 2015; Koyama et al., 2009; Kuzminski et al, 2019; Stronach et al, 2019; Yu et al., 2020), our study also found that females had greater autism knowledge than males. Women also tend to display less stigmatizing attitudes towards autistic individuals (Yu et al., 2020). Adherence to traditional gender roles results in women taking on the task of being caregivers more often than men, a position in which one is more likely to come into contact with autistic individuals. This familiarity or prior encounters

with autistic individuals lead to more autism knowledge as supported by past literature (Mitchell & Locke, 2015) and reduced stigma toward individuals with disabilities (Hinkelman et al., 2003; Phelan & Basow, 2007). Another sociodemographic factor that has persistently shown to be strongly associated with autism knowledge is education level, where participants with higher educational attainment demonstrated higher autism knowledge and more positive attitude towards people with autism (Holt & Christensen, 2013; Mitchell & Locke, 2015; Stronach et al., 2019). The current study revealed similar findings in that more education equated to more autism knowledge. This may be attributed to the fact that graduates from higher learning institutions are generally better equipped with autism knowledge either from their academic or professional settings (Holt & Christensen, 2013). Research has also revealed that education, as a process or a product, has a causal relationship with health literacy and awareness (Martin et al., 2009; Stormacq et al., 2019). A higher education level customarily predicts more favorable outcomes, including less prejudicial behavior and wider acceptance of the disabled (Feinsten et al., 2006).

Research has documented that an increase in the global identification of autism is likely related to the global increase in autism awareness in the last 30 years resulting from increased autism research and public health emphasis on autism (Elsabbagh et al., 2012; Zeidan et al., 2022). Given the increased public awareness of autism over time and the correlation with education, we anticipated that middle aged individuals would have the highest amounts of knowledge and thus, used this group as our reference group to examine non-linear trends. In line with our hypothesis, middle aged adults had the highest amounts of autism knowledge. It was not expected that college students would have the lowest autism knowledge because of increased societal exposure through increased public health initiatives (Elsabbagh et al., 2012; Zeidan et al., 2022). This global finding does not align with past research that shows that age has a negative association with autism knowledge (Johnson et al., 2012; Jones et al., 2021); however, this literature is largely mixed with other research documenting no association with age (Stronach et al., 2019; van 't Hof et al., 2020).

Limitations

This study marks the first large scale examination of autism knowledge across a collection using the same measure. The use of a single measure by all researchers allows for a true, more accurate comparison of autism knowledge strengths and weaknesses that has not been possible before due to measurement limitations (Harrison et al., 2017). In spite of this noteworthy strength, it should be noted that because data collection was not coordinated at each site and was instead compiled at a later date, we were missing sociodemographic data that was not collected at most sites (e.g., SES and occupation). In addition, some variability in data collection procedures could impact the psychometrics of the measure and the findings. For example, some studies collected data online and others in person and there were different approaches to collecting that had to be reconciled, meaning that cross-country difference might be confounded by methodological variation. However, these challenges are similar to those faced when trying to compile epidemiological data to estimate true estimates of ASD prevalence (e.g., Elsabbagh et al., 2012; Zeidan et al., 2022). Further, although the measure underwent empirically sound translation procedures in each context (e.g., Bracken & Barona, 1991; Sousa & Rojjanasrirat, 2011), data was collected in multiple languages, making it hard to disentangle cultural and linguistic differences. That said, an examination of the total sample revealed a good internal consistency ($\alpha = 0.84$) and no demonstrated measurement inequivalence for the total knowledge score. Although the ASK-Q has demonstrated strong psychometrics across multiple cultural contexts (e.g., Harrison et al., 2019; Low et al., 2021a, 2021b; Lu et al., 2020), the internal consistency is not unequivocally strong across all studies, particularly when looking at the subscale level (e.g., Saade et al., 2021). The next step is a careful item level analysis within a large culturally diverse sample to determine if the removal of select items with Differential Item Functioning (DIF) by group can serve to improve the measure reliability across all contexts. Following this step, it would then be possible to re-evaluate the measure factor structure and then to conduct a cross-cultural examination at the measure subscale level.

