A systematic review of research on neuropsychological measures in psychotic disorders from low and middle-income countries: The question of clinical utility

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ABSTRACT

Introduction: Several studies of neuropsychological measures have been undertaken in patients with psychotic disorders from low- and middle-income countries (LMICs). It is, however, unclear if the measures used in these studies are appropriate for cognitive screening in clinical settings. We undertook a systematic review to determine if measures investigated in research on psychotic disorders in LMICs meet the clinical utility criteria proposed by The Working Group on Screening and Assessment.

Methods: Preferred Reporting Items for Systematic Reviews and Meta-Analyses were employed. We determined if tests had been validated against a comprehensive test battery, the duration and scope of the tests, the personnel administering the tests, and the means of administration.

Results: A total of 31 articles were included in the review, of which 11 were from Africa. The studies included 3254 participants with psychosis and 1331 controls. 3 studies reported on the validation of the test against a comprehensive cognitive battery. Assessments took 1 h or less to administer in 6/31 studies. The average number of cognitive domains assessed was four. Nonspecialized staff were used in only 3/31 studies, and most studies used pen and paper tests (17/31).

Conclusion: Neuropsychological measures used in research on psychotic disorders in LMICs typically do not meet the Working Group on Screening and Assessment clinical utility criteria for cognitive screening. Measures that have been validated in high-income countries but not in LMICs that do meet these criteria, such as the Brief Assessment of Cognition in Schizophrenia, therefore deserve further study in LMIC settings.

1. Introduction

Various neuropsychological measures have been developed for cognitive screening in patients with psychotic disorders (Reichenberg, 2010; Keefe and Fenton, 2007). This is because cognitive impairment is a key predictor of outcomes like quality of life in patients with psychotic disorders. Cognitive impairment contributes a larger portion of disease burden than behavioral, positive or negative symptoms of psychosis (Green et al., 2019; Emsley et al., 2008; Whiteford et al., 2013). Cognitive screening is therefore an essential component of routine care for patients with psychotic disorders (American Psychiatric Association, 2013; World Health Organization, 1992). Cognitive screening in psychotic disorders involves administering neuropsychological measures to assess for cognitive impairment. Although various cognitive domains can be impaired, research by the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) initiative recommended seven key domains for neuropsychological assessment in patients with psychotic disorders. These are i) working memory, ii) attention/vigilance, iii) verbal learning and memory, iv) visual learning and memory, v) reasoning and problem solving, vi)
information processing speed, and vii) social cognition (Green et al., 2004; Nuechterlein et al., 2008).

The American Psychological Association's Working Group on Screening and Assessment (WGSA) have provided guidelines for assessing whether neuropsychological measures are appropriate for cognitive screening in clinical settings (American Psychological Association, 2014). WGSA was a collaboration of the American Psychological Association's Board of Professional Affairs and the Committee for the Advancement of Professional Practice of the American Psychological Association to help distinguish cognitive screening from comprehensive psychological evaluations (Roebuck-Spencer et al., 2017). Briefly, the guidelines state that for a measure to have clinical utility for cognitive screening it must be: a) able to identify early on individuals at high risk for impairment, b) sensitive enough to determine those who need further review; c) be brief and narrow in scope; d) be administered as part of a routine clinic visit; e) be administered by clinicians or support staff or with electronic devices and; f) be used to monitor progress and outcomes (Roebuck-Spencer et al., 2017). Several brief neuropsychological measures such as the Brief Assessment of Cognition in Schizophrenia (BACS) have been shown to meet these criteria in high-income countries (HIC) (Fervaha et al., n.d.; Hurford et al., 2011).

In low- and middle-income countries (countries with a gross national income of less than $5101 https://data.worldbank.org/income-level/low-and-middle-income) there is a growing literature on neuropsychological measures for psychotic disorders (Araújo et al., 2015; Ayres et al., 2007; Nakasujja et al., 2012b; Ngoma et al., 2010). Such work has been useful in demonstrating the large burden of impairment and its association with poor outcomes (Ayres et al., 2007). However, it is unclear if measures that have been researched are appropriate for cognitive screening. In particular, it is unclear whether these neuropsychological measures meet the criteria for cognitive screening as outlined by the WGSA. It would be useful to know if the tests are used early in the course of the illness, whether these assessments have been validated against comprehensive neuropsychological batteries, duration and scope of the tests, setting where the tests are performed, the personnel administering the tests and whether the tests are used for follow up of patients.

Here we aimed to determine if the neuropsychological measures used in research on patients with psychotic disorders in low- and middle-income country contexts meet the six WGSA clinical utility criteria for cognitive screening. A systematic review was undertaken following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). The study protocol was registered prior to data collection in the open access online registry, PROSPERO, University of York, York, United Kingdom, registration number CRD42018047872. http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018047872.

