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Detecting limited health literacy in Brazil: development of a multidimensional screening tool

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SUMMARY

Screening questions have been proposed as practical tools for detecting limited functional health literacy, but have achieved only moderate accuracy in previous studies. We hypothesized that a combination of screening questions and demographic characteristics could better predict a patient's functional health literacy. Three hundred and twenty-two hospital users from São Paulo, Brazil, were interviewed for demographic information and answered questions about literacy habits and perceived difficulties. The Short Test of Functional Health Literacy in Adults was used to classify individuals as having adequate or limited functional health literacy. Of the 322 participants, 102 (31.7%) presented limited functional health literacy. The final logistic model included six predictors. The three demographic variables were educational attainment, mother's educational attainment and major lifetime occupation (manual or non-manual). The three questions concerned 'frequency of use of computers', 'difficulty with writing that have precluded the individual from getting a better job' and 'difficulty reading the subtitles while watching a foreign movie'. A simple score was derived to constitute a practical tool we named the Multidimensional Screener of Functional Health Literacy (MSFHL). The sensitivity of the MSFHL in detecting limited functional health literacy was 81.4% and the specificity was 87.7%, with an area under receiver operating characteristic (ROC) curve of 0.93 (95% CI 0.89–0.95). The MSFHL was better than educational attainment in accurately classifying functional health literacy status (p = 0.0018). We have developed a screening tool based on three demographic characteristics and three simple questions which provides an accurate prediction of a patient's functional health literacy level.

Key words: health literacy; validity; screening; questions

INTRODUCTION

Health literacy has been defined by the World Health Organization (WHO) as 'the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health' (Nutbeam, 1998). Health literacy means more than being able to understand medical prescriptions, calculating drug dosages and reading pamphlets. It is a multidimensional construct involving interactive and critical skills which are essential to empowerment (Nutbeam, 2000). Although there is no unanimously accepted definition of health literacy and attempts to operationalize the concept vary widely (Sørensen *et al.*, 2012), assessing health literacy is of increasing concern for researchers and clinicians because of accumulating evidence that this construct is associated with several undesirable outcomes.

Functional literacy is the ability to use reading, writing and numeracy skills at a level adequate to meet the needs of everyday life situations (Parker *et al.*, 1995). The terms 'inadequate functional health literacy' and 'limited functional health literacy' have been used to describe one's inability to function adequately in health-care settings, as determined by instruments which access basic literacy and numeracy skills needed to deal with health-related materials (Williams *et al.*, 1995). This somewhat narrow approach misses the richness of health literacy implied by the WHO definition, but warrants practical feasibility for studies investigating the association between health literacy and health outcomes.

Inadequate functional health literacy has been independently associated with poorer ability to take medications appropriately, lower utilization of preventive services, greater use of emergency care, more hospitalizations, poorer overall health status and higher mortality rates (Berkman *et al.*, 2011). Multiple interventions exist to mitigate the negative effects of inadequate functional health literacy (Sheridan *et al.*, 2011), but professionals often overestimate patients' abilities and fail to identify the problem (Kelly and Haidet, 2007). Rapid screening tests have been developed for the measurement of functional health literacy, but even those requiring just a few minutes to complete may be unrealistic for use during busy clinical encounters (Apolinario *et al.*, 2012).

Some researchers have proposed that patients with limited functional health literacy could be identified with a few screening questions such as 'How confident are you filling out forms by yourself?' or 'How often do you have someone help you read hospital materials?' (Chew *et al.*, 2004; Wallace *et al.*, 2006; Morris *et al.*, 2006). However, these questions performed only moderately well in identifying inadequate and marginal functional health literacy, as indicated by areas under receiver operating characteristic (ROC) curves ranging from 0.63 to 0.81 (Chew *et al.*, 2008; Sarkar *et al.*, 2011).

