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Multidimensional vulnerability index in beneficiaries of the Centro Vida program of the Gobernación del Valle del Cauca: A tool for equity and care targeting

Índice multidimensional de vulnerabilidad en beneficiarios del programa Centro Vida de la Gobernación del Valle del Cauca: Una herramienta para la equidad y la focalización de la atención

Índice multidimensional de vulnerabilidade entre os beneficiários do programa *Centro Vida* da Secretaria de Estado do Vale do Cauca: Uma ferramenta para a equidade e o direcionamento da assistência

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ABSTRACT

Introduction: The population of Valle del Cauca is experiencing accelerated aging: 16.9% are aged over 60 years and 86.7% belong to low socioeconomic strata, exposing older adults to simultaneous vulnerabilities across health, economy, and support networks. The Centro Vida program, operated by the Gobernación del Valle del Cauca, provides comprehensive care addressing these needs. **Objective:** To construct and apply a multidimensional vulnerability index in program beneficiaries to stratify risk and strengthen equity in care delivery. **Materials and methods:** Descriptive cross-sectional study with 441 active beneficiaries from four municipalities in Valle del Cauca (2024). An index comprising seven categories — physical health, mental health, socioeconomic conditions, social support network, access to services, demographic factors, and functional status — was constructed and classified into low, medium, and high vulnerability levels using quartile distribution. An ordinal logistic regression model was fitted to identify determinants. **Results:** 91.3% of beneficiaries had at least one active diagnosis, with cardiovascular diseases predominating (71%) and a mean of 2.5 diagnoses per person. 79.7% had no personal income and 28% did not participate in preventive programs despite high insurance coverage. 26.3% were classified as high vulnerability, with statistically significant differences across program sites ($Chi^2 = 55.02$; $p < 0.0001$). Age and multimorbidity were the strongest predictors of vulnerability; educational attainment acted as a protective factor. **Conclusion:** The index constitutes a reproducible, low-cost tool for prioritizing interventions and evaluating program impact. The gap between formal insurance coverage and effective access to preventive services represents the critical node for reducing vulnerability in this population.

Keywords: Aged; vulnerable populations; frailty; Social determinants of health; equity. (Source: DeCS, Bireme).

Sustainable development goals: Health and well-being. (Source: SDG, WHO).

RESUMEN

Introducción: La población del Valle del Cauca experimenta un envejecimiento acelerado, 16,9 % supera los 60 años, 86,7 % pertenece a estratos bajos, esto expone a las personas mayores a vulnerabilidades simultáneas en salud, economía, redes de apoyo. El programa Centro Vida, operado por la Gobernación del Valle del Cauca, atiende integralmente estas necesidade. **Objetivo:** Construir y aplicar un índice multidimensional de vulnerabilidad en beneficiarios del programa para estratificar el riesgo y fortalecer la equidad en la atención. **Materiales y métodos:** Estudio descriptivo de corte transversal con 441 beneficiarios activos de 4 municipios del Valle en 2024. Se construyó un índice con siete categorías: salud física, mental, condiciones socioeconómicas, red de apoyo social, acceso a servicios, factores demográficos y estado funcional, clasificado en niveles bajo, medio y alto mediante distribución cuartílica. Se ajustó un modelo de regresión logística ordinal para identificar determinantes. **Resultados:** El 91,3 % presentó al menos un diagnóstico activo, con predominio cardiovascular (71 %) y promedio de 2,5 diagnósticos por persona. El 79,7 % carecía de ingresos propios, 28 % no participaba en programas preventivos pese a la alta cobertura de aseguramiento. El 26,3 % se clasificó en vulnerabilidad alta, con diferencias significativas entre sedes ($Chi^2 = 55,02$; $p < 0,0001$). La edad y la multimorbilidad fueron los principales predictores de vulnerabilidad; la escolaridad fue factor protector. **Conclusión:** El índice constituye una herramienta reproducible, de bajo costo para priorizar intervenciones y evaluar el impacto del programa. La brecha entre aseguramiento formal y acceso efectivo a servicios preventivos representa el nodo crítico para reducir la vulnerabilidad en esta población.

Palabras clave: Anciano; poblaciones vulnerables; fragilidad; determinantes sociales de la salud; equidad. (Fuente: DeCS, Bireme).

Objetivos de desarrollo sostenible: Salud y Bienestar. (Fuente: ODS, OMS).

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Data and materials availability:
Database at: https://docs.google.com/spreadsheets/d/11hO2Gm2u-ZwlQy-BNSWXZ-GzPYH8amFc

