Profiling Depression Risk and Psychological Well-Being in Elderly: A Fuzzy Multicriteria Approach

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Abstract

The purpose of this study is to analyze depression and psychological well-being in older adults in the city of Bello, Colombia, by identifying clusters of individuals with varying levels of risk to explore the implications for care and support. To achieve this objective, 164 older adults were surveyed using the GDS-15 Scale to measure depression. Cluster analysis was employed to classify groups with similar depression risk profiles and psychological well-being. Additionally, Cronbach's alpha was used to determine the reliability of latent constructs. A Fuzzy Hierarchical Process Analysis model, supplemented by expert input and surveys, was utilized to prioritize risk levels and rank sub-factors by their local and global weight in the model.

The study identifies three critical clusters that influence the level of depression risk in the population: Emotional State and Life Satisfaction (46.78%), Cognitive Ability and Self-Esteem (35.87%), and Social Interaction and Activities (17.35%). These findings underscore the importance of considering a variety of interrelated factors, highlighting that emotional health, cognitive self-esteem, and social interactions are essential determinants in the assessment of depression risk.

This multidimensional approach is crucial for the development of more effective preventive and therapeutic strategies in the fight against depression. The results suggest that a significant proportion of older adults are at high risk for depression, emphasizing the need for comprehensive and tailored interventions to address their unique needs.

Keywords: depression in older adults, mental health, cluster analysis, socioeconomic inequality, aging.

Resumen

El propósito de este estudio es analizar la depresión y el bienestar psicológico en personas mayores en la ciudad de Bello, Colombia, identificando conglomerados de individuos con diferentes niveles de riesgo para explorar las implicaciones para el cuidado y el apoyo de esta población. Para lograr este objetivo, se encuestó a 164 personas mayores utilizando la Escala de Depresión Geriátrica (GDS-15). Se empleó el análisis de conglomerados para clasificar grupos con perfiles similares de riesgo de depresión y bienestar psicológico. Además, se utilizó el alfa de Cronbach para determinar la fiabilidad de los constructos latentes. Un modelo de Análisis Jerárquico de Procesos Difusos (FAHP), complementado con la opinión de expertos y encuestas, se utilizó para priorizar los niveles de riesgo y clasificar los subfactores según su peso local y global en el modelo.

El estudio identifica tres conglomerados críticos que influyen en el nivel de riesgo de depresión en la población: Estado Emocional y Satisfacción con la Vida (46.78%), Capacidad Cognitiva y Autoestima (35.87%), e Interacción Social y Actividades (17.35%). Estos hallazgos resaltan la importancia de considerar una variedad de factores interrelacionados, destacando que la salud emocional, la autoestima cognitiva y las interacciones sociales son determinantes esenciales en la evaluación del riesgo de depresión.
Este enfoque multidimensional es crucial para el desarrollo de estrategias preventivas y terapéuticas más efectivas en la lucha contra la depresión. Los resultados sugieren que una proporción significativa de estas personas mayores está en alto riesgo de depresión, enfatizando la necesidad de intervenciones comprensivas y personalizadas para abordar sus necesidades únicas.
Palabras clave: depresión en personas mayores, salud mental, análisis de conglomerados, desigualdad socioeconómica, envejecimiento.

1. Introduction

The population aging in Colombia, marked by a decline in fertility and changes in morbidity and mortality patterns, presents substantial challenges with economic, social, and health repercussions. This phenomenon demands a thorough review of health and social support systems to adequately respond to the needs of a growing elderly population (O'Donovan et al., 2020; Cortés and Morales, 2021; Reynolds et al., 2021; Jiménez-Mora et al., 2020). Social inequalities and limited access to healthcare services, exacerbated by internal conflicts, enhance the vulnerability of the elderly, highlighting the urgency to address these inequities (García-Ramírez et al., 2020; Cortés, 2022).

The prevalence of depression in the Colombian geriatric population, influenced by psychosocial factors and underlying health conditions, has become a concern. Research indicates that depression is significantly associated with elements such as social isolation, cognitive impairment, and the presence of chronic diseases (Salazar et al., 2023; Alvarado et al., 2022; Choque-Gallegos, 2021). Moreover, the COVID-19 pandemic has intensified mental health issues in older adults, increasing the prevalence of depressive disorders and underscoring the need for comprehensive intervention strategies (Reynolds et al., 2021; O'Donovan et al., 2020; Molina-Vargas et al., 2020).

Cluster analysis emerges as a valuable statistical tool for evaluating depression and its patterns in the elderly. Previous studies, such as those by Félix et al. (2020) and Vilchez-Cornejo and Soriano-Moreno (2018), have

revealed variability in depression rates, significantly varying according to the population context and evaluation methods used. Additionally, a high prevalence of depression has been found in sectors of the elderly population affected by poverty, emphasizing the importance of adequate assessment tools such as the Yesavage test (Mendoza et al., 2021; Sáenz-Miguel et al., 2019).

Based on the framework outlined above, the primary objective of this research is to analyze depression and psychological well-being in elderly people in Bello, Colombia, identifying clusters of individuals with different risk levels for a deeper understanding of the implications for their care and support. This approach aims not only to contribute to the specific knowledge of the Colombian reality but also to generate strategies aimed at improving the quality of life of older adults, considering the demographic and social variables that shape their aging experience.