In a cross-sectional study conducted at a primary care office, a combination of demographic data and screening questions was evaluated for detecting limited functional health literacy (Jeppesen *et al.*, 2009). The regression model included five variables and showed excellent accuracy, with an area under the ROC curve of 0.92. Although that study did not develop a scoring system for practical use, the discriminative performance of the derived model indicates that combining demographic information and simple questions can be a promising strategy.

The purpose of the present study was to identify a combination of screening questions and risk factors that could predict a patient's functional health literacy status among heterogeneous adult populations. We specifically aimed to construct an easy-to-use multidimensional tool based on potentially important demographic characteristics, simple questions about literacy habits and ratings of perceived difficulties.

METHODS

Participants

This study was part of a larger research effort in Brazil to investigate health literacy and its implications for health-care settings. Survey methods have previously been described in detail (Carthery-Goulart *et al.*, 2009; Brucki *et al.*, 2011). Briefly, a convenience sample comprising 325 generally healthy individuals was recruited among users of government-financed hospitals in the city of São Paulo, southeastern Brazil. Most of the participants were patients visiting hospitals for scheduled tests or physician appointments. Data collection sites and recruitment approaches were planned to ensure a sample representative of the local population. To be eligible, participants had to be aged >18 years and be able to speak Portuguese. Individuals who reported being illiterate (i.e. unable to read at all) were excluded from the study, as testing functional health literacy in that circumstance would be otiose. Individuals were also excluded if they had any diagnosis of neurological or psychiatric disorder, were taking medications that could adversely affect cognitive functioning, had corrected binocular visual acuity worse than 20/40 as assessed by a pocket screening card or had hearing problems that precluded adequate interaction with the interviewers.

Because functional health literacy skills are highly dependent on cognitive functions and milder forms of cognitive impairment are commonly undiagnosed (Jacinto *et al.*, 2011), all potential participants were administered the Mini-Mental State Examination (Folstein *et al*., 1975), a widely used screening tool for assessing global cognitive functions. Patients with scores below the education-adjusted cutoff for dementia (Brucki *et al*., 2003) were excluded from the study. The study was approved by the local ethics committee. All participants were informed about the procedures and gave written consent prior to the interviews.

Potential predictors

All participants were interviewed for demographic information, including age, gender, education (highest grade completed), race (white or non-white) and lifetime occupation (predominantly manual or non-manual). Information about family background and childhood environment was collected, including mother's and father's educational level, mother's and father's occupation, residence area when the participant was aged 12 years (urban or rural), and history of failing grades in elementary school. Table 1 shows the characteristics of the sample.

Next we applied a questionnaire to investigate literacy habits and perceived difficulties. The items were developed to capture different aspects of literacy skills applied to everyday situations. Because individuals are likely to underreport limited literacy when asked in a general sense, we inquired about their ability to meet social and occupational demands in specific activities that involve reading, writing, numeracy and use of technology. We developed 12 questions and revised them to increase clarity (Table 2). For items involving habits, participants were asked to rate how often they typically engaged in each activity. Items investigating perceived difficulties and self-efficacy were coded dichotomically. The interviewers read aloud the questions and responses choices.

Standard functional health literacy measure

Functional health literacy skills were directly assessed with the Brazilian version of the Short Test of Functional Health Literacy in Adults (S-TOFHLA), a measure of patients' ability to read and understand materials they commonly encounter in health-care settings (Baker *et al*.,

Table 1: Sociodemographic characteristics and risk of limited functional health literacy ($n = 322$)

