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Life space limitations in visually impaired older adults

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SIGNIFICANCE: Future work should develop and evaluate interventional strategies to help overcome visual and health-related barriers to travel in visually impaired seniors and mitigate adverse impacts of loneliness for those who do not leave town.

PURPOSE: Life space refers to the area in which a person travels within a given time period. We explored whether demographics, vision, and/or health characteristics were related to restrictions in self-reported life space for visually impaired seniors.

METHODS: Visually impaired (n = 114) clinical trial participants aged ≥55 years learned visual assistive iPhone apps and completed the following baseline questionnaires: Life Space, 36-Item Short-Form Health Survey, University of California, Los Angeles Loneliness Scale, and New-General Self-efficacy Scale. Multiple logistic regressions evaluated associations between life space and patient factors after accounting for their distance to the next county or state.

RESULTS: During 2021 to 2023, 17%, 43%, and 70% of participants had not left their town, county, or state, respectively, in the past 3 months, or planned to in the next 3 months. Those with reduced distance best-corrected visual acuity had greater odds of not leaving the county in these time frames (odds ratio [OR] = 3.5; p=0.04). Minority race was associated with greater odds of not leaving town or the county in the past 2 weeks or future 3 months (OR = 4.3 to 6.4; p=0.009 to 0.049). Increased self-efficacy was associated with reduced odds of not leaving the state in the past 3 months, next 3 months, or past and/or future 3 months (OR = 0.54 to 0.55; p=0.02 to 0.03). Better physical function was associated with reduced odds of not leaving the state in the past 2 weeks or 3 months (OR = 0.96 to 0.98; p=0.01 to 0.04). Increased loneliness was related to greater odds of not leaving town in the past and/or future 3 months (OR = 1.8 to 2.0; p=0.007 to 0.009).

CONCLUSIONS: Minority race, reduced vision, self-efficacy, and physical health were related to life space restrictions in this cohort of visually impaired seniors, whereas loneliness was greater among those who were not leaving town.

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Life space refers to the area in which a person travels in a given time period,[1] which can be evaluated by an established questionnaire.[2] In geriatric populations, constricted life space is related to development of frailty,[3,4] fear of falling,[5] depression,[6–8] cognitive decline,[8,9] decreased physical activity,[10] hearing loss,[11] dual sensory impairment of hearing and vision,[12] and performance of activities of daily living,[8] as well as sociodemographic factors.[13] In older adults with visual impairment due to glaucoma or age-related macular degeneration, reduced travel away from home has been previously documented.[14–16]

One might expect that visually impaired seniors who do not drive would have reduced life space. When compared with normally sighed seniors as controls, patients with age-related macular degeneration, glaucoma, or Fuchs corneal dystrophy had reduced life space and were less likely to drive.[17] However, this study did not report if life space was different for drivers versus nondrivers among patients with ocular disease. In another study, there was no difference in life space according to driving status for age-related maculopathy patients who presented for vision rehabilitation services.[18] Additionally, reduced useful field of view can be associated with restricted life space.[2] However, other potential associations between restricted life space and characteristics of visually impaired older adults have not been previously elucidated.

Isolation and loneliness are potential adverse consequences of limited life space. Visually impaired individuals with greater loneliness have reported lower levels of life satisfaction.[19] During the COVID-19 pandemic, there was a report of increased loneliness over time among the visually impaired. This group also reported greater loneliness than individuals without disabilities.[20] In another study during the COVID-19 pandemic, high levels of loneliness were experienced by visually impaired adults who lived alone or were unable to move independently.[21] Even prior to the COVID-19 pandemic, loneliness was commonly reported by the visually impaired and occurred more frequently than in the general population,[19] and it was associated with reduced outdoor mobility and participation in activities.[22]

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Therefore, we sought to determine whether loneliness was associated with a certain degree of restricted spatial extent of mobility (i.e., life space) or other factors in visually impaired older adults, in order to help develop targeted interventions for at-risk individuals in the future.

We hypothesized that for cognitively intact, visually impaired older adults, life space outside of the town, county, or state would be more restricted among those with increased nonvisual physical limitations, greater distance visual acuity loss, and reduced self-efficacy, as well as impacted by socioeconomic factors. Furthermore, we anticipated that reduced life space in visually impaired seniors would be associated with negative psychosocial factors, such as greater loneliness and depressive symptoms. We explored these hypotheses among clinical trial participants who were motivated to learn new visual assistive technology (i.e., iPhone mobile applications [apps]). The ability to make excursions into farther areas outside of one's town over a recent or upcoming period of time may be an important aspect of well-being. Identification of factors that are associated with limited life space in seniors with vision loss could lead to targeted interventional programs to address specific barriers to travel in this population.