RESUMO

Introdução: A população do Vale do Cauca enfrenta um envelhecimento acelerado; 16,9 % tem mais de 60 anos e 86,7 % pertencem a faixas de renda mais baixas, o que expõe os idosos a vulnerabilidades simultâneas nas áreas da saúde, da economia e das redes de apoio. O programa Centro Vida, administrado pelo Governo do Vale do Cauca, atende de forma integral a essas necessidades. **Objetivo:** Construir e aplicar um índice multidimensional de vulnerabilidade nos beneficiários do programa para estratificar o risco e fortalecer a equidade na assistência. **Materiais e métodos:** Estudo descritivo transversal com 441 beneficiários ativos de 4 municípios do Vale em 2024. Foi construído um índice com sete categorias: saúde física, mental, condições socioeconômicas, rede de apoio social, acesso a serviços, fatores demográficos e estado funcional, classificado em níveis baixo, médio e alto por meio de distribuição cuartílica. Foi ajustado um modelo de regressão logística ordinal para identificar determinantes. **Resultados:** 91,3 % apresentavam pelo menos um diagnóstico ativo, com predominância cardiovascular (71 %) e média de 2,5 diagnósticos por pessoa. 79,7 % não possuíam renda própria, 28 % não participavam de programas preventivos, apesar da alta cobertura de seguro. 26,3 % foram classificados como de alta vulnerabilidade, com diferenças significativas entre as unidades ($Chi^2 = 55{,}02$; $p < 0{,}0001$). A idade e a multimorbidade foram os principais preditores de vulnerabilidade; o nível de escolaridade foi um fator protetor. **Conclusão:** O índice constitui uma ferramenta reproduzível e de baixo custo para priorizar intervenções e avaliar o impacto do programa. A lacuna entre o seguro formal e o acesso efetivo a serviços preventivos representa o ponto crítico para reduzir a vulnerabilidade nessa população.

Palavras-chave: Idoso; populações vulneráveis; fragilidade; determinantes sociais da saúde; equidade. (Fonte: DeCS, Bireme).

Metas de desenvolvimento sustentável: Saúde e bem-estar. (Fonte: MDS, ONU).

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INTRODUCTION

The progressive aging of the Colombian population poses a structural challenge for social protection and public health systems. This phenomenon is not merely a demographic transition; it also reflects the accumulation of multidimensional vulnerabilities among older adults that social care programs must recognize, stratify, and systematically prioritize. The Centro Vida Program of Valle del Cauca Governor's Office serves older adults living in vulnerable conditions, but its ability to allocate available resources equitably and focus care on those facing the greatest social and health risks depends on having measurement tools that go beyond administrative eligibility and reflect the real complexity of its beneficiaries' living conditions.

The rationale for this type of tool lies in the very nature of vulnerability in old age. Evidence from Latin American settings shows that functional dependence, declining mental health, structural poverty, and social isolation do not occur separately but tend to coexist and reinforce each other among older adults who access social care programs[1]. This accumulation of disadvantages means that an eligibility classification based solely on socioeconomic criteria is insufficient to guide differentiated interventions according to the intensity and type of vulnerability. Building a composite index overcomes this limitation by condensing information from multiple dimensions into a single indicator that classifies beneficiaries by risk level, helping to prioritize care and ensure the efficient allocation of program resources.

From an epidemiological and demographic perspective, the context of Valle del Cauca heightens the urgency of this type of instrument. Globally, the World Health Organization estimates that by 2050 the number of people over 60 will exceed 2 billion, with the fastest growth concentrated in low- and middle-income countries[2]. In Latin America, this process is fast and occurs amid persistent inequity: the region is aging before reaching the levels of economic and institutional development that have historically sustained social protection systems in high-income countries[3]. In Colombia, the population over 60 accounted for 13.8% of the national total in 2022, with a projection placing it above 23% by 2050, according to DANE (Colombia's National Administrative Department of Statistics). Valle del Cauca, for its part, ranks third in the country in terms of the number of older adults, accounting for approximately 10% of the national total[4]. In 2022, the population over 60 in the department numbered 773,956, equivalent to 16.9% of the departmental total, with an aging index of 70.5 points and a demographic dependency index of 64.5 points. This population shows marked internal inequity: 86.7% belong to low socioeconomic strata, more than 68% report incomes at or below one legal monthly minimum wage, and only 30.1% receive a contributory pension, which increases their economic dependence. Although enrollment in the General System of Social Security in Health reaches 96.6%, this formal coverage indicator does not guarantee effective access or continuity of care, particularly in rural areas, where the figure drops to 93%.

In this context, the Centro Vida Program—created under Law 1276 of 2009 and operated by the Valle del Cauca Governor's Office under departmental decrees since 2017—is one of the main comprehensive care strategies for older adults living in vulnerable conditions. The program provides meals, psychosocial counseling, primary health care, recreational activities, and active aging promotion in 42 centers funded through the "pro-well-being" tax stamp (a dedicated public revenue stamp supporting services for older adults), serving more than 4,600 older adults through 64 agreements signed with 40 municipalities during 2024. Nevertheless, the program's ability to allocate its resources according to equity criteria and to intervene more intensively with those facing a critical accumulation of vulnerabilities depends on having a risk classification system that goes beyond basic sociodemographic descriptions. This study aims to develop and apply a Multidimensional Vulnerability Index among program beneficiaries to stratify risk and strengthen equity in care.

Ethics approval and consent to participate:
Circular No. 035 of September 1, 2025, approved by the Secretariat of Development, Inclusion and Social Participation of the Valle del Cauca Governor's Office.

Conflict of interests:
The authors declare that there are no conflicts of interest.

Responsibility statement:
The authors declare that they are responsible for the content and accuracy of the information presented.

Consent for publication:
All authors reviewed and approved the final version for publication in the journal.

Additional considerations:
This study contributes to Sustainable Development Goal 3 (Good Health and Well-being), specifically to targets 3.4, 3.8, and 3.d.

