# CULTURAL VALIDATION OF WECHSLER PRESCHOOL AND PRIMARY SCALE OF INTELLIGENCE-IV (YOUNGER VERSION) IN BANGLADESH

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**ABSTRACT**

Lack of indigenous instruments creates difficulty to measure early childhood development. Cultural validation is prerequisite for available foreign measures. Very few tools that assess cognitive development of children are culturally appropriate for Bangladesh. The aim of this study was to culturally validate the younger version of Wechsler Preschool and Primary Scale of Intelligence-IV (WPPSI-IV) to assess cognitive abilities of children in rural Bangladesh. A systematic validation protocol was followed including forward and backward translation, modification of pictures, items, and questions without altering underlying construct. Then psychometric properties were tested by measuring reliability and validity of the WPPSI-IV. The results indicated perfect inter-observer reliability ($r$ = 1), and strong test-retest reliability within an interval of 7 days ($r$ = 0.63 to 0.92) of the WPPSI-IV. We found significant correlations among the subtests of the scales of WPPSI-IV indicating its internal consistency. A total of 107 children was included to test the concurrent validity of WPPSI-IV. Concurrent validity was determined by comparing the WPPSI-IV with Bayley-III and found significant moderate association between them ($r$ = 0.51). Thus, the younger version of WPPSI-IV is a valid and reliable instrument to measure the cognitive ability of children in Bangladesh. This has important implications to reduce the developmental deficit of children in Bangladesh.

**KEYWORDS:** cultural validation, cognitive ability, reliability, validity

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## Introduction

Early childhood development (ECD) is a concerning issue in developing countries specially that over 250 million children under 5 years of age are not attending their full potential due to malnutrition, poor health facilities, poverty, and lack of care in these countries (Black et al. 2017). As over 6 million deaths in children are prevented in developing countries every year (Jones et al., 2003), programs to address development of surviving young children has become vital. However, evaluation of these programs in developing countries becomes difficult because most ECD measurements are developed in Western countries.

It is therefore, important to adapt developmental assessment tools that show good psychometric properties in Bangladeshi culture. WPPSI-IV is designed to measure the cognitive ability of children from 2 years, 6 months to 3years, 11 months (Younger version) and from 4 years to 7 years, 7 months (Older version) (Wechsler, 2012). This is one of the appropriate individually administered tests requiring response from the children and is an updated version of WPPSI-III.

It is basically developed for children in developed countries, and its psychometric characteristic is for population in the United States. Despite its foreign properties, the test has been used in various developing countries on the underprivileged children living in poverty to measure their cognitive ability (Murtaza et al., 2019, John et al., 2022, Wasserman et al., 2007; Solon et al., 2008; Walker, Chang, Younger, & Grantham-Mcgregor, 2010). The scale was sensitive to nutrition interventions in Indonesia, and to the impacts of a preschool program conducted in Bangladesh (Prado et al., 2010; Moore, Akhter, & Aboud, 2005).

The aforementioned studies, however, reported little information about the validation and psychometric properties of the WPPSI-IV, which are crucial to interpret the findings evolved from the data. In Pakistan, the WPPSI-III was adapted following systematic adaptation procedure with a cohort of 1,273 rural children, at 4 years of age (Rasheed et al., 2017). Unfortunately, there was no study that measures the psychometric properties of WPPSI-IV on the Bangladeshi population. The present study, therefore, aimed to culturally validate the younger version of WPPSI-IV for use in Bangladesh.

## Methods

***Participants***

A total of 107 children aged 2.5 to 3.5 years participated in the present study. The children included in the study were born between 25 April 2017 to 10 May 2018.

***Site***

The test was administered in Rupganj, a rural area under the district of Narayanganj, Bangladesh. Children were brought to the nearest field office of icddr,b for tests.

***Structure of the WPPSI-IV***

For ages 2 years 6 months to 3 years 11 months, the test framework of the WPPSI-IV is composed of three Primary Index scales: Verbal Comprehension, Visual Spatial and Working Memory. The subtests within each scale delineates the corresponding primary index score (i.e., Verbal Comprehension, Visual Spatial and Working Memory). The Full Scale includes all subtests from each Primary Index scale, along with any additional supplemental subtests used to determine the FSIQ, such as Picture Naming.