METHODS

The institutional review board at the University of California, Los Angeles (UCLA) approved the conduct of the study protocol at two sites: UCLA and the New England College of Optometry (NECO). The study conduct followed the tenets of the Declaration of Helsinki. All participants provided either written informed consent in person or oral informed consent by phone, which was obtained by the study coordinator at the enrollment site. The participants who were enrolled at UCLA were from the state of California (n = 46 of 114; 40%), whereas the participants who were enrolled at NECO were from the New England region, which included Massachusetts, Rhode Island, Connecticut, and New Hampshire (n = 68 of 114; 60%). The study protocol was registered on ClinicalTrials.gov (identifier NCT04926974) prior to the enrollment of the first participant. Study enrollment occurred between June 2021 and March 2023.

A total of 114 participants completed baseline data for the Life Space questionnaire and other questionnaires or surveys of potentially relevant factors. As per the inclusion criteria for the clinical trial on visual assistive apps in which they were participating, they were visually impaired, English-speaking older adults aged 55+ years with distance best-corrected visual acuity worse than 0.28 logMAR due to any eye disease, and no greater than mild cognitive impairment (scores 20+ on the modified Telephone Interview for Cognitive Impairment [m-TICS]).[23] All participants had an ocular or low vision examination within 12 months of study enrollment, and the visual acuity data were collected either during that visit or at an in-person study visit. The vast majority had previously received vision rehabilitation services (~98%). Participants' ocular diseases included age-related macular degeneration (n = 38; 33.3%), glaucoma (n = 18; 15.8%), optic neuropathies (n = 10; 8.8%), retinitis pigmentosa (n = 9; 7.9%), myopic degeneration (n = 8; 7%), diabetic retinopathy or retinal vascular (n = 6; 5.3%), other retinal (n = 9; 7.9%), other maculopathies (n = 5; 4.4%), and other ocular diseases (n = 12; 10.5%).

Participants primarily enrolled in the study to receive training and evaluation with visual assistive iPhone apps, i.e., SuperVision+ magnifier,[24] Seeing AI for optical character recognition, [25] and Aira for remote human assistance,[26] but completed the baseline questionnaires, including Life Space, prior to app training. Results for outcomes with the visual assistive apps on loaner iPhones are reported elsewhere (Malkin AG, et al. IOVS 2022;63:ARVO E-Abstract 4053; Malkin AG, et al. IOVS 2023;64:ARVO E-Abstract 2848). Participants also used low vision device(s) or aid(s) (e.g., optical or electronic magnifiers, or telescopes) that they were prescribed prior to the study.

After enrollment, all study questionnaires and surveys were administered to participants via phone by research assistants and investigators at NECO or UCLA. A demographics survey was used to inquire about participants' age, gender, race, ethnicity, level of educational attainment, whether they had hearing loss, were living alone, or able to drive themselves to clinical visits for vision rehabilitation. Those questions were worded, "Do you have any loss of hearing, and if so, what is the severity in the ear with better hearing when using a hearing aid?" "With whom do you primarily live?" and "What is your current primary source of transportation to your low vision care provider?" At the same assessment, the following previously validated questionnaires were administered: Life Space,[2] 3-item UCLA Loneliness Scale,[27] New General Self-efficacy Scale,[28] 36-Item Short-Form Health Survey (SF-36) general health,[29] m-TICS,[21] and Beck Depression Inventory.[30]

The Life Space inventory was created to evaluate the spatial extent of travel; it has been previously validated[2] and applied in low vision patient samples.[2,18] It consists of nine interrelated items asking participants whether they had left a specific geographic location, ranging from the room where they sleep (item requiring the least life space) to their region of the United States (item requiring the most life space), during a given time period. In this study, patients provided a yes or no response to each question based on the previous 2 weeks (consistent with previous literature), the previous 3 months, and the next 3 months (which corresponded to our clinical trial assessments). The additional 3-month time points were included to gain a better understanding of life space limitations in visually impaired seniors over an extended period of time.

Distance best-corrected visual acuity for participants was either measured at the study site after enrollment for 64% of participants or otherwise extracted from a retrospective records review of clinical records if it was obtained within the past 3 months (36% of participants). Distance best-corrected visual acuity was measured following subjective refraction (either through the phoropter or with trial framed lenses, or if the refraction was up to date, with the patient's own habitual spectacles or contact lenses) using either an electronic Snellen chart calibrated for 20 ft (25% of participants) or Early Treatment of Diabetic Retinopathy Studies (ETDRS) logMAR chart typically at 2 or 3 m (or 1 m for severe impairment >1.3 logMAR) at both sites (75% of participants). When the habitual or presenting visual acuity was improved with subjective refraction at the clinical exam within 3 months of study enrollment, the new prescription was provided to the patient who obtained new spectacles or contact lenses that were used during the study period. Visual acuity was measured by one of three optometrists at each of the two sites, based on the measurement in the eye with better visual acuity, and scored by letter, with clinician-guided termination rules. Snellen visual acuity data were converted to logMAR units using a published formula.[31,32]

