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RESEARCH ARTICLE

Sensory impairment and dementia risk among older adults in rural South Africa

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Abstract

INTRODUCTION: South Africa faces growing dementia challenges, worsened by limited medical resources and low education. Modifiable risk factors like hearing and vision impairments remain understudied despite their high prevalence.

METHODS: We analyzed data from 567 participants in a rural South African cohort to examine the associations between vision and hearing impairment, and dementia outcomes. Multinomial logistic regression assessed associations between sensory impairments (distance vision, near vision, hearing) and mild cognitive impairment (MCI) or dementia. Linear regression examined sensory impairment and predicted dementia probability score 2 years later.

RESULTS: Half of the participants were over 70, with no formal education. Sensory impairments were common, especially in dementia cases. Distance vision impairment was linked to both MCI and dementia, while near vision and hearing impairments were associated with dementia. Hearing impairment also predicted higher dementia probability after 2 years.

DISCUSSION: Addressing sensory impairments is key to dementia prevention in rural South Africa.

KEYWORDS
dementia, distance vision, hearing, near vision, rural South Africa, sensory impairment

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HIGHLIGHTS

- Among rural older South Africans, 65% had near vision impairment and 47% had hearing impairment.
- Distance or near vision and hearing impairments are linked to an increased risk of dementia.
- Distance vision impairment is also associated with a higher risk of mild cognitive impairment (MCI).
- Dementia risk was seven times higher with distance vision, near vision and hearing impairment.
- Hearing impairment increased the probability of dementia 2 years later in initially non-demented individuals.

1 | BACKGROUND

By 2050, Sub-Saharan Africa's population of individuals aged 60+ will reach 16.1 million, growing faster than historical trends in developed countries.[1] In South Africa, the demographic shift is even more pronounced such that the share of older adults will increase from 9.1% in 2022 to 15.4% by 2050.[2] Equally alarming is the projected surge in dementia cases, from 0.2 million in 2019 to 0.68 million by 2050,[3] with the economic burden estimated to drain 17.2% of the nation's gross domestic product (GDP) between 2020 and 2050.[4] However, with no effective dementia treatment, prevention is crucial. The Lancet Commission on dementia research identified 14 modifiable risk factors that, if addressed collectively, could prevent up to 45.3% of dementia cases.[5] Notably, hearing loss emerges as one of the most significant contributors, with vision loss, which was recently recognized as another risk factor, respectively accounting for 7% and 2% of cases. However, those estimates of dementia burden have largely relied on data from high-income countries due to limited data from low- and middle-income countries (LMICs),[5] potentially underestimating certain risk factors. For example, a recent study using India-specific data found that vision impairment accounted for 14% of preventable dementia cases.[6]

Despite limited national data,[7] sensory impairment remains a significant public health concern in Sub-Saharan Africa, including South Africa. Regional studies on middle-aged and older South African adults show near vision impairment prevalence ranging from 49% to over 80%, distance vision impairment at approximately 28%,[8,9] and hearing loss at about 17.5%.[10]

Furthermore, hearing impairment is associated with an increased risk of cognitive impairment, dementia, and cognitive decline, as shown by previous systematic reviews and meta-analysis.[11] It is linked to accelerated temporal lobe atrophy, a region critical for auditory and language processing.[12,13] Vision impairment is similarly associated with a higher risk of dementia and cognitive impairment.[14,15]

Compared to hearing impairment, the link between vision impairment and cognition is less consistent, varying by impairment type (distance vs. near),[16,17] cognitive measures,[18] self-reported vision, age group, and follow-up duration.[17,19] When examining vision and hearing impairment together, the findings are more mixed. Some studies show independent associations with cognitive impairment and dementia[20–23]; while others link only vision[24–26] or only hearing impairment.[27] Conversely, other research suggests worse cognitive outcomes only with dual sensory impairments.[28,29]

Most studies focus on high-income countries, with limited research in regions like Africa and Latin America/Caribbean.[5,30] Research on this topic in South Africa is particularly scarce, with only one study examining vision impairment in six low- and middle-income countries (LMICs), including South Africa.[16] Given the high prevalence of vision and hearing impairments in South Africa, along with the increasing incidence of dementia cases, investigating the relationship between these factors remain a crucial research priority. In this study, we examined the associations between objectively measured hearing and vision impairment and late-life cognition and dementia outcomes in a rural South African cohort. We hypothesized that hearing or vision impairment would be associated with increased risk of mild cognitive impairment (MCI), dementia, and a higher predicted probability of future dementia.