MATERIALS AND METHODS

Study design

A descriptive, cross-sectional study with a quantitative approach was conducted in 2024 in four municipalities of the department of Valle del Cauca: Cali (communes 7, 12, 16, and 20), Buenaventura, Buga, and Cartago. The primary source of information was the beneficiary characterization matrix of the Centro Vida Program, systematically completed by the operational teams at each location under the supervision of the central office of the Valle del Cauca Governor's Office..

Study population and sample size

All beneficiaries registered in the program's database at the time of the study were included, totaling 441 older adults. The study population corresponded to the entire census of active beneficiaries at the sites directly operated by the Valle del Cauca Governor's Office during the period analyzed. No probabilistic sampling was performed, as the study included 100% of the available records.

Variables

The program's characterization matrix comprises 120 variables organized into twelve data domains: demographic information (age, sex, place of residence, marital status, ethnic self-identification); educational attainment (highest level reached); income (personal and family income, classification in the Sisbén, Colombia's System for Identifying Potential Beneficiaries of Social Programs); previous occupation; health insurance (enrollment regime, Health-Promoting Entity (EPS), and affiliated Health Service Provider Institution (IPS)); functional status (autonomy and mobility); use of assistive devices (hearing aids, cane, walker, crutches, wheelchair); medical diagnoses (primary diagnosis and comorbidities coded with the International Classification of Diseases, 10th Revision (ICD-10)); reasons for entering the program (nutritional factors, loneliness, economic situation, social isolation); type of violence or abuse (physical, psychological, or sexual abuse, intrafamily violence, abandonment); housing conditions (tenure, access to public utilities); and cohabitation (number and relationship of the people living with the beneficiary).

To construct the vulnerability index, the variables were reorganized operationally into seven risk categories. The operational definition of each category is described below:

- Physical health: presence of at least one active medical diagnosis, existing comorbidities, functional dependence measured through functional status, and no participation in health promotion and prevention programs.

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- Mental health: reported suicide attempt, history of physical or psychological violence, status as a victim of the armed conflict, sexual abuse, intrafamily violence, or abandonment.
- Socioeconomic conditions: personal or family income below one legal monthly minimum wage, precarious housing conditions or lack of access to basic services, and classification in extreme poverty according to the Sisbén socioeconomic classification system.
- Social support network: absence of an identified caregiver and living alone, without family or non-family cohabitants in the household.
- Access to services: non-enrollment in the General System of Social Security in Health and non-attendance at health promotion and prevention activities offered by the service network.
- Demographic factors: age 80 years or older, illiteracy or no formal education, and membership in ethnic minority groups (Afro-Colombian, Indigenous, or other communities).
- Functional status: use of one or more assistive devices for mobility or communication (cane, wheelchair, walker, crutches, or hearing aids).

Construction of the vulnerability index

The variables belonging to each category were dichotomized according to the presence or absence of the corresponding risk factor. For each person, the sum of positive variables within each category was divided by the total number of variables that constituted that category (as a form of standardization), so that the partial score per category ranged from 0 to 1. A score close to one (1) indicates that the beneficiary presents all of the vulnerability markers within that dimension. The overall index was obtained as the sum of the partial scores of the seven categories, assigning equal weight to each one. Based on the distribution of the index in the study population, measures of central tendency and dispersion were calculated per category, and an ordinal risk classification was established using quartiles: low vulnerability (percentile 0 to 50, quartiles 1 and 2), medium vulnerability (percentile 50 to 75, quartile 3), and high vulnerability (percentile 75 to 100, quartile 4).

Data sources and quality control

The information was obtained from the beneficiary characterization matrix, recorded in a spreadsheet shared on Google Workspace among all program sites. The central-level team provided ongoing supervision of data entry; outliers and inconsistencies detected were reviewed jointly with the operational teams at each site for correction. The research team performed a final verification of all records, cross-checking medical diagnosis information against each beneficiary's individual clinical record, maintained by the general practitioner assigned to each site. Primary diagnoses and comorbidities were coded with the International Classification of Diseases, 10th Revision (ICD-10), and grouped into the 23 diagnostic categories of the global burden of disease study (Global Burden of Disease).

Statistical methods

For quantitative variables, measures of central tendency (mean, median) and variability (standard deviation (SD), interquartile range) were calculated. Qualitative variables were described using absolute frequencies and proportions. Vulnerability index scores were analyzed by site and for each of the seven categories that compose it. The association between vulnerability level (low, medium, high) and the sociodemographic variables not included in the construction of the index was assessed using the chi-square test (χ^2), at a 95% significance level. Finally, an ordinal logistic regression model was fitted to estimate the independent contribution of sociodemographic and socioeconomic variables including income to the index outcome, adjusting for the other covariates in the model.

Ethical considerations

Given its cross-sectional design and minimal risk level, the study was exempted from informed consent in accordance with Resolution 8430 of 1993 of the Ministry of Health and Social Protection and the principles of the Declaration of Helsinki. Personal data were processed in compliance with Law 1581 of 2012 and Decree 1377 of 2013. The authors declare that they have the express authorization of the head of the

database of the Valle del Cauca Governor's Office, Centro Vida Program, for its use for academic and programmatic improvement purposes.