Data analysis

Descriptive statistics were used to summarize the participants' baseline data and findings. Rasch analyses using the Method of Successive Dichotomizations[33] were used to estimate person measures for the New General Self-efficacy Scale and Beck Depression Inventory using the R package "msd" (https://cran.rstudio.com/web/packages/msd/msd.pdf). Eight participants (data not reported) had ceiling effects for the Beck Depression Inventory due to a lack of depressive symptoms, and it was not possible to generate person estimates. The Life Space questionnaire was analyzed for whether each participant had left their town, county, or state in the past 2 weeks or past 3 months or was planning to leave in the next 3 months. Town refers to a city or urban area with a defined name, boundary, and local government, which is larger than a

TABLE 1. Descriptive statistics for our participants' demographics and questionnaire scores, with continuous variables as mean (SD) and range, whereas the proportion of participants is indicated for dichotomous variables

Variable	Mean (SD), range
Age (y)	72.2 (9.8), 55–94
Distance best-corrected visual acuity (logMAR)	0.74 (0.40), 0–2
m-TICS raw score	37.2 (5.0), 23–50
BDI raw score	7.4 (5.2), 0–24
BDI person measure (logits)	−2.41 (0.93), −4.8 to 0.42
SF-36 physical function subscale	69.7 (26.0), 5–100
UCLA Loneliness Scale raw score	4.66 (1.62), 3–9
Self-efficacy person-measure (logits)	0.81 (1.05), −2.14 to 3.17
Distance from home to next county (miles)	25.1 (27.8), 0.3–113
Distance from home town to closest state line (miles)	98.2 (91.9), 1.7–302
Variable	**Proportion (%)**
Minority race	29.8
Female gender	57.9
College graduate	64.9
Able to drive to vision rehabilitation exam	8.8
Live alone	37.7

BDI = Beck Depression Inventory; m-TICS = modified Telephone Interview for Cognitive Impairment; SD = standard deviation; SF-36 = 36-Item Short-Form Health Survey; UCLA = University of California, Los Angeles.

neighborhood that is a geographically located community within a town that does not have a separate political structure. A county is a larger political and administrative division of a state that provides certain local governmental services and is composed of multiple towns. Although the Life Space questionnaire inquires about travel outside the bedroom, home, neighborhood, or US region, there were too few participants in our sample who had not left their neighborhood (2%) or who had left their US region (3%) in the past 2 weeks; therefore, we did not analyze those results.

Multiple logistic regression models evaluated whether there were any significant factors related to life space limitations outside of participants' towns, counties, or states. All models included all potentially influential variables, which were participants' age, gender, race, ethnicity, level of educational attainment, whether they were living alone, able to drive themselves to clinical visits for vision rehabilitation, UCLA Loneliness Scale raw scores, New General Self-efficacy Scale person measures, SF-36 physical function subscale raw scores, m-TICS raw scores, Beck Depression Inventory person measures, and distance best-corrected visual acuity. In the multiple logistic regression models, we dichotomized race/ethnicity into two groups for minorities versus non-Hispanic Whites and dichotomized education level as college graduate versus non-college graduate; both of these variables were included as potential proxies for socioeconomic status in the United States.[34,35] We considered the various subscales for the SF-36 questionnaire as possible variables to include in the models and chose to include the physical function subscale because it helped explain the most variance in the models. Given the differences in county and state sizes, for each participant, we calculated the driving distance in miles from their home to the closest county line, as well as from their town to the closest state line, in order to account for the physical distance to travel to the next county or outside their state as a potential barrier to consider in the multiple logistic regression models. Given the exploratory nature of this study, we did not adjust for multiple statistical comparisons, which could increase the potential for a type 1 error; thus, future studies are needed to confirm our findings.[36] Data were analyzed using R statistical software (v.4.3.0; R Core Team 2022),[37] msd package, for the Rasch analyses, and