Characteristics	Categories	*N* (%)	OR (95% CI)	
			Crude	Corrected for education
Educational attainment	≥12 years	120 (37.3)	1	NA
	8–11 years	92 (28.6)	24.51 (5.65–106)	NA
	4–7 years	68 (21.1)	62.58 (14.30–273)	NA
	0–3 years	42 (13.0)	560.50 (98.74–3182)	NA
Age	<65 years	261 (81.1)	1	1
	≥65 years	61 (18.9)	2.77 (1.56–4.90)	1.62 (0.77–3.43)
Gender	Female	204 (63.4)	1	1
	Male	118 (36.6)	0.98 (0.60–1.59)	0.93 (0.49–1.77)
Race	White	228 (70.8)	1	1
	Non-white	94 (29.2)	2.26 (1.37–3.74)	1.41 (0.74–2.69)
Occupation	Non-manual worker	162 (50.3)	1	1
	Manual worker	160 (49.7)	10.60 (5.81–19.37)	3.54 (1.74–7.19)
Residence area at age 12	Urban	234 (72.7)	1	1
	Rural	88 (27.3)	6.15 (3.61–10.49)	1.63 (0.84–3.17)
Grade failure in elementary school	No failure	235 (73.0)	1	1
	One or more failures	87 (27.0)	2.22 (1.33–3.70)	2.07 (1.07–3.99)
Mother's educational attainment	≥4 years	137 (42.5)	1	1
	0–3 years	185 (57.5)	16.66 (7.71–35.98)	4.32 (1.78–10.49)
Father's educational attainment	≥4 years	166 (51.6)	1	1
	0–3 years	156 (48.4)	8.58 (4.76–15.45)	2.43 (1.18–4.99)
Mother's occupation	Non-manual worker	63 (19.6)	1	1
	Manual worker	259 (80.4)	8.98 (3.16–25.49)	3.49 (1.02–11.93)
Father's occupation	Non-manual worker	133 (41.3)	1	1
	Manual worker	189 (58.7)	6.11 (3.37–11.08)	1.99 (0.94–4.20)

Table 2: Habits, perceived difficulties and risk of limited functional health literacy ($n = 322$)

Questions	Response options	*N* (%)	OR (95% CI)	
			Crude	Corrected for education
How often do you use a computer?	Sometimes/frequently	166 (51.6)	1	1
	Never/rarely	156 (48.4)	17.5 (9.0–34.1)	4.29 (1.97–9.37)
How often do you use a cell phone?	Frequently	196 (60.9)	1	1
	Never/rarely/sometimes	126 (39.1)	4.3 (2.6–7.1)	1.42 (0.75–2.71)
How often do you read texts in your routine activities?	Daily	208 (64.6)	1	1
	Less than once a day	114 (35.4)	3.9 (2.4–6.3)	1.03 (0.54–1.99)
How often do you handle numbers in your routine activities?	At least once a week	179 (55.6)	1	1
	Less than once a week	143 (44.4)	6.2 (3.7–10.5)	1.84 (0.95–3.57)
How often do you interpret graphs in your routine activities?	At least once a month	148 (46.0)	1	1
	Less than once a month	174 (54.0)	7.4 (4.1–13.2)	1.53 (0.72–3.24)
Do you have difficulties with writing that have precluded you from getting a better job?	No	245 (76.1)	1	1
	Yes	77 (23.9)	15.4 (8.3–28.7)	5.33 (2.60–10.91)
Do you have difficulties with calculation that have precluded you from getting a better job?	No	255 (79.2)	1	1
	Yes	67 (20.8)	12.8 (6.7–24.2)	4.32 (2.07–9.04)
Do you have difficulties with reading that have precluded you from getting a better job?	No	235 (73.0)	1	1
	Yes	87 (27.0)	8.7 (5.0–15.1)	3.17 (1.62–6.18)
How often did you have reading materials available in the childhood years?	Frequently or daily	162 (50.3)	1	1
	Never or sometimes	160 (49.7)	5.5 (3.2–9.3)	1.07 (0.52–2.17)
How often do you visit libraries?	Frequently or daily	109 (33.9)	1	1
	Never or sometimes	213 (66.1)	22.4 (7.9–62.9)	4.94 (1.60–15.25)
Are you able to watch foreign movies with subtitles?	Yes, without any difficulty	222 (68.9)	1	1
	With difficulty or not at all	100 (31.1)	10.8 (6.2–18.8)	3.56 (1.84–6.89)
How often do you read during you leisure time?	At least once a week	214 (66.5)	1	1
	Less than once a week	108 (33.5)	2.1 (1.28–3.4)	0.91 (0.48–1.74)