RESULTS

Information was collected and processed from 441 beneficiaries of the Departmental Centro Vida Program, distributed across the following sites: Buenaventura, 105 (23.8%); Buga, 58 (13.1%); Cartago, 60 (13.6%); Cali Commune 12, 62 (14%); Cali Commune 16, 50 (11.3%); Cali Commune 20, 53 (12%); and Cali Commune 7, 53 (12%). Table 1 shows the results for the demographic variables of the population:

Table 1.
Sociodemographic characteristics of the beneficiaries. 2024

Variable	Value	Frequency	(Indicator, %)
Gender	Women	300	68.03
	Men	141	31.97
Age (years)	Range	54-97	Promedio: 75 años
	Median	75	Percentile 25 (69); 75 (81)
Marital status	Married	51	11.6
	No data	2	0.5
	Separated	15	3.4
	Common-law union	77	17.5
	Single	202	45.8
	Widowed	94	21.3
Educational attainment	Primary	416	94.3
	Secondary	21	4.8
	Higher education	2	0.5
	No data	2	0.5
Religion	Catholic	386	87.5
	Christian	51	11.5
	Evangelical	2	0.45
	Other	2	0.45
Previous occupation	Various odd jobs	152	34.4
	Not indicated	143	30.3
	Homemaker	47	10.5
	Merchant	15	3.4
	Vendor	14	3.17
	General services	10	2.26
	Others	60	14
SISBEN group	B	226	51.2
	C	117	26.5
	A	90	20.4
	D	3	0.7
	No data	5	1.1
Ethnic self-identification	Afro-Colombian	157	35.6
	Indigenous	16	3.6
	Raizal	2	0.5
	None	266	60.3
Social security	Subsidized	422	95.7
	Contributory	17	3.9
	No data	2	0.5
Enrolled in a P&P program	Yes	311	70.5
	No	121	27.4
	No data	9	2.0

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The beneficiary population of the Centro Vida Program is predominantly female (68%), with a median age of 75 years.

Educational attainment is low: 94.3% of beneficiaries completed only basic education, and their previous occupations were largely odd jobs, vending, or homemaking, which may contribute to low economic income.

Regarding the social security regime, 95.7% of participants are enrolled in the subsidized regime, which shows a high dependence on this regime. In addition, according to Sisbén classification data, 20.4% of the population is classified in group A and 51.2% in group B[5].

Results of the category analysis:

1. Physical health

Only seven people (1.59%) reported functional dependence. Regarding diagnoses, the characterization matrix contains data on up to seven diagnoses coded according to the ICD-10 classification. Based on these codes, the diagnoses were grouped into the following categories, presented in order of frequency (Table 2).

Table 2.
Diagnostic categories. Older adults. Centro Vida Program

Description	Frequency	%	Cumulative %
Cardiovascular diseases	288	71	71
Endocrine diseases	22	5	77
Diseases of the sense organs	18	4	81
Unspecified diseases	15	4	85
Neuropsychiatric conditions	14	3	89
Musculoskeletal diseases	14	3	92
Digestive diseases	6	1	94
Genitourinary diseases	6	1	95
Nutritional deficiencies	3	1	96
Diabetes mellitus	3	1	97
Infectious and parasitic diseases	3	1	97
Respiratory diseases	3	1	98
Skin diseases	3	1	99
Malignant neoplasms	2	0.5	99
Other neoplasms	2	0.5	100
Congenital anomalies	1	0.2	100
Total	403	100	

Of the program's 441 beneficiaries, 91.3% had at least one diagnosis. The leading category was cardiovascular diseases (71%), followed by endocrine diseases (5%) and, in third place, diseases of the sensory organs (4%). Arterial hypertension was the most frequent diagnosis among cardiovascular diseases (70%), followed by lipid metabolism disorders (3%) and hypothyroidism (1.2%). Among comorbidities, 287 people (71%) reported a second diagnosis, with endocrine diseases being the most frequent (26.1%), followed by diabetes mellitus (21%), and genitourinary diseases ranking third with 8.71%. The number of diagnoses per beneficiary was calculated (Table 3).

Tabla 3.
Number of diagnoses per older adult

Total diagnoses	Frequency	%
0	36	8.2
1	112	25.4
2	117	26.5
3	76	17.2
4	52	11.8
5	31	7.0
6	14	3.2
7	3	0.7
Total	441	100

8.2% of beneficiaries reported no diagnosis; 112 people had only one diagnosis (25.4%); with two diagnoses, 117 people (26.5%). On average, older adults have at least one comorbidity, and one-quarter of beneficiaries have at least two comorbidities, with as many as 17 people having between six and seven diagnoses simultaneously.

2. Mental health conditions

31.3% of beneficiaries presented at least one recorded condition with potential impact on mental health. A history of victimization by the armed conflict was the most frequent event, reported by 119 people (27.1%). In smaller proportions, histories of physical or psychological violence (3.4%), abandonment (3.0%), suicide attempt (1.4%), and sexual abuse (1.4%) were identified. Nine people (2.1%) simultaneously recorded three or more adverse conditions in this category, forming profiles of high accumulated exposure to traumatic events. These conditions were not assessed with validated psychometric scales but through reports in the characterization matrix, so the values obtained represent a conservative estimate of the population's potential mental health burden.

