Multiple Correspondence Analysis of the Impact of Sample Composition Heterogeneity on Primary-Level Chronic Disease Management Quality Survey Results: Postprint

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Abstract

Objective To investigate the quality of chronic disease management in primary healthcare institutions in Chengdu City, and to explore the impact of heterogeneity in sample composition on scale evaluation results and propose countermeasures. **Methods** Using multistage stratified cluster sampling, 889 medical staff were selected as samples from 46 primary healthcare units in 23 prefecture-level cities, districts (counties) of Chengdu City. The Chinese version of the Assessment of Chronic Illness Care scale (ACIC) was used to obtain chronic disease management quality scores for the healthcare units. Multiple correspondence analysis was employed to explore the impact of sample heterogeneity arising from differences in gender, years of work experience, professional title, educational background, and position composition on the scores. **Results** The correlation test between the total score of chronic disease management capability and educational background, professional title was statistically significant ($p<0.05$). Among the 6 sub-dimensions, the correlation test between the decision support dimension score and years of work experience, and between the information systems dimension score and years of work experience, educational background was statistically significant ($p<0.05$). Multiple correspondence analysis indicated that overall, higher educational background was associated with lower total scores for chronic disease management; intermediate professional titles tended to give the highest scores. In the decision support score, personnel with longer years of work experience tended to give higher scores. In the information systems score, personnel with shorter years of work experience tended to give higher scores; college/bachelor' s degree holders tended to give the highest scores. **Conclusion** Heterogeneity in sample composition exerts a definite impact on the results of primary chronic disease management quality evaluation

scales, which means the evaluation will be biased, particularly not conducive to fair comparison between institutions. This suggests that scale development needs to strictly standardize the scope of application, and that reliability and validity testing as well as promotion and use should pay attention to sample composition to ensure its homogeneity, thereby guaranteeing the objectivity and effectiveness of primary chronic disease management quality evaluation.

Full Text

Multiple Correspondence Analysis of the Influence of Sample Composition Heterogeneity on Survey Results of Primary-Level Chronic Disease Management Quality: An Investigation Based on the Chinese Version of the Assessment of Chronic Illness Care Scale

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Abstract

Objective: To investigate the quality of chronic disease management in primary medical institutions in Chengdu, explore the impact of sample composition heterogeneity on scale evaluation results, and propose countermeasures.

Methods: Using multi-stage stratified cluster sampling, 889 medical workers were selected from 46 primary medical units across 23 prefecture-level cities, districts, and counties in Chengdu. The Chinese version of the Assessment of Chronic Illness Care (ACIC) was used to obtain chronic disease management quality scores for medical institutions. Multiple correspondence analysis was employed to explore how sample heterogeneity arising from differences in gender, working years, professional title, educational background, and position composition affected the scale scores.

Results: Statistical significance was found in the correlation between total chronic disease management ability scores and both educational background and professional title ($p < 0.05$). Among the six dimensions, the decision support dimension score showed significant correlation with working years, while

the information system dimension score demonstrated significant correlation with both working years and educational background ($p < 0.05$). Multiple correspondence analysis revealed that higher educational background generally corresponded to lower total chronic disease management scores, while intermediate professional titles tended to give the highest scores. For decision support scores, personnel with longer working years tended to give higher ratings. For information system scores, personnel with shorter working years tended to give higher ratings, while college/bachelor's degree holders tended to give the highest scores.

Conclusion: Sample composition heterogeneity exerts a definite influence on the results of primary-level chronic disease management quality evaluation scales, meaning that evaluations may be biased, particularly compromising fair comparisons between institutions. This suggests that scale development requires strict standardization of applicable scope, and that reliability and validity testing as well as general use must pay close attention to sample composition to ensure homogeneity, thereby guaranteeing the objectivity and effectiveness of primary-level chronic disease management quality evaluation.

Keywords: chronic disease; management quality; evaluation; influencing factors; scale; primary level

Introduction

A 2015 report indicated that the national chronic disease mortality rate was 533 per 100,000, accounting for 86.6% of total deaths. With population aging intensifying, chronic diseases are projected to become a massive burden on China' s economy and society. Primary healthcare institutions play a pivotal role in chronic disease prevention and control, and China' s Medium and Long-Term Plan for Chronic Disease Prevention and Treatment (2017–2025) explicitly prioritizes enrolling chronic disease patients in family doctor contract services. Quality evaluation constitutes a core element of primary-level chronic disease management, serving as the standard for comparing management levels across different regions, institutions, and personnel, and as a powerful tool for promoting continuous improvement and enhancement.

