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Structure and replicability of oral health-related quality of life networks across patients with schizophrenia and the general community

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Abstract

Objectives: Schizophrenia is a disabling mental disorder associated with severe social dysfunction. Individuals with long-term mental conditions have poorer Oral Health-Related Quality of Life (OHRQoL) compared to the general population, but little is known about the measurement properties of OHRQoL instruments in this group of patients. This study aimed to examine the replicability of OHRQoL networks across samples of the general community (GC) and patients with schizophrenia (PWS).

Methods: Data were obtained from 603 community-dwelling participants and 627 patients with schizophrenia. OHRQoL was measured using the short form of the Oral Health Impact Profile (OHIP-14) questionnaire. A regularized partial correlation network was estimated for each sample. The number of dimensions and structural stability were assessed using Exploratory Graph Analysis. Global strength, edge weights and centrality estimates were compared. Network replicability was examined fitting the PWS data to the GC network structure.

Results: A single OHIP-14 dimension was identified in the GC sample, whereas three dimensions were detected in the PWS sample. Structural consistency was perfect in the network of GC participants (1), and considerably low in at least two dimensions of the PWS network (0.28; 0.65; 0.16). A moderate correlation for node strength estimates was observed (τ: 0.43; 95% CI: 0.13, 0.72), although edge weights were not correlated (τ: 0.025; 95% CI: −0.11, 0.16). The fit of the PWS data to the GC network structure was deemed unacceptable.

Conclusion: Network models of OHRQoL did not replicate across samples of the general community and outpatients with schizophrenia. Prudent use of OHIP-14 to compare measures of OHRQoL between groups with significant cognitive impartment and the general population is recommended.

KEYWORDS
network analysis, oral health, psychometrics, psychosis, quality of life, schizophrenia

1 | INTRODUCTION

A seminal work by Locker in 1988 set the way for understanding the impacts of poor oral health on individuals' quality of life. Locker (1998) theorized that poor oral health significantly impacts daily activities such as eating, communicating, socializing, enjoying life and performing regular tasks. Potential oral effects on quality of life were conceptualized as five causally related domains, which can be represented as a linear model with domains sequentially connected (impairment, functional limitation, pain/discomfort, disability and handicap) or connected out of order (e.g., functional limitation can directly lead to handicap).[1,2] This framework was later used to inform the development of one of the most widely used instruments designed to assess oral health-related quality of life (OHRQoL), the Oral Health Profile Impact (OHIP) questionnaire.[3–5]

OHRQoL is a subjective construct influenced by patients' perceptions and expectations, levels of oral morbidity and oral health needs, frames of reference of what a healthy mouth means, previous experiences accessing health services, sociodemographic characteristics such as gender and age, and psychosocial wellbeing.[1] Among patients with severe mental illness, low OHRQoL is associated with sociodemographic characteristics, smoking, lower number of teeth, xerostomia, and diagnostic of schizophrenia or depression.[6,7] Evidence also indicates that individuals living with severe mental illness have substantially higher chances of having lost all their teeth and presenting higher dental caries experience compared to the general community.[8] As a result of poorer clinical outcomes, these patients are likely to experience increased oral impacts on their quality of life.

Schizophrenia is a severe, debilitating, chronic mental illness characterized by a marked deterioration in cognitive, social, emotional and occupational functioning.[9] It is estimated that 0.28% of the world's population is affected by the condition, with the number of cases rising from 13.1 million to 20.9 million between 1990 and 2016.[10] Despite relatively low prevalence rates, schizophrenia has remained one of the leading causes of disability both in Brazil and worldwide.[11,12] Studies have shown that the overall quality of life of PWS is affected by the severity of psychiatric symptoms, the duration of untreated psychosis, and lower levels of physical activity compared to healthy control.[13,14] Furthermore, long-term medical treatment required for the management of schizophrenia often triggers important side effects in the oral cavity such as xerostomia, sialorrhea and oral dyskinesia, further compromising the OHRQoL of these patients.[15] A meta-analysis demonstrated that individuals with schizophrenia present a significantly greater number of teeth affected by dental caries, higher number of missing teeth and lower access to restorative treatments than the general community.[16]