2. Methods

2.1. Study selection

Exclusion and inclusion criteria were determined using the PICOSS (Population, Intervention, Comparator, Outcomes, Study design, Setting) framework (Robinson et al., 2011). We considered articles written in English with no time limit on when the studies were conducted. The population of interest was participants with psychosis. Psychosis was defined as participants with schizophrenia spectrum and related psychotic disorders, bipolar affective disorder and depression with psychotic features. We selected these disorders given the current literature that highlights their shared genetic and neurobiological underpinnings (Rosen et al., 2012; Mark and Touloupoulo, 2016). The intervention included any study in which neuropsychological measures were performed in at least one cognitive domain. This was done to ensure that neuropsychological measures that are used for assessment and not screening, such as the MATRICS consensus cognitive battery, were excluded. The comparator was healthy controls. Our outcomes included the clinical diagnosis, whether these assessments had been validated against comprehensive batteries, duration and scope of the tests, setting where the tests were performed, the personnel who administered the tests and whether the tests are used for follow up of patients. All study designs irrespective of sample size were included in the review. The review was limited to the low and middle-income country setting. This was done due to the disparity in care between high income (GNI > $5101) and low-income countries (GNI < $5101).

2.2. Data sources, search strategy, screening and abstraction

In consultation with a librarian (RS), data sources included (a) electronic search of databases, (b) search for gray literature (conference proceedings, clinical trial registers) and (c) using the reference bibliography of full text articles to identify potentially relevant studies. The electronic search strategy followed the PICOS approach (Population, Intervention, Comparator, Outcome and Study design/setting), and was conducted in three databases including PubMed, Embase and PsycINFO. Only English language articles were included into the review. The complete search strategy is in the supplementary files. The search strategy used Boolean logic to combine terms in the PICOS framework. Articles were saved into Endnote (Brahmi and Gall, 2006), duplicates removed and two authors (EKM & JLO) independently screened the titles and abstracts to determine which articles were eligible for the review in parallel, before retrieving full texts. A consensus meeting was held when there was disagreement. For each study, abstracted data included name of the test, the domains they assessed, duration of assessments, personnel administering the tests, the types of assessments (paper vs computerized), and whether the tests had been validated against a gold standard.

2.3. Quality assessment

Studies with a poor risk of bias assessment were not excluded from the final analysis. However, duplicate publications were removed to limit publication bias. Bias assessment was undertaken by the primary reviewer (EKM) in consultation with DA, JLG and EAO.

2.4. Data synthesis

We performed a structured narrative synthesis were words and text are used to summarize and explain the findings of the review (Popay et al., 2006). Quantitative data was analyzed using Stata version 14. (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP). The criterion (a) of a test being able to identify early on individuals at high risk for impairment was assessed by abstracting the clinical diagnosis to determine which tests were performed early at the first episode of psychosis. The criterion (b) of a test needing to be sensitive enough to determine those who need further review was assessed by determining the tests that had been validated against a comprehensive neuropsychological battery. The criterion (c) of a test being brief and narrow in scope was assessed by the number of domains assessed and the duration of the assessment. The criterion (d) of a test administered as part of a routine clinic visit was assessed by determining the setting (inpatient versus outpatient) in which the tests were performed. These settings were chosen since neuropsychological assessments are performed on resolution of psychotic symptoms which is often in outpatient not inpatient settings (Harvey, 2013; Reichenberg, 2010). The criterion (e) of a test administered by clinicians or support staff with electronic devices was assessed by determining the mode of delivery of the test (pen and paper versus computerized) and the personnel administering the tests. Finally, the criterion (f) of a test used to monitor
progress and outcomes was assessed by determining the studies that employed a longitudinal study design as well as those that assessed quality of life in participants.

3. Results

3.1. Study setting and population

The last search using PubMed was undertaken on April 10th, 2020, while the last search using PsycINFO & Embase, was undertaken on 18th October 2018. After removal of duplicates, eligible titles and abstracts were screened according to the inclusion criteria until a final list was agreed upon. The process is highlighted in Fig. 1. Thirty-one studies were included in the final analysis. The articles were published between 1994 and 2018 with many (15/31) published between the years 2000 and 2010. Seven (7) studies were from Central and South American countries, thirteen (13) were from Asian countries and eleven (11) were from African countries. South Africa had the highest number of individual studies making up 7 of the 31 studies. In total, the final table included 3254 participants with psychosis and 1331 controls.

3.2. Early neuropsychological assessment

Only 3 studies were performed early among patients with a first episode of psychosis. The different diagnostic characteristics of the participants are shown in Table 1.

3.3. Validation of tests

Only 3 out of 31 studies specifically evaluated a measure against a comprehensive neuropsychological battery. A summary of the publications and associated validation statistics are shown in Table 2.

