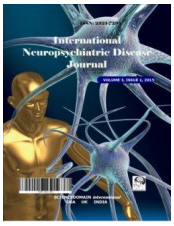

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Comparison between the Electronic Version and Traditional Methods of a Test for Dyslexia: A Cost-benefit Analysis

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Authors' contributions

This work was carried out in collaboration between both authors. Authors FT and TF designed the study and wrote the protocol. Author TF preformed the statistical analysis, managed the literature search and wrote the first draft of the manuscript with assistance from author FT. Both authors read and approved the final manuscript.

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ABSTRACT

Background: The psycholinguistic ability testing of phonological and orthographic skills is one of the assessment tools to measure children's learning development. The traditional method to administer the test has been face to face with a scale box. Continuing advancements in reducing the test burden are expected to provide new methods of network evaluation for medical assessment.
Aims: To compare the electronic version with a net work evaluation and the face-to-face version of a psycholinguistic test and to conduct a cost-benefit analysis.
Study Design: To calculate and compare the cost and benefit of two possible methods using the data from a cost survey when administering the traditional psycholinguistic test in a sample of

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outpatient children from the Chinese Capital Institute of Pediatrics as well as to predict the cost of the electronic version at similar consumption levels.

Methodology: We sought to calculate the average cost per hour according to the average incomes of 283 parents of thousands of outpatients by counting the sub-costs of time and materials for a single test administered using both methods. We compared the numbers of cases that could be performed if the initial investments of the two versions were similar as well as the sub-costs inside and outside the family, the time and materials. We generated equations after Bayes' discrimination with two groups with the test methods and used Fisher's coefficient analysis as the number of cases increased. The Pareto chart demonstrated the 'useful many' and 'vital few' of the two methods.

Results: The initial costs were assumed to be same for the production, design, data and platform needed for the electronic method and the reference norm constructed beforehand using the traditional method. The cumulative cost curves were typically U-shaped when the subsequent cases increased exponentially. The former method could analyze 5000 cases and the latter only 1000 cases given the balanced U-shaped curve. The sub-costs of the methods were compared with Bayes' discrimination, and Fisher's coefficient could form a common trend equation showing a 20/80% phenomenon by classification. Therefore a Pareto chart was subsequently generated. The highest sub-cost was 'in the family' with the electronic online method; the traditional assessment method gave priority to 'time consumption' with the lowest sub-cost of materials greater than the highest consumption with the electronic method. The results showed that the network evaluation method was far favorable to the face to face format, especially as the scale matured, and its use became more widespread.

Conclusions: Dyslexia is a chronic, non-medicinally treated brain disorder. An electronic method for screening would save more time and money for family assessments in Chinese cities.

Keywords: Test versions of children's psycholinguistic ability; electronic with network and traditional face-to face box comparison; cost-benefit analysis.

1. INTRODUCTION

The evaluation of children with dyslexia involves the assessment of psycholinguistic scores to address their current phonologic and orthographic tasks [1]. With testing, we also detect whether children have discomfort or are delayed in their learning abilities, and we can predict whether they will adapt to their school surroundings in the primary stage [2,3]. We demonstrated two mental development levels of representation and automation and five processes, including comprehension, association, closeness, memory, and expression, to characterize their phonological and orthographic abilities [4,5]. The Chinese writing system differs from an alphabetic system in that it contains a large number of visual symbols or characters that represent units of meaning, rather than phonemes as in an alphabet. The task of learning to read is therefore a considerable feat for Chinese children, who must learn literally hundreds of visually complex characters that contain phonetic and radical components [6-9]. There have been few reports of Chinese psycholinguistic assessment. However, the data from the scales of general intelligence administered in face to face assessments of Chinese children with dyslexia are abundant, with heterogeneities among the scores of the studies [10,11]. Chinese children aged 0 to 9 years old number approximately 215.78 million. Approximately 10% suffer from dyslexia or are at risk for learning disabilities; as a rough estimate, millions of school-aged children are expected to undergo psycholinguistic evaluations. Given the phonologic and orthographic tests involved determining modern media audio and visual effectiveness, it is expected that we will perform assessments on networks adapted to highly advanced, modern information and computer technology, attempting to develop big data and cloud models for collecting and analyzing the data [12,13]. The specific big data and cloud model must accomplish trust evaluation, time sequence mining, and extensive fields, and it is also predicted that biological and medical data managers will emerge in the next decade of this century, for research, integration, contact, transparency and support for these screenings [14-21]. The Chinese version of the psycholinguistic scale for children with dyslexia has been announced to be appearing in an electronic format, which also has the following levels: phonological and orthographic. The present study aimed to compare the Chinese psycholinguistic evaluation scale between the electronic version of testing by network and the

traditional face to face method, using a cost-benefit analysis.