3. Economic conditions

40% of beneficiaries presented two or more indicators of economic precariousness. 79.7% reported having no personal or family income; 30.3% reported insufficient food availability; 13.3% live in housing in poor condition; and 20.4% were classified in Sisbén group A, corresponding to the extreme poverty category, a proportion slightly lower than the departmental average (24.0%) recorded by the National Planning Department (Departamento Nacional de Planeación) for the same period. The combination of primary-only education (94.7%), high labor informality across occupational trajectories, and low pension coverage is consistent with a pattern of structural socioeconomic vulnerability in this population (Table 4).

Table 4.
Events related to mental health and economic condition

Number of factors present	Mental health (frequency)	%	Economic condition (frequency)	%
0	296	68.7	126	28.6
1	111	25.8	140	31.7
2	15	3.5	60	13.6
3	3	0.7	65	14.7
4	2	0.5	40	9.1
5	2	0.5	10	2.3
6	2	0.5		
Total	431	100	441	100

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4. Social support network

18% of beneficiaries reported at least one deficient factor in their social support network. 15% live alone, a proportion consistent with the national average reported by DANE (16%). 10% have a friend or neighbor as their only caregiver, a condition operationally classified as absence of a formal support network. 3.0% reported having no caregiver of any kind. In addition, 57% stated that they spend most of the day alone as their main reason for entering the program, 38% reported economic difficulties, and 22% reported social isolation. 5% of beneficiaries had two simultaneous negative factors in this category.

5. Access to health services for older adults

Although most beneficiaries are enrolled in the social security system, 27.4% do not participate in the Health Promotion and Prevention (P&P) programs offered by their EPS, and 60% lack a complete vaccination schedule for their age group. The concurrence of both conditions—non-participation in P&P programs and incomplete vaccination—occurred in 113 people (25.6%), reflecting a gap between the formal coverage of insurance and effective access to available preventive services. Vulnerability in this category is not determined by enrollment but by the underutilization of the services offered by the system's network of IPS.

It is important to clarify that the Centro Vida Program conducts the initial assessments upon entry, and when it identifies that older adults are not participating in any health service offering, it makes the appropriate referrals and recommendations.

Comprehensive care for older adults, particularly health promotion and disease prevention actions, is an essential responsibility of the health system, as established by current regulations (Law 1251 of 2008, art. 6)[6].

6. Demographic factors

30.3% of beneficiaries were 80 years or older at the time of the study. 9% had attained no formal educational level, and 3.6% belong to Indigenous communities. The combination of advanced age with illiteracy and membership in an ethnic minority creates profiles of accumulated demographic vulnerability that amplify risk in the other categories of the index.

7. Functional status

18.7% of beneficiaries use at least one assistive device for mobility or communication. This percentage far exceeds the proportion of those who reported declared functional dependence (1.6%), which suggests a systematic underestimation of functional limitations in the characterization record and reinforces the relevance of incorporating standardized functional assessment instruments into the program's monitoring.

Calculation of the vulnerability index (VI)

Table 5 presents the mean values and the standard deviation of the index for each category. The physical health category recorded the highest mean (0.79; SD = 0.52), followed by access to services (0.43; SD = 0.40) and economic condition (0.30; SD = 0.28). The categories with the lowest average contribution to the index were mental health (0.07; SD = 0.13) and social support (0.14; SD = 0.27), although their high standard deviations relative to the mean indicate substantial internal heterogeneity and the presence of subgroups with critical risk profiles.

Table 5.
Vulnerability index by factor

Category	Standard	Mean	SD
Physical health	4	0.79	0.52
Mental health	6	0.068	0.13
Economic condition	5	0.3	0.28
Social support	2	0.14	0.27
Access to health services	2	0.43	0.4
Demographic factors	2	0.22	0.3
Functional status	1	0.19	0.39

Based on the quartile distribution of the overall index, beneficiaries were classified into three levels: low vulnerability (index 0 to < 1.4; n = 111; 25.2%), medium vulnerability (index 1.4 to < 2.7; n = 214; 48.5%), and high vulnerability (index ≥ 2.7; n = 116; 26.3%). Table 6 presents the distribution of these levels by sociodemographic variables and care site.

Table 6.
Vulnerability by care center

Variable	Value	1. Low (VI: 0-<1.4) n = 111	2. Medium (VI: 1.4-<2.7) n = 214	3. High (VI: ≥ 2.7) n = 116	Total n = 441	Chi²/ Fisher	Pr.
Gender	Female	75	143	82	300	0.5317	0.76
	Male	36	71	34	141		
Marital status	Married	13	27	11	51	12.34	0.137
	Separated	7	3	5	15		
	Single	49	98	55	202		
	Common-law union	24	39	14	77		
	Widowed	18	45	31	94		
Ethnic group	Afro-Colombian	47	63	47	157	12.4459	0.053
	Indigenous	0	10	6	16		
	None	63	138	63	264		
	Raizal	1	1	0	2		
Educational level	Primary	104	202	110	416	1.0848	0.897
	Secondary	6	10	5	21		
	Higher education	0	1	1	2		
SISBEN group	A	16	38	36	90	20.8338	0.002
	B	71	107	48	226		
	C	23	65	29	117		
	D	0	3	0	3		
CENTRO VIDA	Buenaventura	37	45	23	105	55.0159	0.0000
	Buga	13	26	19	58		
	Cartago	30	27	3	60		
	Cali Commune 12	11	32	19	62		
	Cali Commune 16	5	27	18	50		
	Cali Commune 20	6	35	12	53		
	Cali Commune 7	9	22	22	53		