Fig. 1. Article selection using PRISMA guidelines.
Table 1
Summary of studies included in the review.

| Year | Author       | Country                    | Study design | Population | Population group | Total number of participants | Diagnostic type                  | Number |
|------|--------------|----------------------------|--------------|------------|------------------|------------------------------|----------------------------------|--------|
| 1994 | Gureje       | Nigeria                    | CS           | Inpatient  | Black            | 128                          | Schizophrenia                    | 43     |
|      |              |                            |              |            |                  |                              | Mania                             | 32     |
|      |              |                            |              |            |                  |                              | HC                               | 53     |
|      |              |                            |              |            |                  |                              | Schizophrenia positive symptoms  | 53     |
|      |              |                            |              |            |                  |                              | Schizophrenia negative symptoms  | 20     |
| 1997 | Mattson      | South Africa               | CS           | Outpatient | Caucasian        | 40                           | Schizophrenia                    | 60     |
|      |              |                            |              |            |                  |                              | HC                               | 30     |
|      |              |                            |              |            |                  |                              | Schizophrenia English speaking   | 5      |
|      |              |                            |              |            |                  |                              | Schizophrenia Afrikaans speaking | 24     |
| 2002 | Ertugrul     | Turkey                     | Case control | Outpatient | Caucasian        | 90                           | Schizophrenia                    | 20     |
|      |              |                            |              |            |                  |                              | HC                               | 10     |
| 2002 | Harvey       | South Africa               | CS           | Outpatient | Caucasian        | 29                           | Schizophrenia                    | 15     |
|      |              |                            |              |            |                  |                              | HC                               | 15     |
|      |              |                            |              |            |                  |                              | Schizophrenia                     | 98     |
|      |              |                            |              |            |                  |                              | HC                               | 15     |
| 2005 | Aleptekin    | Turkey                     | CS           | Outpatient | Caucasian        | 69                           | Schizophrenia                    | 38     |
|      |              |                            |              |            |                  |                              | HC                               | 31     |
| 2006 | Leppanen     | South Africa               | CS           | Outpatient | Black            | 84                           | Schizophrenia                    | 44     |
|      |              |                            |              |            |                  |                              | HC                               | 40     |
| 2007 | Salgado      | Brazil                     | CS           | Outpatient | Caucasian        | 40                           | Schizophrenia                    | 20     |
|      |              |                            |              |            |                  |                              | HC                               | 20     |
| 2007 | Trivedi      | India                      | CS           | Outpatient | Oriental         | 45                           | Schizophrenia                    | 15     |
|      |              |                            |              |            |                  |                              | HC                               | 15     |
| 2007 | Ayres        | Brazil                     | CS           | Outpatient | Caucasian        | 553                          | Schizophrenia                    | 98     |
|      |              |                            |              |            |                  |                              | HC                               | 31     |
| 2008 | Pradhan      | Brazil                     | CS           | Outpatient | Caucasian        | 103                          | Schizophrenia                    | 83     |
|      |              |                            |              |            |                  |                              | HC                               | 48     |
| 2008 | Leppanen     | South Africa               | CS           | Outpatient | African          | 81                           | Schizophrenia                    | 47     |
|      |              |                            |              |            |                  |                              | HC                               | 23     |
| 2008 | Savitz       | South Africa               | CS           | Outpatient | Caucasian        | 230                          | Schizophrenia                    | 49     |
|      |              |                            |              |            |                  |                              | HC                               | 22     |
| 2008 | Schneider    | Brazil                     | CS           | Outpatient | Caucasian        | 94                           | Schizophrenia                    | 49     |
|      |              |                            |              |            |                  |                              | HC                               | 28     |
| 2009 | Savitz       | South Africa               | CS           | Outpatient | Caucasian        | 110                          | Schizophrenia                    | 49     |
|      |              |                            |              |            |                  |                              | HC                               | 24     |
| 2010 | Ayres        | Brazil                     | CS           | Outpatient | Caucasian        | 160                          | Schizophrenia                    | 61     |
|      |              |                            |              |            |                  |                              | Affective psychosis              | 56     |
|      |              |                            |              |            |                  |                              | HC                               | 34     |
|      |              |                            |              |            |                  |                              | HC                               | 70     |
|      |              |                            |              |            |                  |                              | HC                               | 153    |
|      |              |                            |              |            |                  |                              | Brief psychotic disorder         | 68     |
|      |              |                            |              |            |                  |                              | Schizophreniform                 | 50     |
|      |              |                            |              |            |                  |                              | Schizophrenia                    | 70     |
|      |              |                            |              |            |                  |                              | Schizophrenia                    | 34     |
|      |              |                            |              |            |                  |                              | HC                               | 34     |
|      |              |                            |              |            |                  |                              | Schizophrenia                    | 9      |
|      |              |                            |              |            |                  |                              | HC                               | 9      |
|      |              |                            |              |            |                  |                              | Schizophrenia                    | 578    |
|      |              |                            |              |            |                  |                              | Schizophreniform                 | 120    |
|      |              |                            |              |            |                  |                              | Mania                            | 312    |
|      |              |                            |              |            |                  |                              | Psychosis NOS                     | 16     |
|      |              |                            |              |            |                  |                              | Schizophrenia                    | 100    |
|      |              |                            |              |            |                  |                              | Depression                       | 55     |
|      |              |                            |              |            |                  |                              | Schizophrenia                    | 100    |
|      |              |                            |              |            |                  |                              | FEP                              | 101    |
| 2010 | Cabral-Calderin | Cuba                 | Longitudinal | Outpatient | Caucasian        | 68                           | Schizophrenia                    | 50     |
| 2011 | Mehta        | India                      | CS           | Outpatient | Oriental         | 18                           | Schizophrenia                    | 34     |
|      |              |                            |              |            |                  |                              | Schizophrenia                    | 9      |
| 2011 | Guo          | China                      | Longitudinal | Outpatient | Oriental         | 698                          | Schizophrenia                    | 578    |
|      |              |                            |              |            |                  |                              | Schizophreniform                 | 120    |
| 2012 | Nakasujsa    | Uganda                     | Longitudinal | Inpatient | Black            | 483                          | Schizophrenia                    | 100    |
|      |              |                            |              |            |                  |                              | Depression                       | 55     |
|      |              |                            |              |            |                  |                              | Schizophrenia                    | 100    |
|      |              |                            |              |            |                  |                              | FEP                              | 101    |
| 2013 | Santosh      | India                      | CS           | Longitudinal | Oriental         | 100                          | Schizophrenia                    | 60     |
| 2014 | Heeramun-     | China                      | CS           | Longitudinal | Oriental         | 101                          | Schizophrenia                    | 30     |
|      | Aubeeuluck   |                            |              |            |                  |                              | Schizophrenia                    | 50     |
| 2014 | Okasha       | Egypt                      | CS           | Outpatient | Black            | 90                           | Schizophrenia                    | 116    |
| 2014 | Mazhari      | Iran                       | CS           | Outpatient | Persian          | 100                          | Schizophrenia                    | 58     |
| 2015 | Aras’ jo     | Brazil                     | CS           | Outpatient | Caucasian        | 174                          | Schizophrenia                    | 116    |
| 2016 | Hou          | China                      | CS           | Outpatient | Oriental         | 80                           | Schizophrenia                    | 40     |
| 2016 | Tang         | China                      | CS           | Outpatient | Oriental         | 148                          | Schizophrenia                    | 40     |
| 2017 | Charernboon  | Thailand                   | CS           | Outpatient | Oriental         | 72                           | Schizophrenia                    | 36     |
| 2017 | Zhou         | China                      | Longitudinal | Inpatient | Oriental         | 49                           | Schizophrenia                    | 32     |