2. Materials and Methods

The study methodology, conducted in Bello, was meticulously designed to explore the prevalence of depression in the geriatric population over 65 years old and examine how this incidence is associated with sociodemographic variables such as socioeconomic level (SEL), age, and gender. Research on the prevalence of depression in the elderly population over 65 and its association with sociodemographic variables like socioeconomic level, age, and gender is crucial for understanding and addressing this public health issue.

To carry out this cross-sectional study with scientific rigor, a sample of 164 individuals was selected from an approximate universe of 30,000 inhabitants, applying a random convenience sampling strategy that allowed for the collection of a varied and significant representation of the population.

Data collection was conducted at various community points, ensuring confidentiality and respect for the privacy of participants at all times. The Geriatric Depression Scale (GDS-15) was used as the primary instrument for depression assessment, complemented by statistical analysis using SPSS software. Techniques included descriptive statistics and K-means cluster analysis, the latter being especially relevant for its ability to uncover heterogeneity in depression manifestations. By grouping individuals according to the similarity of their responses on the GDS-15, specific patterns and differentiated profiles of depression could be identified.

This quantitative approach not only enabled the diagnosis of depression prevalence in numerical terms but also provided valuable insights into severity and specific symptoms through the clusters formed. This subgroup analysis, based on a solid literature review and expert validation, paved the way for more personalized treatments and early intervention strategies and allowed for a more complex and nuanced understanding of the factors influencing depression within this age cohort, laying the groundwork for more focused and effective therapeutic approaches.

2.1. Instruments

The data collection process included the use of a Socioeconomic Level Questionnaire (SEL) and the Geriatric Depression Scale (GDS-15). The SEL questionnaire gathered information on demographics, education, income, and family size for classification from low to high, considering years of education and income adjusted for family size. This approach is consistent with previous research that has used similar methods to assess socioeconomic factors (Hernández et al., 2023), highlighting the importance of SEL in research due to its influence on aspects like academic performance and health.

The GDS-15 is a globally recognized and utilized tool for assessing depression in older adults (Sacuiu et al., 2019; Gómez et al., 2022). Its use has extended to different cultural and linguistic contexts, including Chinese, Korean, Igbo, and Hindi populations, demonstrating its intercultural versatility (Zhao et al., 2019; Zhang et al., 2022; Mgbeojedo et al., 2022; Mehra et al., 2021; Quiroz et al., 2020; Jeong et al., 2020). Studies have confirmed its psychometric properties, such as internal consistency, sensitivity, and specificity, ensuring its reliability and validity in various settings (Wongpakaran et al., 2019; Peláez et al., 2020; Shrestha et al., 2020).

The GDS-15 has proven effective in identifying depressive symptoms in older adults, confirming its utility in varied clinical contexts (Rensma et al., 2020; Luna-Orozco et al., 2020). It has also been used in longitudinal studies to monitor the evolution of depressive symptoms over time, evidencing its utility in the continuous assessment of depression in older adults (Rensma et al., 2020).

Although the GDS-15 is widely used and possesses strong psychometric properties, studies have noted limitations such as its inability to detect somatic symptoms and its inadequacy in certain cultural groups (Calle et al., 2022; Zhang et al., 2019). Its multidimensional nature and the challenges of its factorial structure are also discussed (Quiroz et al., 2020). Nevertheless, the GDS-15 remains a reliable and validated tool for screening depressive symptoms in the elderly in various contexts, underscoring its relevance in geriatric mental health assessment.

The study methodology involved evaluating depression using statistical analysis, literature review, and expert confirmation, employing the Geriatric Depression Scale (GDS-15), as indicated in Table 1, and variables such as SEL, age, and gender. Data collection was carried out at community points, maintaining confidentiality. Analysis was conducted with SPSS, using descriptive statistics and cluster analysis.

To determine the risk of depression in the elderly population using the 15-item Geriatric Depression Scale (GDS-15), the scores obtained in each question are summed. Thus, the overall score can vary between 15, indicating a very high risk of depression, and 75, reflecting a very low risk. This total sum is contrasted with Table 1, which classifies the levels of depression risk on a scale of 1 to 7, with level 1 corresponding to scores between 15 and 20, indicating a very high risk of depression, while level 7, corresponding to scores between 71 and 75, indicates a very low risk. This method provides a quantitative framework for assessing the risk of depression and facilitates the identification of individuals who may require specialized care, thereby providing a clear and structured framework for identifying and classifying depressive symptoms in the elderly and facilitating the design of appropriate intervention strategies.

Table 1. Classification of depression levels.

Risk level	Description	Range of values
1	Very high risk of depression	15-20
2	High risk of depression	21-30
3	Medium-high risk of depression	31-40
4	Medium risk of depression	41-50
5	Medium-low risk of depression	51-60
6	Low risk of depression	61-70
7	Very low risk of depression	71-75

Source: Own elaboration.