At the Primary Index Scale level, there are six core subtests and two for each index. Specifically, the VCI is based on Receptive Vocabulary and Information, the VSI is based on Block Design and Object Assembly, and the WMI is based on Picture Memory and Zoo Locations. No supplemental subtests are available for calculating the primary index scores.

At the Full-Scale level, there are five main subtests: i) Receptive, ii) Vocabulary, ii) Information, ii) Block Design, iv) Object Assembly, and v) Picture Memory; and two supplemental subtests: i) Zoo Locations and ii) Picture Memory. While Zoo Locations may take the place of Picture Memory, Picture Naming may replace Receptive Vocabulary, but not Information. Notably, only one supplemental subtest substitution is allowed when calculating the FSIQ.

***Permission for validation*** Prior to validation, permission was taken from the publishing company of the original WPPSI-IV (Pearson Ltd, USA) for the cultural modifications and translations of the test.

***Validation of WPPSI-IV***

The validation of WPPSI-IV was completed in six steps. The steps were divided into two phases.

***Phase 1: Translations and Modifications***

**Step 1**: forward translation

A team of five members reviewed the items of seven subtests of the WPPSI-IV. All members of the team are experts in psychology and child development research, and fluent in English, as well as the local language. They have previous experience in the translation and adaptation procedures of child development tests. They translated and modified the items into Bangla.

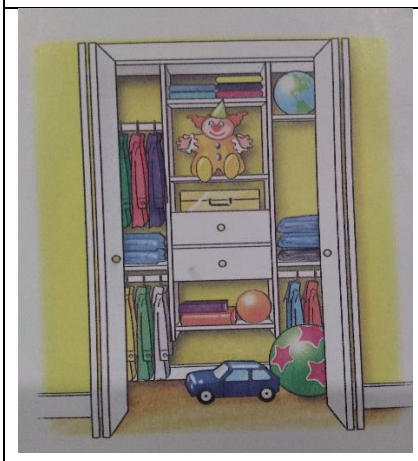
To culturally validate the scale, unfamiliar pictures, verbal items, and difficult questions were changed, without altering the underlying construct. In the Receptive Vocabulary subtest, out of 31 items one item (Item 11, the picture of 'Closet') was replaced with the 'Local Closet'.

In the Information subtest, 2 pictures out of 4 picture items were changed: 'Burger' is not a known type of food in rural areas and was replaced with 'Banana' (Item 1) and 'Bathtub' was replaced with a 'Bucket and Water Tube well' (Item 2) which is more common for taking a bath in Bangladesh.

| | |
|---|---|
|  |  |
| Original item#1 of information | Adapted item#1 of information |

Original item#11 of picture naming

Adapted item#7(new order) of picture naming



Original item#11 of receptive vocabulary

Adapted item#12 (new order) of receptive vocabulary

**Figure 1.** Samples of original and adapted pictures

In the Picture Naming subtest, 4 out of 24 items were changed: 'Kangaroo' was replaced with the 'Monkey' (Item 11), 'Broom' was replaced with 'Local Broom' (Item 13), 'Ladybug' was replaced with 'Cockroach' (Item 9) and 'Shell' was replaced with 'Local Shell' (Item 12).

***Reranking***

We performed all the items of the selected sub-tests on 107 children and re-ranked the serial numbers of the items of each subtest according to the difficulty level and the children's ability to understand. We, however, tried to keep the original serial numbers when possible.

New ranking items and responses of the subtests are described below.