(continued on next page)
24.64% of all tests in the studies. Fig. 3 highlights the proportions of impairment in the reasoning and problem-solving domain accounting for shown in the bar graph (Fig. 2) below. Most tests assessed for impair-
ment in only one domain while 5 out of 31(17%) studies assessed publications with 8 out of 31 publications (25.8%) assessing for im-
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pairment in only one domain while 5 out of 31(17%) studies assessed publications with 8 out of 31 publications (25.8%) assessing for im-
 dissusions which is attractive for clinical application. Most tests assessed for impairment in the reasoning and problem-solving domain (Gureje et al., 1994; Mattson et al., 1997; Ertugrul and Uluğ, 2002; Harvey et al., 2003; Alptekin et al., 2005; Ayres et al., 2007; Salgado et al., 2007; Trivedi et al., 2007; Pradhan et al., 2008; Savitz et al., 2008; Savitz et al., 2009; Ngoma et al., 2010; Guo et al., 2011; Nakasuji et al., 2012a; Mazhari et al., 2014; Araujo et al., 2015; Hendricks et al., 2017; Zhou et al., 2017; Sagar et al., 2018). This seems clinically useful give only one study (Alptekin et al., 2005) reported on the quality of life of the participants. Only 6/31 studies (19.4%) utilised a longitudinal study design. These longitudinal studies are highlighted in Table 1.

4. Risk of bias across studies

There was extensive publication bias (p ≤ 0.005) as shown in the funnel plot (Fig. 4). Published studies (circles) and unpublished studies (squares) in the funnel plot were estimated from the trim-and-fill method. The solid line corresponds to adjustments for the impact of publication bias summary effect and the dashed line to the unadjusted summary effect.

5. Discussion

The research done to date suggests several gaps in the field. Only three studies performed neuropsychological assessments in patients with a first episode of psychosis (Heeramun-Aubeeluck et al., 2015; Hou et al., 2016; Zhou et al., 2017). It is recommended that assessments are performed at the earliest opportunity (American Psychiatric Association, 2013; World Health Organization, 1992; Reichenberg, 2010; Keefe and Fenton, 2007). There is need to validate tools for use among patients with a first episode of psychosis in LMICs (González-Blanch et al., 2011; Moreno-Granados et al., 2014).