In addition, because the study design was not coordinated a priori, some study populations were only represented in certain countries, and certain countries only represented one study population. Although we partially counteracted this by controlling all models for country differences in study population, it remains unclear whether these results would replicate in a more balanced design that would include all study populations for each country. One other limitation related to measurement was that we did not directly assess worldview at a participant level and instead inferred worldview based on country of residence. Future research like this would benefit from examining how autism knowledge assessed at an individual level relates to worldview given the variability in worldview that exists in many countries (Jensen, 2003). Of note, in this sample the constructs of worldview and country economy were significantly correlated ($r = 0.85$, $p < 0.001$). This aligns with literature suggesting that individualistic identity correlates strongly with national wealth (Takemura et al., 2016) and many countries of the world are moving from collectivism to individualism due to economical affluence (Ciochinã & Faria, 2013). That said, one country-wide variable to consider in future studies

might be country healthcare system but the large majority of countries in the in the current study had universal healthcare leaving insufficient variability to study this question.

Conclusions

This study provides information that is especially important to healthcare professionals and policy makers in formulating strategies and interventions to raise public and professional awareness on autism by targeting those groups who demonstrate the most meaningful deficits. Heightened public awareness among caregivers, teachers and other service providers, health care professionals is crucial for early diagnosis of autism as it leads to prompt treatment initiation and better outcomes. More recently within the international community, the continued need for greater training with regard to autism knowledge has been documented specifically among current medical providers (Snijder et al., 2021), future doctors (Austriaco et al., 2019), and educators (Gómez-Marí et al., 2021). Heightened awareness among the general public is needed for cultivation of positive attitudes among the community towards autistic individuals and their family members to help mitigate global disparities in care (Franz et al., 2017; Kang-Yi et al., 2018).

Appendix

Data sharing instructions for researchers.

Please review the following participation steps. We will walk you through these in the attached Qualtrics survey but wanted you to be aware of how to format the data in advance and what will be expected of you. Hopefully this should be a relatively easy process! We SO appreciate your help!

Research Participation Steps

1. Researcher participation
    a. First complete a general agreement statement with a checkbox that indicates you agree to upload their raw, de-identified data and allow for the use of the data for psychometric data analysis and for various aspects of ongoing scale refinement and validation.
    b. Answer a short survey about the researcher and the survey administration:

    For example:

        i. What's the researcher name
        ii. Email address/phone number
        iii. University name/organization
        iv. What country was it administered in?
        v. Was it translated?

        1. If yes, to what language?
        2. Select items that align with the procedures you used

        vi. Which of the following populations were included in the sample? Describe the capacity in which the person was taking the survey or why they were specifically recruited to take the study (i.e., which group would they fall into: Parents, teachers, general public, doctor, etc.)
        vii. Format of survey (i.e., paper and pencil or online)

2. Directions for uploading
    a. If the data was collected as part of a multi-site study, please upload a different dataset for each country/language administered.

    Similarly, if multiple populations were specifically targeted (e.g., doctors and teachers), please upload separate files for each group OR ensure this is a variable included and defined.
    b. Upload an excel or CSV file that matches the parameters outlined below and aligns with attached excel example.
    c. Configure the data so that each participant is one row
    d. Include the following variables as new columns in this order for each row of data:

        i. First Variable = Unique Participant ID
        ii Enter item level ASK-Q data (agree or disagree) for each of the 49 item (as responded by the participant)
        iii. Consider also including optional demographic variables as columns in this original uploaded file.
        iv. Additional optional participant variables may include:

        1. Gender
        2. Age
        3. Race Ethnicity
        4. Educational Level
        5. SES data
        6. Occupation
        7. Experience with ASD
        8. Birth Country

9. Describe the capacity in which the person was taking the survey or why they were specifically recruited to take the study (i.e., which group would they fall into: Parents, teachers, general public, doctor, etc.)

3. If you opted to upload additional demographic data, please also upload a second Excel file that will serve as a data code for the above sociodemographic variables. For this file each column should be a different sociodemographic variable and each row should reflect the answer options or responses so we can interpret the data. See attached excel file for an example.

Thank you again for participating!!

Funding This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Declarations

Conflict of interest No funding was received to assist with the preparation of this manuscript. The authors have no conflicts of interest to report related to this work.