**Table 1.** Receptive Vocabulary ranking at Rupganj ($n$ = 107)

| Previous Item | New Ranking Item | Frequency (Yes) | Percentage (%) |
|---|---|---|---|
| 1. Show me the foot | 1. Show me the foot | 105 | 98.1 |
| 2. Show me the cup | 2. Show me the cup | 93 | 86.9 |
| 3. Butterfly | 3. Dancing | 72 | 67.3 |
| 4. Painting | 4. Butterfly | 65 | 60.7 |
| 5. Snail | 5. Raining | 51 | 57.0 |
| 6. Raining | 6. Painting | 47 | 43.9 |
| 7. Dancing | 7. Snail | 42 | 39.3 |
| 8. Window | 8. Swimming | 38 | 35.5 |

| | | | |
|---|---|---|---|
| 9. Swimming | 9. Lying down | 32 | 29.9 |
| 10. Wallet | 10. Window | 28 | 26.2 |
| 11. Closet | 11. Wallet | 28 | 26.2 |
| 12. Stirring | 12. Local Closet | 17 | 15.9 |
| 13. Lying down | 13. Paying | 15 | 14.0 |
| 14. Desert | 14. Stirring | 12 | 11.3 |
| 15. Paying | 15. Desert | 9 | 8.4 |
| 16. Curly tail | 16. Curly tail | 6 | 5.6 |
| 17. Telescope | 17. Telescope | 4 | 3.7 |
| 18. Cymbals | 18. Cymbals | 4 | 3.7 |
| 19. Fancy | 19. Girl between the boys | 2 | 1.9 |
| 20. Girl between the boys | 20. Easel | 2 | 1.9 |
| 21. Bird beneath the tree | 21. Bird beneath the tree | 1 | 0.9 |
| 22. Easel | 22. Fancy | 1 | 0.9 |
| 23. Shaggy | 23. Clinging | 1 | 0.9 |
| 24. Clinging | 24. Narrow | 1 | 0.9 |
| 25. Crouching | 25. Shaggy | 0 | 0 |
| 26. Gnawing | 25. Crouching | 0 | 0 |
| 27. Narrow | 26. Gnawing | 0 | 0 |
| 28. Cylinder | 28. Cylinder | 0 | 0 |
| 29. Parallel | 29. Parallel | 0 | 0 |
| 30. Equivalent | 30. Equivalent | 0 | 0 |
| 31. Horizontal | 31. Horizontal | 0 | 0 |

**Table 2.** Information ranking at Rupganj

| Previous Item | New Ranking Item | Frequency (Yes) | Percentage (%) |
|---|---|---|---|
| †1. Eat | †1. Eat (2. The picture of 'Burger' was replaced with the 'Banana') | 102 | 95.3 |
| †2. Bath | †2. Bath (4. The picture of 'Bathtub' was replaced with the 'Water Tap and Bucket') | 102 | 95.3 |
| 3. Meow | 3. Cut | 99 | 92.5 |
| 4. Cut | 4. Meow | 93 | 86.9 |
| *†5. Mouth | *†5. Mouth | 96 | 89.7 |
| *†6. Knee | 6. Write | 45 | 42.5 |
| 7. Old | 7. Knee | 43 | 40.2 |
| 8. Cup | 8. Eyes | 31 | 29.0 |
| 9. Write | 9. Cup | 27 | 25.2 |
| *†10.Dirt | 10. Eggs | 23 | 21.5 |
| †11.Eyes | 11. Legs | 12 | 11.2 |
| 12. Rain | 12. Old | 10 | 9.3 |
| *13. Eggs | 13. Rain | 7 | 6.5 |
| 14. Ground | 14. Chew | 6 | 5.6 |
| 15. Crown | 15. Vegetable | 4 | 3.7 |
| †16. Legs | 16. Finger | 3 | 2.8 |
| †17. Finger | 17. Saturday | 2 | 1.9 |
| 18. Chew | 18. Dirt | 1 | 0.9 |
| 19. Vegetable | 19. Ground | 1 | 0.9 |
| *20. Saturday | 20. Breathe | 1 | 0.9 |
| 21. Breathe | 21. Crown | 0 | 0 |
| *22. Planet | *22. Planet | 0 | 0 |
| 23. Winter | 23. Winter | 0 | 0 |

| | | | |
|---|---|---|---|
| 24. Mouths | 24. Mouths | 0 | 0 |
| 25. Cheese | 25. Cheese | 0 | 0 |
| *26. South | *26. South | 0 | 0 |
| 27. Ocean | 27. Ocean | 0 | 0 |
| *28. Noodles | *28. Noodles | 0 | 0 |
| *29. Sun | *29. Sun | 0 | 0 |