The number of studies in which tests were validated against a comprehensive neuropsychological battery was low (Mehta et al., 2011; Mazhari et al., 2014; Araujo et al., 2015). More studies in which the performance of brief tests is compared against comprehensive batteries like the MATRICS consensus cognitive battery (MCCB) are needed. To date most studies have compared the performance of comprehensive batteries like the CogState and the MOCA which have little utility in LMICs with MCCB (Gil-Brerazpe et al., 2020; Lees et al., 2015). However, the results of these studies provide some support for validity.

In 6 out of 31 studies (Salgado et al., 2007; Savitz et al., 2008; Savitz et al., 2009; Mazhari et al., 2014; Araujo et al., 2015; Sagar et al., 2018), the assessment took < 1 h to assess for impairment in five do-

mains, which is attractive for clinical application. Most tests assessed for impairment in the reasoning and problem-solving domain (Gureje et al., 1994; Mattson et al., 1997; Ertugrul and Uluğ, 2002; Harvey et al., 2003; Alptekin et al., 2005; Ayres et al., 2007; Salgado et al., 2007; Trivedi et al., 2007; Pradhan et al., 2008; Savitz et al., 2008; Savitz et al., 2009; Ngoma et al., 2010; Guo et al., 2011; Nakasuji et al., 2012a; Mazhari et al., 2014; Araujo et al., 2015; Hendricks et al., 2017; Zhou et al., 2017; Sagar et al., 2018). This seems clinically useful given literature from high-income countries that the greatest burden of cognitive impairment is in the cognitive domains of attention/vigi-

lance, memory and reasoning and problem-solving among chronic pa-

nents (Rund, 2002).

In this review, only three studies used nonspecialised staff to per-
form the neuropsychological assessments (Harvey et al., 2003; Savitz et al., 2008; Savitz et al., 2009). This raises concern about the clinical utility of these measures in LMICs, where there are few specialized sta-
mHealth applications are more efficient, accurate, accessible and

Table 2 (continued)

| Year | Author     | Country | Study design | Population | Population group | Total number of participants | Diagnostic type                  | Number |
|------|------------|---------|--------------|------------|------------------|-----------------------------|---------------------------------|--------|
| 2017 | Hendricks  | South Africa | CS          | Inpatient  | Caucasian        | 29                          | Alcohol induced psychosis       | 13     |
| 2018 | Sagar      | India    | Longitudinal | Outpatient | Oriental         | 178                         | Alcohol use                     | 16     |
|      |            |          |             |            |                  |                             | BPD depressed                    | 36     |
|      |            |          |             |            |                  |                             | BPD manic                       | 41     |
|      |            |          |             |            |                  |                             | BPD euthymic                     | 52     |
|      |            |          |             |            |                  |                             | HC                              | 49     |

FES = first episode schizophrenia, HC = healthy controls, BPD = bipolar affective disorder, FEP = first episode psychosis, NOS = not otherwise specified.
Most tests were performed using pen and paper tests (Gureje et al., 1994; Mattson et al., 1997; Ertuğrul and Uluğ, 2002; Harvey et al., 2003; Alptekin et al., 2005; Ayres et al., 2007; Salgado et al., 2007; Pradhan et al., 2008; Savitz et al., 2008; Savitz et al., 2009; de Mello Ayres et al., 2010; Ngoma et al., 2010; Guo et al., 2011; Nakasujja et al., 2012a; Mazhari et al., 2014; Okasha et al., 2014; Araujo et al., 2015; Hendricks et al., 2017; Sagar et al., 2018). Limitations of paper based assessments include human error in data collection, the additional time required to score the assessments after they have been administered, costs associated with obtaining copyrighted and proprietary forms, and the burden of transporting and storing hard-copy questionnaires (Robbins et al., 2014a). Further work is warranted on the use of electronic assessments using mobile technology (mHealth applications, or “apps”) as is already being done in other populations such as persons living with HIV/AIDS (Brian and Ben-Zeev, n.d.; Robbins et al., 2014b; Robbins et al., 2018).

Few studies were of a longitudinal study design, and so it is unclear whether these tests are useful for monitoring progress and outcomes (Cabral-Calderin et al., 2010; Guo et al., 2011; Nakasujja et al., 2012a; Heeramun-Aubeeluck et al., 2015; Zhou et al., 2017; Sagar et al., 2018).

Also, only one study assessed for quality of life as an outcome (Alptekin et al., 2005) highlighting the strong associations between cognitive impairment and quality of life. There is need for further studies on the ability of tests to be used in longitudinal studies.

One limitation of our own work deserves emphasis: we searched for English publications only and so may have missed studies published in other languages. Also, the WGSA criteria are not entirely specific on what characteristics constitute the threshold for meeting a criterion. We welcome scrutiny of our study descriptions into what may constitute meeting the WGSA criteria. A further limitation is that our criteria were based on findings from research on these measures, whereas the criteria are intended to address clinical use of these measures.

