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The Impact of a Sense of Belonging on the Health-Related Quality of Life among the Elderly in New York City

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Abstract: This study aims to enhance the existing literature on the sense of belonging by exploring its impact on health-related quality of life among older adults in New York City. It also examines how this sense of belonging varies across different demographic characteristics and health conditions. We conducted a cross-sectional study using the Sense of Belonging Instrument-Psychological State (SOBI-P) and Health-related Quality of Life-4 (HRQOL-4) to collect online data from 378 participants, all aged 60 and above, residing in the five boroughs of New York City. Our findings indicate that males have a lower sense of belonging, while Black/African Americans scored significantly higher than those in the 'other' category. Additionally, individuals with hearing and visual impairments scored significantly lower on the sense of belonging compared to those with other health conditions. The study also indicates that a stronger sense of belonging is linked to better perceived health. Conversely, it found that a lower sense of belonging is associated with more days of poor physical and mental health, which in turn are connected to fewer days of engaging in usual activities. Recommendations to enhance the sense of belonging among older adults are provided.

Keywords: *Sense of Belonging, belongingness, Quality of life, Health-related quality of life, NYC*

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1. Introduction

Humans harness the safety and security of our social circles not merely to survive, but also to thrive and achieve well-being [1] However, in later life, many individuals experience a diminution in the aggregate magnitude of their social network [2,3], the periodicity of their social interactions [4] and the count of individuals from whom they procure emotional and social support [5]. This is because individuals aged 50 and above have a higher propensity to encounter many risk factors that may contribute to or intensify feelings of social isolation or loneliness [6]. This could be attributed to the bereavement of their spouse and friends, solitary living conditions, relinquishment of societal roles, limited mobility and cognitive capabilities, chronic diseases, worsening vision and hearing, and cessation of favorite activities, all of which contribute to a reduction in their ability to sustain social interaction [2,7,8]. According to the report from the National Academies of Sciences, Engineering and Medicine [6], more than one-third of Americans aged 45 and above express feelings of loneliness, and approximately a quarter of adults aged 65 and over are deemed to be socially estranged. Older adults who experience social isolation are at increased risk of experiencing loneliness [8]. The Gallup National Health and Wellbeing Index [9] showed that individuals living in large urban areas are more likely to report experiencing significant loneliness, with a rate that is notably higher (20%) than those in rural areas (12%).

Loneliness is postulated to emanate from a human need to belong and humans inherently strive to build and maintain a minimum quantity of social connections, indicating a natural inclination towards fostering a sense of belonging [10]. While loneliness and a sense of belonging can often be used interchangeably, a sense of belonging is characterized as the feeling that one is an integral part of a social system or environment [11]. In other words, by accentuating the subjective and emotional experience, the experienced sense of belonging is firmly within the individual's appraisal of their own fit and valued involvement among others [11]. Research has found that a sense of belonging is crucial for older adults, as the process of aging often leads to increased social

isolation and loneliness, which can have significant effects on one's health [12,13]. A high sense of belonging has been linked to positive health outcomes such as better physical and mental health, longer lifespan, and quicker recovery from illness [14]. For example, a study by Kitchen and his colleagues [15] found that a stronger connection to one's local community correlates with better physical and mental health, lower stress, stronger social support, and increased physically activity. This sense of community is more pronounced among women residing in rural settings and those who are financially comfortable. Choenarom and his colleagues [16] emphasized the psychological facets of sense of belonging and found that there is a negative correlation between a sense of belonging and both stress and depression. In other words, as sense of belonging increases, levels of stress and depression decrease.

The psychological experience of sense of belonging, such as valued involvement and fit, has been found to impact overall health among the aging population, particularly a reduction in anxiety about one's fit within their community. However, only 32% of American adults feel that they belong nationally, meaning that 68% feel excluded and that they do not fit in [17]. In New York City, 20% of older adults above the age of 45 years felt a sense of psychological distress in 2022, and psychological distress was lower among older adults that had strong social ties and support within their community [18]. Several research studies have shown that limited contact from family and friends negatively impacts sense of belonging among older adults, resulting in higher levels of stress and anxiety [19,20,21]. Disruptions in daily routines and social contact within the community also negatively impacts quality of life in older adults [22,23,24]. It has also been found that mental health is negatively impacted by increased depression and loneliness among older adults [21,25]. These negative health outcomes can sometimes compound the overall quality of life among older adults, which may result in lower life expectancy.

Defining quality of life is challenging due to its multifaceted nature involving various parameters such as economic stability, health-related factors, and environmental conditions. Particularly, health-related quality of life demotes an individual's self-perceived health status, reflecting their subjective perceptions, satisfaction, and the importance they attribute to various health domains, including physical, mental and social aspects [26,27,28,29,30]. It transcends simple metrics like life expectancy or absence of disease, emphasizing instead on the capacity to respond to factors in physical and social environments to maintain a healthy life [31]. A crucial aspect of caring for older adults is to sustain or enhance their quality of life. Hence, comprehending how various social environments, such as a sense of belonging, affect health-related quality of life is a pivotal agenda for an aging society.

The health outcomes of sense of belonging in older adults have been well documented, but these studies often focus on social ostracism, loneliness, social acceptability, community integration, and/or place attachment, rather than their psychological experiences with others. Moreover, while one study has made efforts to explore the different levels of loneliness among older ethnic minority people through qualitative study [32], there remains a substantial gap in research on sense of belongingness among older adults with different demographic characteristics and health conditions, particularly for those residing in metropolitan areas. Existing literature has reached a consensus that a strong sense of belonging has been linked to positive health outcomes. However, the crucial research question that requires comprehensive examination across various populations is how a sense of belongingness relates to individual's health-related quality of life, which extends beyond just the absence of illness or infirmity. Hence, this study aims to address the above gaps in the literature review by examining sense of belonging and its impact on health-related quality of life. To accomplish the study aim, five research questions were formulated: (1) how does a sense of belonging affect self-rate health? (2) how does a sense of belonging affect physical health? (3) how does a sense of belonging affect mental health? (4) how does a sense of belonging affect activity limitation? and (5) are there any differences in the sense of belongingness among older adults with different demographic characteristics and health conditions in New York City?

2. Materials and Methods

In this cross-sectional study, we collected data from 378 participants using an online survey that was distributed through Qualtrics. The participants, all aged 60 years and above, were residents of the five boroughs of New York City. The survey included demographic questions to better understand the diverse population of New York City and employed two survey instruments: the Sense of Belonging Instrument (SOBI) – Psychological State subscale (SOBI-P), and the Health-Related Quality of Life scale (HRQOL-4).

2.1. Sense of Belonging Instrument-Psychological State (SOBI-P):

This instrument is an eighteen-item subscale (negatively worded) of the sense of belonging instrument, developed by Hagerty and Patusky [33] to measure the psychological perception and experience of belonging (i.e., valued involvement and fit). Respondents rated the items on a 4-point Likert scale, ranging from 1 (strongly disagree) to 4 (strongly agree). Examples of items from the SOBI-P are: "If I died tomorrow, very few people would come to my funeral" (valued involvement); and "I wonder if there is any place on earth where I really fit in" (fit).

2.2. Health- related Quality of Life (HRQOL-4)

This instrument is a set of 4 questions, developed by the Centers for Disease Control and Prevention [34] to measure self-perceived health status, including self-rated health, physically unhealthy days, mentally unhealthy days, and activity limitation days. The single-item self-rated general health question from the HRQOL-4 (Q1) is an ordinal variable that asks, "Would you say that in

general your health is," with five response levels scored from 1, indicating "excellent" health, to 5, indicating "poor" health. The remaining three items from the HRQOL-4 (Q2, Q3, and Q4) were analyzed as continuous variables to measure health over the past 30 days. These items included the number of physically unhealthy days ("Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?"), the number of mentally unhealthy days ("Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?"), and the number of days with activity limitation ("During the past 30 days, approximately how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation").

2.3. Key Health Covariates

Body Mass Index (BMI): Participants BMIs were calculated by their mass (kg) divided by their height $(m)^2$. BMI was categorized as underweight (below 18.5), normal (18.5-24.9), overweight (25.0-29.5), and obese (30 and above).

Health Conditions: Participants were asked to identify all the health conditions that have at the time they answered the survey. The number of health conditions were tallied for each participant and categorized as 0-1, 2-3, and 4 or more health conditions.

2.4. Data Analyses

Participant characteristics were summarized using cell counts and percentages for categorical variables; N, mean, and standard deviation (SD) were used to summarize numeric variables. The participant characteristics included demographics (age, gender, race/ethnicity, household income, education, BMI category, and number health conditions), psychological sense of belonging index (SOBI-P), and health-related QoL variables HRQOL-4. The HRQOL-4 variables included the questions: 'in general your health is', 'number days in the month your physical health was not good', 'number days in the month your mental health was not good', and 'number days in the month poor physical or mental health kept you from your usual activities'.