**Table 3.** Picture Naming ranking at Rupganj

| Previous Item | New Ranking Item | Frequency (Yes) | Percentage (%) |
|---|---|---|---|
| †1. Car | †1. Car | 106 | 99.1 |
| 2. Bear | 2. Banana | 101 | 94.4 |
| 3. Banana | 3. Toothbrush | 69 | 64.5 |
| 4. Balloon | 4. Balloon | 66 | 61.7 |
| 5. Star | 5. Scissors | 65 | 60.7 |
| 6. Clock | 6. Clock | 57 | 53.3 |
| 7. Scissors | 7. Kangaroo (The picture of Kangaroo was replaced with the 'Monkey') | 43 | 40.2 |
| *8. Toothbrush | 8. Broom (The picture of 'Broom' was replaced with the 'Local Broom') | 42 | 39.3 |
| 9. Ladybug | 9. Ladybug (The picture of 'Ladybug' was replaced with the 'Cockroach') | 41 | 38.3 |
| 10. Guitar | 10. Pineapple | 16 | 15.0 |
| 11. Kangaroo | 11. Guitar | 14 | 13.1 |
| 12. Shell | 12. Star | 12 | 11.2 |
| 13. Broom | 13. Microphone | 6 | 5.6 |
| 14. Caterpillar | 14. Bear | 4 | 3.7 |
| 15. Microphone | 15. Shell (The picture of 'Shell' was replaced with the 'Local Shell') | 2 | 1.9 |
| 16. Pineapple | 16. Caterpillar | 2 | 1.9 |
| 17. Nail | 17. Nail | 2 | 1.9 |
| 18. Teapot | 18. Teapot | 0 | 0 |
| 19. Globe | 19. Globe | 0 | 0 |
| 20. Xylophone | 20. Xylophone | 0 | 0 |
| 21. Thermometer | 21. Thermometer | 0 | 0 |
| 22. Harp | 22. Harp | 0 | 0 |
| 23. Stethoscope | 23. Stethoscope | 0 | 0 |
| 24. Tripod | 24. Tripod | 0 | 0 |

† Corrective feedback is provided on initial teaching items to facilitate the child's understanding of the task.
* Items with specific sample responses that require query.
*† Items require both a query and corrective feedback are marked with an asterisk.

**Step 2** (synthesis), all the translated and modified items were combined together to make a synthesized version of the stimulus book.
**Step 3** (back translation) involved the back translation of the synthesized Bangla version of WPPSI-IV. This back translation was carried out by two qualifie d translators, who were not members of our team and did not have access to the English version.
***Phase 2: Piloting and Psychometric Test***
**Step 4** was connected to preparing the pre-final version of the modified WPPSI-IV. For this purpose, an expert review committee was formed. In a consensus meeting, they discussed and all agreed on the pre-final version of the WPPSI-IV, in the presence of all the investigators and translators.
Pilot testing of the pre-final version of WPPSI-IV was conducted in the **5th step**. It involved 107 children in Rupganj, and individual cognitive debriefing was done at the time of piloting. The result of the piloting data did not reveal any overall floor or ceiling effects in any of the subtests.
In the **final step**, Bayley-III was administered to measure the psychometric properties of this modified version of the WPPSI-IV.