In conclusion, measures that have been used in research on psychotic disorders in low- and middle-income countries meet only some WCGBL clinical utility criteria. Several candidate assessments are, however, attractive in terms of their scope and duration, and at least one of these, the Brief Assessment of Cognition in Schizophrenia; has been validated in high-income settings (Chianetta et al., 2008; Keefe et al., 2008; Salgado et al., 2007; Mazhari et al., 2014; Araujo et al., 2015). Further work on the administration of measures performed by non-specialized staff using mHealth apps is recommended in low and middle-income contexts.

**List of abbreviations**

- **LMIC**: low- and middle-income country
- **Apps**: application
- **mHealth**: mobile health
| Author           | Subtest/scale/battery | Domains assessed | Administration time (hours) | Mode of delivery          | Person administering test | Training received |
|------------------|-----------------------|------------------|-----------------------------|---------------------------|---------------------------|-------------------|
| Gureje, 1994     | Verbal memory         | VLM, RP, WM, AV  | NR                          | Pen and paper             | Neuropsychologist         | NR                |
|                  | Verbal Fluency        |                  |                             |                           |                           |                   |
|                  | Design fluency        |                  |                             |                           |                           |                   |
|                  | Wechsler Adult Intelligence Scale (WAIS) (Performance subtests) | |                             |                           |                           |                   |
|                  | Wechsler Adult Intelligence Scale (WAIS) (Verbal subtests) | |                             |                           |                           |                   |
| Mattson, 1997    | Rey Auditory Verbal Learning Test (RAVLT) | VLM, RP, IP, AV | NR                          | Pen and paper             | Clinical psychologist     | NR                |
|                  | Wisconsin Card Sorting Test (Modified) |                  |                             |                           |                           |                   |
|                  | Austin Maze           |                  |                             |                           |                           |                   |
|                  | Rey Complex Figure (RCF) |                  |                             |                           |                           |                   |
|                  | Controlled Oral Word Association Test (COWAT) | |                             |                           |                           |                   |
|                  | Trail making test     |                  |                             |                           |                           |                   |
|                  | Stroop Color and Word Test | |                             |                           |                           |                   |
|                  | Wechsler Memory Scale Revised | |                             |                           |                           |                   |
|                  | Wisconsin card sorting test | |                             |                           |                           |                   |
| Mattson, 1997    | Rey Auditory Verbal Learning Test (RAVLT) | VLM, RP, IP, AV | NR                          | Pen and paper             | Clinical psychologist     | NR                |
|                  | Wisconsin Card Sorting Test (Modified) |                  |                             |                           |                           |                   |
|                  | Austin Maze           |                  |                             |                           |                           |                   |
|                  | Rey Complex Figure (RCF) |                  |                             |                           |                           |                   |
|                  | Controlled Oral Word Association Test (COWAT) | |                             |                           |                           |                   |
|                  | Trail making test     |                  |                             |                           |                           |                   |
|                  | Stroop Color and Word Test | |                             |                           |                           |                   |
|                  | Wechsler Memory scale (revised) | WM, VLM, AV, IP | NR                          | Pen and paper             | Research assistants       | YES               |
| Ertugrul, 2002   | Verbal memory         | VLM, RP, WM, VSM | 2                           | Pen and paper             | NR                        | NR                |
|                  | Verbal Fluency        |                  |                             |                           |                           |                   |
|                  | Design fluency        |                  |                             |                           |                           |                   |
|                  | Wechsler Adult Intelligence Scale (WAIS) | |                             |                           |                           |                   |
|                  | Wisconsin Card Sorting Test | |                             |                           |                           |                   |
| Harvey, 2002     | Verbal memory         | VLM, RP, WM, AV  | NR                          | Pen and paper             | Psychiatric nurse, Research assistants | YES               |