Scientific quality evaluation scales require good reliability and validity to ensure objective and effective results. However, in practice, we often overlook sample heterogeneity—a crucial factor affecting reliability and validity. A scale' s good reliability and validity may be limited to the normative sample used in its development. During general use, if the sample exhibits heterogeneity compared with the norm (e.g., different composition in gender, age, education level, etc.), the reliability and validity may change. Consequently, evaluation results may be biased when sample composition differs. The Assessment of Chronic Illness Care (ACIC), developed by the MacColl Institute for Healthcare Innovation in the United States, has been translated into multiple languages and widely applied.

Chinese scholars have produced a Chinese version with demonstrated good validity and reliability. During our investigation of chronic disease management capacity in primary medical institutions in the Chengdu region using the Chinese version, we observed that sample heterogeneity significantly affected survey results—different respondent compositions yielded different evaluation outcomes. Literature review revealed that this phenomenon has not received adequate attention in previous chronic disease management capacity surveys using various methods, which compromises objective evaluation of chronic disease management capacity. To explore the impact of sample heterogeneity on results, we conducted multiple correspondence analysis on our data, with findings reported as follows.

1.1 Subjects

Using multi-stage stratified cluster sampling, we first included all 23 prefecture-level cities, districts, and counties in the Chengdu region as the sampling frame. Second, we randomly selected two primary medical units in each prefecture-level city, district, and county using random numbers. Third, all family doctor team members from each selected unit were taken as survey subjects to form the final sample. Inclusion criteria were: holding formal practice qualifications; having the primary practice location at the unit; and voluntary participation. Exclusion criteria were: having mental illness or cognitive impairment; and non-voluntary participation. Based on completion time statistics from previous ACIC survey studies and small-scale pilot testing, we determined that questionnaire completion required at least 10 minutes; therefore, all questionnaires completed in less than 10 minutes were excluded. The study ultimately surveyed 46 units, distributing 1,256 questionnaires and receiving 1,120 responses. After excluding questionnaires with insufficient completion time, logical errors, or duplicate answers, we obtained 889 valid questionnaires, yielding an effective recovery rate of 70.8%.

1.2 Methods

The chronic disease management capacity survey questionnaire used the Chinese version of ACIC, which comprises two parts. The first part includes six dimensions from the Chronic Care Model with 28 items: system organization, community linkages, self-management support, decision support, delivery system design, and information systems. Each item has four response levels (D, C, B, A), with each level further divided into three grades, resulting in 12 grades per item represented by values from "0 to 11," where higher values indicate more comprehensive implementation of the described service measure. The mean score for each dimension was calculated by dividing the total score by the number of items, representing the evaluation result for that dimension. The overall score, representing the general level of chronic disease management, was calculated by dividing the sum of the six dimension scores by six. The sec-

ond part addresses integration of components in the Chronic Care Model. In practice, we considered the first part sufficient to reflect chronic disease management capacity, while the second part was overly cumbersome and burdensome for respondents. Therefore, we used only the first part for evaluating chronic disease management capacity. Simultaneously, we collected information on gender, working years, professional title, educational background, and position as factors characterizing sample heterogeneity.

1.3 Statistical Analysis

Survey data were grouped and coded as follows: total score and each dimension score: $ $3=1, 3-6=2, 6-9=3, $ $9=4; gender: male=1, female=2; working years (years): $ $5=1, 5-10=2, 10-15=3, 15-20=4, $ $20=5; educational background: secondary school/high school and below=1, college/bachelor' s=2, master' s and above=3; professional title: junior=1, intermediate=2, associate senior and above=3; position: clinical/TCM physician=1, nursing=2, public health personnel=3, pharmacist=4, other=5. Statistical analysis was performed using SPSS 17.0. For analyzing associations between scores and sample heterogeneity factors, Spearman rank correlation was used for bidirectional ordinal data, Mann-Whitney U test for two-group rank data, and Kruskal-Wallis H test for multi-group rank data. Variables showing statistical significance were further subjected to multiple correspondence analysis. The test level was set at α=0.05, with two-tailed P-values.