Measuring the OHRQoL of patients with schizophrenia (PWS) using reliable instruments is key to understanding the perceived burden of oral conditions affecting this population. Few studies have examined the validity of OHRQoL instruments in PWS.[17,18] To the best of our knowledge, this is the first study to assess the psychometric properties of the OHIP-14 questionnaire in a group of PWS. To address the question regarding whether OHRQoL has been measured in a reliable way across individuals with schizophrenia and the general population, we employed a novel and powerful analytical approach that models the relationships between variables as complex networks.[19] Although network models are statistically equivalent to factor models, they assume rather different data-generating mechanisms, adding an insightful framework to conceptualizing, assessing and understanding constructs of oral health.[20] For instance, in a psychometric network perspective, the emergence of dimensions arises from the bidirectional interaction between items rather than from latent common causes. Traditional factor analysis (latent variable perspective) conceptualizes the construct (OHRQoL) as the underlying cause for the variation in item responses (factor scores obtained from observed variables are interpreted as measures of the *unmeasured* latent construct). Network models, on the contrary, assume that statistical relationships between items are not attributable to a common latent variable and rather result from a *system* (network) of multiple dynamics between observable variables (items do not measure a latent trait but *are* the trait itself). The psychometric network model also allows a fuzzy interpretation of traits in which the delineation of limits between dimensions is treated as a matter of degree.[21]

This study aims to examine the replicability of OHIP-14 networks across samples of the general community (GC) and patients with schizophrenia (PWS). We hypothesize that network models obtained from these populations present substantially different properties and structures.

2 | METHODS

2.1 | Samples

Data were obtained from two cross-sectional studies conducted in major cities located in the state of São Paulo, Brazil.

a. A sample of 603 community-dwelling individuals living near Primary Healthcare Units (PHUs) from different regions of Piracicaba city was recruited between August 2018 and August 2019. Piracicaba is one of the largest cities in the state of São Paulo, with an estimated population of 400.000 individuals. Six PHUs regions with different sociodemographic characteristics were selected. Each PHU provides health services to approximately 3000 individuals. The sampling frame for the six PHUs selected for the study was 18 000 individuals. Eligibility criteria included being 18 years or older, not being under the influence of drugs or alcohol at the time of the interview as it could affect the ability to provide answers to questions, providing informed consent, and being able to communicate in Portuguese. A sample of 523 participants were identified and selected via a simple random process based on the information system of the selected PHUs. The information system of PHUs records information on all individuals living in the households within their jurisdiction. Another 80 participants visiting a Dental Specialty Center were recruited through a convenience sample strategy.[22]

b. A random sample of 627 PWS under treatment in Psychosocial Care Centers from São Paulo city was selected over the course of 2016. The Psychosocial Care Centers adopt a community approach to provide multidisciplinary care within the Brazilian public health system for outpatients with mental disorders. A simple random sampling procedure was employed to select two adult Psychosocial Care Centers from each of the five macro regions of São Paulo city. Participants who met the following inclusion criteria were invited to take part in the study: being aged 18–65 years, having a diagnosis of schizophrenic spectrum disorder (codes F20–F29 of the 10th revision of the International Statistical Classification of Diseases and Related Health Problems [ICD-10]), being regularly followed-up by the psychiatric health teams (at least every two months) to ensure that all participants were under treatment, and being able to communicate in Portuguese.[6]

Ethical approval for each study was obtained from the Research Ethics Committee of relevant institutions. All participants provided written and verbal informed consent.

2.2 | Measures

OHRQoL was assessed using the short form of the Oral Health Impact Profile (OHIP-14) questionnaire, a 14-item instrument that measures the perceived impact of oral conditions on quality of life across 7 conceptual domains (functional limitation, physical pain, psychological discomfort, physical disability, psychological disability and handicap). OHIP-14 provides an easy and convenient assessment of participants' OHRQoL due to its reduced number of items compared to the original OHIP-49. Responses to each item were recorded on a 5-point Likert-type scale (0 = never, 1 = hardly ever, 2 = occasionally, 3 = fairly often, 4 = very often). Higher scores indicate a higher oral impact on quality of life.[23] The same Portuguese version of the OHIP-14 questionnaire was used for both samples.[23] Table 1 provides a description of OHIP-14 items. OHIP-14 data and sociodemographic characteristics were obtained using a pen-and-paper structured questionnaire at participants' homes or healthcare services.

