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Review Article

Structure equation modeling in oral health research: A review of applications and considerations

Abhishek Purohit[1], Abhinav Singh[1], Bharathi M. Purohit[2]

[1]Department of Dentistry, Regional Training Centre for Oral Health Promotion, All India Institute of Medical Sciences, Bhopal, Madhya Pradesh, [2]Division of Public Health Dentistry, Centre for Dental Education and Research, WHO Collaborating Centre for Oral Health Promotion, All India Institute of Medical Sciences, New Delhi, India

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Address for correspondence:
Dr. Abhinav Singh,
Department of Dentistry,
Regional Training Centre
for Oral Health Promotion,
All India Institute of
Medical Sciences, Bhopal,
Madhya Pradesh, India.
E-mail: drabhinav.singh@
gmail.com

ABSTRACT

This review provides an overview of structure equation modeling (SEM) and its applications in dental research. SEM is a statistical technique that allows researchers to examine the relationships between variables and is useful for analyzing data from a wide range of research designs, including cross-sectional, longitudinal, and experimental studies. The process involves specifying a theoretical model, testing the model with data, and evaluating the model fit. It has been used in dental research to investigate a wide range of topics, including dental diseases, oral health-related quality of life, and dental anxiety. SEM is particularly useful in modeling the relationships between various risk factors and dental diseases and also has the potential to provide a deeper understanding of the multifactorial nature of dental diseases such as periodontitis, dental caries, and oral cancer. Moreover, the insights provided can aid in the development of effective strategies for the prevention and treatment of dental diseases. It is a powerful statistical tool that can be used by dental researchers to gain a better understanding of the intricate interplay of factors that underlie dental diseases and other oral health-related outcomes.

Key Words: Dental research, oral health research, structure equation modeling

INTRODUCTION

Medical research is a critical field that aims to advance our understanding of various diseases, their causes, and potential treatments.[1] With the increasing complexity of medical data, researchers have turned to advanced statistical methods to extract meaningful insights from the data. These methods have proven to be essential in identifying trends, patterns, and relationships in medical data that would otherwise go unnoticed.[2,3] Advanced statistical methods in medical research have revolutionized the way we approach health care, from personalized medicine to precision diagnostics.[4,5]

Dental research is a constantly evolving field that involves the study of the anatomy, physiology, pathology, and treatment of teeth and the oral cavity. Researchers in this field employ a wide range of scientific methods, including experimental, observational, and epidemiological studies, to investigate various aspects of dental health. They explore topics such as the etiology and pathogenesis of dental diseases, the efficacy and safety of dental treatments, and the development of new materials and technologies for dental care.[6] Dental research plays a crucial role in advancing our understanding

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of oral health and in developing effective strategies for the prevention, diagnosis, and treatment of dental diseases.[7] Moreover, dental research has significant implications for overall health, as oral health is closely linked to a range of systemic diseases, including diabetes, cardiovascular disease, and cancer. Therefore, continued investment in dental research is essential for improving oral health and enhancing overall health outcomes.[8,9]

Structure equation modeling (SEM) is a statistical technique that has become increasingly popular in dental research. It is a powerful tool for analyzing complex relationships among multiple variables and can be used to test theoretical models, identify important predictors, and estimate causal effects. This review article aims to provide an overview of SEM, its applications in dental research, and the key considerations for conducting SEM studies.[4]

WHAT IS STRUCTURE EQUATION MODELING?

SEM is a statistical technique that allows researchers to test complex theoretical models. It is a combination of factor analysis and regression analysis, and it is used to determine the relationships among variables. SEM is a multivariate statistical technique that allows researchers to examine how variables are related to one another and how they contribute to a particular outcome or dependent variable. SEM is a flexible technique that can be used to analyze data from a wide range of research designs, including cross-sectional, longitudinal, and experimental studies.[8] The SEM process involves specifying a theoretical model, testing the model with data, and evaluating the model fit. The theoretical model is based on *a priori* assumptions about the relationships among variables, and it is typically represented graphically as a path diagram. The path diagram consists of variables represented as boxes and arrows representing the hypothesized relationships between the variables.[8] The data used to test the theoretical model are collected from a sample of participants. The data are then analyzed using SEM software, which estimates the relationships between the variables and the fit of the model to the data. The model fit is assessed using a variety of fit indices, which provide information about how well the model fits the data.[10,11]