References

Altay, M. A. (2019). Family physicians' awareness of autism spectrum disorder: Results from a survey study. *Open Access Macedonian Journal of Medical Sciences, 7*(6), 967–972. https://doi.org/10.3889/oamjms.2019.199

Alyami, H. S., Naser, A. Y., Alyami, M. H., Alharethi, S. H., & Alyami, A. M. (2022). Knowledge and attitudes toward autism spectrum disorder in Saudi Arabia. *International Journal of Environmental Research and Public Health, 19*(6), 3648. https://doi.org/10.3390/ijerph19063648

Atun-Einy, O., & Ben-Sasson, A. (2018). Pediatric allied healthcare professionals' knowledge and self-efficacy regarding ASD. *Research in Autism Spectrum Disorders, 47*, 1–13. https://doi.org/10.1016/j.rasd.2017.12.001

Austriaco, K., Aban, I., Willig, J., & Kong, M. (2019). Contemporary trainee knowledge of autism: How prepared are our future providers? *Frontiers in Pediatrics, 7*, 165. https://doi.org/10.3389/fped.2019.00165

Bakare, M. O., Onu, J. U., Bello-Mojeed, M. A., Okidegbe, N., Onu, N. N., & Munir, K. M. (2022). Picture of Autism Spectrum Disorder (ASD) research in West Africa—A scoping review. *Research in Autism Spectrum Disorders, 90*, 101888. https://doi.org/10.1016/j.rasd.2021.101888

Ball, R. (2001). Individualism, collectivism, and economic development. *The Annals of the American Academy of Political and Social Science, 573*(1), 57–84. https://doi.org/10.1177/000271620157300104

Ballantyne, C., Gillespie-Smith, K., & Wilson, C. (2021). A comparison of knowledge and experience of autism spectrum disorder among teachers in the United Kingdom and China. *International Journal of Disability, Development and Education, 68*(2), 160–171. https://doi.org/10.1080/1034912X.2019.1674254

Barnes, J., Cote, J., Cudeck, R., & Malthouse, E. (2001). Checking assumptions of normality before conducting Factor Analyses. *Journal of Consumer Psychology, 10*(1), 79–81.

Bollen, K. A. (1989). *Structural equations with latent variables*. Wiley.

Bracken, B. A., & Barona, A. (1991). State of the art procedures for translating, validating and using psychoeducational tests in cross-cultural assessment. *School Psychology International, 12*(1–2), 119–132. https://doi.org/10.1002/9781118619179

Byrne, B. M., Shavelson, R. J., & Muthrn, B. (1989). Testing for the equivalence of factor covariance and mean structures: The issue of partial measurement invariance. *Psychological Bulletin, 105*, 456–466. https://doi.org/10.1037/0033-2909.105.3.456

Cardon, A., & Marshall, T. (2020). To raise a child with autism spectrum disorder: A qualitative, comparative study of parental experiences in the United States and Senegal. *Transcultural Psychiatry, 58*(3), 335–350. https://doi.org/10.1177/1363461520953342

Cheung, G. W., & Rensvold, R. B. (1999). Testing factorial invariance across groups: A reconceptualization and proposed new method. *Journal of Management, 25*(1), 1–27. https://doi.org/10.1177/014920639902500101

Ciochinã, L., & Faria, L. (2009). Individualism and collectivism: What differences between Portuguese and Romanian adolescents? *The Spanish Journal of Psychology, 12*(2), 555–564. https://doi.org/10.1017/S113874160000192X

Cohen, L. L., La Greca, A. M., Blount, R. L., Kazak, A. E., Holmbeck, G. N., & Lemaneck, K. L. (2008). Introduction to special issue: Evidence-based assessment in pediatric psychology. *Journal of Pediatric Psychology, 33*(9), 911–915. https://doi.org/10.1093/jpepsy/jsj115

Darwish, A. F., & Huber, G. (2003). Individualism vs collectivism in different cultures: A cross-cultural study. *Intercultural Education, 14*(1), 47–56. https://doi.org/10.1080/1467598032000044647

Diamantopoulos, A., Siguaw, J., & Siguaw, J. A. (2000). *Introducing LISREL: A guide for the uninitiated*. Sage Publications.