2.3 | Statistical analysis

Descriptive statistics were employed to characterize the sociodemographic profile of each sample and presented as frequencies, percentages, median and interquartile range (Q1–Q3). A Monte Carlo simulation method available in R package *powerly* was used to estimate the sample size needed for estimating a GGM network model with 14 nodes, edge density of 0.4, sensitivity of 60% and power of 80%. The required sample was 542.

TABLE 1 Description of OHIP-14 items.

Item	Label	Description
1	OHIP1	*...trouble pronouncing any words*
2	OHIP2	*...sense of taste has worsened*
3	OHIP3	*...pain*
4	OHIP4	*...uncomfortable to eat any foods*
5	OHIP5	*...self-conscious because of teeth or mouth*
6	OHIP6	*...tense*
7	OHIP7	*...diet unsatisfactory*
8	OHIP8	*...interrupt meals*
9	OHIP9	*...difficult to relax*
10	OHIP10	*...embarrassed*
11	OHIP11	*...irritable with other people*
12	OHIP12	*...difficulty doing usual jobs*
13	OHIP13	*...life in general less satisfying*
14	OHIP14	*...totally unable to function*

Note: Response options: Never (0); Hardly ever (1); Occasionally (2); Fairly often (3); Very often (4).

2.4 | Dimensionality and structural consistency

We examined the OHIP-14 dimensionality in each sample via Exploratory Graph Analysis (EGA) with the *EGAnet* R package.[20] Initially, partial correlation networks comprising OHIP-14 items were modelled as Gaussian graphical models (GGM). We used a nonparanormal approach (SKEPTIC) to relax the assumption of normality when estimating the partial correlation coefficients.[24] Subsequently, the Walktrap community detection algorithm was applied to each GGM model to identify the number and structure of subnetworks (i.e., densely connected communities of nodes) within the overall network.[25]

A bootstrap approach (*bootEGA*) was used to replicate the EGA network of each sample with resampled data. The procedure was repeated 2000 times, generating a sampling distribution of the number and composition of dimensions which was used to compute measures of structural consistency and item stability for each model. Structural consistency assesses the homogeneity and interrelatedness of items in each dimension given the multidimensional structure of the scale. Values range from 0 to 1 and inform the proportion of times that each dimension obtained in the original network is retrieved with identical item composition in the replicate bootstrap samples. For instance, if the same item composition of a given dimension is obtained in 50% of the replicate samples, the corresponding structural consistency is 0.5. To identify which items may be the source of structural inconsistency within each dimension, we assessed item stability (i.e., the proportion of times that each item was correctly identified in the original dimension across all replicate samples). Values of item stability range from 0 to 1.[21]

2.5 | Centrality and stability

Measures of node centrality provide important insights on the relative importance of each node to the overall network. In this study, we estimated node strength, a measure that assesses how strongly connected to the network each node is. Strength is computed by summing all edge weights connecting a given node. Estimates were reported as standardized z-score. Within a network psychometric perspective, node strength measures are equivalent to factor loadings in Confirmatory Factor Analysis.[26] Node strength was estimated using R package *qgraph*.

The stability of node strength estimates of each model was examined employing a bootstrap case-dropping procedure that computes the maximum proportion of participants that can be dropped and still retain a correlation of at least 0.7 with the original centrality values. Centrality stability (CS) coefficients should, ideally, be greater than 0.50, and must not be lower than 0.25.[27]

2.6 | Comparison of network models

We compared several parameters between the network models of the GC and PWS samples. The network comparison test (NCT), a permutation-based hypothesis test, was used to assess the differences in global strength (i.e., network overall connectivity computed as the absolute sum of all edge weights) and between each specific edge. The NCT was performed with 2000 permutations and against an alpha level of 0.05.[28] Kendall's rank correlations were used to examine the similarity of the networks by (1) correlating edge weights from each pair of nodes and (2) correlating nodes' strength centrality estimates.