SOBI-P was analyzed using an ANCOVA model that included all demographic variables as predictors; the statistical tests of each demographic variable (overall F test and pairwise comparisons to a reference category) were adjusted for the other demographics. SOBI-P was further analyzed, using the 2-sample t-test as a function of the reported presence or absence of 15 individual health conditions. Each condition was analyzed separately, and due to the small number reported for many conditions, no attempt was made to adjust for covariates.

The Likert-type general health variable 'in general your health is' was analyzed as a function of demographics similarly to SOBI-P using a proportional odds regression model for ordinal outcomes. The distribution of the 'number days' health-related QoL variables is heavily concentrated at zero days, at a rate beyond that which can be analyzed using a count model like Poisson or negative binomial. Consequently, these variables were analyzed using a zero-inflated negative binomial (ZINB) model using the same covariate approach as that used for 'in general your health is'. The ZINB models the overabundance of zeros via a mixture of a 'zero' component (logistic regression model) and a count component (negative binomial model with log link) [35]. 95% confidence intervals and p-values associated with ZINB model-based estimates of the mean and the proportion of zeros were based on parametric bootstrap sampling [36].

The general health variable was further analyzed using a proportional odds model that included SOBI-P as the key predictor, while adjusting for demographics by including them as covariates. The 'number days' variables were analyzed similarly as a function of SOBI-P using the ZINB model. As this study was exploratory in nature, no adjustment for multiple comparisons was planned or implemented. No imputations of missing data were used; only observed data were analyzed. P-values < 0.05 were considered statistically significant. All analyses were conducted using R version 4.3.3 (R Core Team, 2024). The proportional odds regression model and the ZINB model were fit using the VGAM package (version 1.1-10) [37] and the pscl package (version 1.5.9), respectively. The regression models underlying summaries in selected tables and figures are detailed in the Supplemental Tables.

3. Results

Table 1 shows that 378 individuals aged 60 and older, and all but one residing in New York City, participated in the study. However, 20 respondents had missing age data, and one individual reported living in Washington DC. The age distribution was as follows: 47.5% participants were aged 60-65, 41.3% were aged 66-75, and 11.2% were over 75. Among the respondents, 57.9% were female and 42.1% were male. In terms of ethnicity, 48.5% identified as white, 27.6% as Hispanic, 15.6% as African American, and 8.2% as other. The distribution across New York City boroughs was Manhattan (25.2%), Brooklyn (24.1%), Queens (24.4%), Bronx (18.8%), and Staten Island (7.6%). Annual household income varied, with the largest group (34.4%) reporting incomes between $35,000 and $74,999. Additionally, 78.8% of respondents had a college degree, 64.1% were overweight or obese, and 66.2% had two or more health conditions. The participants had an average sense of belonging score of 55.5 out of 72, with scores ranging from 19 to 72. Regarding general health, 6.9% rated their health as excellent, 27.0% as very good, 41.8% as good, 18.5% as fair, and 5.8% as poor. Over the past 30 days, participants reported an average of 6.8 days of poor physical health and 4.4 days of poor mental health. Additionally, they experienced an average of 4.0 days where poor physical or mental health prevented them from engaging in usual activities like self-care, work, or recreation.

Table 2a summarizes the ANCOVA analysis of Sense of Belonging (SOBI-P) versus demographic variables. This table reports a statistically significant association

with gender (p=0.014), where females had a higher SOBI-P mean score of 56.7, compared to 54.3 for males. Within race, a statistically significant pairwise comparison was observed for Black/African American versus 'Other' (p=0.045), where the SOBI-P mean score for Black/African American was 57.8, compared to a lower mean score of 53.1 for 'Other'. However, compared to Black/African Americans, there were no statistically significance differences versus Hispanic or White. None of the other demographics showed a statistically significant association with SOBI-P. No statistically significant associations were observed for age, household income, education, BMI category, and number health conditions.

Table 2b summarizes the t-test analysis of SOBI-P versus individual health conditions. Attention was restricted to health conditions for which the number of participants reporting the condition was 10 or more. This table shows a statistically significant association with hearing impairment (p=0.043) and visual impairment/eye health issues (p<0.001). For each of these conditions, a lower mean score for SOBI-P was observed for those reporting the condition: 51.9 versus 55.9 for hearing impairment, and 50.3 versus 56.3 for visual impairment/eye health issues.

Table 3a presents the proportional odds regression analysis of the self-reported general health status versus the demographic variables. Participants who earned a graduate degree were more likely to report favorable general health compared to those who earned a high school degree or less (p=0.006); the percentage reporting very good or excellent health among those with a graduate degree was 46.2%, compared to 24.5% for those with a high school degree or less. Individuals who were obese reported less favorable general health compared to those who were underweight or normal weight (p=0.022); the percentage reporting very good or excellent health among obese participants was 24.8%, compared to 38.2% for the underweight/normal weight participants. Statistically significant comparisons (p<0.001) to the lowest health conditions category (0-1 conditions) were observed for the 2-3 and 4+ conditions categories; the percentage reporting very good or excellent health was 53.3%, 26.9%, and 16.8% for the 0-1, 2-3, and 4+ categories, respectively. No statistically significant associations were observed for age, gender, race, and household income. Therefore, in this sample, general health status was positively associated with higher educational attainment, while negatively associated with increased number of health conditions and BMI.

Table 3b presents the zero-inflated regression analysis of the number of days within a month that their physical health was not good versus the demographic variables. The only demographics with a statistically significant association with this 'number days' variable were number of health conditions and race. Participants who had four or more health conditions had a statistically significantly higher mean score (p<0.001) of days when their physical health was not good (mean=10.7), compared to those who had at most one health condition (mean=4.5). Table 3b also shows that the model-based percentage with zero days decreased from 65.0% for those with 0-1 conditions to 26.1% for those with 4+ conditions. White participants had a statistically significantly higher mean score (p=0.036) of days when their physical health was not good (mean=7.7) compared to Black/African American participants (mean=4.4); the model-based percentage with zero days was 44.1% for White participants compared to 64.1% for Black/African American participants.

Table 3c summarizes the zero-inflated regression analysis of the number of days within a month that their mental health was not good versus the demographic variables. Although none of the pairwise comparisons of means to the lowest age category was statistically significant, the overall test of the association between age and number days their mental health was not good was statistically significant (p=0.004), driven by the increasing trend in the model-based percentage of zero days: 46.9%, 57.2%, and 83.3% for the 60-65, 66-75, and 76+ age categories, respectively. Similarly, none of the pairwise comparisons of means to the lowest number health conditions category was statistically significant, but the overall test of the association with number health conditions was statistically significant (p=0.001), driven primarily by a lower percentage of zero days in the highest category: 67.6%, 60.1%, and 34.0% for 0-1, 2-3, and 4+ conditions, respectively. White participants had a statistically significantly higher mean score (p<0.001) of days when their mental health was not good (mean=5.7) compared to Black/African American participants (mean=2.7); the percentage with zero days was 44.6% for White participants compared to 66.4% for Black/African American participants. Hispanic participants also had a statistically significant higher mean score (p=0.024; mean=4.1) compared to Black/African American participants. Their percentage of zero days (57.0%) was also lower than that for Black/African American participants. No statistically significant associations were observed for gender, household income, education, and BMI category.

Table 3d presents the zero-inflated regression analysis of the number of days within a month that poor physical or mental health kept them from their usual activities, versus the demographic variables. Statistically significant associations with activity limitations were observed for race and number health conditions. White participants had a statistically significantly higher mean score (p=0.007) of activity limitation days (mean=4.8) compared to Black/African American participants (mean=2.6); the model-based percentage with zero days was 58.4% for White participants compared to 73.2% for Black/African American participants. Hispanic participants also had a statistically significant higher mean score (p=0.013; mean=4.3) compared to Black/African American participants; their percentage of zero days (54.2%) was also lower than that for Black/African American participants. Health conditions negatively impacted usual activities. Participants with four or more health conditions had a statistically significantly higher mean score (p<0.001) of activity limitation days (mean=6.8) compared to those with at most one (mean=2.6); the percentage of zero days was 36.9% for the 4+ category, compared to 74.6% for the 0-1 category.