Divan, G., Bhavnani, S., Leadbitter, K., Ellis, C., Dasgupta, J., Abubakar, A., Elsabbagh, M., Hamdani, S. U., Servili, C., Patel, V., & Green, J. (2021). Annual Research Review: Achieving universal health coverage for young children with autism spectrum disorder in low- and middle-income countries: A review of reviews. *Journal of Child Psychology and Psychiatry, 62*(5), 514–535. https://doi.org/10.1111/jcpp.13404

Durkin, M. S., Elsabbagh, M., Barbaro, J., Gladstone, M., Happe, F., Hoekstra, R. A., Lee, L. C., Rattazzi, A., Stapel-Wax, J., Stone, W. L., Tager-Flusberg, H., Thurm, A., Tomlinson, M., & Shih, A. (2015). Autism screening and diagnosis in low resource settings: Challenges and opportunities to enhance research and services worldwide. *Autism Research, 8*(5), 473–476. https://doi.org/10.1002/aur.1575

Elsabbagh, M., Divan, G., Koh, Y.-J., Kim, Y. S., Kauchali, S., Marcín, C., Montiel-Nava, C., Patel, V., Paula, C. S., Wang, C., Yasamy, M. T., & Fombonne, E. (2012). Global prevalence of autism and other pervasive developmental disorders. *Autism Research, 5*(3), 160–179. https://doi.org/10.1002/aur.239

Feinstein, L., Sabates, R., Anderson, T. M., Sorhaindo, A., & Hammond, C. (2006). *What are the effects of education on health?* Measuring the Effects of Education on Health and Civic Engagement Copenhagen: Proceedings of the Copenhagen Symposium.

Fombonne, E., MacFarlane, H., & Salem, A. C. (2021). Epidemiological surveys of ASD: Advances and remaining challenges. *Journal of Autism and Developmental Disorders, 51*(12), 4271–4290. https://doi.org/10.1007/s10803-021-05005-9

Fong, V. C., Gardiner, E., & Larocci, G. (2021). Cross-cultural perspectives on the meaning of family quality of life: Comparing Korean immigrant families and Canadian families of children with autism spectrum disorder. *Autism, 25*(5), 1335–1348. https://doi.org/10.1177/1362361321989221

Franz, L., Chambers, N., von Isenburg, M., & de Vries, P. J. (2017). Autism spectrum disorder in sub-saharan Africa: A comprehensive scoping review. *Autism Research, 10*(5), 723–749. https://doi.org/10.1002/aur.1766

Gabbay-Dizdar, N., Ilan, M., Meiri, G., Faroy, M., Michaelovski, A., Flusser, H., Menashe, I., Koller, J., Zachor, D., & Dinstein, I. (2021). Early diagnosis of autism in the community is associated with marked improvement in social symptoms within 1–2 years. *Autism, 26*, 1353–1363. https://doi.org/10.1177/13623613211049011

Garrido, M., Hansen, S. K., Yaari, R., & Hawlena, H. (2022). A model selection approach to structural equation modelling: A critical evaluation and a road map for ecologists. *Methods in Ecology and Evolution, 13*(1), 42–53.

Gillespie-Lynch, K., Brooks, P. J., Someki, F., Obeid, R., Shane-Simpson, C., Kapp, S. K., Daou, N., & Smith, D. S. (2015). Changing College Students' Conceptions of Autism: An online training to increase knowledge and decrease stigma. *Journal of Autism and Developmental Disorders, 45*(8), 2553–2566. https://doi.org/10.1007/s10803-015-2422-9

Gómez-Marí, I., Sanz-Cervera, P., & Tárraga-Mínguez, R. (2021). Teachers' knowledge regarding Autism Spectrum Disorder (ASD): A systematic review. *Sustainability, 13*(9), 5097. https://doi.org/10.3390/su13095097

Handayani, M. M., & Paramita, P. P. (2020). Stigma and knowledge about autism spectrum disorder among parents and professionals in Indonesia. *Proceedings of the 3rd International Conference on Psychology in Health, Educational, Social, and Organizational Settings - ICP-HESOS*, 97–100. https://doi.org/10.5220/0008585800970100

Harrison, A. J., Bradshaw, L. P., Naqvi, N. C., Paff, M. L., & Campbell, J. M. (2017). Development and psychometric evaluation of the autism stigma and knowledge questionnaire (ASK-Q). *Journal of Autism and Developmental Disorders, 47*(10), 3281–3295. https://doi.org/10.1007/s10803-017-3242-x

Harrison, A. J., Paff, M., Eilenberg, J. S., & Long, K. A. (2019). Disparities based on race, ethnicity, and socioeconomic status over the transition to adulthood among adolescents and young adults on the autism spectrum: A systematic review. *Current Psychiatry Reports*. https://doi.org/10.1007/s11920-019-1016-1