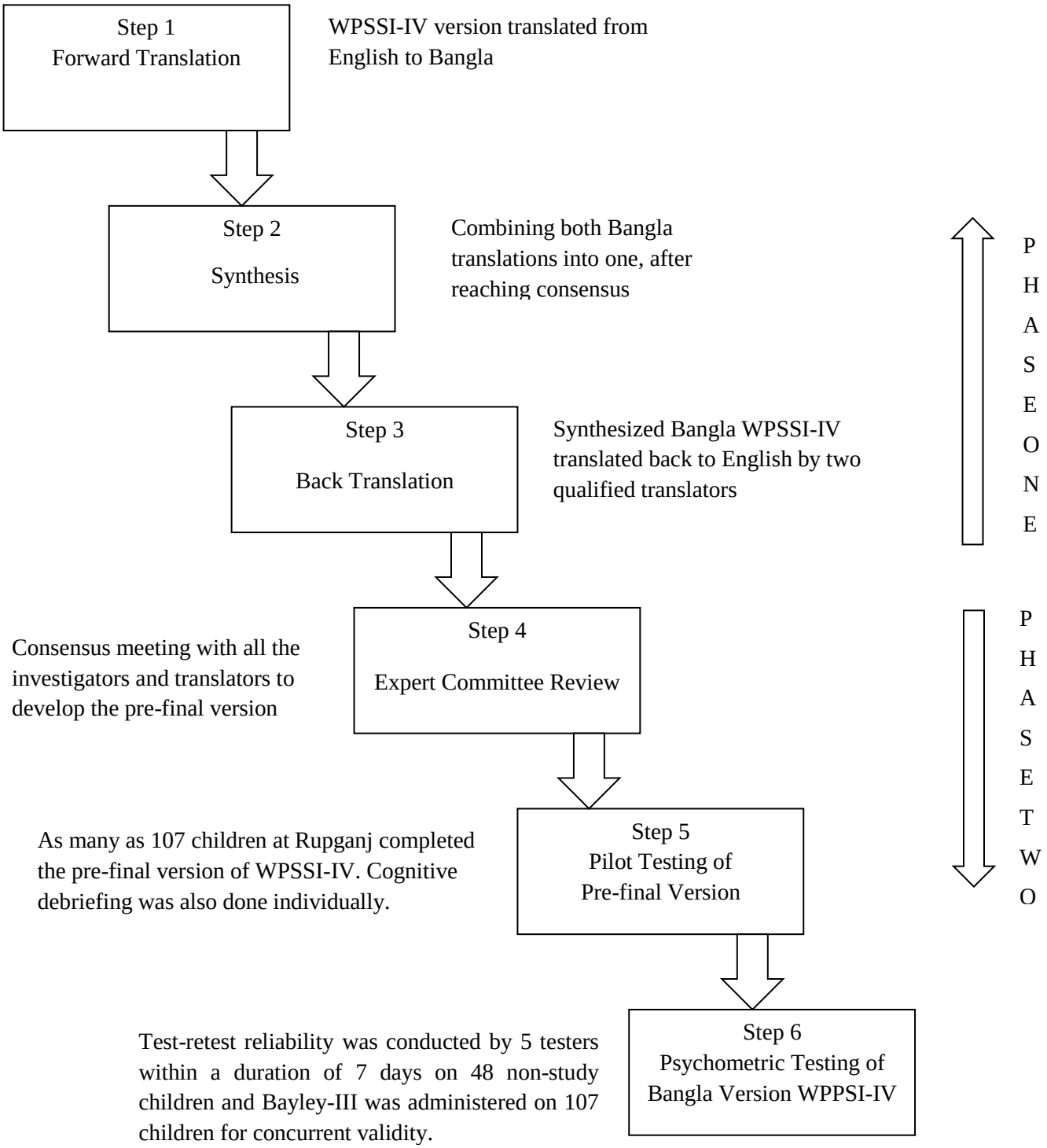



**Figure 2.** The flow chart of WPPSI-IV Validation

## Results

***Inter-observer reliability***

At the beginning of the study, four testers received training on the use of WPPSI-IV and all of them were Psychology graduates as well as well trained on psychometric assessment tools. The testers achieved a satisfactory agreement with the trainer which was determined by the Pearson correlation method. The range of the correlation was perfect (inter-observer reliability, $r = 1$). As much as 10% of all tests were rated by a supervisor (Kippler et al., 2012).

***Test-Retest Reliability***

The test-retest reliability of the WPPSI-IV was ascertained on 48 children within an interval of 7 days, and moderate to strong correlations were obtained between the two assessments of the scales (Table 4). The correlation coefficient $r$ ranged from 0.63 to 0.92.