1.1 Expert Judgments and Fuzzy Analytic Hierarchy Process

1.2

After the cluster analysis for classifying the elderly, the final step of the proposed methodology focused on determining the relative importance of the dimensions and variables established in the cluster analysis. To this end, the opinions of a group of 10 professionals in gerontology were collected through a non-probabilistic convenience sampling (Otzen & Manterola, 2017) to identify the priority risk factors for depression in the elderly population. Additionally, the process of collecting expert judgments was conducted in person using a structured questionnaire with the 9-point scale proposed by Saaty (2008), considering the following values: 1 (equal priority), 3 (moderately prioritized), 5 (strongly prioritized), 7 (very strongly prioritized), 9 (extremely prioritized), and 2, 4, 6, and 8 for intermediate values between two adjacent judgments.

Once the expert judgments were collected, the Fuzzy Analytic Hierarchy Process (FAHP) model developed by Zadeh (1965) was employed, recognizing that this tool is highly effective in capturing, analyzing, and representing human verdicts using Triangular Fuzzy Numbers (TFNs). Thus, to apply the FAHP model, the expert judgments were first converted into TFNs to allow a more precise interpretation of the priorities of the gerontology professionals, as expressed in the membership function shown in Equation (1).

$$1.1.\ \mu_{\tilde{A}}(x) = \begin{cases} 0,\ x < l \\ \frac{(x-l)}{(m-l)}, l \le x \le m \\ \frac{(u-x)}{(u-m)}, m \le x \le u \\ 0, x > u \end{cases} \quad (1)$$

Considering the structure of the membership function and the arithmetic laws of fuzzy logic (Aghdaie, 2017), the following steps were followed in the FAHP model to determine the general and specific weights of depression risk factors in older adults:
Step 1: Once the expert judgments were converted into TFNs, the triangular values ($lower\ value = l_i$, middle value= m_i, $upper\ value = u_i$) were structured into individual pairwise comparison matrices between variables, as highlighted in Equation (2).
Wheter $\widetilde{D}^k = \left[\tilde{a}_{ij}^k\right]$ The fuzzy comparative matrix in pairs of $k^{ésimo}$ evaluators, $where\ k = 1,2, \dots, p$

$$\widetilde{D}^k = \begin{bmatrix} (1,1,1) & \tilde{a}_{12}^k & \cdots & \tilde{a}_{1n}^k \\ \tilde{a}_{21}^k & (1,1,1) & \cdots & \tilde{a}_{2n}^k \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1}^k & \tilde{a}_{n2}^k & \cdots & (1,1,1) \end{bmatrix} \quad (2)$$

Where $\tilde{a}_{ij}^k \times \tilde{a}_{ji}^k = 1$ i=j=1,2…, n

Step 2: Seeking to synthesize the judgments into a single matrix per category, the fuzzy comparison matrices were combined by using the geometric mean proposed by Buckley (1985), as highlighted in Equation (3).

Wheter $\widetilde{D} = [\tilde{a}_{ij}]$ The fuzzy matrix of combined pairwise comparison.

$$\widetilde{D} = \begin{bmatrix} (1,1,1) & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & (1,1,1) & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & (1,1,1) \end{bmatrix} \quad (3)$$

Where $\tilde{a}_{ij} \times \tilde{a}_{ji} = 1$ i=j=1,2…, n y $\tilde{a}_{ij} = \left(\tilde{a}_{ij}^{1} \otimes \tilde{a}_{ij}^{2} \otimes \ldots \otimes \tilde{a}_{ij}^{p}\right)^{\frac{1}{p}}$

Step 3: The consistency of the combined fuzzy matrix of pairwise comparison is calculated by defuzzifying the fuzzy number. It is assumed that if the combined fuzzy comparison matrix is consistent, then the combined fuzzy comparison is also consistent.

Step 4: Following Buckley (1985), the diffuse weight $\tilde{w}_i$ for each criterion (i) It is calculated using the geometric mean, as highlighted in the equations (4) y (5).

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{in})^{\frac{1}{n}} \quad (4)$$

$$\tilde{w}_i = \tilde{r}_i \times (\tilde{r}_1 \otimes \tilde{r}_2 \otimes \ldots \otimes \tilde{r}_n)^{-1} \quad (5)$$

Where $\tilde{r}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ y $(\tilde{r}_{ij})^{-1} = \left(\frac{1}{u_{ij}}, \frac{1}{m_{ij}}, \frac{1}{l_{ij}}\right)$

Step 5: Once the final diffuse weights for each general and specific risk factor have been obtained, the diffuse weights $\tilde{w}_i = (l_i, m_i, u_i)$ they are defuzzified using the center of area defuzzification (COA) method, as suggested by Pehlivan et al. (2017) to obtain the final weight represented by a sharp number and as highlighted in Equation (6).

$$w_i = \frac{l_i + m_i + u_i}{3} \quad (6)$$

Step 6: Finally, the weights obtained from the defuzzification method were centrally normalized so that the sum of the proportions of all categories was equal to 1, as shown in Equation (7).

$$w_{n_i} = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (7)$$

2. Resultados

Following the implementation of the proposed methodology, the initial results, presented in Table 2, indicate that 32.9% of the studied population falls within the low socioeconomic level (SEL) category, and 20.7% within the lower-middle category, making up over half of the sample (53.7%) in the lower levels. Additionally, 29.3% are classified as middle SEL, while only 7.3% and 9.8% are categorized as upper-middle and high SEL, respectively, indicating a lower representation in these higher strata. This distribution highlights that the majority of individuals have a low or lower-middle socioeconomic status.