2. METHODS

2.1 Participants

We obtained ethical approval for study by Chinese Capital Institute of Pediatrics, the parents of 283 patients among thousands of at-risk outpatients from the hospital attached Institute informed consent to participate. Their children also assent to join our plan of retesting. Parents filled in the questionnaires involved in family economics, degree of education and so on, when they and their children came to the activity again. Their average income was 5343(RMB-yuan) per month, which is similar to reports of the average incomes of people in the Beijing area, in terms of the cost accounting for the time and materials with both methods.

2.2 Time Cost per Hours

The working-hour-cost was determined according to 22 workdays per month and eight hours perworkday: 5343(yuan)/22 workdays / 8 hours = 30 yuan.

2.3 The Network Cost

RBM1.8-2.4yuanwas generally reported and was averaged to2 yuan.

2.4 Hourly (T) Electric Charge and Power Cost

These costs were calculated as follows: voltage (U) =220(v); current (I) = 4(a); electric power (P) = UI = 220 * 4 = 880(w);energy consumption (W) = PT (time=1 hour) = 880 * 1/1000 = 0.88 kw/h (degrees);0.6 yuan for one kilowatt-hour, so 0.6 * 0.88 = 0.88 yuan. The cumulative computer loss was approximately RMB 1 yuan per hour for the total electric and computer costs.

2.5 Cost of the Scale Calculation

-- Production costs included the following: The electronic version that was generated had normal references shaped by cloud cultivation on the Internet; otherwise, the traditional method was used to sample the normal group, which was tested by manual measurement.
-- Measuring time costs included hospital staff, parents, and working sites.
-- Un-measuring time cost included time on the road and waiting for assessment.
-- Measuring material cost included network computers and office-room employees.
-- Un-measuring material cost included the nervous concentration of the tester.
-- Real cost included online payments, registration fees and assessment fees.
-- Un-real cost included investigating the norms and counting the total scores.

2.6 Comparison of How Many Cases could be Assessed with the Norm

If the initial investments were assumed to be same, which included producing of the two methods, the electronic version required the additional cost of the data platform, and the traditional method required the same additional cost to reference the norm constructed ahead.

We undertook the comparison on single assessment sub-costs between the two test methods, the sub-costs inside and outside the family, materials and time spent.

We compared the two test methods with Bayes' theorem and Fisher's coefficient equation: Arranging D to a partition of sample space (D1, D2,..., Dn), with P (Di) incidence of the said event Di, and P (Di) > 0, (i = 1, 2,..., n). For any event x, P (x) > 0, as shown in the following equation:

$$P(D_j/x) = \frac{p(x/D_j)P(D_j)}{\sum_{i=1}^{n} P(X/D_i)P(D_i)}$$

We generated a Pareto chart to show 'useful many' and 'vital few'.

3. RESULTS

3.1 Comparison of How Many Cases could be Assessed on Average between the Two Methods of Assessment

The initial cost was assumed to be the same, which included the production, design, and data platform required by the electronic method but the reference norm constructed beforehand by the traditional method. The cumulative cost curves showed a typical U-shape when subsequent cases increased exponentially. The

former method could assess 5000 cases and the latter only 1000 cases with the U-shaped curve balanced. Nevertheless, random sampling was needed for both (Fig. 1).

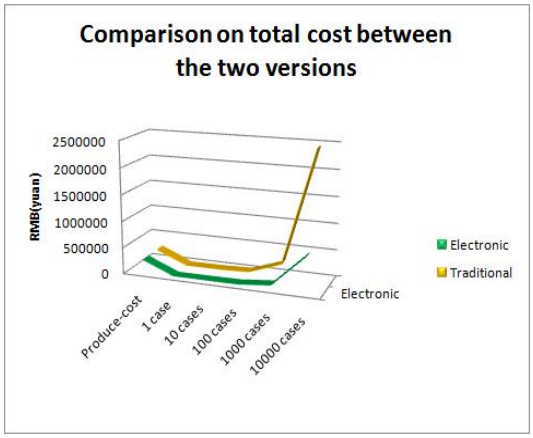

Fig. 1. Thecomparison of how many cases could be assessed with the norm

3.2 The Comparison of Sub-costs of a Single Assessment between the Two Methods

The average income was considered to be 30RMB per hour based on a survey of a parent sample in the capital of Beijing; sub-costs included time costs, system costs, site occupancy costs, electricity costs, and network costs. The single assessment cost for the electronic version was 66RMB, including 48RMB for the family and 18RMB for the system; in contrast, the cost was 245RMB for manual measurement, including 150RMB for the family and 95RMB for the hospital (Table 1). The cost of the electronic method costs far less than traditional method in an average singleton evaluation.