**Table 4.** Correlation coefficients ($p < 0.01$) of test-retest reliability of validated WPPSI-IV.

| Name of Subtests | *r* |
|---|---|
| Receptive Vocabulary | 0.92 |
| Block Design | 0.85 |
| Picture Memory | 0.92 |
| Information | 0.77 |
| Object Assembly | 0.78 |
| Zoo Locations | 0.86 |
| Picture Naming | 0.87 |
| VCI | 0.77 |
| VSI | 0.63 |
| WMI | 0.83 |
| FSIQ | 0.90 |

***Structural Validity***

The scaled scores of subtests of WPPSI-IV were weak-to-moderate significantly correlated with each other. The highest correlation coefficient was between picture memory and information ($r$ = 0.60) and the weakest value was between receptive vocabulary and object assembly ($r$ = 0.23).

**Table 5.** Inter-correlations of scaled scores ($n$ = 107).

| Name of Subtests | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1.Receptive Vocabulary | - | | | | | |
| 2.Block Design | 0.40** | | | | | |
| 3.Picture Memory | 0.42** | 0.39** | | | | |
| 4.Information | 0.53** | 0.44** | 0.60** | | | |
| 5.Object Assembly | 0.23* | 0.41** | 0.37** | 0.47** | | |
| 6. Zoo location | 0.37** | 0.44** | 0.42** | 0.42** | 0.33** | |
| 7.Picture Naming | 0.40** | 0.33** | 0.48** | 0.57** | 0.38** | 0.40** |

**$p < 0.01$, *$p < 0.05$

***Concurrent Validity***

Concurrent validity of the WPPSI-IV was determined by comparing the Bayley-III and WPPSI-IV. We calculated the correlations among the cognitive and language composite scores of Bayley with FSIQ of WPPSI-IV. We found significant moderate association between Bayley-III and WPPSI-IV.

**Table 6.** Association between Bayley-III and WPPSI-IV

| Bayley-III | FSIQ of WPPSI-IV |
|---|---|
| Cognitive Composite Score | 0.51** |
| Language Composite Score | 0.51** |

**$p < 0.01$

## Discussion

The original WPPSI-IV was designed to measure the cognitive ability (Intelligence Quotient) in English speaking children. For its use in Bangladesh, the WPPSI-IV was translated into Bangla with the help of professionals having long years of experience in the area of child development research. The Bangla translated questionnaires were again transformed into English following the back-translation procedure by the experts to ensure the adequacy of translation. Then the scale was applied on 2.5 to 3.5 years old children to produce the reliability and validity. The data presented in this article yields evidence for the potentiality of the WPPSI-IV for its use in Bangladesh. We are not aware of any other study in Bangladesh which measured the validity of WPPSI-IV.

For cultural validation, unfamiliar pictures, verbal items, and difficult questions were modified without altering the underlying construct. In the Receptive Vocabulary subtest, one item (Item 11) was modified out of 31 items. In the Information subtest, 2 pictures out of 4 picture items were changed and, 4 items out of 24 items were changed in the Picture Naming subtest. The similar validation procedure for WPPSI-IV was followed in the previous studies in Indonesia, Malaysia, and India (John et al., 2022; Murtaza et al., 2019; Schneider et al., 2018). The cultural adaptation of WPPSI-III in seven LMICs including Bangladesh was also based on the same protocol used in WPPSI-IV. (Ruan-lu et al., 2020).

Inter-observer reliability was strong as we found perfect agreement between the trainers and the testers ($r$ = 1). The test-retest reliability was confirmed by administering the modified WPPSI-IV on the 48 participants with an interval of 7 days. We found moderate to strong correlations coefficients between the two-time point administration ($r$ ranged from 0.63 to 0.92). This reliability evidence is consistent with that of original WPPSI-IV reported in the technical and interpretive manual (Wechsler, 2012). The value of correlations among the scaled scores of each subtest determined the structural validity of the WPSSI-IV, this reliability coefficients are stronger than that of the WPPSI-III adapted in Pakistan (Rasheed et al., 2017).