No statistically significant differences were found in the distribution of the index by sex (Chi² = 0.53; $p = 0.76$), marital status (Chi² = 12.34; $p = 0.137$), educational level (Chi² = 1.08; $p = 0.897$), or ethnic group (Chi² = 12.45; $p = 0.053$). In contrast, the Sisbén classification showed a statistically significant association with vulnerability level (Fisher = 20.83; $p = 0.002$): beneficiaries in group A accounted for the highest proportion in the high level (40%), while in group B this proportion dropped to 21.2%. The distribution by care site was also statistically significant (Chi² = 55.02; $p < 0.0001$): the Cali Commune 7 site recorded the highest proportion of beneficiaries with high vulnerability (41.5%), followed by Cali Commune 16 (36.0%) and Cali Commune 20 (31.1%). The Cartago site showed the most favorable distribution, with 50% of its beneficiaries in the low level.

To estimate the independent contribution of the sociodemographic and income variables not included in the construction of the index, an ordinal logistic regression model was built with vulnerability level (low, medium, high) as the response variable and age, sex, Sisbén group, educational level, insurance regime, number of

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clinical diagnoses, and attendance at P&P programs as covariates. The model was fitted on 429 observations with complete information (LR $Chi^2(7) = 310.6$; $p < 0.0001$; pseudo-$R^2 = 0.347$), which indicates a satisfactory overall fit that explains approximately 35% of the variation in vulnerability level (Table 7).

Table 7.
Results of the ordinal logistic regression model. Dependent variable: vulnerability level. *Centro Vida* Program, Valle del Cauca

Variable	Coeficiente	*p*-valor	Interpretación
Edad	(0,128)	$p < 0,001$	Cada aumento de un año en la edad incrementa significativamente la probabilidad de pertenecer a un nivel más alto de vulnerabilidad. Es el factor con mayor peso positivo.
Género	(-0,039)	$p = 0,864$	No es significativo. El sexo del beneficiario (hombre/mujer) no se asocia con el nivel de vulnerabilidad.
Grupo Sisbén	(0,113)	$p = 0,637$	No significativo. La categoría SISBEN por sí sola no predice diferencias estadísticamente relevantes en vulnerabilidad, aunque su signo positivo sugiere una tendencia leve a mayor riesgo en niveles bajos del SISBEN y resultará significativo en el análisis bivariado.
Nivel educativo	(-1,183)	$p = 0,004$	Significativo. Las personas con mayor nivel educativo tienen una probabilidad significativamente menor de encontrarse en niveles altos de vulnerabilidad. La educación actúa como un factor protector.
Régimen salud	(0,181)	$p = 0,781$	No significativo. No hay evidencia de diferencia entre el régimen subsidiado y el contributivo en cuanto al nivel de vulnerabilidad, lo que sugiere que el problema no está en la afiliación, sino en la calidad o uso del servicio.
Total diagnósticos del beneficiario	(1,126)	$p < 0,001$	Altamente significativo. Cada diagnóstico adicional aumenta sustancialmente la probabilidad de estar en un nivel más alto de vulnerabilidad. Es el segundo factor más influyente.
Asistencia a programas de PyP	(1,608)	$p < 0,001$	Significativo y positivo. Los beneficiarios que no participan en programas de promoción y prevención (PYP) presentan mayor probabilidad de estar en alta vulnerabilidad. La participación activa en PYP se asocia con menor riesgo.

DISCUSSION

The multidimensional characterization of the 441 beneficiaries of the Departmental Centro Vida Program using a vulnerability index composed of seven categories makes it possible to move beyond the program's socioeconomic and administrative classification and advance toward a risk stratification that guides programmatic decision-making with greater precision. Although the program establishes beneficiary selection criteria, the categories grouped in the index make it possible to quantify vulnerability as the accumulation of multiple situational disadvantages that affect the quality of life of older adults[7]. The findings are organized around three themes: the distribution and magnitude of vulnerability by category, the conceptual and comparative validity of the constructed index, and the operational implications for the program.

1. Contribution of the categories to the index and risk profile of beneficiaries

Physical health was the dimension with the greatest contribution to the overall index (mean = 0.79; SD = 0.52). 91.3% of beneficiaries had at least one active medical diagnosis, with a predominance of cardiovascular diseases (71%) and arterial hypertension as the primary diagnosis in 70% of cardiovascular cases. This diagnostic concentration is consistent with national estimates from the Ministry of Health and Social Protection, according to which 78% of older adults in Colombia suffer from at least one chronic disease[8,9], indicating that the population served at the Centro Vida centers carries a similar burden, with a high prevalence of arterial hypertension. The observed multimorbidity burden—a mean of 2.5 diagnoses per person and 40% with four or more concurrent conditions—exceeds the risk threshold documented in the literature using the deficit accumulation model, the logic underlying the frailty index in social and health care centers (IF-CSS) developed in the Spanish institutional context[10]. Multimorbidity does not operate as a mere descriptive indicator but as an active determinant of the functional trajectory. Comparative evidence indicates that older adults with a high diagnostic burden have a significantly greater risk of functional decline and two-year mortality, with an odds ratio of 4.2 compared with those who do not reach the vulnerability threshold on the Vulnerable Elders Survey (VES-13), an instrument validated in community-dwelling populations across multiple settings[11]. It is important to note that, although direct provision of health services is not an obligation of the program, the medical assessment at entry and the clinical characterization of beneficiaries make it possible to formulate an individualized intervention plan within the terms of the service offering established by regulation, contributing to the control and mitigation of the risk factors present in the population.