1999; Carthery-Goulart *et al.*, 2009). The reading section comprises two health-related texts and employs a modified Cloze technique (Taylor, 1953), where selected words are replaced with blank spaces. For each blank space, respondents are required to select, from a list of four options, the word that best fit into the sentence. The numeracy section comprises labeled medicine bottles and cue cards containing information about medicine intake time, date of appointments and results of a laboratory test. For the numeracy items, participants are handed the corresponding materials and subsequently asked oral questions about the information.

The S-TOFHLA total score ranges from 0 to 100 points. Using established cutoff scores, individuals were categorized into three groups. Those scoring between 0 and 53 have difficulty reading the simplest materials, including prescriptions and appointment slips (inadequate functional health literacy). Individuals scoring 54–66 perform the simplest tasks, but have trouble comprehending more complex materials such as educational brochures (marginal functional health literacy). Individuals who score 67–100 are able to complete most tasks required to function in health-care settings (adequate functional health literacy).

Statistical analyses

For dichotomically categorizing functional health literacy, inadequate and marginal levels of the S-TOFHLA were combined into one category designated ‘limited functional health literacy’, defined by a score <67 on the S-TOFHLA. We took years of formal education as an *a priori* independent variable for constructing the model because it is widely available and presents a strong relationship with functional health literacy skills (Barber *et al.*, 2009). After inspecting the association between formal education and functional health literacy, we detected an approximately linear association and observed no threshold effects between 0 and 12 years. Therefore, education was categorized into 4-year clusters: 0–3 years; 4–7 years; 8–11 years; ≥12 years. All other data were transformed into dichotomous variables to enhance the simplicity of the final tool. To recode responses given to Likert-type questions into two categories, we constructed an ROC curve for each question and chose the cutoff presenting the highest Youden index (sensitivity + specificity − 1) (Youden, 1950).

We explored relationships of the variables with functional health literacy in bivariate analysis by calculating odds ratios (ORs) along with 95% confidence intervals (CIs). Variables that maintained predictive power after adjustment for education were selected to be subsequently considered in a logistic regression model. Because the number of variables under consideration was large, the regression model was conducted with forward selection, a rather conservative procedure which tends to admit a smaller set of explanatory variables when compared with backwards elimination. To protect the derivation model from overfitting and to validate the choice of variables, we used a bootstrap resampling procedure to assess the stability of the predictors. We generated 1000 bootstrap samples using the forward stepwise logistic regression. Factors retained in the model were those returning regression coefficients significant in at least 50% of the bootstrap samples. We used the Hosmer–Lemeshow goodness-of-fit test to evaluate overall model quality.

Subsequently, we developed a point-based scoring system from the final multi-variable logistic regression model. The number of points was assigned to each predictor by rounding each β-coefficient to the nearest integer. We summed individual component scores to create an index score. Taking the S-TOFHLA as a reference, we used the Spearman rank coefficient to investigate if the score of the newly developed tool presented a good correlation with a patient's functional health literacy level. We calculated areas under ROC curves (AUCs) to analyze the discriminative power of the tool and to compare it with educational attainment alone. We used DeLong's method to compare AUCs from different measures (DeLong *et al.*, 1988). Alternatively, we analyzed the proportion of the participants correctly classified according to each criterion and conducted comparisons using the McNemar test. We calculated sensitivity, specificity, predictive values and likelihood ratios for each cutoff point. A significance level of $p < 0.05$ was used to determine statistical significance. We used MedCalc for Windows version 12.3 (MedCalc Software, Mariakerke, Belgium) for ROC curve analyses and Stata 12.1 (College Station, TX, USA) for all other analyses.