Cognitive and language composite of Bayley-III was significantly associated with the FSIQ of the WPPSI-IV, which indicated the concurrent validity of the modified version of the WPPSI-IV. In the original WPPSI-IV, FSIQ was highly correlated with the Bayley-III cognitive and language composites than the motor composites (Wechsler, 2012). It is observed that no reliability and validity evidences were reported in the previous studies with regard to the cultural adaptations of WPPSI-IV in the Asian countries (Gilani, 2017; John et al., 2022; Murtaza et al., 2019; Schneider et al., 2018). The study strengths include a validation process following a rigorous methodology and the child development unit of icddr,b involved in this work comprises diverse expertise having long years of experience in the field of cultural adaptations and psychometric properties of foreign instruments. The team was fluent in both Bangla and English languages. The weakness of this study included small sample size from only a rural area of Bangladesh. Psychometric properties of the adapted Bayley-III used to measure concurrent validity were unknown.

## Conclusion

Our findings suggest that the culturally modified version of WPPSI-IV is valid and reliable for use in Bangladesh. Furthermore, it can be administered to a broad range of the population covering all socio-economic statuses, which will extend its applicability.

## Conflict of Interest

The authors declared no conflict of interest.

## Authors Contributions

SS, AP and JDH conceived and designed the study. SS, MSS and AYM developed the manuscript and incorporated the feedback from all the authors. AP and SS adapted the questionnaires. AP and MSA led the data collection. SS conducted statistical analysis and JDH helped interpret the data. AYM and JDH review the manuscript. All authors contributed to the interpretation of findings and approved the manuscript.

## Acknowledgements

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## Ethics Statement

The Institutional Review Board (IRB) of icddr,b approved the proposal (IRB approval no. PR-20037). At the time of enrolment, mothers were informed about the program and requested to sign a written informed consent form.

## Funding

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## Data availability

The study data are available from the corresponding author upon request for research purposes related to this paper, to ensure confidentiality.

## References

1. Community-University Partnership for the Study of Children, Youth, and Families (2011). *Review of the Wechsler Preschool and Primary Scale of Intelligence – Third Edition [Canadian] (WPPSI-IIICDN).* Edmonton, Alberta, Canada.
2. Gilani, I. (2017). Cognitive Potential and Its Predictors in Children from A Rural District of Pakistan. *Journal of Ayub Medical College, Abbottabad: JAMC*, *29*(1), 68–73.
3. Gorman, K. S., & Pollitt E. (1996). Does schooling buffer the effects of earlyrisk? *Child Development,67*, 314–26.
4. icddr,b (2009). Health and demographic surveillance system, Matlab. *Registration of Health and Demographic events 2007, 41*.
5. Hamadani, J. et al., (2011). International Journal of Epidemiology 2011; 40:1593-1604. doi:10.1093/ije/dyr176
6. John, H. B., Arumugam, A., Priya, M., Murugesan, N., Rajendraprasad, N., Rebekah, G., Paul, P., Chandna, J., Lawn, J. E., & Santhanam, S. (2022). South Indian Children's Neurodevelopmental Outcomes After Group B Streptococcus Invasive Disease: A Matched-Cohort Study. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*, *74*(Suppl_1), S24–S34. https://doi.org/10.1093/cid/ciab792
7. Jones, G., Steeketee, R. W., Black, R. E., Bhutta, Z. A., Morris, S., and the Bellagio Child Survival Study Group (2003). How many deaths can we prevent this year? *Lancet,362*, 65–71
8. Kippler, M., Tofail, F., Hamadani, J. D., Gardner, R. M., Grantham-McGregor, S. M., Bottai, M., &Vahter, M. (2012). Early-Life Cadmium Exposure and Child Development in 5-Year-Old Girls and Boys: A Cohort Study in Rural Bangladesh. *Environmental Health Perspectives*, *120*(10), 1462–1468. http://doi.org/10.1289/ehp.1104431
9. Moore, A. C., Akhter, S., & Aboud, F. (2005). Evaluation of pilot preschool programs of Plan Bangladesh. *Bangladesh Education Journal*, *4*(1), 33–39.
10. Murtaza, S. F., Gan, W. Y., Sulaiman, N., Mohd Shariff, Z., Ismail, S. I. F. (2019). Sociodemographic, nutritional, and environmental factors are associated with cognitive performance among Orang Asli children in Malaysia. *PLOS ONE*, *14*(7), e0219841. https://doi.org/10.1371/journal.pone.0219841
11. Prado, E. L., Hartini, S., Rahmawati, A., Ismayani, E., Hidayati, A., Hikmah, N., ... & Alcock, K. J. (2010). Test selection, adaptation, and evaluation: A systematic approach to assess nutritional influences on child development in developing countries. *British Journal of Educational Psychology*, *80*(1), 31–53.
12. Rasheed, M. A., Pham, S., Memon, U., Siyal, S., Obradović, J., & Aisha K. Yousafzai, A. K. (2018). Adaptation of the Wechsler Preschool and Primary Scale of Intelligence-III and lessons learned for evaluating intelligence in low-income