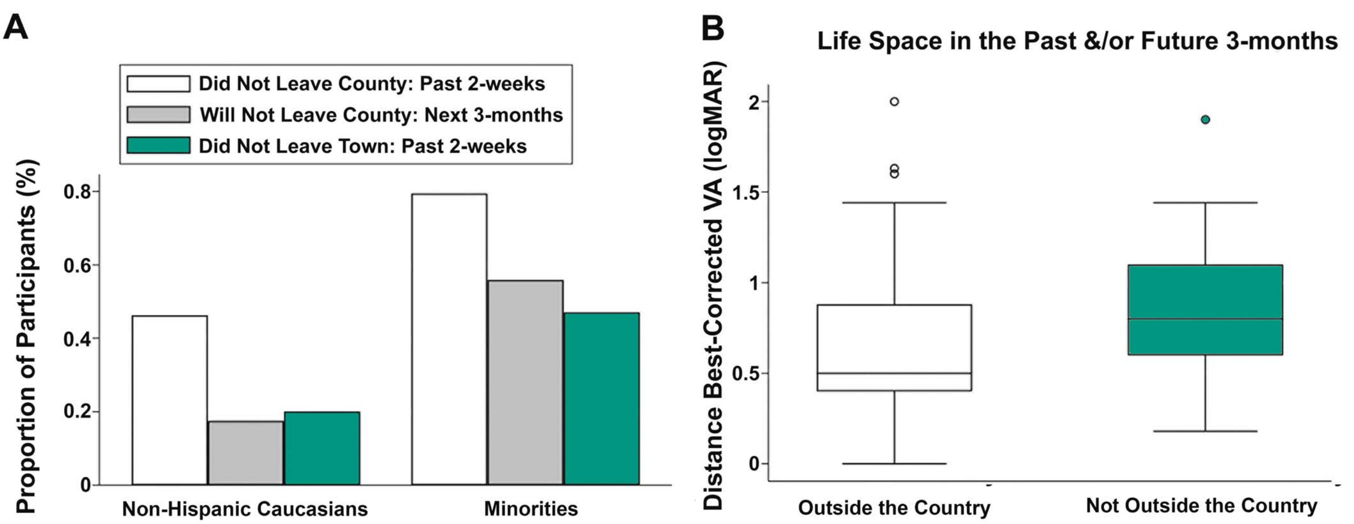

FIGURE 1. (A) A bar graph for minority races versus non-Hispanic Whites with the proportion of participants who left their county or town in the past 2 weeks, as well as those who were not planning to leave their county in the next 3 months. (B) A box plot with the distribution of distance best-corrected visual acuity (logMAR; better eye) according to whether the participant had gone outside their county in the past 3 months and/or was planning to leave their county in the next 3 months. In the box plots, the bottom and top of the box are the 25th and 75th percentiles (i.e., the upper and lower quartiles, respectively), the band near the middle of the box is the 50th percentile (i.e., the median), and the whiskers (lines) are drawn to span all data within 1.5 interquartile range of the nearer quartile. The dots represent outlier data from four participants.

TABLE 2. Statistically significant results from multiple logistic regression models for odds of leaving a region (i.e., town, county, or state) over various time frames for significant factors (each p<.05), with 95% confidence intervals indicated in parentheses (nonsignificant results are omitted)

	Proportion (%)	Minority race	Distance BCVA	Distance to next county/state	Loneliness	TICS	Self-efficacy	SF-36 Phys. Fxn.
Not leaving town								
Past 2 wk	28	OR = 4.61 (1.46–14.59); p=0.009						
Past 3 mo	12				OR = 2.006 (1.21–3.34); p=0.007	OR = 0.84 (0.71–0.995); p=0.043		
Next 3 mo	12	OR = 5.69 (1.007–32.19); p=0.049						
Past and/or next 3 mo	17				OR = 1.82 (1.16–2.86); p=0.009	OR = 0.83 (0.72–0.96); p=0.012		
Not leaving the county								
Past 2 wk	57	OR = 6.36 (1.89–21.40); p=0.003		OR = 1.02 (1.003–1.04); p=0.021				
Past 3 mo	38							
Next 3 mo	30	OR = 4.41 (1.41–13.87); p=0.011					OR = 0.57 (0.33–0.997); p=0.049	
Past and/or next 3 mo	43		OR = 3.45 (1.05–11.34); p=0.042					
Not leaving the state								
Past 2 wk	83			OR = 1.01 (1.003–1.023); p=0.009				OR = 0.96 (0.93–0.99); p=0.012
Past 3 mo	67			OR = 1.01 (1.003–1.016); p=0.003			OR = 0.55 (0.33–0.94); p=0.028	OR = 0.98 (0.96–0.999); p=0.038
Next 3 mo	48						OR = 0.55 (0.33–0.89); p=0.016	
Past and/or next 3 mo	70			OR = 1.008 (1.002–1.015); p=0.014			OR = 0.54 (0.31–0.94); p=0.028	

The multiple logistic regression models were adjusted for all of the factors listed in the table, as well as nonsignificant factors (each p≥0.05 in all models) that included age, gender, college graduate, patient drives to eye care provider, lives alone, and Beck Depression Inventory score. BCVA = best-corrected visual acuity; OR = odds ratio; Phys. Fxn. = physical function subscale; SF-36 = 36-Item Short-Form Health Survey; TICS = Telephone Interview for Cognitive Status.