RESULTS

Among the 325 participants recruited, 3 had incomplete data and were therefore excluded from analysis. Thus, the analyzed sample consisted of 322 generally healthy adults. The mean age (SD) was 47.2 (16.8) years and participants aged ≥65 years represented 18.9% of the sample. Mean educational attainment was 9.6 (5.2) years, with 47.5% of the individuals having less than a high-school diploma. The proportion of women was 63.4% and white participants represented 70.8% of the total sample. Prevalence rates of inadequate and marginal functional health literacy as measured by the S-TOFHLA were 23.0 and 8.7%, respectively, constituting a total of 102 (31.7%) participants with limited functional health literacy.

Of the 23 candidate predictors surveyed, 12 (6 demographic characteristics and 6 questions) maintained predictive power after adjustment for education and thus met the selection criteria to be subsequently considered in the regression model. Six independent variables (three demographic characteristics and three questions) remained in the final model as shown in Table 3. The three demographic variables included were educational attainment, mother's educational attainment and major lifetime occupation (manual or non-manual). The three questions included concerned 'frequency of use of computers', 'difficulty with writing that have precluded the individual from getting a better job' and 'difficulty reading the subtitles while watching a foreign movie'. All of the six variables selected presented regression coefficients significant in at least 50% of the bootstrap samples, varying from 57.9% for 'trouble reading subtitles' to 98.4% for educational attainment. The Hosmer–Lemeshow test yielded a $\chi^2 = 6.5044$ and p-value of 0.4822, indicating an appropriate model fit to the data. Table 3 presents detailed information on the final logistic regression model.

We combined the significantly associated factors from the logistic model to form an easy-to-

Table 3: Final logistic regression model for predicting limited functional health literacy ($n = 322$)

Factors	OR (95% CI)	Coefficient (SE)	*p*-value	Bootstrapping selection (%)
Educational attainment (four levels)	2.22 (1.42–3.49)	0.80 (0.23)	0.0005	98.4
Mother's educational attainment (four levels)	3.80 (1.57–9.21)	1.33 (0.45)	0.0032	90.7
Lifetime occupation categorized as manual or non-manual	2.81 (1.27–6.25)	1.03 (0.41)	0.0111	75.0
Frequency of use of personal computer	2.51 (1.04–6.04)	0.92 (0.45)	0.0397	61.2
Difficulty with writing that have precluded the individual from getting a better job	3.45 (1.59–7.48)	1.24 (0.39)	0.0017	89.5
Difficulty reading the subtitles while watching a foreign movie	2.23 (1.06–4.69)	0.80 (0.38)	0.0354	57.9

Variables are listed in the order of introduction into the model during the step-forward process. Odds ratios and coefficients reported are per unit increase. Bootstrapping selection is the proportion of times in 1000 replications a variable was retained in the final forward stepwise model at a level of $\alpha = 0.05$.

use tool we named the Multidimensional Screener of Functional Health Literacy (MSFHL). We derived a simple score ranging from 0 (lowest literacy level) to 10 (highest literacy level). Table 4 shows scoring criteria. The MSFHL-derived scores were highly correlated with those obtained on the S-TOFHLA, as indicated by a Spearman correlation coefficient of 0.81 ($p < 0.0001$). The AUC for the detection of limited functional health literacy was 0.93 (95% CI 0.89–0.95) for the MSFHL and 0.89 (95% CI 0.85–0.92) for reported educational attainment. On direct comparison, the newly developed screening tool was better than educational attainment alone in accurately classifying functional health literacy status, as indicated by a significantly greater AUC ($p = 0.0018$). The proportion of participants correctly classified was also significantly greater for the MSFHL compared with education (85.7 vs. 78.6%; $p = 0.0017$). Figure 1 presents the ROC plots for both measures. We also carried out a ROC analysis to detect inadequate functional health literacy, a more restrictive criterion indicated by a score <54 on the S-TOFHLA. In this case, the AUC was 0.93 (95% CI 0.90–0.96) for the MSFHL and 0.91 (95% CI 0.87–0.94) for educational attainment. There was no significant difference between the AUCs ($p = 0.0964$), although a greater proportion of participants were classified correctly by the MSFHL (83.5 vs. 76.4%; $p = 0.0017$).

