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ASSESSING MOTOR NEUROLOGICAL SOFT SIGNS IN SCHIZOPHRENIA: CONFIRMATORY FACTOR ANALYSIS OF PORTUGUESE VERSION OF BMS-P

AVALIAÇÃO DOS SINAIS NEUROLÓGICOS MOTORES DISCRETOS: ANÁLISE CONFIRMATÓRIA DA VERSÃO PORTUGUESA DA BRIEF OF MOTOR SCALE (BMS-P)

EVALUACIÓN DE SIGNOS NEUROLÓGICOS MOTORES BLANDOS EN LA ESQUIZOFRENIA: ANÁLISIS FACTORIAL CONFIRMATORIO DE LA VERSIÓN PORTUGUESA DEL BMS-P

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ABSTRACT
Motor Neurological Soft Signs (MNSS) has been increasingly studied in people with schizophrenia spectrum, contributing to the knowledge of psychomotor disorders. However, there is still scarce the availability of valid and reliable instruments for this assessment worldwide, and in Portugal there is none. Objective: The aim of this study was to analyze the factor structure model of the Portuguese version of the Brief Motor Scale. Method: The confirmatory factor analysis was conducted in a sample of 103 participants with schizophrenia, 82 males and 21 females, mean age 44.21 (+11.25). A one-factor model was compared with three two-factor models based on the literature and a previous exploratory factor analysis. Results: The results of this study showed good fit indices and provide evidence to support a two-factor model for the assessment of motor neurological soft signs in persons with schizophrenia. Conclusions: It was proposed a new construct for MNSS assessment consists of 2 domains and 9 items distributed among them.

KEYWORDS: Confirmatory Factor Analysis (CFA). Schizophrenia. Motor Neurological Soft Signs. Psychomotor Skills. Portuguese version of Brief Motor Scale (BMS-P).

RESUMO
Os Sinais Neurológicos Motores Discretos (SNMD) têm sido cada vez mais estudados em pessoas com espectro da esquizofrenia, contribuindo assim para o conhecimento das perturbações psicomotoras. No entanto, ainda é escassa a disponibilidade de instrumentos válidos e fidedignos para esta avaliação a nível mundial, e inexistente em Portugal. Objetivo: O objetivo deste estudo é analisar o modelo de estrutura fatorial da versão em português da *Brief of Motor Scale*. Método: A análise fatorial confirmatória foi realizada numa amostra de 103 participantes com esquizofrenia, 82 do sexo masculino e 21 do sexo feminino, com idade média de 44.21 (±11.25). Um modelo de apenas um fator foi comparado com três modelos de dois fatores baseados na literatura e numa análise fatorial exploratória prévia. Resultados: Os resultados deste estudo mostraram bons índices de ajustamento, destacando evidências que apoiam um modelo de dois fatores para a avaliação SNMD em pessoas com esquizofrenia. Conclusões: Foi proposto um novo construto para avaliação dos SNMD composto por 2 domínios e 9 itens distribuídos entre eles.

PALAVRAS-CHAVE: Análise Fatorial Confirmatória (AFC). Esquizofrenia. Sinais Neurológicos Motores Discretos. Habilidades Psicomotoras. Versão Portuguesa da *Brief of Motor Scale* (BMS-P).

RESUMEN
Los Signos Neurológicos Motores Blandos (SNMB)) han sido cada vez más estudiados en personas con esquizofrenia, contribuyendo así al conocimiento de los trastornos psicomotores. Sin embargo, la disponibilidad de instrumentos válidos y fiables para esta evaluación es todavía escasa en todo el mundo, e inexistente en Portugal. Objetivo: El objetivo de este estudio fue analizar el modelo de estructura factorial de la versión portuguesa de la Escala Motora Breve. Método: Se realizó un análisis

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factorial confirmatoria en una muestra de 103 participantes con esquizofrenia, 82 hombres y 21 mujeres, con una edad media de 44,21 (+11,25). Se comparó un modelo de un factor, con tres modelos de dos factores basados en la literatura y en un análisis factorial exploratoria previa. Resultados: Los resultados de este estudio mostraron buenos índices de ajuste, destacando la evidencia para apoyar un modelo de dos factores para la evaluación del SNMB en personas con esquizofrenia. Conclusiones: Se propuso un nuevo constructo para la evaluación del SNMB compuesto por 2 dominios y 9 ítems distribuidos entre ellos.