Table 2. Socioeconomic level.

	Frequency	Percentage	Cumulative percentage
Low	54	32,9%	32,9%
Medium Low	34	20,7%	53,7%
Middle	48	29,3%	82,9%
Medium High	12	7,3%	90,2%
High	16	9,8%	100,0%
Total	164	100,0%	

Fuente: Elaboración propia.

Continuing with the results, Table 3, based on a K-means cluster analysis, classifies individuals into three clusters according to their responses on well-being and depressive symptoms. This classification enables a breakdown by dimensions that reveals critical areas for intervention and therapeutic support.

Cluster 1: "Moderate Well-being": This group, constituting 56.1% of the respondents (92 individuals), shows a more positive outlook on life, with moderate levels of satisfaction, happiness, and fewer depressive symptoms. Despite some emotional challenges, most report an acceptable level of life satisfaction. However, 33% of this group might be experiencing depressive symptoms, although to a moderate degree.

Cluster 2: "Emotional Distress and Depression": This cluster comprises 43.9% of the sample (72 individuals) and is characterized by higher emotional distress and depressive symptoms. This group reports low levels of life satisfaction, feelings of worthlessness, emptiness, and difficulties in concentration and feeling happy. They often compare their current situation unfavorably with others, feel more insecure and discouraged, and prefer to stay at home. The prevalence of depression in this group is 44%, with an average level of moderate depression.
To better understand the various facets of depression and identify key areas for intervention and therapeutic support, Table 3 groups the questions into three dimensions. A Likert scale was used to measure perceptions related to depression, where 1 indicates greater frequency or intensity of depressive symptoms and 5 indicates lesser.

Table 3. *Cluster centers.*

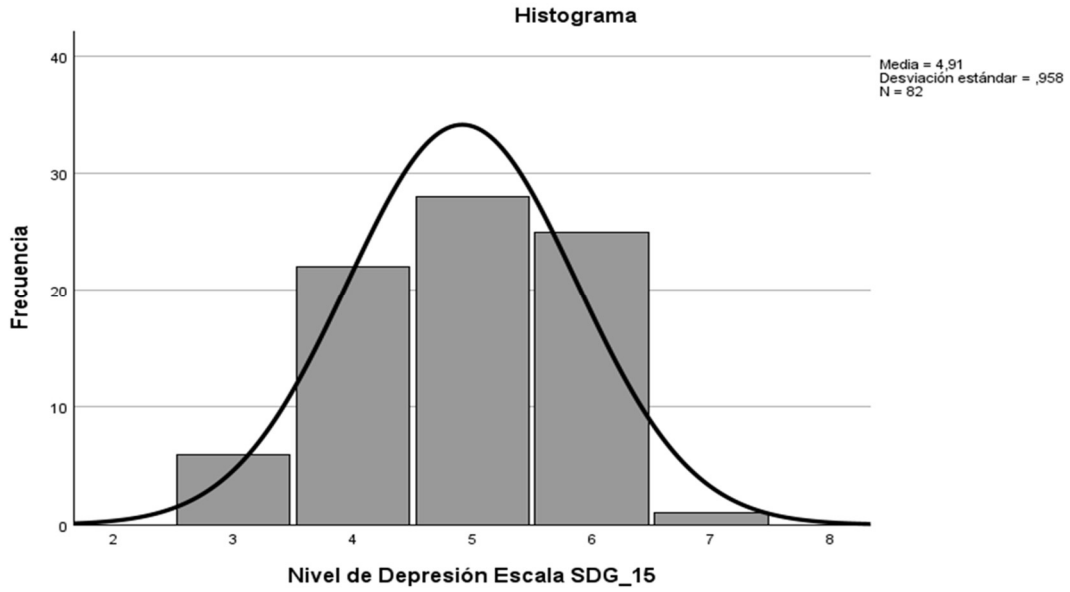
Cluster hubs		Cluster		Dimensions
		Moderate well-being	Malaise-Depression	
p1	How would you rate your satisfaction with your life in general?	3	1	Dimension 1: Emotional State and Life Satisfaction
p2	What is your level of utility compared to before?	3	2	
p3	How empty do you feel your life is?	3	1	
p5	How often do you feel happy?	3	1	
p7	How often do you feel worthless?	3	1	
p13	How would you rate your sense of despair in your current situation?	3	1	
p14	Do you feel that most people are against you?	2	1	
p4	How often do you experience difficulty concentrating on your usual tasks?	3	2	Dimension 2: Cognitive

p8	How would you rate your energy level?	3	1	Ability and Autonomy
p9	How often do you feel discouraged and fearful?	3	2	
p12	Do you find it easy to make decisions?	3	4	
p6	How do you compare to most people in terms of your current situation?	3	4	Dimension 3: Social Interaction and Activities
p10	How often do you prefer to stay home instead of going out and doing new things?	3	2	
p11	How empty do you feel your life is?	3	2	
p15	How often do you feel like your interests and activities have declined?	3	2	
Prevalence of depression		33%	44%	
Level of depression		4	6	
Number of participants per cluster		92 (56,1%)	72 (43,9%)	
Total valid data		164		

Source: Authors.

