INVITED EDITORIAL

NETWORK ANALYSIS AND AGING: A NEW LOOK AT RESEARCH IN OLDER ADULTS

Análise de redes e envelhecimento: um novo olhar para as pesquisas em idosos

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The investigation of clinical issues related to aging poses specific challenges because the most critical health conditions in older adults result from a complex interaction between multiple etiologic and modifying factors.[1,2] For example, the nearly inevitable presence of multimorbidity (diabetes, chronic renal failure, arrhythmias) and geriatric syndromes (lack of social support, cognitive impairment, urinary incontinence, instability, and falls) can hinder studies of a specific clinical condition such as high blood pressure.[3] In this context, network analysis is a research approach that can describe, explore, and understand the simultaneous connections among several aspects related to one or more health conditions.[4-6] This method uses graphic representations to illustrate connections between multiple factors, which allows investigators to analyze multiple simultaneous associations between variables in a manner hardly possible with other statistical techniques.[2,6]

It is worth mentioning that this model of analysis is based on the notion of the network, conceived as a set of relationships between actors.[5,6] Therefore, for the delimitation of a social network, two essential components must be defined: actors and connections. Network analysis is both a theory (network theory) and a method (analysis of regularities or patterns of interaction within the network).[5,6] Both structural analysis and network theorizing encompass two important analytical perspectives: to estimate the predictors or the consequences of networks. On the one hand, there are concerns about the properties of the network that serve as a dependent variable (outcome) and, therefore, the challenge is to understand the predictors that led to the emergence of this phenomenon. On the other hand, the network construct can be regarded as an independent variable (predictor), in which case the interest is to evaluate the consequences of this phenomenon.[5,6]

Network analysis originated in the field of mathematics in the 18th century.[4-6] Later, it was widely used by sociologists and anthropologists in pioneering research on social networks among human beings. These works are responsible for the significant development of network analysis starting in the 1970s, and served as the basis for what is now known as structural network analysis.[4-6] In recent decades, with the advent of technology and statistical software, use of this method has become increasingly widespread in the fields of administration and sciences, with particular impact on research in public health.[4] As examples, network analysis has been used to investigate models of disease dissemination, the role of social relationships on lifestyle habits, and the way experts organize research networks.[5,7] Modern network software incorporates high-quality layouts which help investigators interpret findings for these difficult research questions.[4,5]

Although the methods used in network analysis are becoming more common, most researchers and health professionals are still unfamiliar with them.[4] Wider dissemination and training on these methods are urgently needed to expand network analysis into areas where, despite enormous potential, it is still underutilized.[2,4] In this line, the article by Leme et al. published in this issue of *Geriatrics, Gerontology and Aging* fills a gap by offering valuable information for health professionals on

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DOI: 10.5327/Z2447-2123202020141EDT2

how to interpret and even implement network analysis in practice.[8] The authors present both the theoretical aspects and practical applicability of the method, using examples and language accessible to readers with basic and advanced research knowledge.[8]

Particularly in the field of geriatrics and gerontology, network analysis emerges as a key opportunity for advancing research on various topics related to older adults.[2] Examples include the biological mechanisms involved in the aging process, aspects related to frailty and other geriatric syndromes, and the validation of instruments employed in the geriatrics and gerontology field.[2,9,10]

The aging process results from the interaction between several key biological processes, such as inflammation, cellular and immune senescence, mitochondrial dysfunction, and reduced resistance to stressors.[9,11] While the mechanisms underlying these processes have a modest effect on aging when acting individually, the interactions between them determine a complex network that affects various organic systems and causes the decline in physiological function associated with age. In this area, the use of the network analysis enables a more comprehensive understanding of the connections between genetic factors, molecular substances, physiological functions, and psychological aspects, which helps to disentangle the complexity of the health and disease states associated with age.[11] Network analysis has also been applied to investigate the network of processes that control cellular homeostasis, to elucidate the different theories of aging and the origin and evolution of diseases in humans.[9,11]

Network analysis has also become an interesting option for studies on the frailty syndrome.[2,12-14] While the complex needs of frail patients continue to grow and overwhelm health services, the concepts of frailty syndrome remain under debate among specialists.[2] There is an urgent need for a deeper understanding of how different aspects of health interact along the path that leads to frailty and its adverse consequences. In a prior study on this syndrome using a deficit accumulation model composed of 35 health-related items, Garcia-Pena et al. demonstrated that self-perceived health and the ability to walk a block play a central role in the association of frailty with the mortality outcome.[2] However, the interactions between variables presented distinct patterns depending on the level of accumulated deficits. In people with few deficits, the interactions between items were smaller, and aspects related to vitality, such as level of physical activity, body mass index, weight loss, and exhaustion, play core roles in the progression to frailty. On the other hand, in those older adults who are more impaired (i.e., experience more accumulated deficits), there is intense connectivity between items, and characteristics related to mobility (e.g., transfer, ability to walk, climb or descend stairs, carry large objects) are more important than other health characteristics in defining the frail phenotype.[2] Further research should focus on the meaning of the interactions and how they change over time. It is also important to elucidate how these characteristics that define frailty are associated with genetic and cellular mechanisms.[13] This scenario reveals how network analysis can be useful in producing cutting-edge knowledge about the syndrome, with a view to developing better approaches to care for frail older people in future.

Other topics of great interest in the field of aging can also benefit from the network analysis approach. One example is research on multimorbidity which seeks to understand how different chronic conditions and pathophysiological mechanisms interact with each other leading to adverse outcomes in older adults.[11,15] A recent study in this area revealed genetic factors shared among diseases and linked to specific multimorbidity patterns, highlighting possible associations between breast cancer, diabetic neuropathy, and nutritional anemia as well as between diseases of the nervous system and nutritional anemias.[15]

Finally, network analysis can be very useful for the field of studies that integrates psychometrics and aging.[10] It is noteworthy that, unlike in other areas of clinical research, the most relevant predictors and outcomes in geriatrics and gerontology are clinical diagnoses or instruments often composed of a large number of items, such as cognitive impairment.[1] In this field, network analysis allows investigators to make more robust conclusions about the construct validity of an instrument, supplementing the findings of factor analysis. This strategy has already been used to demonstrate that the Mini-Mental State Examination consists of a single global measure of cognitive functioning, after results from factor analyses of the same subject proved inconsistent.[16]

In conclusion, Leme et al. offer a valuable contribution to expand awareness of network analysis among health professionals, especially in the field of geriatrics and gerontology.[8] This technique has the potential to contribute to research involving older adults. While studies on such relevant topics as the aging process, frailty, and multimorbidity are already ongoing, others will soon emerge on subjects such as comprehensive geriatric assessment, access to health care, and quality of life. This should prompt major advances on these topics in the coming years. Health professionals will be charged with interpreting and translating information derived from such research into better care for older adults. Reading this issue of *Geriatrics, Gerontology and Aging* is an important step toward the success of this mission.

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