Hernández-González, O., Spencer-Contreras, R., Sanz-Cervera, P., & Tárraga-Mínguez, R. (2022). Analysis of the Autism Spectrum Disorder (ASD) knowledge of Cuban teachers in primary schools and preschools. *Education Science, 12*, 284–297. https://doi.org/10.3390/educsci12040284

Hinkelman, L., & Granello, D. H. (2003). Biological sex, adherence to traditional gender roles, and attitudes toward persons with mental illness: An exploratory investigation. *Journal of Mental Health Counseling, 25*(4), 359–270. https://doi.org/10.17744/mehc.25.4.tglx0uudjk7q5dpk

Hofstede, G. (2011). Dimensionalizing cultures: The Hofstede model in context. *Online Readings in Psychology and Culture, 2*(1), 1–26. https://doi.org/10.9707/2307-0919.1014

Holt, J. M., & Christensen, K. M. (2013). Utahns' understanding of autism spectrum disorder. *Disability and Health Journal, 6*(1), 52–62. https://doi.org/10.1016/j.dhjo.2012.08.002

Jafarabadi, M. A., Gholipour, K., Shahrokhi, H., Malek, A., Ghiasi, A., Pourasghari, H., & Iezadi, S. (2021). Disparities in the quality of and access to services in children with autism spectrum disorders: A structural equation modeling. *Archives of Public Health, 79*(1), 58. https://doi.org/10.1186/s13690-021-00577-5

Jensen, C. M., Martens, C. S., Nikolajsen, N. D., SkyttGregersen, T., Heckmann Marx, N., Goldberg Frederiksen, M., & Hansen, M. S. (2016). What do the general population know, believe and feel about individuals with autism and schizophrenia: Results from a comparative survey in Denmark. *Autism, 20*(4), 496–508. https://doi.org/10.1177/1362361315593068

Jensen, L. A. (2003). Coming of age in a multicultural world: Globalization and adolescent cultural identity formation. *Applied Developmental Science, 7*(3), 189–196. https://doi.org/10.1207/S1532480XADS0703_10

Johnson, P., Porter, K., & McPherson, I. (2012). Autism knowledge among pre-service teachers specialized in children birth through age five. *American Journal of Health Education, 43*(5), 279–287. https://doi.org/10.1080/19325037.2012.10599246

Jones, S. C., Akram, M., Gordon, C. S., et al. (2021). Autism in Australia: Community knowledge and autistic people's experiences. *Journal of Autism and Developmental Disorders, 51*, 3677–3689. https://doi.org/10.1007/s10803-020-04819-3

Kang-Yi, C. D., Grinker, R. R., Beidas, R., Agha, A., Russell, R., Shah, S. B., Shea, K., & Mandell, D. S. (2018). Influence of community-level cultural beliefs about autism on families' and professionals' care for children. *Transcultural Psychiatry, 55*(5), 623–647. https://doi.org/10.1177/1363461518779831

Kitchin, J. L., & Karlin, N. J. (2022). Awareness and stigma of autism spectrum disorders in undergraduate students. *Psychological Reports, 125*(4), 2069–2087. https://doi.org/10.1177/00332941211014144

Koyama, T., Tachimori, H., Sawamura, K., Koyama, A., Naganuma, Y., Makino, H., & Takeshima, T. (2009). Mental health literacy of autism spectrum disorders in the Japanese general population. *Social Psychiatry and Psychiatric Epidemiology, 44*(8), 651–657. https://doi.org/10.1007/s00127-008-0485-z

Kuzminski, R., Netto, J., Wilson, J., Falkmer, T., Chamberlain, A., & Falkmer, M. (2019). Linking knowledge and attitudes: Determining neurotypical knowledge about and attitudes towards autism. *PLoS ONE, 14*(7), e0220197. https://doi.org/10.1371/journal.pone.0220197

Love, A., Usher, E. L., Toland, M. D., Railey, K. S., Campbell, J. M., & Spriggs, A. D. (2021). Measuring police officer self-efficacy for working with individuals with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 51*(4), 1331–1345. https://doi.org/10.1007/s10803-020-04613-1

Low, H. M., Wong, T. P., Lee, L. W., Makesavanh, S., Vongsouangtham, B., Phannalath, V., Che Ahmad, A., & Lee, A. S. S. (2021b). Can pictorial narration offer a solution to teacher training on the effective inclusion of students with autism spectrum disorder in low-resource settings? Investigation on knowledge and stigma change. *Autism, 25*(5), 1216–1233. https://doi.org/10.1016/j.rasd.2020.101694