Additionally, it is crucial to highlight that Figure 1 illustrates the histogram of depression risk levels. The mean score of 4.91 indicates a moderate average level of depression within the sample. The median of 5.0 suggests that most participants are at a moderately high risk of depression. This observation is reinforced by the mode, which is also 5. The standard deviation of 0.958 indicates a moderate dispersion of scores.

Figure 1. Histogram of frequencies.



Source: Own elaboration.

Continuing with the results, Table 4 presents the iteration history of the K-means cluster analysis in SPSS, offering a detailed view of the algorithm's convergence process towards a stable solution. The evolution of the centroids over the seven iterations required for complete convergence shows decreasing changes in their positions until reaching zero, confirming the clusters' stability and the model's consistency. This is further supported by the absence of significant changes in case assignments between successive iterations.

Additionally, the minimal distance between the initial centers suggests a clear distinction between clusters, which is essential for the validity and interpretation of the analysis.

The information in Table 4 confirms the success of the cluster analysis and indicates that the resulting groups are statistically significant and relevant for further interpretation. It also ensures that the results are replicable and that the model is appropriate for the analyzed data.

Table 4. Iteration history.

Iteration history [a]

Iteration	Change in cluster hubs		
	1	2	3
1	5,532	3,871	1,324
2	,669	,551	,234
3	,466	,590	,345
4	,087	,098	,034
5	,142	,175	,120
6	,098	,127	,098
7	,000	,000	,000

a. Convergence achieved because there is no or no change in cluster centers. The change in the absolute maximum coordinate for any center is .000. The current iteration is 7. The minimum distance between the initial centers is 12,845.

Source: Authors.

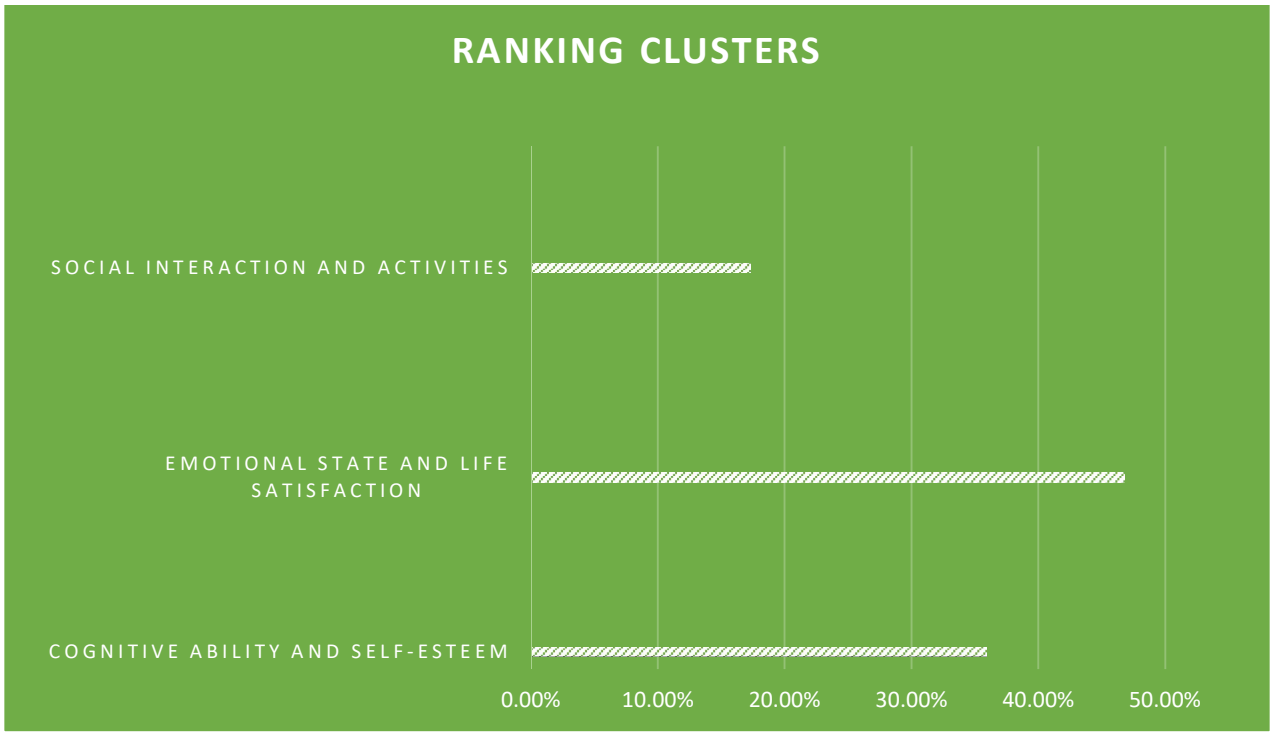
Furthermore, Table 5 presents the results of a FAHP model applied to classify the depression risk levels in a population of 164 adults. The study is broken down and analyzed as follows:
First, the importance proportions of the criteria are identified, with the following values noted: Cognitive Ability and Self-Esteem (35.9%), which holds significant weight, indicating that self-esteem and cognitive skills are crucial for assessing depression risk. Emotional State and Life Satisfaction (46.8%) is the most important criterion, underscoring the influence of emotional well-being and overall life satisfaction on mental health. Finally, Social Interaction and Activities (17.3%) is less weighted but acknowledges the importance of social interactions and daily activities in mental health.