The second-largest dimension was access to health services (mean = 0.43; SD = 0.40), whose contribution to the index reveals a relevant structural paradox. Formal insurance coverage reached 100% of beneficiaries, while 28% did not participate in health promotion and prevention programs and 60% lacked a complete vaccination schedule for their age group. This dissociation between enrollment and the effective use of preventive services reproduces the pattern that the specialized literature identifies as programmatic vulnerability: the inability of care systems to translate formal coverage into real access to interventions of proven impact in the older adult population[12]. Barbosa, et al. identified the inability of health services and frequent hospitalizations as structural antecedents of individual vulnerability in older adults[13,14]. In the context of the Centro Vida Program, this antecedent is expressed in the underutilization of the preventive services available in the network of IPS. Although the program has medical and gerontological care and monitoring that defines a multidisciplinary intervention plan, the responsibility for facilitating access to care pathways and to health promotion and maintenance programs lies with the Health-Promoting Entities (EPS), as established by current regulations.

Economic condition contributed to the index with a mean of 0.30 (SD = 0.28). 79.7% of beneficiaries lacked personal or family income, 30.3% reported insufficient food availability, and 20.4% were classified in extreme poverty according to Sisbén group A, a figure slightly lower than the departmental (24%) and national (21%) averages reported by the National Planning Department[6]. A statistically significant association was found between poverty level classification and vulnerability level (Fisher's test = 20.83; $p = 0.002$) in the bivariate analysis; however, this association was not maintained in the multivariable model, which suggests that the effect of poverty on vulnerability operates in a mediated manner—through variables that the index measures directly, such as diagnostic burden, functional status, and access to services—rather than as an independent predictor. This interpretation is consistent with Osorio's position, which warns against reducing vulnerability to material poverty, noting that vulnerability is a dynamic situation of accumulating disadvantages and not a fixed state

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determined by income. This economic dependence, associated with low educational levels (94% of beneficiaries attained only basic education), limits people's capacity to respond to threats or unexpected situations, increasing their vulnerability. Along the same lines, Cihlar et al.[15], in an analysis of multidimensional vulnerability among older adults in Germany, demonstrated that the material dimension interacts with functional limitation, multimorbidity, mental health problems, and solitary living to form a latent vulnerability construct whose association with life satisfaction is significantly moderated by available social support.

Social support averaged 0.14 (SD = 0.27). 15% of beneficiaries lived alone, a figure consistent with the national average of 16% reported by DANE, and 10% relied on a friend or neighbor as their only caregiver. Although the mean appears contained, the high standard deviation indicates substantial internal heterogeneity and the existence of a subgroup with severe isolation profiles. The systematic review by Sanchini et al.[7], which analyzed 38 publications on the bioethics of geriatric care, identifies relational and interpersonal vulnerability as one of the six constitutive dimensions of vulnerability in old age, noting that dependence on informal caregivers without family ties constitutes an additional layer of situational vulnerability that amplifies risk in the other dimensions. Regarding the reasons for entering the program, 57% of the population reported being alone all day, 38% cited their economic situation, and 22% reported a lack of social support, which positions Centro Vida not only as a health care facility but as a protective structure against social isolation. Qualitative studies at Centro Vida centers in Villavicencio have described this social integration function as a determinant of the psychosocial well-being of older adults in the Colombian context[16].

The mental health dimension showed the lowest mean in the index (0.07; SD = 0.13), although 31.3% of beneficiaries had accumulated at least one condition with potential impact on mental health. A history of victimization by the armed conflict was the most frequent event (27.1%), followed by physical or psychological violence (3.4%), abandonment (3.0%), suicide attempts (1.4%), and sexual abuse (1.4%). These events are categorized in the literature as expressions of "psychological vulnerability", a situation intensified by factors such as loneliness, the loss of emotional support, and the loss of loved ones[17]. It is worth clarifying that this dimension was constructed from reports in the characterization matrix, not from validated psychometric scales such as the PHQ-9 or the Geriatric Depression Scale, so the values obtained are conservative estimates of the population's true mental health burden. This methodological limitation is noted by Cihlar et al.[18] as a relevant challenge in the construction of multidimensional indices; they propose the use of the PHQ as the reference instrument for the mental dimension. Incorporating standardized mental health screening instruments into the characterization process would represent a substantial methodological strengthening for future versions of the index.

The demographic factors revealed a highly aged population: 30.3% were 80 years or older, 9.0% had attained no formal educational level, and 3.6% belonged to Indigenous communities. Regarding functional status, 18.7% of beneficiaries used at least one assistive device for mobility or communication. This percentage far exceeds the proportion of those who reported functional dependence (1.6%), which suggests a systematic underestimation of functional limitations in the characterization record and reinforces the relevance of incorporating standardized functional assessment instruments into the program's follow-up[19].