2.7 | Confirmatory network modelling

We formally tested the replicability of the OHIP-14 network across samples using the R package *Psychonetrics*.[29] First, a partial correlation matrix was obtained from the GC data. Potentially spurious partial correlations were pruned at the alpha level of 0.05 (i.e., only partial correlations at the significance level of .05 were kept in the network models). Next, we retrieved the adjacency matrix, which contains information on the network structure (i.e., which edges are present and which edges are absent). Finally, the adjacency matrix was fitted in the PWS data to test whether the network extracted from the GC sample replicates. A non-significant chi-square test, Comparative Fit index (CFI) > 0.95, Tucker–Lewis index (TLI) > 0.95 and root mean square error of approximation (RMSEA) < 0.07 were considered indicative of model fit.

2.8 | Visualization

The network graphs are essentially formed by nodes (representing OHIP-14 items) and edges (representing regularized partial correlations between corresponding items after conditioning for all other items in the network). Edge thickness and colour saturation indicate the magnitude of the relationships between nodes. Positive edges are plotted as green lines, whereas negative edges are plotted as red dotted lines. Nodes with the same colour belong to the same community of items. Plots were generated using R package *qgraph*.

3 | RESULTS

Descriptive characteristics of the samples included in the study are presented in Table 2. Regarding network structures, a single OHIP-14 dimension was identified by the EGA in the GC sample, whereas three dimensions were detected in the sample with (Figure 1). The composition of node communities identified by EGA reflects the following dimensions in the PWS network: (1)

TABLE 2 Sample characteristics.

	General community (*n* = 603)		Patients with schizophrenia (*n* = 627)	
Variable	***n***	**%**	***n***	**%**
Sex				
Women	401	66.5	332	53.0
Men	202	33.5	295	47.0
Age				
18–34	221	36.7	159	25.4
35–54	197	32.8	369	58.8
55 or older	183	30.5	99	15.8
Ethnicity				
White	370	61.4	306	48.8
Black	62	10.3	121	19.3
Yellow	14	2.3	17	2.7
Mixed	157	26.0	183	29.2
Education (years)				
0	5	0.8	15	2.4
1–8	214	35.6	312	49.8
9–11	240	39.9	263	41.9
12+	142	26.6	37	5.9
OHIP-14 score				
Median (Q1–Q3)	8 (1–17)		10 (4.5–20)	