Figure 1 summarizes the proportional odds analysis of the general health variable 'in general your health is' by SOBI-P. The regression coefficient for SOBI-P was positive and statistically significant (p=0.005), indicating

that a greater sense of belonging is associated with more favorable answers to the general health question. Figure 2 reports the model-based percentages for 3 selected SOBI-P values: the 15th, 50th, and 85th percentiles; these percentiles were chosen to represent a lower, middle, and upper value for SOBI-P, respectively. The percentages in the very good/excellent categories were 25.5%, 30.7%, and 30.0% for the 15th, 50th, and 85th percentiles, respectively. Full details of the model are included in Supplemental Tables.

Figures 2a-c summarize the ZINB analyses of the health-related 'number days' variables, by SOBI-P. A statistically significant association ($p<0.001$) with SOBI-P was found for each 'number days' variable. As shown in Figure 2a, a greater sense of belonging is associated with less days their physical health was not good, and a greater percentage of zero days physical health was not good. Similar trends are evident for the 'number days' variables in Figures 2b and 2c. Full details of the ZINB models are included in Supplemental Tables.

Table 1. Summary of Participant Demographics, Sense of Belonging (SOBI-P), and Health-Related QoL variables (N=378)

Variable	Category	Type Statistic	Value
NYC Borough (N=377)	Bronx	n (%)	70 (18.6)
	Brooklyn	n (%)	94 (24.9)
	Manhattan	n (%)	92 (24.4)
	Queens	n (%)	92 (24.4)
	Staten Island	n (%)	29 (7.7)
Age (N=358)	60-65	n (%)	170 (47.5)
	66-75	n (%)	148 (41.3)
	> 75	n (%)	40 (11.2)
Gender (N=378)	Female	n (%)	219 (57.9)
	Male	n (%)	159 (42.1)
Race (N=377)	Black or African American	n (%)	59 (15.6)
	Hispanic	n (%)	104 (27.6)
	White	n (%)	183 (48.5)
	other	n (%)	31 (8.2)
Household income (N=358)	< 15,000	n (%)	45 (12.6)
	15,000 - 34,999	n (%)	85 (23.7)
	35,000 - 74,999	n (%)	123 (34.4)
	>= 75,000	n (%)	105 (29.3)
Highest degree (N=378)	high school or less	n (%)	80 (21.2)
	some college/2 year or assoc degree	n (%)	123 (32.5)
	4 year or Bachelors degree	n (%)	100 (26.5)
	Graduate degree	n (%)	75 (19.8)
BMI category (N=378)	underweight or normal weight (<25)	n (%)	136 (36.0)
	overweight (25-29.9)	n (%)	125 (33.1)
	obese (30+)	n (%)	117 (31.0)
Number health conditions (N=378)	0-1	n (%)	128 (33.9)
	2-3	n (%)	145 (38.4)
	4+	n (%)	105 (27.8)
SOBI-P (N=378)		Mean	55.5
		SD	11.2
		Median	55
		Min	19
		Max	72
In general your health is (N=378)	Poor	n (%)	22 (5.8)
	Fair	n (%)	70 (18.5)
	Good	n (%)	158 (41.8)
	Very Good	n (%)	102 (27.0)
	Excellent	n (%)	26 (6.9)
Number days your physical health was not good (N=378)		Mean	6.8
		SD	10.6
		Median	1
		Min	0
		Max	31
Number days your mental health was not good (N=378)		Mean	4.4
		SD	8
		Median	0
		Min	0
		Max	31
Number days poor physical or mental health kept you		Mean	4.0

Variable	Category	Type Statistic	Value
from usual activities (N=378)		SD	8.1
		Median	0
		Min	0
		Max	31

Table 2a. Analysis of SOBI-P by Demographics

Variable	Category	n	Mean (SD)	LS Mean*	95% CI	P-value
Age (overall p = 0.273)	60-65	164	56.2 (10.8)	56.4	54.6, 58.2	
	66-75	137	54.5 (11.9)	54.4	52.5, 56.3	0.144
	> 75	37	57.1 (10.6)	56.7	52.9, 60.5	0.900
Gender (overall p = 0.014)	Female	187	56.7 (11.6)	57.0	55.4, 58.7	
	Male	151	54.3 (10.8)	53.9	52.0, 55.7	0.014
Race (overall p = 0.195)	Black or African American	58	57.8 (11.0)	57.9	54.9, 60.9	
	Hispanic	100	55.3 (12.1)	54.9	52.6, 57.2	0.116
	White	152	55.5 (10.7)	55.8	54.0, 57.7	0.267
	other	28	53.1 (11.5)	52.6	48.3, 56.9	0.045
Household income (overall p = 0.449)	< 15,000	42	54.7 (12.2)	54.1	50.5, 57.6	
	15,000 - 34,999	80	55.8 (11.5)	54.8	52.2, 57.4	0.735
	35,000 - 74,999	113	55.3 (10.8)	55.3	53.3, 57.4	0.545
	>= 75,000	103	56.2 (11.3)	57.2	54.9, 59.6	0.159
Highest degree (overall p = 0.175)	high school or less	68	55.9 (12.8)	55.9	53.2, 58.7	
	some college/2 year or assoc degree	114	56.3 (10.6)	56.3	54.2, 58.4	0.834
	4 year or Bachelors degree	89	56.4 (9.5)	56.7	54.3, 59.1	0.706
	Graduate degree	67	53.2 (12.7)	52.8	4.9, 55.6	0.133
BMI category (overall p = 0.686)	underweight or normal weight (<25)	120	55.3 (11.9)	55.2	53.1, 57.3	
	overweight (25-29.9)	113	56.3 (11.2)	56.4	54.3, 58.5	0.435
	obese (30+)	105	55.3 (10.7)	55.3	53.0, 57.6	0.950
Number health conditions (overall p = 0.766)	0-1	117	56.5 (12.7)	56.3	54.2, 58.4	
	2-3	131	55.2 (10.1)	55.3	53.3, 57.2	0.489
	4+	90	55.2 (10.9)	55.3	52.9, 57.8	0.580

*Least-squares mean from an ANCOVA regression model that included the other demographics in the table as covariates. The p-values in the last column are for pairwise comparisons to the first category of the demographic. The overall p-value is that from the overall F test of any effect of the demographic. 95% CI: 95% confidence interval for the mean.

Table 2b. Analysis of SOBI-P by Health Conditions

Variable	Category	n	Mean (SD)	95% CI	P-value*
Arthritis	no	251	55.7 (11.6)	54.3, 57.1	
	yes	127	55.1 (10.5)	53.2, 57.1	0.639
Back Issues	no	289	55.2 (11.3)	53.9, 56.5	
	yes	89	56.6 (11.1)	54.2, 58.9	0.306
Cancer	no	354	55.7 (11.2)	54.5, 56.9	
	yes	24	53.1 (11.3)	48.6, 57.6	0.282
Diabetes	no	311	55.6 (11.5)	54.4, 56.9	
	yes	67	54.9 (9.8)	52.2, 57.6	0.619
Fibromyalgia	no	368	55.7 (11.2)	54.5, 56.8	
	yes	10	49.0 (10.8)	42.0, 56.0	0.063
Hearing Impairment	no	343	55.9 (11.2)	54.7, 57.1	
	yes	35	51.9 (11.0)	48.1, 55.6	0.043
High blood pressure	no	206	56.0 (11.9)	54.4, 57.5	
	yes	172	55.0 (10.4)	53.3, 56.7	0.390
High cholesterol	no	206	55.6 (11.8)	54.0, 57.1	
	yes	172	55.5 (10.6)	53.8, 57.2	0.936
Hip Issues	no	349	55.6 (11.3)	54.5, 56.8	
	yes	29	54.0 (10.9)	49.9, 58.1	0.441
Kidney disease	no	366	55.5 (11.3)	54.3, 56.6	
	yes	12	56.2 (10.5)	49.9, 62.6	0.819

Variable	Category	n	Mean (SD)	95% CI	P-value*
Knee issues	no	311	55.8 (11.2)	54.6, 57.1	0.234
	yes	67	54.0 (11.3)	51.3, 56.7	
Lung disease	no	343	55.2 (11.2)	54, 56.4	0.077
	yes	35	58.7 (11.6)	55, 62.4	
Osteoporosis	no	351	55.2 (11.4)	54.1, 56.4	0.085
	yes	27	59.1 (7.9)	54.9, 63.4	
Shoulder Issues	no	344	55.6 (11.3)	54.4, 56.8	0.560
	yes	34	54.4 (10.8)	50.6, 58.2	
Visual impairments/ eye health	no	331	56.3 (11.0)	55.1, 57.5	<0.001
	yes	47	50.3 (11.7)	47.1, 53.5	

*p-value from 2-sample t-test. 95% CI: 95% confidence interval for the mean. Attention was restricted to health conditions for which at least 10 participants reported the condition.