For detecting limited functional health literacy with the MSFHL, the Youden index was highest (0.69) at a cutoff ≤3. At this point sensitivity was 81.4% and specificity was 87.7%. The Youden index was fairly similar for cutoffs ≤4 and ≤5 (0.67 and 0.66, respectively). These higher cutoffs are good alternatives for screening

Table 4: MSFHL scoring criteria

Educational attainment[a]	Score
0–3 years	0
4–7 years	1
8–11 years	2
≥12 years	3
Mother's educational attainment[b]	
0–3 years	0
4–7 years	1
8–11 years	2
≥12 years	3
Lifetime occupation[c]	
Predominantly manual	0
Predominantly non-manual	1
Use of technology[d]	
Do not use computers or do it only occasionally	0
Use computers at least once a week	1
Writing	
Difficulty with writing that have precluded the individual from getting a better job	0
No significant difficulty	1
Reading[e]	
Difficulty reading the subtitles while watching a foreign movie	0
No significant difficulty	1
Interpretation	Total (0–10): _______
0–3: Inadequate functional health literacy	
4–5: Marginal functional health literacy	
≥6: Adequate functional health literacy	

[a]Highest grade completed (in years).
[b]Individuals who are unable to give an exact answer should be asked to make an estimation.
[c]Manual occupations are defined as those that do not require intensive training or supervisory elements (e.g. farming, mining, construction, manufacturing, mechanical maintenance, garden maintenance, housekeeping and cleaning). Individuals who never had a paid job score zero in this item.
[d]Desktops, laptops, and tablets should be considered computers.
[e]Individuals who allege they simply 'do not watch movies with subtitles' score zero in this item.

strategies that favor a greater sensitivity at the expense of specificity. Therefore, we suggest that the MSFHL scores can be interpreted according to the following practical rule: 0–3, inadequate functional health literacy; 4–5, marginal functional health literacy; 6–10, adequate functional health literacy. Table 5 shows performance parameters for the MSFHL in detecting limited functional health literacy.

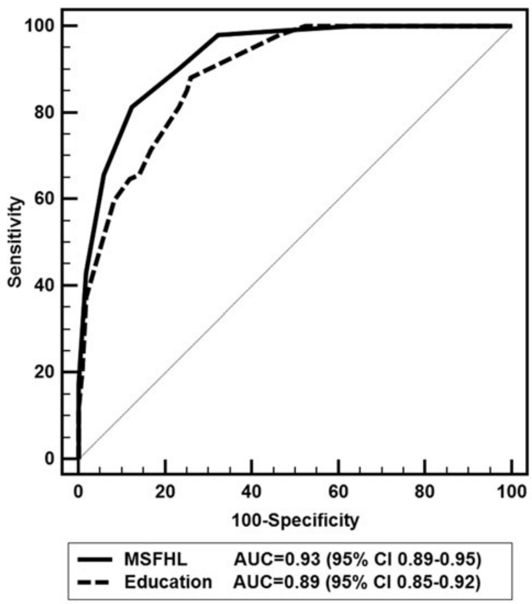

Fig. 1: Receiver operating characteristic (ROC) plots for the MSFHL and education in detecting limited functional health literacy.

DISCUSSION

In this study, we developed and evaluated the properties of the MSFHL, a tool designed to screen for limited functional health literacy. The resulting instrument is based on three demographic characteristics and three questions that investigate habits and perceived difficulties. Derived scores of the MSFHL presented excellent accuracy and were shown to be highly correlated with S-TOFHLA scores.