PALABRAS CLAVE: Análisis Factorial Confirmatoria (AFC). Esquizofrenia. Signos Neurológicos Motores Blandos (SNMB). Habilidades Psicomotoras. Versión portuguesa de la Escala Motora Breve (BMS-P).

INTRODUCTION

Motor Neurological Soft Signs (MNSS) are the motor components of Neurological Soft Signs (NSS) and they have been increasingly studied in persons with Schizophrenia Spectrum, contributing to the knowledge of the psychomotor disorders (Afonso *et al.,* 2021; Guimarães *et al.,* 2017, 2018, 2020; Janssens *et al.,* 2017; Zakaria *et al.,* 2013) that seems to precede and predict the onset of the disorder. MNSS have been described as having two components: motor coordination and motor sequentialization, indicators of neurological abnormalities in persons with schizophrenia (Bachmann *et al.,* 2014). These both domains are considered valid indicators of neurological deficits (Jahn et al., 2006a, b, Zakaria *et al.,* 2013), referring the existence of minor brain lesions, namely in the prefrontal areas of the cortex (Bombin *et al.,* 2005; Gil, 2014;) and sensory-motor areas (Chan *et al.,* 2006). Chan *et al.* (2006) found that sensorimotor cortex, thalamus, and right-side cerebellum have more activity in more complex motor tasks. Neuroimaging studies suggest that the frontal lobe is associated with motor coordination tasks, and the prefrontal lobe with motor sequencing tasks (Bombin *et al,* 2005). The screening of MNSS may be useful in psychomotor planning, monitoring effects and tracking outcomes.

Historically MNSS have been studied within the larger evaluation of neurological soft signs (NSS) corresponding only to a one or two factors in those scales. All the NSS include motor tasks to measure the MNSS and distribute them in a nonconsensual way in several domains. Various motor tasks are assessed, but the motor domain allocated to the tasks is frequently different (Table 1).

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Table 1. BMS-PT motor tasks and their distribution by domains in the Neurological Soft Signs scales (authors' summary)

BMS motor tasks	BMS Domain	NES	Heidelberg NSS	CNI	SEA	EPSiD
Diadochokinesia	MOCO	MOCO	MOCO		MOCO	MOIN
Oseretzky	MOCO	MOSE	MOCO	MOCO		
Foot tapping	MOCO				MOCO	MOIN
Bilateral rhythm tapping	MOCO					
Gaze impersistent	MOCO	other				
Pronation-supination	MOSE		MOCO	MOCO		MOIN
Finger-thumb-opposition	MOSE	MOCO	MOCO	MOCO	MOCO	MOIN
Fist-ring	MOSE	MOSE				
Fist-edge-palm	MOSE	MOSE	MOSE	MOCO	MOCO	MOIN
Rhythm production	MOSE	MOSE				
MOCO = motor coordination; MOSE = motor sequencialization; MOIN = motor integration (MOCO+MOSE)						

In the *Neurological Evaluation Scale – NES* (Buchanan; Heinrichs, 1989) only Pearson's correlation was performed and findings pointed out that all domains were related to the total and none were correlated with each other. The *Heidelberg NSS Scale* (Schröder *et al.,* 1992) revealed a Cronbach's alpha of .85, interrater reliability of .88 (p<.005) and a six-factor principal component factor analysis (rotated by VARIMAX), that explained 63% of the total variance (Schröder *et al.,* 1992). *The* reliability and validity of the *Cambridge Neurological Inventory – CNI* (Chen *et al.,* 1995) were addressed by interrater reliability with Kendall's w between .82 and 1.00 (p<.05) and Pearson's correlation between groups with significant correlation between almost groups (Chen *et al.,* 1995). The *Standardized Examination Assessing Neurological Soft Signs - SEA* (Krebs et al., 2000) demonstrated a Croanbach's Alpha of .85, and a five-factors principal component factor analysis (rotated by VARIMAX) which explained 55.15% of total variance (Krebs *et al.,* 2000). The most recent scale - *Evaluation Psychomotrice des Signes Doux – EPSiD* (Marionneau; Servant; Albaret, 2016) do not present any statistical data.