|                  | Verbal Fluency        |                  |                             |                           |                           |                   |
|                  | Design fluency        |                  |                             |                           |                           |                   |
|                  | Wechsler Adult Intelligence Scale (WAIS) | |                             |                           |                           |                   |
|                  | Wisconsin Card Sorting Test | |                             |                           |                           |                   |
| Aleptekin, 2005  | Verbal memory         | AV, WM, RP       | NR                          | Pen and paper             | NR                        | NR                |
|                  | Verbal Fluency        |                  |                             |                           |                           |                   |
|                  | Design fluency        |                  |                             |                           |                           |                   |
|                  | Wechsler Adult Intelligence Scale (WAIS) | |                             |                           |                           |                   |
|                  | Wisconsin Card Sorting Test | |                             |                           |                           |                   |
|                  | Controlled Oral Word Association Test (COWAT) | |                             |                           |                           |                   |
| Leppanen, 2006   | Facial affect recognition | Social cognition | NR                          | Computer                  | Psychiatrist              | NR                |
| Salgado, 2007    | 15 item word list     | Social cognition | NR                          | Computer                  | Psychiatrist              | Single            |
|                  | Digit sequencing task | VLM, WM, AV, IP  | 0.72                        | Pen and paper             | Psychiatric nurse          | NR                |
|                  | Token motor task      |                  |                             |                           |                           |                   |
|                  | Category fluency      |                  |                             |                           |                           |                   |
|                  | Symbol coding         |                  |                             |                           |                           |                   |
|                  | Tower of London       |                  |                             |                           |                           |                   |
| Trivedi, 2007    | Wisconsin Card Sorting Test | RP, AV      | NR                          | Computer                  | NR                        | NR                |
|                  | Controlled Oral Word Association Test (COWAT) | |                             |                           |                           |                   |
| Ayres, 2007      | Controlled Oral Word Association Test (COWAT) | VSM, AV, WM | NR                          | Pen and paper             | NR                        | NR                |
| Pradhan, 2008    | Wisconsin Card Sorting Test | RP, VLM, WM, IP, AV | 3.5                        | Pen and paper             | NR                        | NR                |
|                  | Trail B               |                  |                             |                           |                           |                   |
|                  | Controlled Words Association Test | |                             |                           |                           |                   |
|                  | PGI Memory scale      |                  |                             |                           |                           |                   |
|                  | Bender Visual Motor Gestalt Test | |                             |                           |                           |                   |
|                  | Trail A               |                  |                             |                           |                           |                   |
| Leppanen, 2008   | Facial affect recognition | Social cognition | NR                          | Computer                  | Neuropsychologist, Graduate students | NR                |
| Savitz, 2008     | Wechsler Adult Intelligence Scale (WAIS) | Social cognition | 1                           | Pen and paper             | Neuropsychologist, Graduate students | Yes               |
|                  | Controlled Oral Word Association Test (COWAT) | VLM, IP, RP | | | | |
|                  | Rey Complex Figure (RCF) | | | | | |
|                  | Stroop Color and Word test | | | | | |
|                  | Rey Auditory Verbal Learning Test (RAVLT) | | | | | |
|                  | Wisconsin Card Sorting Test (64 item) | | | | | |
| Schneider, 2008  | Wechsler Adult Intelligence Scale (WAIS) III | VSM, WM, IP | NR                          | NR                        | NR                        | NR                |
| Savitz, 2009     | Digits span           | WM, VLM, AV, IP, RP | 1                           | Pen and paper             | Neuropsychologist, Graduate students | Yes               |
|                  | Controlled Oral Word Association Test (COWAT) | VLM, IP, RP | | | | |
|                  | Rey Complex Figure (RCF) | | | | | |
|                  | Stroop Color and Word test | | | | | |
|                  | Rey Auditory Verbal Learning Test (RAVLT) | | | | | |
|                  | Wisconsin Card Sorting Test (64 item) | | | | | |
| Ayres, 2010      | Controlled Oral Word Association Test (COWAT) | VSM, AV, WM | NR                          | Pen and paper             | NR                        | NR                |