Regarding the risk levels, Table 5 shows that High Risk of Depression carries the highest proportion of importance at 51.6%, suggesting that this area should be prioritized for interventions. This is followed by the Medium Risk of Depression level at 30.95%. Lastly, the No Risk (9.65%) and Low Risk of Depression (7.78%) levels indicate a less critical situation but still warrant monitoring.

Table 5. Aggregated Results by Risk Level according to each cluster.

Aggregated results for each alternative according to each criterion		High Risk Depression	Medium Risk Depression	Low Risk Depression	No Risk
Criterion	Pesos (Ni)				
Cognitive Ability and Self-Esteem	35,9%	47,7%	31,7%	8,5%	12,2%
Emotional State and Life Satisfaction	46,8%	52,1%	31,5%	7,8%	8,6%
Social Interaction and Activities	17,3%	58,5%	28,1%	6,3%	7,1%
Total (Alternative Value x Criterion Weight)		51,6%	30,9%	7,8%	9,7%

Source: Authors.



Clústeres	*Weight*	*Order*	*Subfactors*	*Local Weight*	*Global Weight*	*Order*	*Subfactor*	*Global Weight*
Cognitive Ability and Self-Esteem	*35,87 %*	2	*Energy Level*	43,3 %	15,5 %	*1*	*Life Satisfaction*	21,42 %
		3	*Feeling of Worthlessness*	25,8 %	9,2%	*2*	*Energy Level*	15,54 %
		11	*Feelings of Fear and Insecurity*	10,3 %	3,7%	*3*	*Feeling of Worthlessness*	9,25 %
		13	*Difficulty making decisions*	7,6%	2,7%	*4*	*Interest in New Activities*	7,57 %

		9	*Difficulty concentrating*	13,0 %	4,7%	*5*	*Desperation Current situation*	6,34 %
Emotional State and Life Satisfaction	*46,78 %*	1	*Life Satisfaction*	45,8 %	21,4 %	*6*	*Level of Usefulness in the Environment*	6,12 %
		6	*Level of Usefulness in the Environment*	13,1 %	6,1%	*7*	*Sentimiento de vacío con la vida*	5,07 %
		7	*Sentimiento de vacío con la vida*	10,8 %	5,1%	*8*	*Feeling of appreciation for your life*	4,72 %
		10	*Feeling Happy*	8,9%	4,2%	*9*	*Difficulty concentrating*	4,66 %
		5	*Desperation Current situation*	13,6 %	6,3%	*10*	*Feeling Happy*	4,17 %
		12	*Sentiment of People Against You*	7,8%	3,7%	*11*	*Feelings of Fear and Insecurity*	3,69 %
Social Interaction and Activities	*17,35 %*	4	*Interest in New Activities*	43,6 %	7,6%	*12*	*Sentiment of People Against You*	3,67 %
		8	*Feeling of appreciation for your life*	27,2 %	4,7%	*13*	*Difficulty making decisions*	2,74 %
		14	*You'd rather be at home than interact*	9,6%	1,7%	*14*	*You'd rather be at home than interact*	1,66 %
		15	*Feeling less capable than others*	6,9%	1,2%	*15*	*Feeling less capable than others*	1,20 %

Another significant result of the FAHP model is presented in Figure 2, which indicates the priority levels of the subfactors evaluated in the study of depression risk in older adults. This includes the global weights of each subfactor and their overall importance ranking. This provides a deeper understanding of the specific areas contributing to mental health and how they interrelate to form risk profiles.

The Cognitive Ability and Self-Esteem category includes critical components that directly affect an individual's perception of themselves and their environment. Within this category, Energy Level (15.5%) stands out as the second most important subfactor in the entire hierarchy, reflecting that the energy to face daily activities is crucial for self-esteem and cognition. Additionally, the subfactors Feeling of Worthlessness (9.2%) and Feeling of Fear and Insecurity (3.7%) also highlight the impact of personal utility and safety perceptions on mental state.

In the Emotional State and Life Satisfaction category, the subfactor Life Satisfaction (21.4%) emerges as the most influential among all the subfactors studied, confirming that happiness is fundamental to mental health. Other subfactors, such as Current Situational Despair (6.34%) and Sense of Usefulness in the Environment (6.12%), demonstrate how current life perception and feeling useful in one's surroundings significantly impact mental health.

In contrast, the Social Interaction and Activities category contains the subfactors with lower importance levels. However, Interest in New Activities (7.6%) is the most notable factor, suggesting that engagement in new activities can be an important indicator of well-being.

Table 6. Global weights of the subfactors for the different levels of risk.

Source: Authors.

The presentation of results in Table 7 outlines the general profile of the study participants. The sample consisted of 80.5% female and 19.5% male participants.

Other notable participant characteristics include 28% having incomplete primary education, 30.5% being part of families with three members, and 46.3% reporting a family income of less than one minimum wage. Additionally, 87.8% reported not living alone, and 65.9% indicated that they do not engage in physical activity.