Low, H. M., Wong, T. P., Lee, L. W., Makesavanh, S., Vongsouangtham, B., Phannalath, V., San, S., Che Ahmad, A., & Lee, A. S. S. (2021). A grassroots investigation of ASD knowledge and stigma among teachers in Luang Prabang, Lao PDR. *Research in Autism Spectrum Disorders, 80*, 101694. https://doi.org/10.1016/j.rasd.2020.101694

Low, H. M., & Zailan, F. (2018). Medical students' perceptions, awareness, societal attitudes and knowledge of autism spectrum disorder: An exploratory study in Malaysia. *International Journal of Developmental Disabilities, 64*(2), 86–95. https://doi.org/10.1080/20473869.2016.1264663

Lu, M., Wang, R., Zou, Y., & Pang, F. (2022). Chinese college students' knowledge of autism spectrum disorder (ASD) and social distance from individuals with ASD: The mediating role of negative stereotypes. *Journal of Autism and Developmental Disorders, 52*(8), 3676–3685.

Lu, M., Zou, Y., Chen, X., Chen, J., He, W., & Pang, F. (2020). Knowledge, attitude and professional self-efficacy of Chinese mainstream primary school teachers regarding children with autism

spectrum disorder. *Research in Autism Spectrum Disorders, 72*, 101513. https://doi.org/10.1016/j.rasd.2020.101513

Marsh, H. W., & Hocevar, D. (1985). Application of confirmatory factor analysis to the study of self-concept: Firstand higher order factor models and their invariance across groups. *Psychological Bulletin, 97*, 562–582. https://doi.org/10.1037/0033-2909.97.3.562

Martin, L. T., Ruder, T., Escarce, J. J., Ghosh-Dastidar, B., Sherman, D., Elliott, M., & Lurie, N. (2009). Developing predictive models of health literacy. *Journal of General Internal Medicine, 24*(11), 1211–1216. https://doi.org/10.1007/s11606-009-1105-7

Mavropoulou, S., & Padeliadu, S. (2000). Greek teachers' perceptions of autism and implications for educational practice: A preliminary analysis. *Autism, 4*(2), 173–183. https://doi.org/10.1177/1362361300004002005

McClain, M. B., Harris, B., Schwartz, S. E., Benallie, K. J., Golson, M. E., & Benney, C. M. (2021). Correction to: Brief Report: Development and validation of the autism spectrum knowledge scale general population version: Preliminary analyses. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-021-05408-8

McCoach, D. B., Newton, S. D., & Gambino, A. J. (2022). Multilevel model selection: Balancing model fit and adequacy. In M. S. Khine (Ed.), *Methodology for multilevel modeling in educational research* (pp. 29–48). Springer.

McCormack, G., Dillon, A. C., Healy, O., Walsh, C., & Lydon, S. (2020). Primary care physicians' knowledge of autism and evidence-based interventions for autism: A systematic review. *Review Journal of Autism Developmental Disorders, 7*, 226–241. https://doi.org/10.1007/s40489-019-00189-4

McNabb, C. B., & Murayama, K. (2021). Unnecessary reliance on multilevel modelling to analyse nested data in neuroscience: When a traditional summary-statistics approach suffices. *Current Research in Neurobiology, 2*, 100024. https://doi.org/10.1016/j.crneur.2021.100024

Miller, J. J. (1977). Asymptotic properties of maximum likelihood estimates in the mixed model of the analysis of variance. *The Annals of Statistics, 5*, 746–762.

Mitchell, G. E., & Locke, K. D. (2015). Lay beliefs about autism spectrum disorder among the general public and childcare providers. *Autism, 19*(5), 553–561. https://doi.org/10.1177/1362361314533839

Muhammad, Z., Al-Deen, L. D., & Muhsin, H. A. (2013). Knowledge about childhood autism among care providers in Baghdad. *Arab Journal of Psychiatry, 24*(1), 27–31. https://doi.org/10.12816/0000095

Murza, K. A., Schwartz, J. B., Hahs-Vaughn, D. L., & Nye, C. (2016). Joint attention interventions for children with autism spectrum disorder: A systematic review and meta-analysis. *International Journal of Language & Communication Disorders, 51*(3), 236–251. https://doi.org/10.1111/1460-6984.12212

Muthén, L. K., & Muthén, B. O. (2012). *Mplus user's guide* (7th ed.). Muthén and Muthén.