Table 3a. Analysis of 'In general your health is' by Demographics

Variable	Category	n	Poor (%)	Fair (%)	Good (%)	Very Good (%)	Excellent (%)	P-value*
Age (overall p = 0.507)	60-65	164	6.7	18.3	40.9	25.0	9.1	
	66-75	137	4.4	19.7	39.4	29.9	6.6	0.272
	> 75	37	10.8	16.2	45.9	24.3	2.7	0.979
Gender (overall p = 0.374)	Female	187	5.9	15.5	43.9	28.9	5.9	
	Male	151	6.6	22.5	37.1	24.5	9.3	0.376
Race (overall p = 0.231)	Black or African American	58	3.4	20.7	39.7	31.0	5.2	
	Hispanic	100	4.0	20.0	38.0	27.0	11.0	0.853
	White	152	7.2	18.4	40.8	26.3	7.2	0.214
	other	28	14.3	10.7	53.6	21.4	0.0	0.222
Household income (overall p = 0.238)	< 15,000	42	7.1	23.8	40.5	23.8	4.8	
	15,000 - 34,999	80	10.0	23.8	38.8	21.2	6.2	0.893
	35,000 - 74,999	113	5.3	16.8	46.9	25.7	5.3	0.706
	>= 75,000	103	3.9	14.6	35.9	34.0	11.7	0.147
Highest degree (overall p = 0.036)	high school or less	68	7.4	25.0	39.7	20.6	7.4	
	some college/2 year or assoc. degree	114	9.6	14.9	43.0	28.9	3.5	0.308
	4 year or Bachelors degree	89	3.4	24.7	40.4	25.8	5.6	0.453
	Graduate degree	67	3.0	10.4	38.8	31.3	16.4	0.006
BMI category (overall p = 0.071)	underweight or normal weight (<25)	120	3.3	11.7	40.8	34.2	10.0	
	overweight (25-29.9)	113	6.2	20.4	36.3	28.3	8.8	0.267
	obese (30+)	105	9.5	24.8	45.7	17.1	2.9	0.022
Number health conditions (overall p <0.001)	0-1	117	1.7	8.5	35.0	39.3	15.4	
	2-3	131	6.1	21.4	42.0	26.7	3.8	<0.001
	4+	90	12.2	27.8	46.7	11.1	2.2	<0.001

*p-values in the last column are for pairwise comparisons to the first category for the demographic, based on a proportional odds regression model for ordinal data that included the other demographics in the table as covariates. The overall p-value is that from the overall chi-squared test of any effect of the demographic.

Table 3b. Analysis of 'Number days your physical health was not good' by Demographics

Variable	Category	n	Mean (SD)	Percent Zero	95% CI Percent Zero	LS Mean	95% CI Mean	P-value
Age (overall p = 0.314)	60-65	164	7.1 (10.5)	41.6	33.1, 50.7	7.6	5.5, 9.7	
	66-75	137	6.3 (10.4)	55.2	45.3, 64.6	5.5	3.6, 7.4	0.149
	> 75	37	7.0 (11.5)	54.6	35.7, 72.2	5.3	1.5, 9.2	0.330
Gender (overall p = 0.275)	Female	187	6.0 (9.8)	49.1	40.1, 58.1	5.6	4.1, 7.2	
	Male	151	7.8 (11.4)	47.7	38.7, 56.9	7.7	5.4, 9.9	0.160
Race (overall p = 0.387)	Black or African American	58	4.4 (8.2)	64.1	49.3, 76.6	3.9	1.6, 6.2	
	Hispanic	100	6.4 (9.4)	47.1	36.0, 58.4	6.3	4.1, 8.5	0.140
	White	152	7.7 (11.7)	44.1	35.0, 53.7	7.5	5.3, 9.7	0.036
	other	28	8.3 (11.7)	44.3	24.3, 66.3	7.9	2.7, 13.0	0.175
Household income (overall p = 0.639)	< 15,000	42	6.0 (9.7)	41.8	26.2, 59.2	5.6	2.4, 8.8	
	15,000 - 34,999	80	6.6 (9.6)	45.2	33.2, 57.9	6.0	3.4, 8.6	0.847
	35,000 - 74,999	113	7.2 (10.9)	47.9	37.8, 58.2	6.5	4.3, 8.7	0.641
	>= 75,000	103	6.8 (11.4)	54.9	43.2, 66.1	7.1	4.0, 10.2	0.540
Highest degree	high school or less	68	6.0 (8.8)	48.3	34.9, 62.0	6.5	3.2, 9.7	

Variable	Category	n	Mean (SD)	Percent Zero	95% CI Percent Zero	LS Mean	95% CI Mean	P-value
(overall p = 0.999)	some college/2 year or assoc degree	114	6.9 (10.9)	49.8	39.1, 60.6	6.4	4.2, 8.7	0.988
	4 year or Bachelors degree	89	7.4 (11.0)	48.8	37.3, 60.4	6.2	3.8, 8.7	0.913
	Graduate degree	67	6.6 (11.1)	45.7	32.7, 59.2	6.9	3.7, 10.0	0.861
BMI category (overall p = 0.927)	underweight or normal weight (<25)	120	6.3 (10.8)	50.0	39.7, 60.4	6.5	4.1, 8.9	
	overweight (25-29.9)	113	6.0 (9.9)	47.2	37.2, 57.5	6.0	3.9, 8.1	0.774
	obese (30+)	105	8.2 (10.9)	47.9	36.3, 59.7	7.0	4.4, 9.5	0.805
Number health conditions (overall p <0.001)	0-1	117	4.5 (9.5)	65.0	54.8, 74.0	3.8	2.1, 5.4	
	2-3	131	6.2 (10.0)	51.3	41.9, 60.5	6.0	4.1, 7.9	0.087
	4+	90	10.7 (11.6)	26.1	17.6, 36.8	11.7	7.9, 15.4	<0.001

The Percent Zero, LS Mean, 95% confidence intervals, and p-values are estimated using a zero-inflated negative binomial model that included the other demographics in the table as covariates. P-values in the last column are for pairwise comparisons of the mean to the first category for the demographic. The overall p-value is that from the overall chi-squared test of any effect of the demographic across the zero and count components of the zero-inflated model.

Table 3c. Analysis of 'Number days your mental health was not good' by Demographics

Variable	Category	n	Mean (SD)	Percent Zero	95% CI Percent Zero	LS Mean	95% CI Mean	P-value
Age (overall p = 0.004)	60-65	164	4.1 (7.2)	46.9	37.0, 57.2	4.4	3.1, 5.6	
	66-75	137	5.2 (9.3)	57.2	46.4, 67.4	4.7	3.1, 6.4	0.755
	> 75	37	3.4 (7.7)	83.3	66.7, 92.5	2.2	-0.5, 4.9	0.158
Gender (overall p = 0.131)	Female	187	3.9 (7.5)	54.3	44.4, 63.8	3.8	2.6, 4.9	
	Male	151	5.2 (8.9)	56.8	46.9, 66.3	5.2	3.4, 7.0	0.189
Race (overall p = 0.004)	Black or African American	58	2.7 (6.0)	66.4	50.5, 79.2	2.0	0.8, 3.2	
	Hispanic	100	4.1 (7.2)	57.0	45.1, 68.1	4.6	2.8, 6.5	0.024
	White	152	5.7 (9.5)	44.6	34.4, 55.3	6.2	4.4, 8.0	<0.001
	other	28	2.6 (6.3)	81.1	61.6, 92.0	1.8	-0.5, 4.1	0.855
Household income (overall p = 0.073)	< 15,000	42	3.4 (6.7)	51.1	31.8, 70.0	3.1	1.1, 5.1	
	15,000 - 34,999	80	4.3 (8.7)	67.9	54.7, 78.7	4.6	1.9, 7.3	0.357
	35,000 - 74,999	113	4.4 (8.0)	56.7	45.7, 67.1	4.3	2.7, 5.9	0.343
	>= 75,000	103	5.1 (8.6)	46.8	34.5, 59.4	4.5	2.8, 6.3	0.314
Highest degree (overall p = 0.598)	high school or less	68	3.3 (6.6)	59.9	44.8, 73.4	4.8	1.8, 7.7	
	some college/2 year or assoc. degree	114	4.9 (9.0)	54.2	42.4, 65.7	5.2	3.2, 7.1	0.828
	4 year or Bachelors degree	89	4.8 (8.4)	56.8	44.6, 68.2	3.7	2.0, 5.4	0.544
	Graduate degree	67	4.5 (7.9)	51.1	36.3, 65.8	3.6	1.9, 5.3	0.515
BMI category (overall p = 0.128)	underweight or normal weight (<25)	120	5.3 (9.3)	51.1	39.8, 62.4	5.7	3.7, 7.7	
	overweight (25-29.9)	113	3.9 (8.0)	62.5	51.5, 72.3	3.8	2.2, 5.4	0.153
	obese (30+)	105	4.1 (6.9)	52.6	40.2, 64.7	3.6	2.2, 4.9	0.087
Number health conditions (overall p = 0.001)	0-1	117	4.1 (8.2)	67.6	56.6, 76.9	3.7	2.0, 5.4	
	2-3	131	3.7 (7.8)	60.1	49.7, 69.7	3.4	2.1, 4.6	0.768
	4+	90	6.0 (8.6)	34.0	22.5, 47.8	6.5	4.2, 8.7	0.070

The Percent Zero, LS Mean, 95% confidence intervals, and p-values are estimated using a zero-inflated negative binomial model that included the other demographics in the table as covariates. P-values in the last column are for pairwise comparisons of the mean to the first category for the demographic. The overall p-value is that from the overall chi-squared test of any effect of the demographic across the zero and count components of the zero-inflated model.