3.3 Comparison of the Sub-costs Inside and Outside the Home, Time and Materials Spent, Cumulative Costs and Indexed Cases, with Bayesian Discrimination

The cost of the electronic method was significantly lower inside and outside the family; in particular, it was lowest for “out of family expenses”. The order was that “electronic outside family” was less than "electronic inside family”, which was less than “traditional outside family”, which was less than “traditional inside family” (Fig. 2). The cost of the traditional method showed geometric growth when the number of cases increased. The costs for time and materials spending were also significantly lower with the electronic method with the following order: “electronic time” was less than “electronic materials”, which was less than “traditional materials”, which was less than “traditional time” (Fig. 3). Group1 used the electronic method, and group2 used the traditional method. The outcomes from Bayesian discrimination are shown in Table 2 and Fig. 4. Fisher’s coefficient was used to form a common trend equation, which showed: b(constant) = -0.663; a_1(time)= 0.581; a_2(family-out)=0.563, a_3(cumulative cost)= 0.499, a_4(family-in)=0.458, a_5(materials)= 0.276. The equation was $Y= b+a_1X_1 +a_2X_2 +a_3X_3 +a_4X_4 +a_5X_5$, or:

$$Y= -0.663 +0.581X_1 +0.563X_2 +0.499X_3 +0.458X_4 +0.276X_5$$

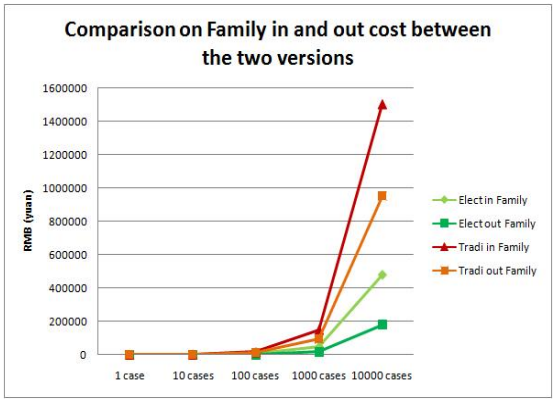

Fig. 2. The comparison on family-in or family-out costs between the two versions

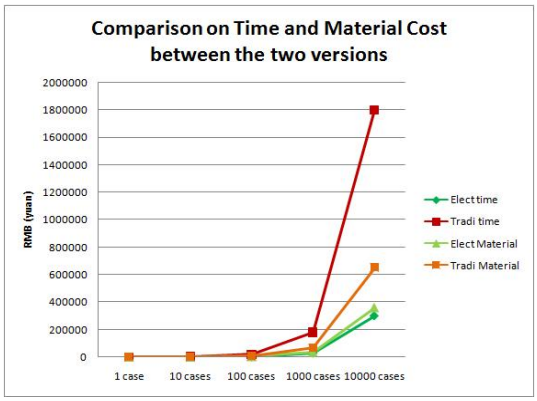

Fig. 3. Comparison of time and material costs between the two versions

Table 1. Comparison of single test cost (yuan) between the two versions

	Electronic for internet				Traditional face to face			
Items	**Sub-items**	**Time-cost(h)**	**Cost**	**Sub-total**	**Sub-items**	**Time-cost(h)**	**Cost**	**Sub-total**
1 Test timing cost	By parents	1	30		By nurses	1	30	
					Accompany by parent	1	30	
Sub-total				30				60
2 Un-test timing cost	On the way		0		On the way	2	60	
	Waiting		0		Waiting	2	60	
Sub-total				0				120
3 Material cost	Family net	2			Outpatient site	1	30	
	Family computer	1						
	Website	2						
	Website computer	1						
Sub-total				6				30
4 Un-material cost	Paid attention by parent	0.5	15		Paid attention by nurse	0.5	15	
	Checking norms	0	0		Checking norms	0.5	15	
	Results showed	By system	15		Results showed	By register	5	
Sub-total				30				35
Total				66 (48 by family 18 by system)		245 (150 by family, 95 by hospital)		

Table 2. Casewise statistics (original groups)