To be useful, a screening tool should have discriminative power superior to that achieved by readily available demographic data such as educational attainment. Unfortunately, only a few studies proposing screening strategies have compared their accuracy with that provided by educational attainment alone. Ohl *et al.* (Ohl *et al.*, 2010) have reported that educational attainment was a more accurate discriminator of functional health literacy than the frequently used question 'How confident are you filling out medical forms by yourself?'. To our knowledge, the MSFHL is the first questionnaire-based screening tool proved to have better accuracy than self-reported educational attainment. We believe that future studies should not claim usefulness of a screening instrument without properly comparing it with the more simple and available information provided by educational attainment.

All variables selected on the final regression model present a sound conceptual basis. Education and occupation have been recognized to be strongly associated with health literacy levels in other studies (Gazmararian *et al.*, 1999; Hanchate *et al.*, 2008). To our knowledge, the present study was

Table 5: Performance of the MSFHL for detecting limited functional health literacy according to each cutoff point

Cutoff	Youden index	Sensitivity (95% CI)	Specificity (95% CI)	+LR (95% CI)	−LR (95% CI)	+PV (95% CI)	−PV (95% CI)
<1	0.18	17.7 (10.8–26.4)	100 (98.3–100)	–	0.8 (0.8–0.9)	100.0 (81.5–100)	72.4 (67.0–77.3)
≤1	0.41	43.1 (33.4–53.3)	98.2 (95.4–99.5)	23.7 (8.8–64.3)	0.6 (0.5–0.7)	91.7 (80.0–97.7)	78.8 (73.5–83.5)
≤2	0.60	65.7 (55.6–74.8)	94.1 (90.1–96.8)	11.1 (6.4–19.2)	0.4 (0.3–0.5)	83.7 (73.7–91.1)	85.5 (80.5–89.7)
≤3	0.69	81.4 (72.4–88.4)	87.7 (82.6–91.8)	6.6 (4.6–9.6)	0.2 (0.1–0.3)	75.5 (66.3–83.2)	91.0 (86.4–94.5)
≤4	0.67	90.2 (82.7–95.2)	76.8 (70.7–82.2)	3.9 (3.0–5.0)	0.1 (0.1–0.2)	64.3 (55.9–72.2)	94.4 (90.0–97.3)
≤5	0.66	98.0 (93.1–99.8)	67.7 (61.1–73.9)	3.0 (2.5–3.7)	0 (0–0.1)	58.5 (50.7–66.0)	98.7 (95.3–99.8)
≤6	0.52	99.0 (94.7–100)	52.7 (45.9–59.5)	2.1 (1.8–2.4)	0 (0–0.1)	49.3 (42.2–56.3)	99.1 (95.3–100)
≤7	0.37	100 (96.4–100)	36.8 (30.4–43.6)	1.6 (1.4–1.8)	0	42.3 (36.0–48.8)	100 (95.5–100)
≤8	0.11	100 (96.4–100)	11.4 (7.5–16.3)	1.1 (1.1–1.2)	0	34.3 (29.0–40.0)	100 (85.8–100)
≤9	0.06	100 (96.4–100)	5.5 (2.8–9.3)	1.1 (1.0–1.1)	0	32.9 (27.7–38.4)	100 (73.5–100)

+LR, positive likelihood ratio; −LR, negative likelihood ratio; +PV, positive predictive value; −PV, negative predictive value.

the first to test mother's education as a potential predictor of adulthood health literacy. Mother's education represents a basic component of the childhood cultural and social environment with a lasting impact in adulthood (Schoon *et al.*, 2010). The role of this factor, however, may have been overlooked in previous studies. The three screening questions selected in the final model investigate activities involving reading, writing and use of technology. They represent functional aspects of health literacy and provide pieces of information that are complementary to the demographic characteristics. The association between the answers for each of these questions and functional health literacy was not mediated by age, gender or race, as indicated by a set of interaction analyses (data not shown). None of the numeracy questions remained in the final model. It is not clear if the questions did not represent the construct properly or if numeric manipulation abilities are somehow integrated in the other selected variables.