Despite of the importance of MNSS, that tend to reflect a vulnerability for schizophrenia, all the above scales are besides not focused exclusively on motor skills – making use of a more broader assessment methodology, are extensive tests, that presents methodological limitations offering item-clusters/subscales not confirmed, since they are mainly based on correlation measures and Cronbach's alpha. Only two of them used Principal Component Analysis Factory for an exploratory analysis. The hierarchical structure of such scales was not analyzed yet. Having a robust and sound psychometric instrument is therefore emergent.

In 2006, Jahn *et al.* (2006a) developed a specific instrument for assessing exclusively the motor neurological soft signs – the Brief Motor Scale (BMS). Originally, this instrument result from previous longer versions of soft neurological signs assessment, but restricting to specific items, making this a quick and easy evaluation. BMS proposed 10 motor tasks (items) distribute by two motor domains (Guimarães *et al.,* 2018; Jahn *et al.,* 2006a): motor coordination (Diadochokinesia, Oseretzky, foot taping, bilateral rhythm tapping, gaze impersistent) and motor sequentialization (pronation-supination, finger-thumb-opposition, fist-ring, fist-edge-palm, rhythm production). Motor coordination assessment requires motor planning and generalization, which allows the person to choose the best position and speed for the movement (Fonseca, 2010). In motor sequencing, movements evaluated are those require planning and praxis learning (Guimarães *et al.,* 2018; Jahn *et al.,* 2006a,b; Zakaria *et al.,* 2013). In the original BMS, Cronbach's alpha was .77, Cohen's kappa for interrater reliability was greater than .70, and the two subscales were confirmed by principal component analysis and explain 53.1% of the total variance (Jahn *et al.,* 2006a).

Validation of assessment instruments using statistical measures that are considered robust from an international scientific perspective is essential and crucial to its use for correct, valid, and scientifically based therapeutic purposes. In Portugal, the BMS-P was translated, adapted, and validated to Portuguese persons with schizophrenia, with content validity values >.75, reliability between .82 and .87, and *Pearson* correlations between scale items between .93 and .99, for p<.01 (Guimarães *et al.* 2017, 2020), indicating that can be a reliable instrument to be used. However, a precise validation of the instrument and its theoretical construct is required.

Therefore, the aim of this study was to analyze the factor structure model of the Portuguese version of the Brief Motor, obtained through CFA. The BMS-P assumed the same model and organization (items and subscales) than the original version (Guimarães *et al,* 2017, 2020). Based on previous EFA which pointed out two principal components that explain 58.91% of the scale variance, a model with two principal components but with different observed variables for each factor was hypothesized (Guimarães *et al.,* 2020). This study aims to contribute, nationally and internationally, to the theoretical aspects of the assessment of MNSS in people with schizophrenia, and to bring evidence in the areas of psychomotricity that will contribute to a better and more effective psychomotor assessment and, consequently, to the validation of psychomotor intervention programs.

MATERIALS AND METHODS

1. PARTICIPANTS

A convenience sample included 103 participants with a psychiatric diagnosis of schizophrenia according to the DSM 5 (APA, 2013), 82 males and 21 females, aged between 19 and 69 years (44.21±11.25). More than half of participants studied at least 9 years (n=63; 61.2%), 26 (25.2%) studied between 9 and 12 years and 14 (13.6%) had a university degree, and only 29.13% had a professional or academic activity. All participants had a diagnosis of schizophrenia from at least one year ago, being medicated with atypical antipsychotics (53), typical and atypical antipsychotics (35), or receiving monthly electroconvulsive therapy treatment (3). At overage, the participants had 2.75 (±1.89) hospitalizations, and the mean age of onset was 20.21 (±5.78).

Participants were recruited from rehabilitation community centers, according to the following inclusion criteria: adults (over 18 years) with a diagnosis of schizophrenia. 62 (60.19%) of the participants frequented a socio-occupational structure, 5 (4.85%) a residential structure, and 27 (26.21%) of the participants attended both types of structures (socio-occupational and residential). Only 9 (8.74%) had occasional support in this type of community structure. All of participants were under medical care from a psychiatrist. The exclusion criteria were the presence of a condition of substance abuse or any motor impairment.