Case number	Actual group	Highest group					Second highest group		
		Predicted group	**P(D>d | G=g)**		**P(G=g | D=d)**	**Squared mahalanobis distance to centroid**	**Group**	**P(G=g | D=d)**	**Squared mahalanobis distance to centroid**
1	1		0.6444053	1	0.500054	0.2130269	2	0.499946	0.2132368
2	1	1	0.6444406	1	0.5000654	0.2129814	2	0.4999346	0.2132823

Case number	Actual group	Highest group				Second highest group		
		Predicted group	P(D>d | G=g)	P(G=g | D=d)	Squared mahalanobis distance to centroid	Group	P(G=g | D=d)	Squared mahalanobis distance to centroid
3	1	1	0.646051	1 0.5005833	0.2109153	2	0.4994167	0.2153597
4	1	1	0.6622451	1 0.5057625	0.1908078	2	0.4942375	0.2366879
5			0.8317795	1 0.5573028	0.0451222	2	0.4426972	0.5053456
6	1	1	0.0422005	1 0.9089867	4.1271464	2	0.0910133	8.729574
7	2	1	0.6447103	1 0.5001522	0.2126345	2	0.4998478	0.2136297
8	2	2	0.6445645	1 0.5000497	0.212822	1	0.4999503	0.2134419
9	2	2	0.6461749	1 0.5005677	0.2107568	1	0.4994323	0.2155205
10	2	2	0.662369	1 0.5057471	0.1906586	1	0.4942529	0.2368595
11	2	2	0.8318995	1 0.5572928	0.0450569	1	0.4427072	0.5056429
12	2	2	0.0422022	1 0.9091023	4.127076	1	0.0908977	8.7327432

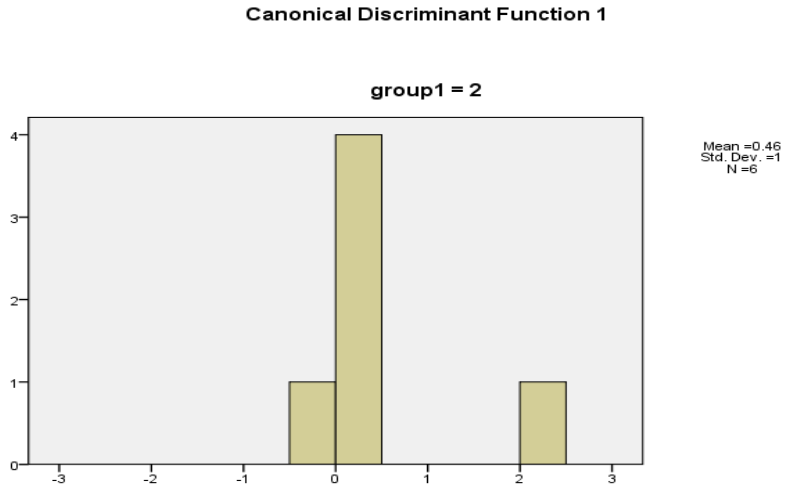

Fig. 4. The Bayesian discrimination

3.4 Comparison of the Pareto Charts of the Sub-costs of two Methods

The classification results were used to determine Pareto efficiency, which is also known as the 80-20 rule, the law of the vital few, and the principle of major factor. The 'vital many' of the sub-cost was 'in the family' for the electronic version (Fig. 5) and 'time consumption' for the traditional method (Fig. 6). Nevertheless, the lowest traditional cost 'materials' was still higher than the highest electronic cost 'in-family'.