Because individuals with similar educational levels can differ substantially in their skills, the use of educational attainment as a proxy measure of functional health literacy have been criticized (Berkman *et al.*, 2010). However, in our study, educational attainment was the variable more strongly associated with functional health literacy levels, indicating that, while it is limited as an isolated measure, it should not be left out of multidimensional tools designed to predict functional health literacy. Educational attainment as an ordinal variable appears to be a useful discriminator especially at the ends of the spectrum. The prevalence of limited functional health literacy was 90.5% for individuals with <4 years of formal education, but only 1.7% for participants with more than 11 years. It can thus be a practical option to assume that individuals with <4 years of formal schooling have limited functional health literacy and that those with more than 11 years have adequate functional health literacy. If we had adopted such a strategy in this sample we would have avoided the use of the MSFHL in 162 (50.3%) participants while maintaining exactly the same proportion of correct classifications. Accordingly, the MSFHL appears to be especially useful for screening individuals with educational attainment between 4 and 11 years.

In developed countries, several studies with representative samples of the general adult population have used the TOFHLA or the S-TOFHLA. In these studies, the prevalence of limited functional health literacy has varied from 6.8% in Australia (Barber *et al.*, 2009) to 19.7% in Switzerland (Connor *et al.*, 2013). Data about the prevalence of limited functional health literacy in developing countries are scarce. In our study, the proportion of participants with limited functional health literacy was 31.7%. This higher prevalence is expected in developing countries such as Brazil, since health literacy levels are strongly associated with socioeconomic factors (Martin *et al.*, 2009). However, comparisons between countries should be made carefully, because versions of functional health literacy instruments in different languages cannot be assumed to provide precisely equivalent scores.

Some strengths of the present study are noteworthy. We have defined limited functional health literacy using the S-TOFHLA, a reliable and well-accepted reference standard. Many potential predictors were available in the initial stages of model building, comprising diverse sources of information and representing all the major dimensions deemed to compose the construct. The questions were developed to represent ubiquitous activities that involve literacy skills, avoiding situations that would be specific to particular regions or subgroups of the population. Education was coded in years so that it could be rated without the necessity of making reference to the educational system of any particular country. Therefore, we believe our instrument to possess good cross-cultural properties.

Some limitations should also be noted. First, although we have studied a sample with a heterogeneous structure and presenting characteristics compatible with census data for the Brazilian population, recruitment was made by convenience. This raises the possibility of selection bias and limits the generalizability of the study's findings. Secondly, the proposed screening questions are not particular to situations encountered in health-care settings. Health literacy has been suggested to not be independent of general literacy skills at the population or subpopulation levels (Rudd, 2007). Nonetheless, the advantages and drawbacks of investigating skills specific to health care are largely unknown and should be evaluated in future studies. Thirdly, we did not include individuals who reported being unable to read at all because functional health literacy was measured with the S-TOFHLA, which is based on the assessment of reading skills. The MSFHL could be administered to illiterate individuals, but its usefulness in those individuals is questionable and should be evaluated in future studies. Finally, we have used a stepwise procedure to identify the best subset of predictors and derive a parsimonious model. Stepwise models are useful for that purpose, but can yield biased coefficient estimates and overfit the data (Steyerberg *et al.*, 1999). Although bootstrap resampling showed stability of the selected variables, we were unable to cross-validate our findings because of the relatively small sample size. This study has an exploratory nature—further investigations to validate our findings in other populations and settings are needed.

In conclusion, the methods employed in this study seem to have successfully derived a simple tool that can be scored in a few seconds and provides an accurate prediction of a patient's functional health literacy level. Because it does not test reading abilities directly the MSFHL is unlikely to cause shame or anxiety. The characteristics of the MSFHL favor its use in busy clinical settings and epidemiologic studies involving populations with low socioeconomic conditions.

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CONFLICT OF INTEREST

The authors declare that they do not have a conflict of interest.

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