settings. *International Journal of School & Educational Psychology*, *6*(3), 197-207, DOI: 10.1080/21683603.2017.1302851

13. Ruan-Iu, L., Pendergast, L. L., Rasheed, M., Tofail, F., Svensen, E., Maphula, A., ... & Murray-Kolb, L. E. (2020). Assessing early childhood fluid reasoning in low-and middle-income nations: validity of the Wechsler Preschool and Primary Scale of Intelligence across seven MAL-ED sites. *Journal of Psychoeducational Assessment*, *38*(2), 256-262.
14. Santos, D. N., Assis, A. M. O., Bastos, A. C. S., Santos, L. M., Santos, C. A. S., Strina, A., ... Barreto, M. L. (2008). Determinants of cognitive function in childhood: A cohort study in a middle income context. *BMC Public health*, *8*(1), 1.
15. Schneider, N., Geiser, E., Gosoniu, L. M., Wibowo, Y., Gentile-Rapinett, G., Tedjasaputra, M. S., & Sastroasmoro, S. (2018). A Combined Dietary and Cognitive Intervention in 3–5-Year-Old Children in Indonesia: A Randomized Controlled Trial. *Nutrients*, *10*(10), 1394. https://doi.org/10.3390/nu10101394
16. Solon, O., Riddell, T. J., Quimbo, S. A., Butrick, E., Aylward, G. P., Bacate, M. L., & Peabody, J. W. (2008). Associations between cognitive function, blood lead concentration, and nutrition among children in the central Philippines. *The Journal of Pediatrics*, *152*(2), 237–243.
17. Stith A. Y., Gorman K. S., & Choudhury N. (2003). The effects of psychosocial risk and gender on school attainment in Guatemala. *Appl Psychol*, *52*,614–29.
18. Tofail, F, Persson, L. A., El Arifeen S et al. (2008). Effects of prenatal food and micronutrient supplementation on infant development: a randomized trial from the Maternal and Infant Nutrition Interventions, Matlab (MINIMat) study. *American Journal of Clinical Nutrition, 87*, 704–711.
19. Walker, S. P., Chang, S. M., Younger, N., & Grantham McGregor, S. M. (2010). The effect of psychosocial stimulation on cognition and behaviour at 6 years in a cohort of term, low-birth weight Jamaican children. Developmental Medicine & Child Neurology, 52(7), e148–e154.
20. Wasserman, G. A., Liu, X., Parvez, F., Ahsan, H., FactorLitvak, P., Kline, J. ... Grazino, J. H. (2007). Water arsenic exposure and intellectual function in 6-year-old children in Araihazar, Bangladesh. Environment Health Perspectives, 115, 285–289. doi:10.1289/ehp.9501
21. Wechsler, D. (2002). Wechsler Preschool and Primary Scale of Intelligence – III. San Antonio, TX: The Psychological Corporation.
22. Wechsler, D. (2012). Wechsler Preschool and Primary Scale of Intelligence – Fourth Edition. San Antonio, TX: The Psychological Corporation.