2. BMS-P (PORTUGUESE VERSION OF BMS)

The Portuguese version of Brief Motor Scale (BMS-P) is the translated version of an instrument developed originally in Germany, which evaluates exclusively the MNSS of adults with schizophrenia spectrum disorders, in two dimensions: motor coordination (MOCO) and motor sequencing (MOSE) (Guimarães *et al.,* 2018; Jahn *et al,* 2006a; Jahn *et al,* 2006b). Both versions, the original and the Portuguese, have been demonstrated to be a reliable instrument with identical psychometrics characteristics to other extensive versions (Guimarães *et al.,* 2020; Jahn *et al,* 2006a; Jahn *et al,* 2006b, Zakaria *et al,* 2013). Each subscale consists of five items, with a maximal summary score for each subscale of 10 points (Guimarães *et al.,* 2020). Each item is classified according to the quality of performance: 0 = no disturbance or difficulty in movement, 1 = some difficulties or disturbances in movement, 2 = greater difficulty or disturbance of the movement. The MOCO and MOSE value are obtained by the arithmetic mean from the correspond items, and the total BMS-P score is the arithmetic mean from the MOCO and MOSE factors (Guimarães *et al.,* 2018).

3. PROCEDURES

The study was carried out in compliance with the Helsinki Declaration, and the Ethic Committee of Faculdade de Motricidade Humana of Universidade de Lisboa approved all design and materials for Investigation (Ethic approved no. 32/2017). All participants signed a written informed consent statement, explaining the study goals and procedures, and ensuring the data confidentiality and participant's anonymity. The BMS-P was applied by qualified psychomotor therapists, who had been previously trained for the scale administration. Training sessions were performed to practitioners who agreed to contribute as applicants. The BMS-P should be administered individually in a quiet room without distractions. Materials needed are a table, two chairs, a pen or pencil, and a sheet of paper. Each session takes 20 minutes.

4. DATA ANALYSIS

Confirmatory factor analysis (CFA) is the preferred approach to formally test a scale’s dimensionality when existing theory and empirical evidence support a particular latent structure of the data, as well as the interrelationships between dimensions (Collier, 2020). Thus, CFA, as model based-approach, were used to test the latent structure of BMS-P and to confirm if data support the scale’s theoretical factor structure. In particular, the research question is whether the data support the theoretical 2-factor second-order structure, that is, whether MNSS can be theoretically explained by two dimensions: motor coordination and motor sequencing. Statistical analysis was conducted using the IBM Statistical Package for the Social Sciences (SPSS) Statistics 28 to presented descriptive statistics, means and standard deviation to characterize the sample, and the IBM SPSS Amos 28 to run Confirmatory Factorial Analysis (CFA). A *p*-value less than .05 was considered statistically significant.

The first phase of research involved examining the first-order measurement model of BMS-P (Model 1). On the second phase, three second-order models were proposed: Model 2 for the original BMS (Jahn *et al.,* 2006a); Model 3 based on previous EFA (Guimarães *et al,* 2020) that hypothesized BMS-P had two main factors (latent variables), like the original BMS, but different items (observed variables) in each one; and Model 4 based to on previous EFA but without Gaze Impersistent item, because in previous statistic tests it was showing only a weak correlation with one item and no correlation with other items, domains or total score (Guimarães *et al.,* 2020).

Models' qualities were evaluated using the *Chi Squares Test* (χ^2/df), Comparative Fit Index (CFI), Goodness-of-Fit (GFI), Adjusted Goodness-of-Fit (AGFI), Normed Fit Index (NFI), Root Mean Residual (RMR), Root Mean Square Error of Approximation (RMSEA). The model was considered to have acceptable fit if *Chi Squares Test* was under 5, RMR and RMSEA were less than .05, CFI and NFI higher than .90 (Collier, 2020) and GFI equal or higher than .93 when N>100 (Cho *et al.,* 2020).

RESULTS

Concerning to the comparison the models it was listed the fit indices for each model (Table 2). Model 1, Model 3, and Model 4 were the most acceptable, nevertheless, and due the knowledge of the literature, Models 3 and 4 were the first choice, with better adjustment of the Model 4.