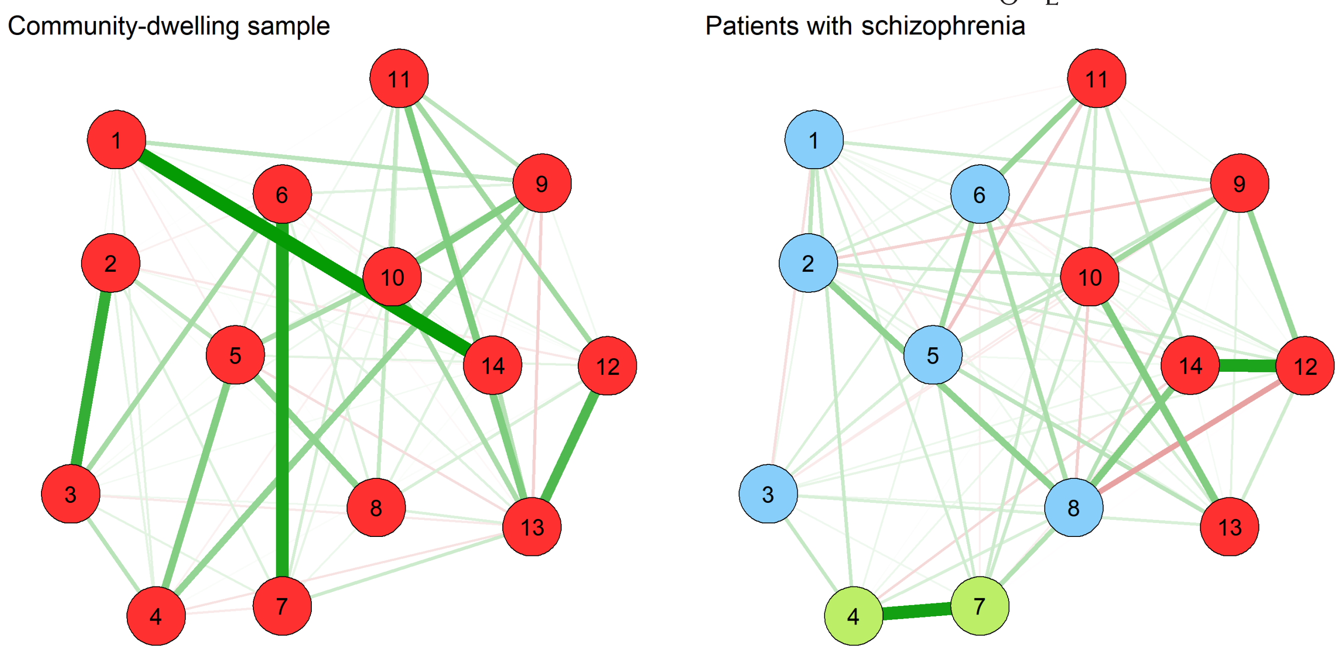

FIGURE 1 OHIP-14 dimensions identified via Exploratory Graph Analysis.

Functional/Psychological impact (item 1: speaking; item 2: sense of taste; item 3: pain; item 5: self-conscious; item 6: tension; item 8: interrupt meals); (2) Food (item 4: uncomfortable eating; item 7: unsatisfactory diet); and (3) Social impact (item 9: difficult to relax; item 10: embarrassed; item 11: irritable; item 12: occupational; item 13: unsatisfaction with life; and item 14: unable to function). The strongest connections in the GC sample emerged between items 1 (trouble speaking) and 14 (unable to function) (r_p = .62), and items 6 (tension) and 7 (unsatisfactory diet) (r_p = .56). In the PWS sample, the strongest edges emerged between items 4 (uncomfortable eating) and 7 (unsatisfactory diet) (r_p = .58), and items 12 (occupational) and 14 (unable to function) (r_p = .56). Edge weights presented a weak relationship across models (τ: 0.025; 95% CI: −0.11–0.16).

The unidimensional structure of the OHIP-14 network for the GC sample was replicated across all bootstrap samples, demonstrating perfect structural consistency. In the OHIP-14 network for PWS, the structural consistency of dimensions was 0.28 (items 1, 2, 3, 5, 6 and 8), 0.65 (items 4 and 7) and 0.16 (items 9, 10, 11, 12, 13 and 14). The analysis of item stability revealed that items 5, 9, 10, 11 and 13 reduced the overall structural consistency of their respective dimensions (Figure 2). In other words, these items did not conform to their originally assigned dimensions in a significant proportion of the bootstrap samples.

The analysis of centrality estimates is presented in Figure 3. The stability of node strength values was excellent for the PWS network (CS-coefficient: 0.671; 95% CI: 0.595, −0.75), and acceptable for the GC network (CS-coefficient: 0.439; 95% CI: 0.362–0.517). We found a moderate correlation for node strength values between networks (τ: 0.43; 95% CI: 0.13–0.72).

The NCT detected a statistically significant difference in connectivity between the PWS network (global strength: 5.73) and the GC network (global strength: 6.81; diff: 1.08; *p*-value <.001). The maximum difference observed in edge weight was r_p = .59 (items 4–7). The fit of the PWS data to the OHIP-14 network structure of GC participants was unacceptable ($\chi 2$ (65) = 912.55, p < .001; CFI = 0.68; TLI = 0.55; RMSEA = 0.14, 90% CI = 0.14–0.15).

4 | DISCUSSION

In this study, we assessed whether properties of OHIP-14 networks are consistent across GC and PWS samples. Our findings showed that the models differed in relation to network structure, dimensionality, structural stability, global strength and edge weight. Model fit indices demonstrated that networks did not replicate across samples. On the contrary, estimates of node strength were moderately correlated.