2.1 Basic Characteristics

The 889 participants came from: Gaoxin District Hezuo and Guixi Community Health Service Centers; Tianfu New District Taiping Central Health Center and Dalin Health Center; Eastern New District Gaoming Health Center and Caoshi Community Health Service Center; Chenghua District Qinglong and Baohe Community Health Service Centers; Jinniu District Simaqiao and Xi' an Road Community Health Service Centers; Jinjiang District Niushikou and Yanshikou Community Health Service Centers; Wuhou District Jinyang and Cujin Community Health Service Centers; Qingyang District Caotang and Wenjia Community Health Service Centers; Wenjin District Jinma and Yongning Street Community Health Service Centers; Shuangliu District Yixin and Yong'an Community Health Service Centers; Xinjin District Baodun and Yongshang Health Centers; Longquanyi District Longhua Community Health Service Center and Xihe Town Health Center; Xindu District Juntun Town Xinmin Health Center and Chengdong Community Health Service Center; Qingbaijiang District Hongyang Community Health Service Center and Yaodu Town Health Center; Dujiangyan City Guankou Jiefang Community Health Service Center and Juyuan Town Central Health Center; Chongzhou City Longxing Town Qiquan Health Center and Guansheng Town Health Center; Qionglai City Sangyuan Town Health Center and Huojing Town Central Health Center; Jianyang City

Sanxing Health Center and Shizhong Town Health Center; Pengzhou City Longmenshan Town and Jiuchi Town Health Centers; Jintang County Zhugao Town Guangxing Branch Center and Gaoban Pingqiao Branch Center; Pidu District Tangchang Town and Sandao Town Health Centers; Dayi County Anren Town and Chujiang Town Public Health Centers; Pujiang County Daxing and Ganxi Health Centers. The sample comprised 227 males and 662 females; 116 with $ $5 working years, 214 with 5–10 years, 198 with 10–15 years, 92 with 15–20 years, and 269 with $ $20 years; 153 with secondary school/high school education or below, 710 with college/bachelor' s degrees, and 26 with master' s degrees or above; 534 with junior professional titles, 294 with intermediate titles, and 61 with associate senior titles or above; 367 clinical/TCM physicians, 287 nurses, 94 public health personnel, 41 pharmacists, and 100 others.

2.2 Correlation Between Chronic Disease Management Scores and Sample Heterogeneity Factors

Statistical significance was found in the correlation between total chronic disease management ability scores and both educational background and professional title ($p < 0.05$) . Among the six dimensions, the decision support dimension score showed significant correlation with working years , while the information system dimension score demonstrated significant correlation with both working years and educational background ($p < 0.05$) .

2.3 Multiple Correspondence Analysis of Chronic Disease Management Scores and Sample Heterogeneity Variables

Correspondence analysis primarily identifies relationships between variables by observing distances between scatter points, where closer distances indicate more obvious associations. For total score, decision support dimension score, and information system dimension score, the cumulative contribution of dimensions 1 and 2 to the original data interpretation exceeded 90%, indicating that two dimensions were sufficient.

Total score 1 was closest to educational background 3, total score 3 was closest to educational background 2, and total score 4 was closest to educational background 1, suggesting that higher educational background generally corresponded to lower chronic disease management ratings. Professional title 2 was closest to total score 4, indicating that intermediate professional titles tended to give the highest scores, while professional titles 1 and 2 were both relatively close to total scores 2 and 3, with professional title 3 being relatively distant, suggesting that personnel with lower professional titles generally tended to give higher ratings. These relationships are illustrated in Figure 1 [Figure 1: see original paper].

In the decision support dimension score, working years 3 and 4 were very close, indicating high similarity between these two groups. Working years 3, 4, and 5 showed obvious clustering with scores 3 and 4, suggesting that personnel with

longer working years tended to give higher ratings for this dimension. Score 1 was distinctly distant from other variables, indicating that personnel across all working year categories had low tendency to give the lowest ratings for this dimension. These patterns are shown in Figure 2 [Figure 2: see original paper].