Table 2 - Fit Indices from Confirmatory Factor Analysis Models

Model	χ^2	df	χ^2/df	RMR	CFI	GFI	AGFI	NFI	RMSEA
Model 1(one-order)	37.912	31	1.205	.035	.982	.937	.887	.911	.047
Model 2 (original BMS)	58.803	34	1.730	.031	.935	.903	.843	.862	.085
Model 3 (EFA 6+4)	39.831	32	1.245	.026	.979	.930	.880	.907	.049
Model 4 (EFA 6+3)	24.723	24	1.030	.023	.998	.951	.907	.938	.017

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Figure 1 is referred to as a path diagram and provides a visual representation of the theoretical relationships between the observed and latent variables. The criteria for keeping the items were the values above .40 and a statistically significant (p<.01). Item 10 was deleted because in the previous EFA it did not correlate with almost items and it proved to be a weak measure (Guimarães *et al.,* 2020). In addition, Average Variance Extracted (AVE) and Composite Reliability (CR) were calculated and found to be AVE=.44 and CR=.82 for motor coordination and AVE=.48 and CR=.78 for motor sequencing. According to Forrell and Lacker (1981), an AVE below .50 could be considered if CR is above .70.

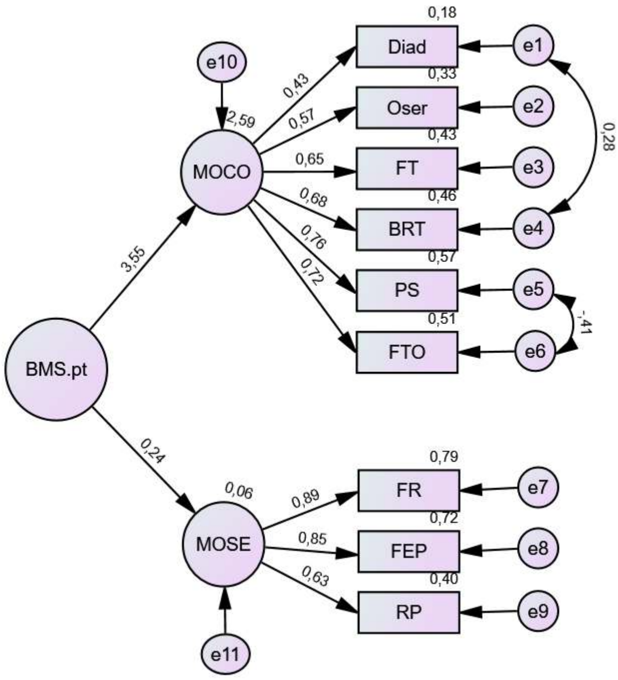

Figure 1. Model 4 – Second-order model for proposed EFA for BMS-PT (Guimarães et al., 2020). Diad = Diadochokinesia; Oser = Oseretzky; FT = Foot Taping; BRT = Bilateral Rhythm Tapping; PS = Pronation-Supination; FTO = Finger Thumb Opposition; GI = Gaze Impersistent; FR = Fist-Ring; FEP = Fist-Edge-Palm; RP = Rhythm Production.

In Model 4 all items of BMS-P were statistically significant (*p*<.001) ranging from .43 (Diadochokinesia) to .89 (Fist-ring) and is only have two covariances (*e*1-*e*4 and *e5*-*e*6) to fit this model, with very good reliability (α=.874).

DISCUSSION

As far as we are concerned, this research is the first carried out in Portugal and extends the knowledge in the literature by (a) developing a valid instrument to assess the MNSS in persons with schizophrenia; (b) advance with a new and robust factor structure for the MNSS assessment; and (c) is the first valid instrument in Portugal to assess psychomotor skills and can be very useful for monitoring and validating the psychomotor intervention in people with schizophrenia. BMS-P has demonstrated adequate psychometric properties throughout the translation to validation process (Guimarães *et al.,* 2017, 2020).