Table 7. Frequency tables of the survey variables.

	Frec.	*%*	*% Acum.*		*Frec.*	*%*	*% Acum.*
Gender							
Male	32	19,5	19,5				
Female	132	80,5	100,0				
Educational Level				Family Size			
No formal education	24	14,6	14,6	One	20	12,2	12,2
Incomplete Primary	46	28,0	42,7	Two	46	28,0	40,2

Complete Primary	26	15,9	58,5	Three	50	30,5	70,7
Incomplete Secondary School	20	12,2	70,7	Four	30	18,3	89,0
Complete Secondary School	38	23,2	93,9	Five	2	1,2	90,2
Technician or Full University	8	4,9	98,8	more than 5	16	9,8	100,0
Graduate	2	1,2	100,0				
Family Income				Income by Family Member			
Less than 1 SMLV	76	46,3	46,3	Between 0 and 0.5 SMLV	88	53,7	53,7
Between 1 y 1,5 SMLV	60	36,6	82,9	Between 0.51 y 1 SMLV	56	34,1	87,8
Between 1,6 y 2 SMLV	14	8,5	91,5	Between 1.01 y 1,5 SMLV	10	6,1	93,9
Between 2.1 y 2,5 SMLV	8	4,9	96,3	Between 1,51 y 2 SMLV	4	2,4	96,3
Between 2,6 y 3 SMLV	4	2,4	98,8	Between 2 y 3 SMLV	2	1,2	97,6
More than de 3 SMLV	2	1,2	100,0	More than 3SMLV	4	2,4	100,0
Do you live alone or accompanied?				Perform physical activity			
Live Alone	20	12,2	12,2	Does not perform AF	108	65,9	66,7
He doesn't live alone	144	87,8	100,0	Engage in physical activity	54	32,9	100,0

Source: Authors.

Complementing the results presented so far, Table 8 highlights aspects of emotional well-being and life perception. The data reveals that 69.5% of participants express life dissatisfaction, over half feel useless (52.4%) and lack energy (56.8%). Additionally, 39% experience concentration problems, 48.8% report a lack of happiness, and 47.6% prefer not to leave their homes to seek new experiences.

There is a general sense of hopelessness (60.5%), a perception of hostility from others (54.9%), and a decrease in interests and activities (54.9%). These findings suggest a tendency towards isolation and potential depressive symptoms among the participants.

Table 8. Frequency tables model ESG-15.

	Frequency	Percentage	Accumulated		Frequency	Percentage	Accumulated
P1 How would you rate your satisfaction with your life in general?				P2 What is your level of utility compared to before?			
- Very dissatisfied	6	3,7	3,7	- Very useless	2	1,2	1,2
- Unsatisfied	8	4,9	4,9	- Useless	36	22,0	22,0
- Neutral	36	22,0	22,0	- Neutral	40	24,4	24,4
- Satisfied	46	28,0	28,0	- Useful	52	31,7	31,7
- Very satisfied	68	41,5	41,5	- Very helpful	34	20,7	20,7
P3 How empty do you feel your life is?				P4 How often do you experience difficulty concentrating on your usual tasks?			
Very empty	80	48,8	48,8	- Always	26	15,9	15,9
Empty	20	12,2	12,2	- Frequently	38	23,2	23,2

Normal	48	29,3	29,3	- Occasionally	50	30,5	30,5
Full	10	6,1	6,1	- Rarely	42	25,6	25,6
Very full	6	3,7	3,7	- Never	8	4,9	4,9
P5 How often do you feel happy?				P6 How do you compare to most people in terms of your current situation?			
- Never	52	31,7	31,7	- Much worse	4	2,4	2,4
- Rarely	28	17,1	17,1	- Worse	12	7,3	7,3
- Ocasionally	66	40,2	40,2	- Equal	78	47,6	47,6
- Frequently	18	11,0	11,0	Better	42	25,6	25,6
P7 How often do you feel worthless?				P8 How would you rate your energy level?			
- Always	72	43,9	43,9	Very Lacking Energy	62	37,8	37,8
- Frequently	20	12,2	12,2	Lack of Energy	32	19,5	19,5
- Occasionally	48	29,3	29,3	Normal	54	32,9	32,9
- Rarely	16	9,8	9,8	Good Energy	12	7,3	7,3
- Never	8	4,9	4,9	Lots of energy	4	2,4	2,4
P9 How often do you feel discouraged and fearful?				P10 How often do you prefer to stay home instead of going out and doing new things?			
- Always	46	28,0	28,0	- Always	42	25,6	25,6
- Frequently	28	17,1	17,1	- Frequently	36	22,0	22,0
- Occasionally	70	42,7	42,7	- Occasionally	56	34,1	34,1
- Rarely	18	11,0	11,0	- Rarely	22	13,4	13,4
- Never	2	1,2	1,2	- Never	8	4,9	4,9
P11 How empty do you feel your life is?				P12 Do you find it easy to make decisions?			
Very empty	36	22,0	22,0	- Very difficult	10	6,1	6,1
Empty	44	26,8	26,8	-Difficult	24	14,6	14,6
Neutral	60	36,6	36,6	Neutral	52	31,7	31,7
Full	18	11,0	11,0	Easy	36	22,0	22,0
Very full	6	3,7	3,7	Very easy	42	25,6	25,6
P13 How would you rate your sense of despair in your current situation?				P14 Do you feel that most people are against you?			
High desperation	72	43,9	43,9	- Always	90	54,9	54,9
Moderate	28	17,1	17,1	- Frequently	18	11,0	11,0
Neutral	42	25,6	25,6	- Occasionally	42	25,6	25,6
Slight desperation	14	8,5	8,5	- Rarely	12	7,3	7,3
Nothing desperation	8	4,9	4,9	- Never	2	1,2	1,2
P15 How often do you feel like your interests and activities have declined?							
- Always	54	32,9	32,9				
- Frequently	36	22,0	22,0				
- Occasionally	48	29,3	29,3				