Stata/IC version 15.1 (Stata Corp., College Station, TX) for the multiple logistic regression models.

RESULTS

Table 1 displays our participants' demographics and questionnaire scores as means, standard deviations, and range of values, as well as the proportion of participants for dichotomous variables.

Not leaving town

Table 2 lists the proportion of participants who did not leave their town during various time periods and the significant factors that were associated with not leaving town after adjusting for all potentially influential factors. Slightly more than a quarter (28%) of participants had not left their town in the past 2 weeks. The odds of not leaving town in the past 2 weeks (odds ratio [OR], 4.6; p=0.009) (Fig. 1A) or next 3 months (OR = 5.7; p=0.049) were significantly greater for participants who were of minority races/ethnicities. Relatively small proportions of participants had not gone out of town in the past 3 months (12%) or past and/or upcoming 3 months (17%). Participants with greater m-TICS cognitive scores had significantly reduced odds of not going outside their town in the past 3 months (OR = 0.84; p=0.04) or the past and/or future 3 months (OR = 0.83; p=0.01) (Fig. 2C), whereas greater loneliness was associated with significantly greater odds of not going out of town in the past 3 months (OR = 2.0; p=0.007) (Fig. 2A) or the past and/or future 3 months (OR = 1.8; p=0.009) (Fig. 2B). Other factors (i.e., distance best-corrected visual acuity, age, gender, education level as a college graduate, living alone, ability to drive to clinical visits for vision rehabilitation, self-efficacy person-measures, SF-36 physical function, and Beck Depression Inventory person-measure scores) were not significantly related to odds of

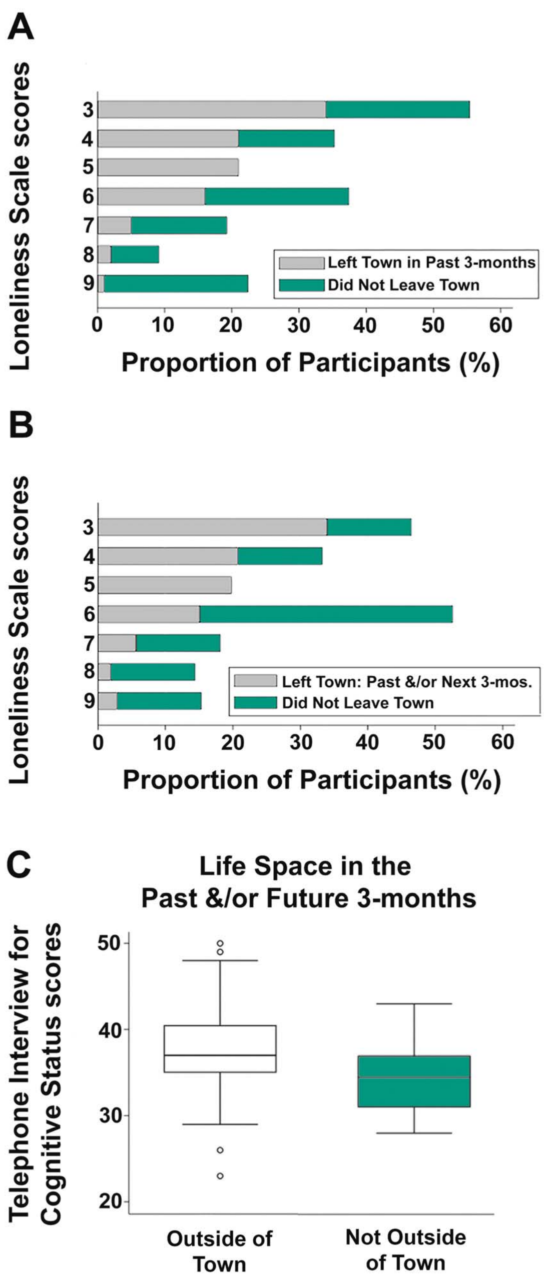

FIGURE 2. Bar graphs for the UCLA Loneliness Scale scores according to life space for not leaving town in the past 3 months (A) or in the past and/or next 3 months (B). Loneliness scale scores can range from a minimum of 3 (hardly ever experience loneliness) to a maximum of 9 (often have loneliness). Panel C displays a box plot with the distribution of m-TICS cognition status scores according to life space. m-TICS scores ranged from 20 (mild cognitive impairment) up to a maximum of 50 (normal cognition). m-TICS = modified Telephone Interview for Cognitive Impairment; UCLA = University of California, Los Angeles.

not going out of town in the fully adjusted model for each time period. The odds of not leaving town in the next 3 months were not significantly related to any of the factors we explored (all p>0.05).