Naqvi, N. C., Wong-Goodrich, S. E., Martinage, A., Gordon, S. L., DeCuffa, J., & Collins, M. (2020). Increasing knowledge of autism spectrum disorders among urban special educators in Tanzania: Results from three teacher training workshops. *International Journal of Teacher Education and Professional Development*. https://doi.org/10.4018/IJTEPD.2020070101

Obeid, R., Daou, N., DeNigris, D., Shane-Simpson, C., Brooks, P. J., & Gillespie-Lynch, K. (2015). A cross-cultural comparison of knowledge and stigma associated with autism spectrum disorder among college students in Lebanon and the United States. *Journal of Autism and Developmental Disorders, 45*(11), 3520–3536. https://doi.org/10.1007/s10803-015-2499-1

Phelan, J. E., & Basow, S. A. (2007). College students' attitudes toward mental illness: An examination of the stigma process. *Journal of Applied Social Psychology, 37*, 2877–2902. https://doi.org/10.1111/j.1559-1816.2007.00286.x

Rahbar, M. H., Ibrahim, K., & Assassi, P. (2011). Knowledge and attitude of general practitioners regarding autism in Karachi, Pakistan. *Journal of Autism and Developmental Disorders, 41*, 465–474. https://doi.org/10.1007/s10803-010-1068-x

Ravet, J. (2018). 'But how do I teach them?' Autism & Initial Teacher Education (ITE). *International Journal of Inclusive Education, 22*(7), 714–733. https://doi.org/10.1080/13603116.2017.1412505

Rohanachandra, Y. M., Dahanayake, D. M. A., & Wijetunge, G. S. (2017). Knowledge about diagnostic features and comorbidities of childhood autism among doctors in a tertiary care hospital. *Sri Lanka Journal of Child Health, 46*(1), 29–32. https://doi.org/10.4038/sljch.v46i1.8093

Ruparelia, K., Abubakar, A., Badoe, E., Bakare, M., Visser, K., Chugani, D. C., & Newton, C. R. (2016). Autism spectrum disorders in Africa: Current challenges in identification, assessment, and treatment: A report on the International Child Neurology Association Meeting on ASD in Africa, Ghana, April 3–5, 2014. *Journal of Child Neurology, 31*(8), 1018–1026. https://doi.org/10.1177/0883073816635748

Saade, S., Bean, Y. F., Gillespie-Lynch, K., Poirier, N., & Harrison, A. J. (2021). Can participation in an online ASD training enhance attitudes toward inclusion, teaching self-Efficacy and ASD knowledge among preservice educators in diverse cultural contexts? *International Journal of Inclusive Education*. https://doi.org/10.1080/13603116.2021.1931716

Samadi, S. A., McConkey, R., Nuri, H., Abdullah, A., Ahmad, L., & Abdalla, B. (2022). Screening children for Autism Spectrum Disorders in low- and middle-income countries: Experiences from the Kurdistan region of Iraq. *International Journal of Environmental Research and Public Health, 19*(8), 1–10. https://doi.org/10.3390/ijerph19084581

Samms-Vaughan, M., Rahbar, M. H., Dickerson, A. S., Loveland, K. A., Hessabi, M., Pearson, D. A., Bressler, J., Shakespeare-Pellington, S., Grove, M. L., Coore-Desai, C., Reece, J., & Boerwinkle, E. (2017). The diagnosis of autism and autism spectrum disorder in low- and middle-income countries: Experience from Jamaica. *Autism, 21*(5), 564–572. https://doi.org/10.1177/1362361317698938

Sanz-Cervera, P., Fernández-Andrés, M., Pastor-Cerezuela, G., & Tárraga-Mínguez, R. (2017). Pre-service teachers' knowledge, misconceptions and gaps about Autism Spectrum Disorder. *Teacher Education and Special Education, 40*, 212–224. https://doi.org/10.1177/0888406417700963

Smith, J., Sulek, R., Abdullahi, I., Green, C. C., Bent, C. A., Dissanayake, C., & Hudry, K. (2021). Comparison of mental health, well-being and parenting sense of competency among Australian and South-East Asian parents of autistic children accessing early intervention in Australia. *Autism, 25*(6), 1784–1796. https://doi.org/10.1177/13623613211010006