2. Comparative validity of the constructed index

In Colombia, quantitative studies have shown that vulnerability among older adults is not limited to isolated health factors but results from a combination of characteristics related to human, physical, social, and functional capital, establishing that around 79% of older adults

present some degree of vulnerability according to an index built with these components[20,21]. Constructing a vulnerability index makes it possible to identify groups at greater risk of losing quality of life, which highlights the need for differentiated interventions in the Centro Vida centers and other social programs.

The Centro Vida Program's vulnerability index shares conceptual foundations with instruments developed in other contexts, but it has features that distinguish it and adapt it to the program's operational conditions. The IF-CSS frailty index[22], developed for institutionalized populations in Spain, takes the deficit accumulation model as its starting point and measures geriatric syndromes, functional dependence, diseases, and cognitive or emotional deficits, with the aim of guiding the appropriate therapeutic intensity.

The social vulnerability index of Mexico's National DIF System (Sistema DIF Nacional de México)[23], operates at the state population scale for budgetary allocation purposes and assigns greater relative weight to the dimensions of child vulnerability in education and health (0.60 combined), making it methodologically incomparable with the index constructed in this research, which is oriented toward the individual stratification of older adult beneficiaries in a targeted social care program. The multidimensional index of Cihlar et al., applied in Germany, constructs a continuous variable that reflects the accumulation of risks across material, physical (ADL and multimorbidity), mental (PHQ), and social (family environment) dimensions, with differential weighting through confirmatory factor analysis. Unlike that model, the equal weighting adopted in the present study is justified by the availability and homogeneity of the variables in the characterization matrix and facilitates its application by operational teams without specialized statistical training, a pragmatic advantage for programmatic sustainability in municipal settings with heterogeneous institutional capacity.

The ordinal logistic regression model confirmed that age (coefficient = 0.128; $p < 0.001$) and the number of clinical diagnoses (coefficient = 1.126; $p < 0.001$) are the two predictors with the greatest weight on vulnerability level, followed by non-participation in health promotion and prevention programs (coefficient = 1.608; $p < 0.001$) and educational level as a protective factor (coefficient = −1.183; $p = 0.004$). The cumulative effect of age is consistent with the deficit model proposed by Rockwood and Mitnitski, on which the IF-CSS is based: the older the age, the greater the probability of accumulating deficits across multiple dimensions[24]. The association between low educational level and greater vulnerability—also observable in the attributes of the concept systematized by Barbosa et al.[13] based on 36 studies—points to education as a protective factor that expands the cognitive, social, and economic resources available to confront risk situations, what Osorio Pérez[7], calls mobilizable symbolic capital in the face of threat.

3. Territorial distribution and operational implications for the program

The distribution of the index by site revealed statistically significant differences ($Chi^2 = 55.02$; $p < 0.0001$). The Cali Commune 7 site recorded the highest proportion of beneficiaries with high vulnerability (41.5%), followed by Cali Communes 16 and 20 (36% and 31.1%, respectively), while Cartago showed the most favorable distribution, with 50% in the low level. These territorial differences are not explained exclusively by individual sociodemographic characteristics—ethnic group (pi = 0.053) and educational level did not reach statistical significance in the bivariate analysis—but probably respond to structural conditions of the community environments: accessibility to the service network, density of informal support networks, and habitability conditions of the urban environment. Ibero-American literature has noted that living in neighborhoods with concentrated socioeconomic disadvantage is associated with greater functional limitation, higher prevalence of depression, and poorer self-rated health among older adults, independently of their individual characteristics, constituting what is known as contextual or neighborhood vulnerability[23].

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The operational application of the index in the program must be linked to concrete programmatic decisions. The results of the vulnerability index support evidence-based decision-making to strengthen the actions already being carried out in the program in four areas: (1) ongoing coordination with the health services network through referral, follow-up, and monitoring of the health conditions of older adults, generating timely alerts that contribute to the prevention of physical and functional decline, early risk detection, and the promotion of adherence to treatments and vaccination schedules; (2) strengthening food security, taking into account the health status, comorbidities, and nutritional status of the population; (3) mental health and psychosocial support actions to activate care pathways in cases of violence, abandonment, loneliness, and depression; and (4) expanding community support networks to integrate older adults into collective activities and mitigate their isolation, creating a protective environment for care.

The ordinal classification of risk into three levels—low, medium, and high—makes it possible to differentiate the intensity of interventions: beneficiaries with high vulnerability should receive more frequent individualized follow-up, priority activation of referral pathways to the health network, and intensified psychosocial support, given that comparative evidence indicates that this group faces the greatest risk of functional decline and mortality in the short and medium term[25]. Beneficiaries at the low and medium levels can benefit from group interventions for active aging. Since vulnerability is, in Osorio's conceptualization[7], a dynamic situation rather than a fixed state, periodic reclassification of beneficiaries would make it possible to identify trajectories of increasing or decreasing risk and to evaluate the impact of the program on vulnerability as an outcome measure.

CONCLUSION

The vulnerability index constructed in this research has been used effectively in the characterization of the cohort analyzed, and its operational application in the program is being institutionalized as a systematic monitoring tool. The combination of factors such as health, access to services, mental health, functional status, and economic conditions makes it possible to classify older adults according to their risk level, define appropriate intervention strategies according to their level of vulnerability and support the equitable allocation of program resources toward those at the greater risk.

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