Not leaving the county

Table 2 lists the proportion of participants who did not leave their county during various time periods and the significant factors that were associated with not leaving the county after adjusting for all potentially influential factors. Slightly more than half (57%) of participants had not left their county in the past 2 weeks. The odds of not leaving the county in the past 2 weeks were significantly greater for participants who were of minority races/ethnicities (OR = 6.4; p=0.003) (Fig. 1A) or for those who had greater driving distance in miles from their home to the closest county line (OR = 1.02; p=0.02). The odds of not leaving the county in the past 3 months were not significantly related to any of the factors we explored (all p>0.05). Nearly a third (30%) of participants were not planning to leave their county in the next 3 months. The odds of not leaving their county in the upcoming 3 months were significantly greater for participants who were of minority races/ethnicities (OR = 4.3; p=0.012) (Fig. 1A) and significantly reduced for those with greater self-efficacy (OR = 0.57; p=0.049). There were 43% of participants who reported they had not left their county in the past 3 months and/or were not expecting to leave their county in the next 3 months. Participants with reduced distance best-corrected visual acuity had significantly greater odds of not leaving their county in the past 3 months and/or anticipated for the next 3 months (OR = 3.45; p=0.04) (Fig. 1B). Other factors (i.e., age, gender, education level as a college graduate, living alone, ability to drive to clinical visits for vision rehabilitation, self-efficacy person-measures, loneliness, m-TICS cognition, SF-36 physical function, and Beck Depression Inventory person-measure scores) were not significantly related to odds of not going out of the county in the fully adjusted model for each time period.

Not leaving the state

Table 2 lists the proportion of participants who did not leave their state during various time periods and the significant factors that were associated with not leaving the state after adjusting for all potentially influential factors. The majority (83%) of participants had not left their state in the past 2 weeks. The odds of not leaving the state in the past 2 weeks were significantly reduced for participants with greater physical function scores on the SF-36 (OR = 0.96; p=0.012) or were significantly greater for those who had greater driving distance in miles from their town to the closest state border (OR = 1.01; p=0.009). Two-thirds (67%) of participants had not left their state in the past 3 months. The odds of not leaving the state in the past 3 months were significantly reduced for participants with greater self-efficacy person-measures (OR = 0.55; p=0.028) (Fig. 3A) or greater physical function scores on the SF-36 (OR = 0.98; p=0.038) (Fig. 3B), whereas the odds were significantly greater for those who had greater driving distance in miles from their town to the closest state border (OR = 1.01; p=0.003) (Fig. 3B). Nearly half (48%) of participants were not planning to leave their state in the next 3 months. The odds of not leaving the state in the upcoming 3 months were significantly reduced for participants with greater self-efficacy (OR = 0.55; p=0.016). Not leaving the state in the past 3 months and/or not expecting to leave the state in the next 3 months was reported by 70%. The odds of not leaving the state in the past 3 months and/or not expecting to leave the state in the next 3 months were significantly reduced for participants with greater self-efficacy (OR = 0.54; p=0.028) or significantly greater for those who had greater driving distance in miles from their town to the closest state border (OR = 1.008; p=0.014). Other factors (i.e., age, gender, minority race, education level as a college graduate, living alone, ability to drive to clinical visits for vision rehabilitation, distance best-corrected visual acuity, loneliness, m-TICS cognition, and Beck Depression Inventory person-measure