Table 3d. Analysis of 'Number days poor physical or mental health kept you from usual activities' by Demographics

Variable	Category	n	Mean (SD)	Percent Zero	95% CI Percent Zero	LS Mean	95% CI Mean	P-value
Age (overall p = 0.517)	60-65	164	3.9 (7.6)	57.8	48.1, 67.0	3.7	2.4, 5.0	
	66-75	137	4.5 (8.9)	62.9	52.4, 72.4	3.6	2.1, 5.0	0.898
	> 75	37	3.2 (7.3)	75.7	57.1, 88.0	2.6	-0.1, 5.4	0.506
Gender (overall p = 0.076)	Female	187	3.4 (7.2)	62.4	53.1, 70.9	2.8	1.9, 3.8	
	Male	151	4.9 (9.1)	61.7	52.0, 70.5	4.7	3.0, 6.4	0.070
Race (overall p = 0.049)	Black or African American	58	2.6 (6.4)	73.2	58.3, 84.2	1.7	0.5, 2.9	
	Hispanic	100	4.3 (7.4)	54.2	42.6, 65.3	4.5	2.7, 6.4	0.013
	White	152	4.8 (9.2)	58.4	48.3, 67.9	4.6	2.9, 6.2	0.007
	other	28	2.5 (6.5)	80.6	60.8, 91.8	1.4	-0.4, 3.2	0.817

Variable	Category	n	Mean (SD)	Percent Zero	95% CI Percent Zero	LS Mean	95% CI Mean	P-value
Household income (overall p = 0.285)	< 15,000	42	2.4 (4.6)	58.1	39.6, 74.6	2.2	0.6, 3.9	
	15,000 - 34,999	80	5.0 (9.1)	66.2	53.2, 77.1	4.5	1.9, 7.1	0.140
	35,000 - 74,999	113	4.5 (8.8)	60.0	49.4, 69.8	4.3	2.5, 6.1	0.093
	>= 75,000	103	3.5 (7.6)	63.3	51.0, 74.1	2.8	1.4, 4.2	0.629
Highest degree (overall p = 0.444)	high school or less	68	2.6 (5.6)	64.5	50.5, 76.4	3.5	0.9, 6.1	
	some college/2 year or assoc. degree	114	5.4 (9.9)	61.0	49.5, 71.4	4.8	2.8, 6.7	0.466
	4 year or Bachelor's degree	89	4.3 (8.1)	59.8	47.3, 71.1	2.8	1.5, 4.2	0.656
	Graduate degree	67	3.0 (6.3)	64.5	50.0, 76.7	2.9	1.2, 4.6	0.702
BMI category (overall p = 0.856)	underweight or normal weight (<25)	120	3.8 (8.0)	58.4	47.6, 68.5	4.2	2.4, 6.1	
	overweight (25-29.9)	113	3.7 (7.6)	64.0	53.2, 73.5	3.4	1.9, 4.9	0.489
	obese (30+)	105	4.9 (8.8)	63.8	51.1, 74.8	3.0	1.7, 4.4	0.320
Number health conditions (overall p <0.001)	0-1	117	2.6 (6.7)	74.6	64.6, 82.6	2.3	1.1, 3.5	
	2-3	131	3.5 (7.8)	67.2	57.7, 75.5	2.9	1.7, 4.1	0.481
	4+	90	6.8 (9.5)	36.9	26.1, 49.2	6.7	4.2, 9.2	0.003

The Percent Zero, LS Mean, 95% confidence intervals, and p-values are estimated using a zero-inflated negative binomial model that included the other demographics in the table as covariates. P-values in the last column are for pairwise comparisons of the mean to the first category for the demographic. The overall p-value is that from the overall chi-squared test of any effect of the demographic across the zero and count components of the zero-inflated model.

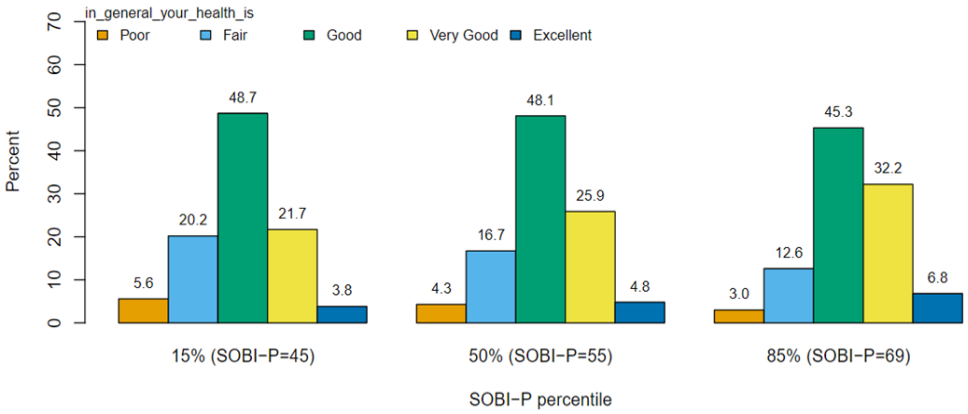

Figure 1. Proportional Odds Model-based Percentages for 'In general your health is' by selected SOBI-P percentiles

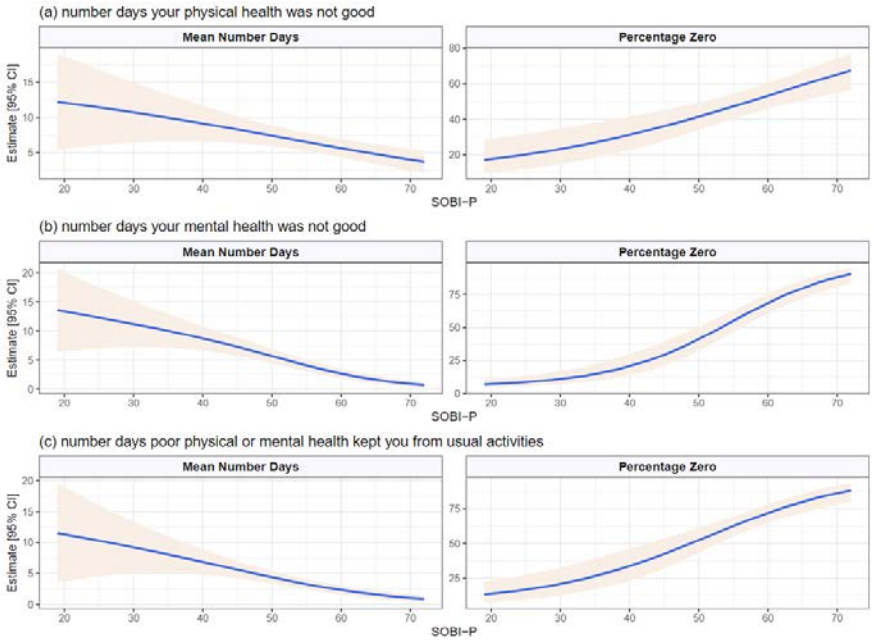

Figure 2. Zero-inflated model-based mean number days and percentage zero days for health-related 'number days' variables by selected SOBI-P percentiles

4. Discussion

This present study examined if the sense of belonging influences the quality of life among older adults particularly, within New York City and how this sense of belonging varies across different demographics characteristics, and health conditions. We found that female participants scored higher on SOBI-P than male participants. Related studies conducted in the U.S. were scarce, however, Cornwell and Cagney [38] investigated neighborhood social cohesion, social ties, and danger among aging adults, and similarly found that older women tend to have greater neighborhood cohesion and ties than older men, but also have a higher perception of danger within their neighborhoods. Levasseur and his colleagues [39] also investigated an association between resilience, community belonging, and social participation among community dwelling older adults in Canada, with 2,560 individuals identifying as female and 2,100 individuals identifying as male, finding that community belonging was also stronger among female participants. Our findings may ensure that older men may experience a lower sense of belonging. To address this issue effectively, there is a need for empirical studies to investigate the underlying reasons for these gender differences.