For the information system dimension score, score 2 was close to working years 3 and 4, while score 3 was close to working years 5, 4, and 3, with scores 2 and 3 clustering with working years 5, 4, and 3. However, score 4 was close to working year 2, indicating that personnel with shorter working years tended to give higher ratings for this dimension. Educational background 2 was close to score 4, suggesting that college/bachelor' s degree holders tended to give the highest ratings for this dimension. These findings are presented in Figure 3 [Figure 3: see original paper].

Discussion

Numerous factors influence scale reliability and validity in questionnaire surveys, with sample heterogeneity being one of them. Sample heterogeneity typically manifests as differences in sample composition. For instance, when comparing chronic disease management capacity between two institutions using a scale, samples drawn from each institution may have different compositions of personnel categories—one might primarily include leaders, medical staff, and junior-title personnel, while the other might have higher proportions of general staff, nursing personnel, and senior-title personnel. Clearly, these two samples are heterogeneous due to compositional differences. Although the same evaluation scale is used, results may be biased due to sample composition differences, leading to non-objective comparative evaluation conclusions about the two institutions. For primary medical institutions, quality evaluation of chronic disease management most directly serves institutional assessment and rating, potentially even forming the basis for resource allocation and salary distribution. Consequently, the objectivity and effectiveness of evaluation scales are critically important. However, the impact of sample heterogeneity on survey results has not received adequate attention in actual research.

In our investigation of chronic disease management capacity in primary medical institutions in the Chengdu region based on the Chinese version of ACIC, we found that sample composition significantly affected results. For example, personnel with higher educational backgrounds gave lower overall ratings for chronic disease management capacity, while those with lower professional titles tended to give higher ratings. Higher education may lead to higher expectations and stricter standards for chronic disease management, resulting in lower scores. Lower professional titles may correlate with relatively insufficient knowledge and experience, leading to less deep understanding of chronic disease management and lower standards, thus producing higher ratings. These findings align with those of Wang Yong et al. Additionally, sample composition effects were ob-

served in the decision support and information system dimensions. Reviewing various ACIC versions, selected samples have differed considerably: the English original comprised administrative decision-makers, physicians, and nursing managers; the Swiss German version included general practitioners and physician assistants; the German version consisted entirely of general practitioners; and the Chinese version reliability and validity study included leaders engaged in chronic disease management, general practitioners/clinicians, nurses, and public health physicians. However, these studies did not address sample heterogeneity effects, making generalization of their conclusions potentially blind. Notably, the Dutch ACIC study did attend to sample heterogeneity, recognizing that considerable differences might exist within teams and conducting individual assessments of disease management teams, yielding differentiated conclusions.

Given these sample heterogeneity effects, ensuring objectivity in primary-level chronic disease quality evaluation requires attention to sample composition issues not only in ACIC research and application but also in the development and use of all quality evaluation scales or questionnaires involving scale content. We recommend that scale development should initially strictly standardize the target population for the scale—whether for leaders or general staff; for physicians or nursing personnel; for junior or senior medical staff; or whether applicable to multiple compositions. Under such population specifications, scale development should involve participation from all corresponding personnel categories. For instance, if a survey is intended for both physicians and nursing personnel, both groups should participate in scale development. Scale reliability and validity testing should also select normative samples according to the intended target population. For example, for a scale intended for both leaders and general staff, the sample for reliability and validity testing should include both groups without extending beyond them. Once developed, scale use should adhere to these specifications, preferably selecting corresponding samples from institutions according to regulations. Particularly in comparative analyses, samples selected from institutions being compared should at least strive to ensure homogeneity. Only through these measures can scale evaluation objectivity be better guaranteed. These are our findings and reflections from investigating chronic disease management capacity in primary medical institutions in the Chengdu region, which we hope will provide useful insights for chronic disease management, particularly in the construction and application of quality evaluation systems.

Author Contributions

YU Guo was responsible for conceptualization, literature review, statistical analysis, and drafting the manuscript. CHEN Jinhua contributed to literature analysis, data organization, and conceptualization. WU Yuelei oversaw project design, quality control, and manuscript revision, bearing overall responsibility for the article. LIU Shuyi contributed to topic direction and manuscript revision. DU Wen participated in data collection and organization. XIAO Zhu participated in

data collection and organization. WANG Yijun participated in data collection and organization.

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Note: Figure translations are in progress. See original paper for figures.