The dimensionality analysis revealed that the networks differ regarding the number of dimensions. While OHIP-14 was originally developed based on seven theoretical domains, we identified unidimensional and three-dimensional structures in our samples. Differences between theoretical and empirical domains are expected due to cultural, social or demographic differences between populations, which can affect how individuals interpret the meaning of items. Previous studies investigating the psychometric properties of OHIP-14 reported different numbers of dimensions for samples of Brazilian adults.[30,31] Researchers have also used EGA to assess the OHIP-14 dimensionality across samples of Indigenous and non-Indigenous populations. Four-dimension network structures were found for all groups, although with different item compositions and dimensions with low structural consistency.[32] In this study, the network representing GC participants yielded perfect structural consistency, which demonstrates the instrument stability in measuring

OHRQoL in this sample of adults. On the contrary, when we investigated the OHIP-14 properties applied to PWS, we found that boundaries between dimensions become blurred and the structural consistency was reduced. In this case, it is plausible that nodes with low item stability present a multidimensional behaviour, contributing to the emergence of different node communities.[21] The analysis of the number of communities not only has a practical value of informing how scale scores should be computed but also provides important information regarding the different states and arrangements of OHRQoL.

Differences in global strength indicate that the PWS network presents a lower level of connectivity (i.e., weaker and/or fewer connections). This characteristic may contribute to the emergence of diffuse and less stable node communities. Rotstein et al. analysed network structures of general quality of life between appraisals obtained directly from PWS and appraisals attributed to them by