Based on literature, on original BMS (Jahn *et al.,* 2006a) and in the previous EFA of BMS-P (Guimarães *et al.,* 2020) it was suggested four models: model 1 – one factor first order model, and model 2 to 4 – two-factors second order model. Model 1 has an acceptable fit, however it does not discriminate the motor factors, coordination, and sequencing, which have been shown to be important in the literature (Buchanan; Heinrichs, 1989; Chen *et al.,* 1995; Jahn *et al.,* 2006a; Krebs *et al.,* 2000; Marionneau, Servant & Albaret, 2016), although there is little consensus on the items that are part of them. On the other hand, it seems that motor coordination is more related to aging than motor sequencing (Guimarães et al., *in press*), which could be an important aspect to analyze separately the factors of BMS-P. Model 2 (two-factors second order) was suggested considering the construct of the original BMS and it was demonstrated to be a model with a good fit, however with an RMSEA value higher than .05. Jahn *et al.* (2006a) built the BMS model by selecting several motor tasks from other instruments, validating its construct through a PCA (principal component analysis) whose main objective is to clustering the variables into components. In our model it was used a FCA based on the theoretical construct and analyzed the impact that each observable variable has on the latent variable and is therefore a more conceptual model.

Model 3 and Model 4 (two-factors second order) were based on a previous study of the BMS-P in which an EFA was conducted to compare it with the original version (Guimarães *et al.,* 2020), and both showed good adjustment properties. In this sense, Model 3 was created based on this theoretical assumption - a two factor-model with motor coordination factor (Diadochokinesia, Oserestzky, Foot tapping, Bilateral rhythm tapping, Pronation-supination, Finger-thumb opposition) and motor sequencing factor (gaze impersistent, Fist-ring, Fist-edge-palm, Rhythm production). When analyzing in detail the items that are suggested in EFA for motor coordination, it can be noted that in other versions where the motor SNS was also evaluated, these items were already allocated to the MOCO, such as Pronation-supination (Chen *et al.,* 1995; Krebs *et al.,* 2000; Schröder *et al.,* 1995) and Finger-thumb opposition (Buchanan; Heinrichs, 1988; Chen *et al.,* 1995; Krebs *et al.,* 2000; Schröder *et al.,* 1995).

In Model 4 a similar model was tested but without the item Impersistent Gaze, because it has shown weak or no correlation with other items and domains of the scale (Guimarães *et al.,* 2020) and in previous studies was highlighted as having an unreliable assessment (Krebs *et al.,* 2000). Besides, Gaze impersistent is not usually used much in motor NSS research, being only in NES (Chen *et al.,* 1995) and in BMS (Jahn *et al.,* 2006). Model 4 proved to be the best fit and robust of all the models tested.

The factorial structure of BMS-P found in this study is similar to the structure of the original BMS at least in two points: (1) both are represented by a two-factor model; and (2) seven items retain their distribution on the same factors. In addition, BMS-P was validated by CFA a major measurement of theoretical constructs. In our scale, comparing with original BMS, the motor coordination included Pronation-supination and Finger-thumb opposition, and motor sequencing have only three items (Fist-ring, Fist-edge-palm, and Rhythm production). All three of these motor sequencing tasks are associated with the premotor cortex and prefrontal area, and are very complex movements that require learning, programming, and execution (Jahn *et al.,* 2006a, Zakaria *et al.,* 2013). Whereas items included in motor coordination are less complex and more automatic tasks.

Thus, it is proposed in this study that the BMS-P consists of 2 domains and 9 items distributed among them: Motor Coordination with 6 items (Diadichokinesia, Oserestzky, Foot tapping, Bilateral rhythm taping, Pronation-supination, and Finger-thumb opposition) and Motor Sequencing with 3 items (Fist-ring, Fist-edge-palm, and Rhythm production).

The main limitation of this study was the sample size, although it was a sample larger than ten and where there was a representation of ten persons per observable variable, as some authors in the scientific community have indicated. Thus, it is suggested that future studies increase the sample size.

CONCLUSIONS

The results of this study showed a good fit indices and provide evidence to support a two-factor model for assessment of motor neurological soft signs in persons with schizophrenia. The results obtained in this research have implications for the assessment and planning of motor intervention programs, namely psychomotor interventions, and consequently for the intervention and rehabilitation of people with schizophrenia.

The results allow scientifically supporting the BMS-P as a two-factor conceptual model for the assessment of MNSS in the Portuguese population and using it in clinical settings as well as in future research.

CONSIDERATIONS

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The authors declare they have no conflicts of interest.

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