(continued on next page)
| Author                      | Subtest/scale/battery                                                                 | Domains assessed          | Administration time (hours) | Mode of delivery | Person administering test | Training received |
|-----------------------------|--------------------------------------------------------------------------------------|---------------------------|----------------------------|------------------|---------------------------|-------------------|
| Ngoma, 2010                 | Wechsler Adult Intelligence Scale (WAIS)                                              | VLM, VSM, WM, AV, MS, RP  | NR                         | Pen and paper     | Clinical psychologist    | NR                |
|                             | Rey 15 Item                                                                          |                           |                            |                  |                           |                   |
|                             | Rey Complex Figure (RCF)                                                             |                           |                            |                  |                           |                   |
|                             | Letter number sequence task                                                         |                           |                            |                  |                           |                   |
|                             | Test of attention                                                                   |                           |                            |                  |                           |                   |
|                             | Trail making test                                                                   |                           |                            |                  |                           |                   |
|                             | Motor speed                                                                          |                           |                            |                  |                           |                   |
|                             | Controlled Oral Word Association Test (COWAT)                                        |                           |                            |                  |                           |                   |
|                             | Stroop Color and Word test                                                          |                           |                            |                  |                           |                   |
|                             | Wisconsin Card Sorting Test (256 version)                                            |                           |                            |                  |                           |                   |
|                             | Trail making test                                                                   |                           |                            |                  |                           |                   |
| Cabral-Calderin, 2010        | Emotional Expression Multimorph task                                                 | social Cognition          | NR                         | NR               | NR                        | NR                |
|                             | Social cognition rating scale in Indian Settings                                    | Social cognition          |                            | NR               |                           |                   |
| Guo, 2011                   | Wechsler Adult Intelligence Scale (WAIS) (Revised)                                   | IP, RP, WM, VSM           | NR                         | Pen and paper     | Neuropsychologist         | NR                |
|                             | Wisconsin card sorting test                                                          |                           |                            |                  |                           |                   |
|                             | Wechsler Adult Intelligence Scale (WAIS) (Revised)                                   |                           |                            |                  |                           |                   |
|                             | Wechsler Memory Scale (Revised)                                                      |                           |                            |                  |                           |                   |
| Nakasuuja, 2012              | WHO UCLA Auditory verbal learning test                                               | VLM, AV, WM, RP, IP       | NR                         | Pen and paper     | NR                        | NR                |
|                             | Symbol digit modalities test                                                         |                           |                            |                  |                           |                   |
|                             | Verbal fluency                                                                      |                           |                            |                  |                           |                   |
|                             | Wechsler Adult Intelligence Scale version III (WAIS)                                 |                           |                            |                  |                           |                   |
| Santosh, 2013                | Trail making test part B                                                             | RP, IP, AV, WM, VLM       | NR                         | NR               | NR                        | NR                |
|                             | Trail making test part A                                                             |                           |                            |                  |                           |                   |
|                             | Stroop test                                                                          |                           |                            |                  |                           |                   |
|                             | Digit span                                                                          |                           |                            |                  |                           |                   |
|                             | Verbal fluency test                                                                  |                           |                            |                  |                           |                   |
| Heeramun-Aubeeluck, 2014     | Paced Auditory Serial                                                               | WM, IP, VLM, VSM          | NR                         | NR               | NR                        | Yes               |
|                             | Wechsler Memory Scale                                                                |                           |                            |                  |                           |                   |
|                             | Wechsler Adult Intelligence Scale (WAIS)                                             |                           |                            |                  |                           |                   |
|                             | Trail making                                                                        |                           |                            |                  |                           |                   |
|                             | Hopkins Verbal Learning Test (Revised)                                               |                           |                            |                  |                           |                   |
| Okasha, 2014                 | Weschler memory scale                                                                | WM, VSM, LVM, AV, RP, IP  | 3.5                        | pen and paper      | Research assistants      | NR                |
|                             | Continuous performance tests                                                         |                           |                            |                  |                           |                   |
|                             | Wisconsin Card Sorting test                                                          |                           |                            |                  |                           |                   |
| Mazhari, 2014                | 15 item word list                                                                    | VLM, WM, AV, RP, IP       | 0.67                       | Pen and paper       | NR                        | NR                |
|                             | Digit sequencing task                                                                |                           |                            |                  |                           |                   |
|                             | Token motor task                                                                    |                           |                            |                  |                           |                   |
|                             | COWAT                                                                               |                           |                            |                  |                           |                   |
|                             | Symbol coding                                                                       |                           |                            |                  |                           |                   |
|                             | Tower of London                                                                     |                           |                            |                  |                           |                   |
|                             | Trail making                                                                        |                           |                            |                  |                           |                   |
| Arausojo, 2015               | Rey Auditory-Verbal Learning Test                                                    | VLM, WM, IP, VSM, AV, RP  | 0.68                       | Pen and paper       | NR                        | NR                |
|                             | Wechsler Adult Intelligence Scale (WAIS) (Version III)                               |                           |                            |                  |                           |                   |
|                             | Trail Making test                                                                    |                           |                            |                  |                           |                   |
|                             | Controlled Oral Word Association Test (COWAT)                                        |                           |                            |                  |                           |                   |
| Hou, 2016                   | Trail making                                                                        | IP, AV, VLM               | NR                         | NR               | NR                        | NR                |
|                             | Stroop color word test                                                               |                           |                            |                  |                           |                   |
|                             | Hopkins Verbal Learning Test-Revised (HVLT-R)                                        |                           |                            |                  |                           |                   |
| Tang, 2016                  | Facial emotional recognition task                                                    | SC                         | NR                         | NR               | NR                        | NR                |
|                             | Emotion perception                                                                   | SC                         | NR                         | NR               | NR                        | NR                |
|                             | Theory of mind                                                                      | SC                         | NR                         | NR               | NR                        | NR                |
|                             | Social knowledge                                                                    | SC                         | NR                         | NR               | NR                        | NR                |
| Charrensoom, 2017            | Hopkins Verbal Learning Test-revised (C-CAMPROMPT)                                  | WM, VLM, AV, RP            | Computer                   | NR               | NR                        | NR                |
| Zhou, 2017                  | Hopkins Verbal Learning Test-revised (Chinese version)                               | WM, VLM, AV, RP            | Computer                   | NR               | NR                        | NR                |
|                             | The Color Trails Test                                                                |                           |                            |                  |                           |                   |
|                             | The Color Word Test Chinese version                                                  |                           |                            |                  |                           |                   |
| Hendricks, 2017              |                                                                                     |                           |                            |                  |                           |                   |
CRediT authorship contribution statement

Emmanuel K. Mwesiga: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing - original draft, Writing - review & editing.

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Declaration of competing interest

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Ethics approval and consent to participate

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Availability of data and material

All data generated or analyzed during this study is included in the supplementary information files.

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Appendix A. Supplementary data

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