- Rarely	26	15,9	15,9	

Source: Own elaboration.

Finally, Table 9 confirms the reliability of the psychometric scale used through Cronbach's Alpha, validating the internal consistency of the data. The 15-item psychometric scale is reliable, with a Cronbach's Alpha of 0.735 and a standardized version of 0.737, reflecting moderate consistency in evaluating the construct under study. Values above 0.7 suggest that the scale is reliable, making it suitable for the study's purpose.

Table 9. Reliability Statistics.

Cronbach's alpha	Cronbach's alpha based on standardized elements	N of elements
0,735	0,737	0,15

Source: Own elaboration.

3. Analysis and Discussion of Results

The study conducted in Bello, Colombia, employed an innovative methodology combining cluster analysis, the Geriatric Depression Scale (GDS-15), and a Fuzzy AHP analysis to evaluate depressive symptoms in the local elderly population. The findings reveal the existence of two main subgroups representing 82.57% of the sample, highlighting the need for differentiated and personalized therapeutic approaches according to the varying levels of identified risk. This personalized approach is crucial for effectively addressing specific risk factors and maximizing the effectiveness of treatment, thereby improving mental health outcomes in this vulnerable population.

The use of the FAHP model allowed for the integration of the inherent uncertainty and subjectivity in evaluations, making the results more adaptive to individual variations within the studied population. Furthermore, the weighting of evaluated criteria revealed the perceived importance of various aspects of daily life and their influence on the mental health of older adults.

These results underscore the necessity of adopting multidimensional approaches in mental health interventions, emphasizing the importance of considering both the internal aspects of the individual and their interactions with their environment. The detailed results by subfactor help understand how various characteristics and behaviors contribute to the overall risk of depression, providing a solid foundation for informed decisions and personalized therapeutic strategies.

The findings are particularly relevant to the Colombian context, where factors such as social isolation and chronic illnesses are confirmed as influential in the incidence of depression, aligning with the consulted literature (Salazar et al., 2023; Alvarado et al., 2022; Choque-Gallegos, 2021). The pandemic has exacerbated these factors, increasing the need for comprehensive strategies that are sensitive to the sociocultural context of the elderly (Reynolds et al., 2021; O'Donovan et al., 2020).

The results emphasize the need to design policies and programs that not only address the identified risk levels but also adapt to the socioeconomic peculiarities of older adults in Colombia. Interventions should be multifaceted, incorporating preventive and therapeutic elements, and promoting healthy and quality aging.

The discussion, focused on depression and psychological well-being, recognizes the diversity of emotional experiences among older adults and proposes holistic strategies that address biological, psychological,

social, and environmental aspects. Promoting an active lifestyle, fostering social inclusion, and encouraging personal development are key components for improving mental and emotional well-being. The results call for a joint and proactive action across different disciplines and services to enhance the mental health and general well-being of the elderly. Implementing these strategies could optimize responses to the challenges of an aging population and strengthen human and social development in the country.

Additionally, it is crucial to reinforce support for the group experiencing emotional distress and depression, a significant proportion of the population at high risk of severe mental health issues. Adopting preventive and therapeutic strategies, as well as destigmatizing professional help, would improve the quality of life for older adults. Promoting resilience skills and activities that reduce isolation is recommended. An integrated approach that includes resilience and mindfulness workshops, physical activity promotion, and community engagement is essential for a better quality of life. Moreover, multidisciplinary collaboration is essential to strengthen the emotional, cognitive, and social connections of older adults.

This comprehensive approach to aging aligns with the recommendations in the literature, highlighting the importance of addressing multiple factors contributing to depression and socioeconomic disparities in this population (Kim and Hwang, 2022; Zhou et al., 2023; Shen et al., 2022; Mishra et al., 2020). Therefore, the study concludes by emphasizing the urgency of intervening in a comprehensive and proactive manner, considering not only depressive symptoms but also addressing the social, economic, and cultural determinants that influence the aging experience in Colombia.

Finally, the main implications of this study are:

Personalized Interventions: Identifying the three main clusters allows for the development of more tailored and targeted interventions.

Public Health Policies: For policymakers, understanding that life satisfaction and social interactions are as critical as cognitive and emotional health suggests the need for policies that promote supportive environments and inclusive communities.

Resource Prioritization: Knowing the specific weight of each cluster in depression risk can help health organizations prioritize resources and funding effectively.

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