When considering differences in sense of belonging by race, the current study found that Black/African Americans scored significantly higher than the 'other' category, however, there were no other significant differences between the Black/African Americans, Hispanic, or White participants. In contrast, Clark and his colleagues [40] found that White community members reported higher sense of belonging than Black community members in a Wisconsin neighborhood; however, the ages of the participants among this difference were not identified. Although research investigating differences in sense of belonging among the aging population in the United States is limited, Gonyea and his colleagues [41] investigated neighborhood safety and sense of belonging among 216 older adults living in the U.S., with a sample made up of 50% that identified as Black and 45% that identified as Latino and found that a greater sense of belonging positively impacted depressive symptoms. Birditt and his colleagues [42] explored the differences in stress, life changes, and social ties among a range of ages in a predominantly White sample (74%) but found no significant racial differences when examining whether pandemic-related stress and social isolation predicted psychological well-being.

Our study also found the sense of belonging varies among individuals with different health conditions. Indeed, individuals with hearing impairments and visual impairments scored significantly lower on the SOBI-P compared to those with other health conditions. While previous literature lacks comprehensive research on the differences in health conditions, some studies have highlighted significant findings. Huang [43] and Shukla [44] discovered that older adults with hearing loss tend to experience increased loneliness and social isolation. Additionally, a study involving 456 middle-aged and elderly participants with visual impairments reveled that these individuals reported high levels of loneliness and low social support [45]. Indeed, researchers have discovered that a lack of sense of belonging in older adults can lead to feelings of loneliness [46,47]. In the same vein, a possible explanation for our results is that health conditions, such as hearing and visual impairments, lead to more social isolation and loneliness. This increased isolation may contribute to a lower sense of belonging, particularly within these populations. Consequently, our findings highlight the importance of further research to better understand and address these disparities.

Additionally, the current study revealed a positive association between sense of belonging and quality of life, including four variables: general health, physical health, mental health, and physical and mental health kept from usual activities, and this association remained significant after adjustment for demographic variables. Our findings suggest that a stronger sense of belonging is linked to better perceived health. This aligns with previous research findings, which consistently shows a significant correlation between belongingness and health [15,48,49,50]. Our findings confirm that fostering a strong sense of belonging for older adults in urban areas is crucial, as it significantly contributes to their overall health.

Our study also found that a sense of belongingness is strongly associated with physical health. It showed a greater sense of belonging is linked to fewer days of poor physical health and a higher percentage of days with good physical health. Indeed, previous studies have found that loneliness is linked to various physical health issues, including self-reported chronic diseases, high cholesterol, and diabetes throughout life [51]. Additionally, loneliness significantly impacts physical health of older adults, being negatively associated with higher blood pressure, poorer sleep quality, and stress responses in the immune system [52]. However, to our knowledge, no study had yet examined the association of a sense of belonging with physical health in the older adult population. Consequently, possible explanation for our findings is that a lower sense of belonging may result in increased loneliness, which in turn could be positively linked to poorer physical health.

It is well established that older adults are more inclined to sustain positive mental health if they feel a sense of belonging [53,54]. Studies have shown that a low sense of belonging has been identified as a strong predictor of increased anxiety [55], and depression [56,57], suicidal thoughts [56], and a lack of sense of purpose [58]. Our findings parallel the extant literature by suggesting that a greater sense of belonging is associated to fewer days of experiencing poor mental health of older adults. According to the report from New York City Department of Health and Mental Hygiene (NYC DHMH), approximately 8% of NYC residents aged 65 and older encounter mental health challenges stemming from social isolation, financial insecurity, and limited access to mental health services [59]. Thus, emphasizing the importance of a sense of belonging by strengthening social support networks and creating a more supportive environment for older adults is crucial for preventing mental health issues.

Lastly, this study provides evidence that a greater sense of belonging is linked to fewer days where poor physical or mental health prevents older adults from engaging in their usual activities. The findings present novel insights

into the relationship between a sense of belonging and their usual activities of older adults as it addresses a gap in the existing literature, with no prior studies exploring this specific connection. More importantly, the body of knowledge on sense of belonging has predominantly concentrated on the community aspect, where individuals feel part of a larger group. This sense of social attachment among individuals signifies their external affiliations and membership within the community [15]. However, our study is more about the individual's internal feelings of being valued and fitting in. Therefore, our research addresses an important gap in the literature by elucidating the significant impact of the psychological experience of belonging on the health of older adults in urban areas. Future studies should continue to investigate this relationship to develop targeted interventions that promote sense of belonging and improve the health of older adults.

There are several limitations to this research. To begin with, the online survey reflects a specific subset of older adults with varying levels of proficiency in using web-based information. Although the survey was designed to be completed on smartphones to accommodate the general older population, not all older adults are familiar with smartphones. Additionally, there may have been memory distortion among participants, especially older adults, who might have encountered difficulties in accurately recollecting past days of poor health, thereby potentially compromising the veracity of their responses. Another limitation is the study's cross-sectional design, where data were collected at a single point in time. Consequently, the exposure and outcome variables were analyzed concurrently, precluding the establishment of a cause-and-effect relationship. Lastly, our sample comprised of older adults from New York City, thus the findings cannot be extrapolated beyond this population.

4.1. Implications

Psychological sense of belonging is vitally important for aging, community-dwelling adults' quality of life and mental and physical well-being. Torres [60] suggested that there are several factors that influence sense of belonging in aging adults in relation to establishments throughout their communities and they are proximity (i.e., distance from home), cost and accessibility, physical design and layout that facilitates socialization, and surveillance (i.e., businesses that allow customers to stay as long as they want). While proximity to these establishments is an aspect that influences sense of belonging, proximity to family, friends, and, particularly, young people is another [61]. Ratnayake [61] recommended strategies and interventions to further influence sense of belonging for aging adults such as education, advocacy, infrastructure and accessibility (i.e., the built environment), and financial support. One suggested approach was the introduction of the Intergenerational Service-Learning model, which was introduced as a student club at the University of Delaware to encourage college students to assist with daily responsibilities in supporting aging individuals with chronic disease [61]. While this is one strategy in improving sense of belonging in community-dwelling, aging populations, there are some that include recreation and leisure opportunities.

Smith and his colleagues [62] suggested that accessible recreation and leisure participation decreases feelings of loneliness and solitude in aging adults, particularly among women. In their study, it was suggested several interventions to reduce loneliness and social isolation: leisure participation (physical activity, social leisure, and home-based leisure) and visits to community recreation and cultural facilities, including cost and ease of getting into [62]. Inoue and his colleagues [63] even suggested that support and morale fostered by attending local or regional sports games as team fans provided significant emotional support that influenced a positive sense of belonging. It was also suggested several approaches and strategies to improve sense of belonging among the aging population such as intergenerational programs [61], aging-friendly communities, community-based group physical and recreational activity, and using technology [64].

The introduction of and access to technology significantly improves social connectedness for older adults living at home [64]. The use of mobile phones and access to the internet/email assists aging adults with maintaining communication with friends and family, accessing digital media, and educational resources. An emerging AI-driven tool (ElliQ) was designed to improve social relationships, improve health outcomes, moods, and reduce loneliness among older adults [65]. Access to technology for educational purposes is boundless and can help aging adults to not only learn more about how to improve their social connectedness and engagement, but other factors that influence their mental and physical health such as diet, sleep, physical activity, and stress [66]. The relationship between these factors and health-related outcomes such as cognitive decline are vital to address, and as Eubank and his colleagues [66] suggested, requires additional educational interventions among aging, community-dwelling African Americans, Hispanic Americans, and other minority populations in the United States.

5. Conclusions

Sense of belonging in older adults influences their health-related quality of life. This research highlighted specific variables, particularly physical health, mental health, activity limitation, and overall wellbeing which are associated with sense of belonging. In addition, sense of belonging was positively associated with being female, and Black, while negatively associated with hearing loss, and visual impairment. Numerous interventions can be used to improve sense of belonging among older adults, such as recreation, leisure activities, using technology, and joining community-based support groups. While this list is not exhaustive, it provides actionable suggestions for older adults to feel connected to others. If older adults engage in some of these interventions, they may experience greater sense of belonging, which could positively improve their overall health and specific health-related quality of life.