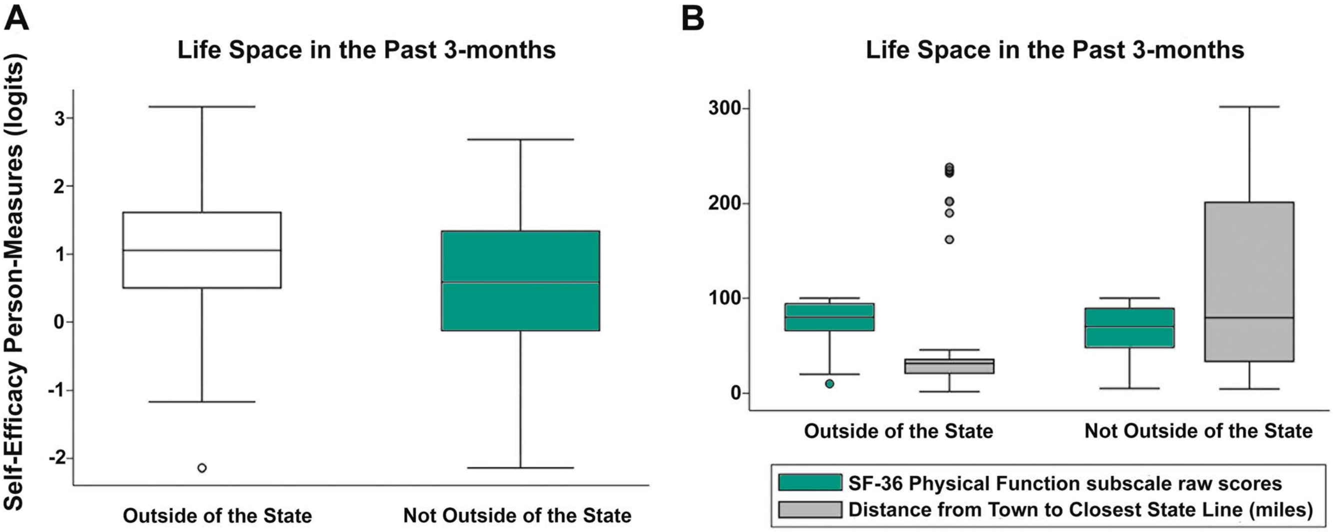

FIGURE 3. (A) A box plot with the distributions of self-efficacy person measures (logits; higher scores indicate greater self-efficacy) according to whether the participant had gone outside their state in the past 3 months. (B) A box plot with the distributions of SF-36 physical function subscale raw scores (range from 0 to 100; higher scores indicate better physical function) and driving distance in miles from the participant's town to the closest state line, both according to whether the participant had gone outside their state in the past 3 months. SF-36 = 36-Item Short-Form Health Survey.

scores) were not significantly related to odds of not going out of the state in the fully adjusted model for each time period.

Life space and nonsignificant factors

Age, gender, education level as a college graduate, living alone, ability to drive to clinical visits for vision rehabilitation, and Beck Depression Inventory scores were all nonsignificantly related to life space outside the participant's town, county, and state at each time point evaluated (i.e., 2 weeks, 3 months, future 3 months, 3 months past, and/or present) (each p>0.05 in the fully adjusted model). Nearly a quarter (23.9%) of participants indicated they had some loss of hearing, but only 6.2% of all participants said their hearing loss was moderate to severe, i.e., not mild or a little. Self-reported hearing loss was not statistically significantly related to any of the life space measures (all p>0.05) in our logistic regression models and therefore was not included.

Loneliness

Without considering life space, increased loneliness scores were significantly associated with higher Beck Depression Inventory person measures indicating greater depressive symptoms (by 0.4 point on average for every 1-logit increase in depressive symptoms; 95% confidence interval [CI], 0.09 to 0.71; p=0.013) and occurred in participants who lived alone (by 0.7 point on average more than those who did not live alone; 95% CI, 0.10 to 1.29; p=0.022), whereas increasing age was significantly associated with reduced loneliness scores (by 0.31 point on average for every 10-year increase in age; 95% CI, −0.61 to −0.02; p=0.039). Interestingly, the following other factors were not statistically significantly related to loneliness, i.e., age, gender, minority race, education level as a college graduate, ability to drive to clinical visits for vision rehabilitation, self-reported hearing loss, distance best-corrected visual acuity, self-efficacy, m-TICS cognition, and SF-36 physical function.

DISCUSSION

This study evaluated several factors related to life space (i.e., the spatial extent of mobility) in older adults with vision loss. Vision, cognitive status, self-efficacy, loneliness, physical function, and race were key factors that influenced life space in visually impaired seniors who enrolled in a clinical trial involving visual assistive app training. Specifically, travel over the course of 3-month periods tended to be influenced by the level of vision loss for excursions outside one's county, reduced cognitive scores (within the range of mild to no significant cognitive impairment) for not going out of town, and reduced self-efficacy for not leaving the state, after accounting for the distance to the closest state or county line. Minorities tended to make less frequent trips out of their town or county because they were less likely to travel in the past 2 weeks, but did make these trips over 3-month periods. Loneliness was associated with not leaving town, whereas reduced physical function was related to not leaving the state.

Leaving the state in the past 3 months was associated with greater physical function and self-efficacy in our study cohort. This poses the question of whether our participants had the perception that farther and longer travel demands more physical ability and/or poses a greater risk of falls or injury, which could be explored in future work. Limitations of this study were that we did not include an objective measure of physical function or walking ability, and did not assess fear of falling or history of injury; therefore, we cannot correlate those potential concerns with the other factors we assessed. Nonetheless, self-reported physical limitations were a barrier to past travel outside the state, which could be further explored in future research. Additionally, our participants tended to have high levels of self-efficacy, which is not surprising given previous work suggesting higher general self-efficacy in visually impaired individuals.[38] Additionally, almost all had previously received vision rehabilitation services and were motivated to learn new visual assistive mobile apps through enrollment in the study. Future interventions to promote self-efficacy for individuals who were not traveling out of their state could focus on engagement in activities or tasks to build confidence while overcoming challenges and enhancing one's ability to succeed.