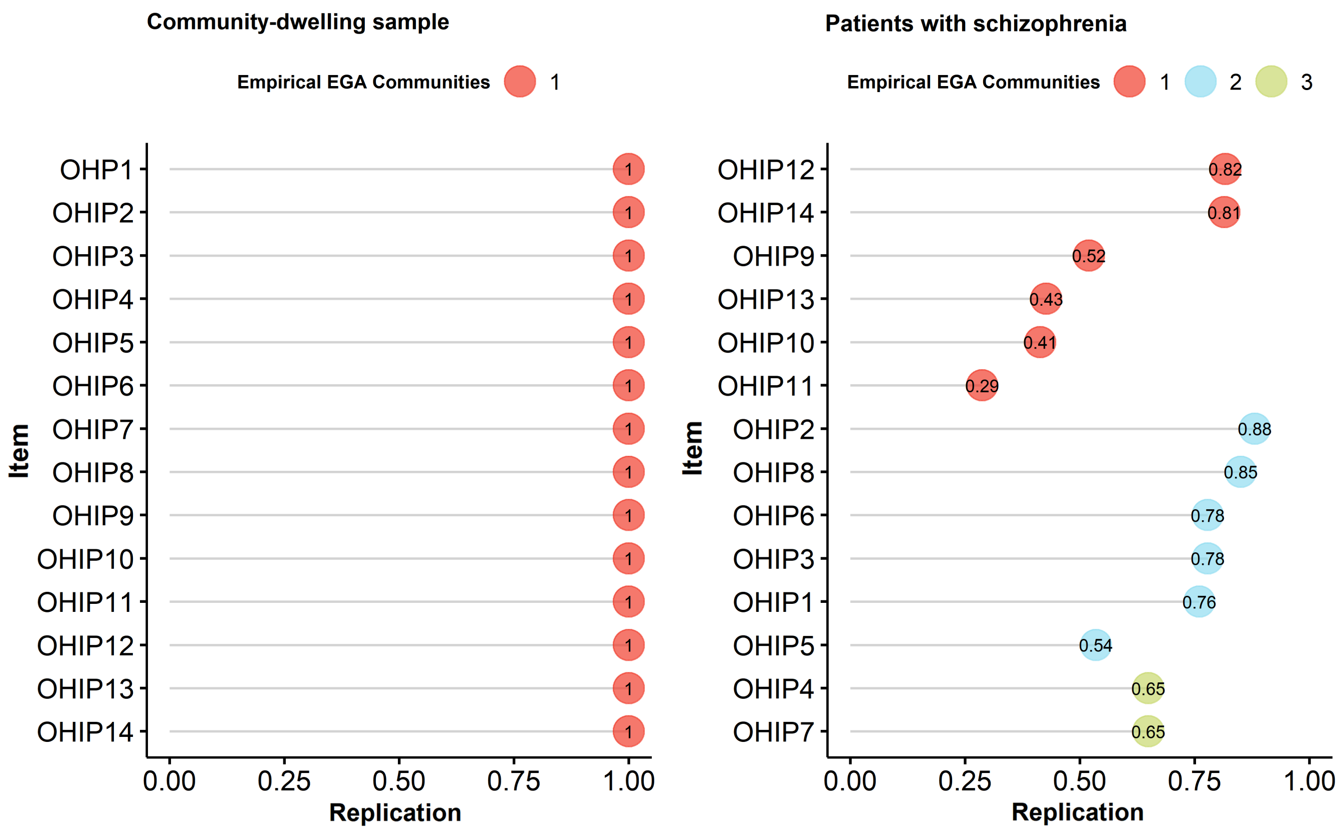

FIGURE 2 Item stability of OHIP-14 networks.

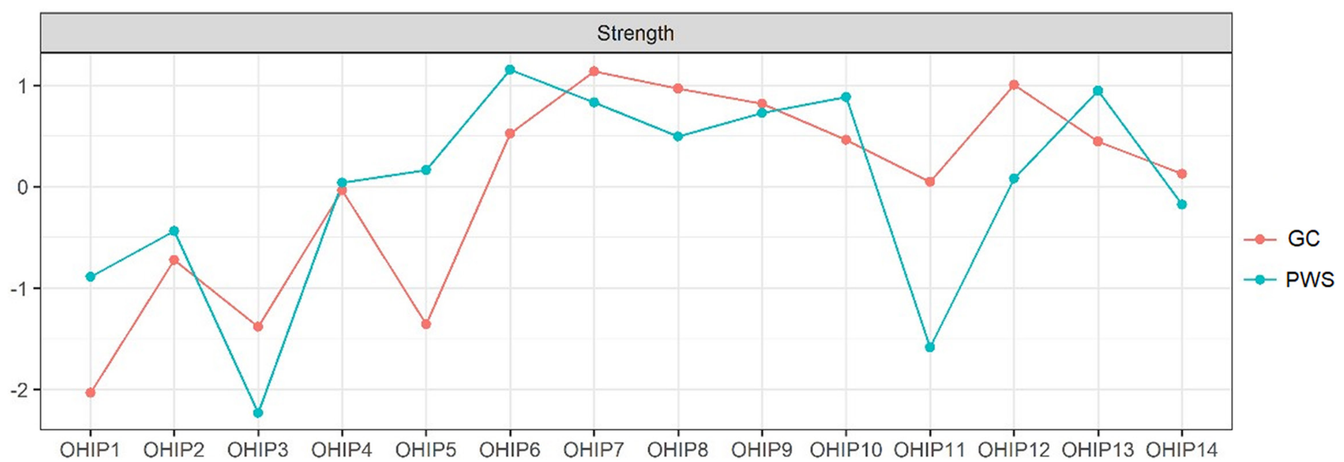

FIGURE 3 Comparison of node strength estimates between OHIP-14 networks of the general community sample (CG) and patients with schizophrenia (PWS).

their primary professional caregivers.[33] Networks differed in terms of number of communities and global strength, with lower overall connectivity in the model with data obtained directly from PWS. Differences in network global strength have also been reported for psychotic symptoms in PWS over time and for depressive symptoms between remitters and non-remitters for psychosis.[34,35] It is hypothesized that models with reduced connectivity may be less sensitive to fluctuations in their structure as a result of the lower efficiency to influence nodes from different parts of the network.[36,37]

Centrality was the only measure consistent across networks. In line with our findings, node strength has been reported in the network science literature as the most stable centrality metric.[38] The observation that node strength estimates (computed as the sum of all edge weights of a given node) were moderately correlated across networks contrasts with findings that specific edge weights differed substantially between models. In other words, even though network structures did not replicate, the order of the most central nodes was still comparable across samples. Central estimates are a common metric of network inference. However, the centrality analysis alone may not be able to uncover important variations in nodes dynamics, connectivity, clustering and overall network functioning. Therefore, we encourage researchers to adopt comprehensive approaches to compare network structures from different populations.