Snijder, M. I. J., Kaijadoe, S. P. T., van't Hof, M., Ester, W. A., Buitelaar, J. K., & Oosterling, I. J. (2021). Early detection of young children at risk of autism spectrum disorder at well-baby clinics in the Netherlands: Perspectives of preventive care physicians. *Autism, 25*(7), 2012–2024. https://doi.org/10.1177/13623613211009345

Someki, F., Torii, M., Brooks, P. J., Koeda, T., & Gillespie-Lynch, K. (2018). Stigma associated with autism among college students in Japan and the United States: An online training study. *Research in Developmental Disabilities, 76*, 88–98. https://doi.org/10.1016/j.ridd.2018.02.016

Sousa, V. D., & Rojjanasrirat, W. (2011). Translation, adaptation and validation of instruments or scales for use in cross-cultural health care research: A clear and user-friendly guideline. *Journal of*

Evaluation in Clinical Practice, 17(2), 268–274. https://doi.org/10.1111/j.1365-2753.2010.01434.x

Stahmer, A. C., Vejnoska, S., Iadarola, S., Straiton, D., Segovia, F. R., Luelmo, P., Morgan, E. H., Lee, H. S., Javed, A., Bronstein, B., Hochheimer, S., Cho, E., Aranbarri, A., Mandell, D., Hassrick, E. M., Smith, T., & Kasari, C. (2019). Caregiver voices: Cross-cultural input on improving access to autism services. *Journal of Racial and Ethnic Health Disparities, 6*(4), 752–773. https://doi.org/10.1007/s40615-019-00575-y

Stormacq, C., Van den Broucke, S., & Wosinski, J. (2019). Does health literacy mediate the relationship between socioeconomic status and health disparities? *Integrative Review. Health Promotion International, 34*(5), e1–e17. https://doi.org/10.1093/heapro/day062

Stronach, S., Wiegand, S., & Mentz, E. (2019). Brief report: Autism knowledge and stigma in university and community samples. *Journal of Autism and Developmental Disorders, 49*(3), 1298–1302. https://doi.org/10.1007/s10803-018-3825-1

Takemura, K., Hamamura, T., Guan, Y., & Suzuki, S. (2016). Contextual effect of wealth on independence: An examination through regional differences in China. *Frontiers in Psychology, 7*, 384. https://doi.org/10.3389/fpsyg.2016.00384

van 't Hof, M., Tisseur, C., Van Berckelear-Onnes, I., Van Nieuwenhuyzen, A., Daniels, A. M., Deen, M., Hoek, H. W., & Ester, W. A. (2020). Age at autism spectrum disorder diagnosis: A systematic review and meta-analysis from 2012 to 2019. *Autism, 25*(4), 862–873. https://doi.org/10.1177/1362361320971107

van 't Hof, M., van Berckelaer-Onnes, I., Deen, M., Neukerk, M. C., Bannink, R., Daniels, A. M., Hoek, H. W., & Ester, W. A. (2020). Novel insights into autism knowledge and stigmatizing attitudes toward mental illness in Dutch youth and family center physicians. *Community Mental Health Journal, 56*(7), 1318–1330. https://doi.org/10.1007/s10597-020-00568-w

Van Steen, T., & Wilson, C. (2020). Individual and cultural factors in teachers' attitudes towards inclusion: A meta-analysis. *Teaching and Teacher Education, 95*, 103127. https://doi.org/10.1016/j.tate.2020.103127

Wireko-Gyebi, S., & Ashiagbor, E. S. (2018). Comparative study on knowledge about Autism Spectrum Disorder among pediatric and psychiatric nurses in public hospitals in Kumasi, Ghana. *Clinical Practice and Epidemiology in Mental Health, 14*, 99–108. https://doi.org/10.2174/1745017901814010099

World Bank. (2022). How does the World Bank classify countries? https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries

Yu, L., Stronach, S., & Harrison, A. J. (2020). Public knowledge and stigma of autism spectrum disorder: Comparing China with the United States. *Autism, 24*(6), 1531–1545. https://doi.org/10.1177/1362361319900839

Zeidan, J., Fombonne, E., Scorah, J., Ibrahim, A., Durkin, M. S., Saxena, S., Yusuf, A., Shih, A., & Elsabbagh, M. (2022). Global prevalence of autism: A systematic review update. *Autism Research, 15*(5), 778–790. https://doi.org/10.1002/aur.2696