All of our study participants had mild to no cognitive impairment. A systematic review found evidence to support that individuals with mild cognitive impairment had deficits in performing instrumental activities of daily living.[39] Therefore, our finding of a relationship between reduced cognition and lack of travel out of town is not surprising given that travel excursions are demanding, as they require planning and coordination, along with the need for appropriate recall and increased judgment making than usual activities within the home or in local settings. Another consideration is that perhaps a recent, slight cognitive decline could have reduced participants' confidence for travel outside of their town, but we did not assess cognition longitudinally so we are unable to conclude whether the slightly reduced cognition was recent or long-standing.

Race may be related to socioeconomic status,[34] which could potentially impact the ability to travel. This would be consistent with previous work identifying significant associations between socioeconomic factors and life space.[13] Future work will need to explore these hypotheses or elucidate the specific ties between minority race and less frequent travel. Educational attainment might also serve as a proxy for socioeconomic status,[35] but in our study, life space was not related to whether participants had graduated college, so perhaps other metrics for socioeconomic status could be explored in the future to determine if they are associated with life space in visually impaired seniors.

Nonsignificant factors that were unrelated to life space in this visually impaired cohort of older adults were age, gender, depressive symptoms, and whether they were college graduates, lived alone, or drove themselves to their eye care provider. Age was significantly correlated with some of the factors that were related to life space in this study, i.e., SF-36 physical function ($R^2 = 0.05$; p=0.017), TICS ($R^2 = 0.06$; p=0.01), and loneliness ($R^2 = 0.035$; p=0.048), but these factors were more strongly associated with life space than age. Depressive symptoms were minimal in our participants; thus, it is not surprising that depression was not a significant factor due to the limited range of this variable. One might anticipate that living alone might reduce life space if there is no travel companion, whereas those who live alone might be more independent and capable of travel. A limitation of this study was that we did not fully inquire about participants' driving habits, such as the distance or frequency of driving, although previous work has failed to detect a relationship between driving history and life space.[18] In our sample, the proportion who drove to their eye care provider was very low (8.8%), and therefore, we suspect that a very small proportion of our cohort was driving themselves out of their town, county, or state. We did not specifically inquire about whether the participants had travel options for leaving the town, county, or state either with a household member or via public transportation that they were willing and able to utilize, as well as their distance to the nearest major airport, which are potential factors that might influence life space.

This study was conducted while the COVID-19 pandemic was ongoing but after vaccines were widely available; therefore, it is possible that the extent of travel may have been impacted by health-related concerns for catching COVID by some individuals; however, the findings are recent and relevant to our current situation, which can be used to develop interventions that are applicable at this time. A limitation of this study was the lack of an age-matched, normally sighted control group; thus, it is not possible to know which factors are specific to visual impairment. Reduced distance best-corrected visual acuity was related to not leaving the county in the past or upcoming 3 months; therefore, the level of visual impairment was the key factor for this life space limitation, whereas other factors were relevant to life space limitations outside of one's town or state. Given the influence of the level of visual acuity loss on travel outside of one's county, future consideration should be given to vision-specific barriers to travel, which becomes particularly important if travel is an ambition in individuals' retirement years.

Loneliness was greater among our participants who had not left their town in the past 3 months, but did not emerge as a significant factor with greater extent of life space (e.g., at the county or state level), suggesting that loneliness is associated with more extreme life space restrictions. Although hearing loss in previous studies has been associated with reduced life space or loneliness,[40] we did not find this in our study, perhaps because greater than mild hearing loss was infrequently reported by only 6% of our sample. In our study cohort, loneliness was significantly positively correlated with depressive symptoms, negatively correlated with age, and greater among those who lived alone. Van der Aa et al.[41] similarly found a minimal correlation between age and depressive symptoms when controlling for outliers in a meta-analysis of 22 studies on psychosocial interventions for the visually impaired. Future research involving interventional programs to target loneliness is needed to improve emotional well-being among older seniors[41] who may be isolated, including those who do not leave their town. Visually impaired seniors reported higher levels of social support than older adults with other chronic diseases,[42] which may be an important protective factor to consider to help reduce loneliness and increase life space.[43] It may also be valuable for future studies to determine the temporal relationships between changes in these variables, in order to develop appropriately targeted interventions.

There were several important factors that were associated with reduced life space among visually impaired seniors in this study, for which we propose that future work with focus groups or qualitative interviews would be valuable to gain a better understanding of the nature of the impacts of these factors,[44] specifically, how mild cognitive loss might impact travel out of town, how the severity of visual impairment creates barriers for travel out of one's county, and how decreased self-efficacy might reduce one's confidence to travel the farthest outside of one's state. An improved conceptual model for how these factors limit travel and life space could enable development of targeted interventional approaches to expand life space for visually impaired older adults.

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