APPLICATIONS OF STRUCTURE EQUATION MODELING IN DENTAL RESEARCH

SEM has been used in dental research to investigate a wide range of topics, including oral health-related quality of life (OHRQoL), dental anxiety, oral health behavior, and dental caries. The following sections provide an overview of some of the key applications of SEM in dental research.[9]

Dental diseases

The use of SEM in dental research has the potential to provide a deeper understanding of the multifactorial nature of dental diseases such as periodontitis, dental caries, and oral cancer. SEM is particularly useful in modeling the relationships between various risk factors and dental diseases. By analyzing these relationships, SEM can identify key factors that contribute to the development of dental diseases and offer insights into potential intervention strategies. For instance, SEM can be employed to model the complex relationships between dietary habits, oral hygiene practices, genetics, and the occurrence of dental caries. In addition, SEM can help explore the influence of environmental factors such as fluoride exposure on the development of dental diseases. In summary, SEM is a powerful statistical tool that can be used by dental researchers to gain a better understanding of the intricate interplay of factors that underlie dental diseases. The insights provided by SEM can aid in the development of effective strategies for the prevention and treatment of dental diseases.[12,13]

Oral health care

Structural equation modeling (SEM) is a statistical technique that is widely used in social science research to evaluate the relationships between latent constructs, observed variables, and measurement errors. In the context of testing a conceptual model of oral health, SEM can be used to examine the complex interrelationships between different oral health factors and their potential impact on overall oral health outcomes. By specifying a set of hypothesized relationships between different constructs and using statistical techniques to estimate the strength and direction of these relationships, SEM can provide researchers with a powerful tool for assessing the validity and generalizability of their conceptual models. Ultimately, the use of SEM in oral health research can help advance our understanding of

the complex factors that contribute to oral health outcomes and inform the development of more effective interventions for promoting oral health and preventing oral diseases.[14]

Oral health-related quality of life

OHRQoL is a multidimensional construct that encompasses physical, psychological, and social aspects of oral health. SEM has been used to investigate the complex relationships among the various dimensions of OHRQoL, as well as the factors that contribute to OHRQoL. A study conducted by Saho *et al.* in 2019 among Japanese university students used SEM to examine the relationships among dental anxiety, perceived oral health status, and OHRQoL in a sample of adults. The results showed that dental anxiety was negatively associated with OHRQoL and that perceived oral health status partially mediated this relationship. The study also found that dental anxiety was directly associated with perceived oral health status.[15]

Dental anxiety

Dental anxiety is a common problem that can have a significant impact on oral health. SEM has been used to investigate the factors that contribute to dental anxiety, as well as the relationships among dental anxiety, oral health behavior, and oral health outcomes. A study conducted by Vigu and Stanciu in 2019 among Romanian medical university students used SEM to investigate the relationships among dental anxiety, oral health behavior, and dental caries in a sample of adolescents. The results showed that dental anxiety was negatively associated with oral health behavior and that oral health behavior was negatively associated with dental caries. The study also found that dental anxiety was indirectly associated with dental caries through its impact on oral health behavior.[16]

Behavior research

Oral health behavior is a key determinant of oral health outcomes. SEM has been used to investigate the factors that influence oral health behavior, as well as the relationships among oral health behavior, oral health status, and other health behaviors. Studies conducted by Qin *et al.* in 2019 and Zhang *et al.* in 2020 among the Chinese population, used SEM to investigate the relationships among oral health behavior, oral health status, and smoking behavior in a sample of adults. The results reflected that oral health behavior was positively associated with oral health status and that smoking behavior was negatively associated with oral health status. The study also found that oral health behavior was indirectly associated with smoking.[12,17,18]