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Supplemental

Table 1: Proportional Odds Regression Model for 'in general your health is' by SOBI-P

Call:
vglm(formula = as.formula(formula_), family = propodds, data = use)

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept):1	2.398308	0.729955	3.286	0.00102	**
(Intercept):2	0.624980	0.709138	0.881	0.37814	
(Intercept):3	-1.505392	0.712979	-2.111	0.03474	*
(Intercept):4	-3.673239	0.741525	-4.954	7.28e-07	***
age2_2	0.287008	0.228960	1.254	0.21001	
age2_3	-0.011418	0.362204	-0.032	0.97485	
gender_2	-0.110963	0.212991	-0.521	0.60238	
race2_2	0.112019	0.317924	0.352	0.72458	
race2_3	-0.326582	0.307239	-1.063	0.28780	
race2_4	-0.435860	0.440700	-0.989	0.32265	
HH_income2_2	-0.060047	0.361621	-0.166	0.86812	
HH_income2_3	0.096096	0.346819	0.277	0.78172	
HH_income2_4	0.444612	0.371607	1.196	0.23152	

```
highest_degree2_2                0.296975   0.289685   1.025  0.30528
highest_degree2_3                0.247080   0.314914   0.785  0.43269
highest_degree2_4                1.075411   0.354341   3.035  0.00241 **
BMI_category2_2                 -0.311502   0.252134  -1.235  0.21666
BMI_category2_3                 -0.618947   0.274493  -2.255  0.02414 *
number_health_conditions_category_2 -1.125404   0.251282  -4.479 7.51e-06 ***
number_health_conditions_category_3 -1.720567   0.297903  -5.776 7.67e-09 ***
SOBI_P                           0.026152   0.009342   2.799  0.00512 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Names of linear predictors: logitlink(P[Y>=2]), logitlink(P[Y>=3]),
logitlink(P[Y>=4]), logitlink(P[Y>=5])

Residual deviance: 855.402 on 1331 degrees of freedom

Log-likelihood: -427.701 on 1331 degrees of freedom

Number of Fisher scoring iterations: 6

No Hauck-Donner effect found in any of the estimates
```

Supplemental

Table 2: Zero-Inflated Negative Binomial Analysis of 'Number Days Your Physical Health Was Not Good' by SOBI-P

```
   Call:
zeroinfl(formula = as.formula(model_formula), data = use, dist = "negbin",
   link = c("logit"))

Pearson residuals:
   Min     1Q  Median     3Q    Max
-0.8276 -0.5473 -0.3920  0.3028  5.2933

Count model coefficients (negbin with log link):
                                 Estimate Std. Error z value Pr(>|z|)
(Intercept)                      2.042569   0.648284   3.151  0.00163 **
age2_2                          -0.096116   0.212528  -0.452  0.65109
age2_3                          -0.084099   0.357704  -0.235  0.81413
gender_2                         0.273950   0.193283   1.417  0.15638
race2_2                          0.086396   0.285756   0.302  0.76239
race2_3                          0.205115   0.291737   0.703  0.48200
race2_4                          0.269567   0.392359   0.687  0.49206
HH_income2_2                     0.113195   0.310974   0.364  0.71586
HH_income2_3                     0.280505   0.304604   0.921  0.35711
HH_income2_4                     0.538578   0.355602   1.515  0.12989
highest_degree2_2                0.064244   0.274154   0.234  0.81472
highest_degree2_3                0.033573   0.293802   0.114  0.90902
highest_degree2_4                0.041357   0.314739   0.131  0.89546
BMI_category2_2                 -0.149959   0.237237  -0.632  0.52732
BMI_category2_3                  0.040771   0.250501   0.163  0.87071
number_health_conditions_category_2 0.134691   0.244023   0.552  0.58098
number_health_conditions_category_3 0.421807   0.270714   1.558  0.11920
SOBI_P                          -0.005326   0.007629  -0.698  0.48508
Log(theta)                      -0.111721   0.166658  -0.670  0.50263

Zero-inflation model coefficients (binomial with logit link):
                                 Estimate Std. Error z value Pr(>|z|)
(Intercept)                      -2.71013    1.12856  -2.401 0.016332 *
age2_2                            0.77398    0.32732   2.365 0.018049 *
age2_3                            0.67445    0.50317   1.340 0.180111
gender_2                          0.10795    0.29245   0.369 0.712036
```

```
race2_2                          -0.62597    0.43906  -1.426 0.153953
race2_3                          -0.86502    0.44196  -1.957 0.050321 .
race2_4                          -0.63810    0.64338  -0.992 0.321299
HH_income2_2                      0.22985    0.57621   0.399 0.689969
HH_income2_3                      0.38855    0.54812   0.709 0.478405
HH_income2_4                      0.67972    0.57172   1.189 0.234477
highest_degree2_2                 0.16342    0.42146   0.388 0.698207
highest_degree2_3                 0.12928    0.44693   0.289 0.772374
highest_degree2_4                 0.15728    0.50114   0.314 0.753637
BMI_category2_2                  -0.32429    0.34685  -0.935 0.349812
BMI_category2_3                  -0.11279    0.36938  -0.305 0.760105
number_health_conditions_category_2 -0.57981    0.32146  -1.804 0.071280 .
number_health_conditions_category_3 -1.85491    0.41310  -4.490 7.11e-06 ***
SOBI_P                            0.05290    0.01437   3.681 0.000232 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Theta = 0.8943
Number of iterations in BFGS optimization: 39
Log-likelihood: -806.3 on 37 Df
```

Likelihood Ratio Chi-squared test of SOBI_P

type_test	Chisq	Df	p_value
Across Models*	18.05	2	<0.001
Within Count Model	0.49	1	0.484
Within Zero Model	16.33	1	<0.001

*any effect in either model.

Zero-inflated model-based estimates for NUMBER_DAYS_YOUR_PHYSICAL_HEALTH_WAS_NOT_GOOD by SOBI-P

SOBI-P	Proportion Zero	95% lower Prop. 0	95% upper Prop. 0	Mean	95% lower Mean	95% upper Mean
19.00	0.17	0.10	0.28	12.25	5.37	19.13
23.82	0.19	0.12	0.31	11.62	5.98	17.25
28.64	0.22	0.14	0.34	10.94	6.40	15.48
33.45	0.26	0.17	0.37	10.22	6.64	13.81
38.27	0.30	0.21	0.40	9.45	6.68	12.23
43.09	0.34	0.26	0.44	8.65	6.53	10.76
45.00	0.36	0.28	0.45	8.32	6.41	10.22
47.91	0.39	0.31	0.48	7.80	6.18	9.43
52.73	0.45	0.37	0.52	6.95	5.61	8.29
55.00	0.47	0.40	0.54	6.54	5.26	7.82
57.55	0.50	0.43	0.57	6.09	4.82	7.35
62.36	0.56	0.48	0.64	5.25	3.90	6.60
67.18	0.62	0.52	0.70	4.45	2.96	5.95
69.00	0.64	0.54	0.73	4.17	2.62	5.71
72.00	0.67	0.56	0.77	3.72	2.10	5.34

15th, 50th, and 85th percentiles for SOBI-P: 45, 55, 69.