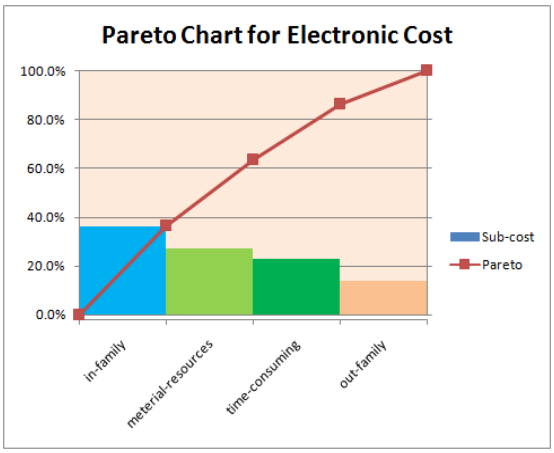

Fig. 5. Pareto chart for electronic sub-costs

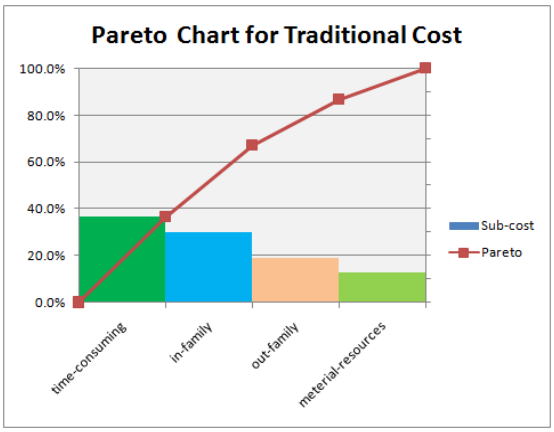

Fig. 6. Pareto chart for traditional sub-costs

4. DISCUSSION

4.1 Dyslexia's Characteristics, Assessments and Resource Allocations

Dyslexia is still diagnosed in mainland China as a syndrome receiving non-medical treatment and as chronic brain dysfunction. The prevalence of the disorder could not be assessed accurately so far because of the different social norms and education levels over such a large geographic area. The disorder is usually classified in the category of child care in large cities, so dyslexic children are given interventions in special schools or in the family. There are cost problems with disorder assessment in many aspects: (1) Norm references, it requires more cases of a posteriori norms due to the large population while if there were a certain amount of funding for field trials, it would be more representative. (2) The costs of assessment and intervention, there are some weightings on the costs, such as work or non-work time cost, the time of concentration or the distribution of the time lost for the accompanying guardian. (3) The cost paid should be commensurate with the severity of disorder affecting children's health. (4) The outcomes for the effectiveness of dyslexia assessment have been limited to soft benefits or social practice aspects, with low impact or social relief in decreasing the economic burden on the whole society. The lower that the cultural level of the population is, the more adverse the impact will be on the whole social civilization as well as its reputation. Therefore it would need to adopt less expensive, more efficient, and more appropriate methods.

4.2 The Growing Trend in Children's Health Evaluations and Assessments

Medical assessments have greatly increased in incidence and have linked villages globally to the Internet. In Western countries, medicine has evolved from bloodletting originally being used to treat various diseases to a variety of advanced precision instruments, such as auxiliary diagnosis, along with the development of science and technology. In China, the treatment of diseases has also evolved from traditional herbs and seeing the face and hearing the voice, instead of the "Western medicine model", to digital outpatient prescriptions, electronic case reports, remote consultations, etc. Scientific research on children psycholinguistic evaluation is of the epitome of medical research with decades of history, but the cerebral mechanisms remaining a "mystery". For the segmentation of metaphysical assumptions, the testing of children for psycholinguistic ability has focused on phonological and orthographic processes, complying with the trends in the development of electronic auditory and visual information [22,23]. In terms of initial costs, digital network applications have relatively higher virtual input than the manual "face to face" methods. However,

the net version could undergo electronic process synchronization with the hospitals' modifications, while the traditional method would require certain input for the norm before the application, although it seemed to be quite visible. The cost of the time and materials for the traditional method was much higher according to the cumulative cases' geometry. Therefore the advantages of the electronic method were gradually revealed, and they comply with the big data in the children's behavioral and brain health research evaluations [12,13].

4.3 Utilitarianism among the Providers of Children's Healthcare Assessments

From the economic perspective of the heath provider, the benefits of children health assessment services should balance the cost to the network or hospitals. Healthcare providers usually choose both the number of patients and the time of care to serve their patients. When providers can adjust the number of patients, there is no incentive to perform too much treatment. In contrast, altruistic providers always provide additional time: they prefer to add an additional patient rather than increase the time of service provided although they have the opportunity to provide special instructions [24,25]. However, the network test was always the same. Additionally, the electronic version had significant superiority regarding cost minimization if there were similar fees collected, although parents pay more attention to the problems of their own children. The Bayes' discrimination showed that the sub-costs of the two methods of dyslexia assessment decreased according to the 80-20 rule of the Pareto principle, which states that, for many events, approximately 80% of the effects come from 20% of the causes [26,27]. The 'useful many' of electronic version seemed to be its soft benefit, and the cost might have accounted for 20%, while the 'vital few' of the traditional method showed that the cost, especially the time cost, might account for 80%.The social benefits are not believed to be similar, the electronic version will be disseminated more rapidly, the measurement will be more convenient, and there will be broader coverage by the network. The costs of evaluation for subsequent children would be less as well as for the family.

5. CONCLUSION

From the point of view of health economics and the soft benefit of administrating the test to children with dyslexia, the electronic evaluation method is better than the face to face operation toolkit because it costs less and is more convenient regarding time. It is expected that the test will be administered on the network in families, the data will be collected and analyzed with a big data and cloud model, and the disorder could be predicted earlier.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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