KEY CONSIDERATIONS FOR CONDUCTING STRUCTURE EQUATION MODELING STUDIES

When conducting an SEM study, there are several key considerations that researchers should keep in mind. It is important to carefully specify the theoretical model, including the hypothesized relationships among variables and the direction of those relationships. Researchers should also consider the appropriate measurement models for each variable, such as confirmatory factor analysis, and should use appropriate statistical tests to assess the validity and reliability of the measures. Researchers should carefully consider the sample size and power of their study. SEM requires a relatively large sample size, as well as adequate power to detect meaningful relationships among variables. Researchers should also consider the distributional properties of their data and use appropriate techniques to address issues such as non-normality and missing data. Researchers should carefully evaluate the fit of their model to the data. There are a variety of fit indices that can be used to assess model fit, including the Chi-square test, the comparative fit index, and the root mean square error of approximation. Researchers should also consider the potential for model misspecification and should use techniques such as sensitivity analysis to assess the robustness of their findings.

Finally, researchers should carefully interpret their findings and consider the limitations of their study. SEM can provide valuable insights into the relationships among variables, but it is important to remember that the results are based on statistical models and may not necessarily reflect causal relationships or generalizable findings. Researchers should carefully consider the implications of their findings and the potential for future research to build on their work.

ADVANTAGES OF STRUCTURE EQUATION MODELING

There are several advantages to using SEM in dental research. SEM allows researchers to test

complex theoretical models that are difficult to analyze using traditional statistical techniques. This can help researchers to better understand the complex relationships among variables and to identify important predictors of dental health outcomes.[19-21] It provides a comprehensive assessment of the measurement models and the structural models and allows researchers to evaluate the fit of the overall model to the data. This can help to ensure that the results are robust and reliable.[9] It can be used to test competing models and to compare the relative strengths of different hypotheses. This can help to refine theoretical models and to identify areas for future research.[22]

Why do we prefer structure equation modeling over regression?

Structural equation modeling (SEM) and regression analysis are two statistical techniques widely used to model relationships between variables. While both techniques have their strengths and limitations, SEM is preferred over regression analysis in certain situations due to its unique features. One of the main advantages of SEM is its ability to model complex relationships between multiple variables. Unlike regression analysis, SEM can handle models with multiple dependent and independent variables, as well as their interrelationships.[23] In addition, SEM allows researchers to test complex theoretical models and compare them to alternative models using goodness-of-fit statistics.

Another benefit of SEM is its capability to account for measurement error in both the dependent and independent variables. By contrast, regression analysis assumes that all variables are measured without error. SEM can also handle missing data more effectively by incorporating all available data into the analysis.[24] Moreover, SEM allows researchers to distinguish between the direct and indirect effects of one variable on another, while regression analysis only measures the direct effects. SEM is a more powerful statistical technique than regression analysis in modeling complex relationships between variables and testing theoretical models.[8] Nonetheless, SEM requires more advanced statistical skills and software and may be more computationally intensive than regression analysis.

LIMITATIONS OF STRUCTURE EQUATION MODELING

Despite its many advantages, SEM also has several limitations that should be considered when interpreting the results of SEM studies. SEM requires a relatively large sample size and may not be appropriate for smaller studies or studies with limited power. SEM relies on assumptions about the measurement models and the structural models, and violations of these assumptions can lead to biased or unreliable results. Researchers should carefully evaluate the assumptions underlying their model and use appropriate statistical techniques to address issues such as nonnormality or missing data. SEM can be computationally intensive and requires specialized software and training. Researchers should be familiar with the software and the underlying statistical principles to ensure that their results are accurate and reliable.[25]

CONCLUSION

SEM is a powerful statistical technique that has become increasingly popular in dental research. It allows researchers to test complex theoretical models, identify important predictors of dental health outcomes, and refine theoretical models for future research. However, SEM also has several limitations that should be carefully considered when interpreting the results of SEM studies. Researchers should carefully specify their theoretical models, consider the appropriate measurement models and statistical tests, evaluate the fit of the model to the data, and carefully interpret their findings. Overall, SEM is a valuable tool for dental researchers and can provide valuable insights into the complex relationships among variables that contribute to oral health outcomes.

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Conflicts of interest

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