Supplemental

Table 3: Zero-Inflated Negative Binomial Analysis of 'Number Days Your Mental Health Was Not Good' by SOBI-P

```
   Call:
zeroinfl(formula = as.formula(model_formula), data = use, dist = "negbin",
   link = c("logit"))

Pearson residuals:
    Min      1Q  Median      3Q     Max
-0.96143 -0.49357 -0.30023 -0.06426  9.18497

Count model coefficients (negbin with log link):
                                    Estimate Std. Error z value Pr(>|z|)
(Intercept)                         2.058161   0.522511   3.939 8.18e-05 ***
age2_2                              0.241657   0.207015   1.167   0.2431
age2_3                              0.488970   0.393136   1.244   0.2136
gender_2                            0.353615   0.194323   1.820   0.0688 .
race2_2                             0.628517   0.323581   1.942   0.0521 .
race2_3                             0.664760   0.305195   2.178   0.0294 *
race2_4                             0.350309   0.490777   0.714   0.4754
HH_income2_2                        0.809850   0.374787   2.161   0.0307 *
HH_income2_3                        0.478875   0.359125   1.333   0.1824
HH_income2_4                        0.365154   0.412804   0.885   0.3764
highest_degree2_2                   0.085837   0.321555   0.267   0.7895
highest_degree2_3                  -0.216352   0.348494  -0.621   0.5347
highest_degree2_4                  -0.472470   0.354198  -1.334   0.1822
BMI_category2_2                    -0.098780   0.230936  -0.428   0.6688
BMI_category2_3                    -0.419271   0.220173  -1.904   0.0569 .
number_health_conditions_category_2 -0.343612   0.234483  -1.465   0.1428
number_health_conditions_category_3 -0.106156   0.276521  -0.384   0.7011
SOBI_P                             -0.014610   0.008002  -1.826   0.0679 .
Log(theta)                          0.075363   0.186711   0.404   0.6865

Zero-inflation model coefficients (binomial with logit link):
                                    Estimate Std. Error z value Pr(>|z|)
(Intercept)                        -6.81167    1.40104  -4.862 1.16e-06 ***
age2_2                              1.07492    0.42622   2.522 0.011669 *
age2_3                              2.53175    0.67739   3.738 0.000186 ***
gender_2                            0.63603    0.35049   1.815 0.069569 .
race2_2                             0.07165    0.51793   0.138 0.889967
race2_3                            -0.81283    0.50818  -1.599 0.109713
race2_4                             2.08519    0.78151   2.668 0.007627 **
HH_income2_2                        0.83638    0.66609   1.256 0.209241
HH_income2_3                       -0.04028    0.63484  -0.063 0.949409
HH_income2_4                       -0.82149    0.70197  -1.170 0.241890
highest_degree2_2                  -0.22390    0.49109  -0.456 0.648449
highest_degree2_3                  -0.22268    0.52118  -0.427 0.669183
highest_degree2_4                  -0.07977    0.60975  -0.131 0.895913
BMI_category2_2                     0.42738    0.39360   1.086 0.277554
BMI_category2_3                     0.01917    0.44884   0.043 0.965936
number_health_conditions_category_2 -0.47547    0.40723  -1.168 0.242984
number_health_conditions_category_3 -1.96647    0.53909  -3.648 0.000265 ***
SOBI_P                              0.12293    0.01958   6.277 3.45e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Theta = 1.0783
Number of iterations in BFGS optimization: 39
Log-likelihood: -641.4 on 37 Df

   Likelihood Ratio Chi-squared test of SOBI_P
       type_test  Chisq  Df  p_value
```

Across Models*	77.93	2	<0.001
Within Count Model	3.35	1	0.067
Within Zero Model	62.24	1	<0.001

*any effect in either model.

Zero-inflated model-based estimates* for NUMBER_DAYS_YOUR_MENTAL_HEALTH_WAS_NOT_GOOD by SOBI-P

SOBI-P	Proportion Zero	95% lower Prop. 0	95% upper Prop. 0	Mean	95% lower Mean	95% upper Mean
19.00	0.07	0.04	0.11	13.58	6.39	20.77
23.82	0.08	0.05	0.13	12.54	6.92	18.16
28.64	0.10	0.07	0.16	11.49	7.19	15.78
33.45	0.13	0.09	0.20	10.39	7.19	13.59
38.27	0.18	0.12	0.27	9.20	6.85	11.54
43.09	0.26	0.18	0.35	7.85	6.11	9.59
45.00	0.29	0.21	0.39	7.27	5.70	8.85
47.91	0.36	0.27	0.46	6.35	4.99	7.72
52.73	0.49	0.40	0.57	4.78	3.67	5.90
55.00	0.55	0.47	0.63	4.06	3.04	5.08
57.55	0.62	0.54	0.69	3.30	2.37	4.24
62.36	0.74	0.66	0.81	2.10	1.30	2.90
67.18	0.84	0.76	0.89	1.24	0.58	1.91
69.00	0.87	0.79	0.92	1.00	0.40	1.61
72.00	0.90	0.83	0.95	0.70	0.18	1.21

15th, 50th, and 85th percentiles for SOBI-P: 45, 55, 69.

Supplemental

Table 4: Zero-Inflated Negative Binomial Analysis of 'Number Days Poor Physical or Mental Health Kept You From Usual Activities' by SOBI-P

Call:
zeroinfl(formula = as.formula(model_formula), data = use, dist = "negbin", link = c("logit"))

Pearson residuals:

Min	1Q	Median	3Q	Max
-0.86023	-0.47369	-0.30422	-0.08867	10.53066

Count model coefficients (negbin with log link):

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	1.43251	0.74291	1.928	0.0538	.
age2_2	0.01926	0.27690	0.070	0.9446	
age2_3	0.34438	0.46692	0.738	0.4608	
gender_2	0.46638	0.23273	2.004	0.0451	*
race2_2	0.55644	0.35958	1.547	0.1217	
race2_3	0.67647	0.34820	1.943	0.0520	.
race2_4	0.10681	0.55080	0.194	0.8462	
HH_income2_2	0.87114	0.43276	2.013	0.0441	*
HH_income2_3	0.64866	0.41718	1.555	0.1200	
HH_income2_4	0.31616	0.49274	0.642	0.5211	
highest_degree2_2	0.41992	0.40405	1.039	0.2987	
highest_degree2_3	-0.16936	0.40879	-0.414	0.6787	
highest_degree2_4	-0.09809	0.47184	-0.208	0.8353	
BMI_category2_2	-0.05640	0.28546	-0.198	0.8434	
BMI_category2_3	-0.13354	0.30116	-0.443	0.6574	
number_health_conditions_category_2	-0.04146	0.27760	-0.149	0.8813	
number_health_conditions_category_3	0.23256	0.30942	0.752	0.4523	
SOBI_P	-0.01320	0.01031	-1.281	0.2003	

Log(theta) -0.09266 0.21957 -0.422 0.6730

Zero-inflation model coefficients (binomial with logit link):

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-4.44950	1.37597	-3.234	0.00122	**
age2_2	0.62832	0.38169	1.646	0.09973	.
age2_3	1.23566	0.58175	2.124	0.03367	*
gender_2	0.34439	0.32748	1.052	0.29296	
race2_2	-0.51090	0.49282	-1.037	0.29988	
race2_3	-0.43010	0.47880	-0.898	0.36903	
race2_4	1.14129	0.74237	1.537	0.12420	
HH_income2_2	0.38034	0.60262	0.631	0.52795	
HH_income2_3	-0.10335	0.58841	-0.176	0.86057	
HH_income2_4	-0.16027	0.64432	-0.249	0.80356	
highest_degree2_2	0.01458	0.47506	0.031	0.97552	
highest_degree2_3	-0.24708	0.50387	-0.490	0.62387	
highest_degree2_4	0.46058	0.60666	0.759	0.44773	
BMI_category2_2	0.07779	0.38782	0.201	0.84103	
BMI_category2_3	0.29776	0.40627	0.733	0.46361	
number_health_conditions_category_2	-0.41205	0.36815	-1.119	0.26303	
number_health_conditions_category_3	-2.00209	0.46444	-4.311	1.63e-05	***
SOBI_P	0.09036	0.01919	4.710	2.48e-06	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Theta = 0.9115
Number of iterations in BFGS optimization: 39
Log-likelihood: -598.5 on 37 Df

Likelihood Ratio Chi-squared test of SOBI_P

type_test	Chisq	Df	p_value
Across Models*	47.02	2	<0.001
Within Count Model	1.63	1	0.202
Within Zero Model	32.09	1	<0.001

*any effect in either model.

Zero-inflated model-based estimates for NUMBER_DAYS_POOR_PHYSICAL_OR_MENTAL_HEALTH_KEPT_YOU_FROM_USUAL_ACTIVITIES by SOBI-P

SOBI-P	Proportion Zero	95% lower Prop. 0	95% upper Prop. 0	Mean	95% lower Mean	95% upper Mean
19.00	0.13	0.07	0.23	11.54	3.47	19.61
23.82	0.16	0.09	0.26	10.55	4.40	16.71
28.64	0.20	0.12	0.31	9.52	4.95	14.09
33.45	0.25	0.15	0.37	8.44	5.14	11.73
38.27	0.31	0.21	0.44	7.29	4.98	9.59
43.09	0.39	0.28	0.51	6.09	4.48	7.70
45.00	0.43	0.32	0.54	5.61	4.20	7.02
47.91	0.48	0.38	0.58	4.88	3.72	6.05
52.73	0.58	0.50	0.66	3.74	2.82	4.67
55.00	0.63	0.55	0.69	3.25	2.39	4.11
57.55	0.68	0.60	0.74	2.74	1.93	3.55
62.36	0.76	0.69	0.82	1.92	1.17	2.67
67.18	0.83	0.75	0.89	1.29	0.60	1.99
69.00	0.85	0.77	0.91	1.10	0.44	1.77
72.00	0.88	0.80	0.93	0.84	0.23	1.46

15th, 50th, and 85th percentiles for SOBI-P: 45, 55, 69.