Several factors may influence how PWS perceive their oral health and its impacts on their OHRQOL, partially explaining the emergence of different OHIP-14 model structures for the GC and PWS samples. Tang et al. reported moderate correlations between OHIP-14 scores and normative assessments of oral health among inpatients with schizophrenia at a psychiatric hospital.[39] In addition to personal experiences related to oral symptoms, views of PWS on OHRQoL include concerns regarding individual autonomy and stress management.[40] Intellectual impairment and severe psychotic symptoms may also play a major role in the OHRQoL of PWS through increased sensitivity to acute pain and barriers to accessing health services.[41,42]

The implications of our findings are twofold. First, this study contributes to advancing an alternative interpretation of OHRQoL within a psychometric network perspective. Different structures of OHIP-14 were identified, which may aid researchers to understand the dynamics between items among populations with schizophrenia. For instance, strong edges between nodes 'uncomfortable eating' and 'unsatisfactory diet', and nodes 'occupational' and 'unable to function' suggest unique relationships in the PWS sample. From a psychometric network perspective, nodes may *activate* other nodes, triggering a different state of the network. Second, reliable assessment of OHRQoL is essential to identify and mitigate the burden of oral conditions on PWS. This study demonstrated that the OHIP-14 network model is not replicated across GC and PWS samples. The OHIP-14 may not measure the underlying construct with equivalent accuracy across these populations, and therefore, comparison between scale scores should be made with caution. It is also important to note that the instrument does not cover important aspects of the OHRQoL of PWS such as the significant side effects of antipsychotics on the oral cavity.[16]

Strengths of this study include the use of a comprehensive approach with multiple network analysis methods to investigate the replicability of OHRQoL models, in addition to adequate sample sizes for detecting moderate differences in network properties. Several limitations should also be noted. The PWS sample included only outpatients, which generally present greater levels of functioning and less severe psychotic symptoms compared to inpatients. Findings are likely generalizable to PWS receiving community care through Psychosocial Care Centers and the population enrolled in the public healthcare network in large urban areas in the Southeast of Brazil (comparison of samples' characteristics with population statistics is presented as Supporting Information). Analyses did not account for different sampling designs, which may have introduced bias to the findings. Differences between network models may partially reflect variations in sample composition regarding gender, age, ethnic background and education. For instance, the higher proportion of adults aged 55 and over in the GC sample might be indicative of increased burden of oral conditions (e.g., tooth loss and denture wearing), with potential impacts on OHRQoL. The general population sample may include participants with mental health conditions as the inclusion criteria for that group did not involve an assessment of mental health. Future research may assess the network structure of OHRQoL and psychotic symptoms and investigate the comparability of measures obtained using OHIP-14 and tools specifically designed to assess the oral health impacts on the quality of life of PWS.[43]

5 | CONCLUSION

Network models of OHRQoL did not replicate across samples of the general community and outpatients with schizophrenia. Estimates of node strength were the only metric consistent across models. Networks differed in terms of structure, number of dimensions, structural consistency, global strength and edge weight. A single dimension with perfect structural consistency emerged in the GC sample, whereas a 3-dimension structure with fuzzy boundaries was detected in the model of PWS. Prudent use of OHIP-14 to compare measures of OHRQoL between groups with cognitive impartment and the general population is recommended.

AUTHOR CONTRIBUTIONS

Gustavo Hermes Soares: Conceptualization, Formal analysis, Interpretation, and Writing—original draft. **Fernanda Maria Rovai Bado and Alexandre Gomes Lopes:** Data collection, data curation, and Writing—review and editing. **Maria Gabriela Haye Biazevic and Edgard Michel-Crosato:** Interpretation, and Writing—review and editing. **Fábio Luiz Mialhe:** Conceptualization, Data curation, Interpretation, and Writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors have no relevant financial or non-financial interests to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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