2 | METHODS

2.1 | Data

This analysis utilized data from the Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community in South Africa (HAALSI), a population-based cohort study conducted in the Agincourt sub-district of Mpumalanga Province. HAALSI is a harmonized sister study to the Health and Retirement Study (HRS) in the United States.[31] and enrolled 5059 adults aged 40 and older to investigate social, economic, and biological risk factors for chronic health conditions, with a focus on cardiovascular disease, human immunodeficiency virus (HIV), cognitive function, and dementia.[32] The majority of this population does not receive formal education, is unemployed, and lives with at least one other family member.[32] To date, HAALSI has completed four waves of data collection, in 2014–2015, 2018–2019, 2021–2022, and

2024–2025, with data from the most recent wave not yet publicly available.

To advance research on cognition and dementia in Africa, a subcohort study was conducted between 2019 and 2020, sampling 710 participants aged 50 and older from HAALSI Wave 2 based on varying levels of cognitive impairment.[33] This study adapted the Harmonized Cognitive Assessment Protocol (HAALSI-HCAP), an internationally harmonized battery of cognitive tests and informant interviews, enabling cross-country comparisons.[34]

2.2 | Study population

Of the 710 participants aged 50 and over sampled from HAALSI Wave 2, 635 completed the HAALSI-HCAP Wave 1 interview (2019–2020). Among them, 567 (89.3%) had complete data on vision, and hearing, tests, and were included in Analysis Sample 1 (Figure 1). Of these, 60 participants (10.6%) died before HAALSI Wave 3 (2021–2022), and 491 (86.6%) were followed up. Among those followed, 399 participants had dementia probability scores and other analytic variables in HAALSI Wave 3 and comprised Analysis Sample 2 (Figure 1).

2.3 | Dementia and cognitive impairment outcomes

We used dementia and cognitive impairment rather than single cognitive test performance, because vision or hearing impairment required participants with additional cognitive load to perform cognitive tests.[35] A previous study found that cognitive function that relied on visual function was only correlated with visual impairment but not with hearing impairment.[36] Specifically, we used consensus-based diagnosis of dementia or MCI data in HAALSI-HCAP Wave 1.[37] This approach recruited a team of clinicians from interdisciplinary backgrounds (neurologists, geriatricians, neuropsychologists, dementia research psychologists) to determine the study sample's dementia status using the criteria set forth by the National Institute on Aging – Alzheimer's Association (NIA-AA).[38] As a result, participants were diagnosed with dementia if there was evidence of cognitive impairment from both the objective cognitive tests and informant report, and additionally, if participants had (1) evidence that cognitive impairment interfered with social and/or occupational function, (2) had experienced cognitive decline based on previous parent HAALSI waves, (3) had cognitive impairments that could not be explained by delirium or psychiatric disorders, and (4) had cognitive impairments in at least two cognitive domains. MCI was defined as evidence of cognitive impairment according to objective testing or informant report but not meeting criteria for dementia. Finally, cognitively normal was defined as no evidence of cognitive or functional impairment based on objective testing or informant report.

These dementia diagnoses informed the development of algorithmic models to estimate dementia probability scores for participants across HAALSI Waves 1–3. The models incorporated cognitive tests, functional assessments, and demographic variables, demonstrating strong performance in identifying dementia cases.[39] For this study, we used the predicted dementia probability score from HAALSI Wave 3 as another measure of dementia outcome. It was obtained based on Model 1 of the published algorithm[39] (cutoff = 0.22; sensitivity = 0.71, specificity = 0.75, accuracy = 0.74). Model 1 includes immediate recall, delayed recall, orientation score, self-reported memory, and activities of daily living (ADLs) as predictors.

RESEARCH IN CONTEXT

1. **Systematic review**: The authors reviewed literature on hearing and vision impairment in relation to dementia and cognitive impairment using Google Scholar and PubMed. Most evidence comes from high-income countries, with limited research in Sub-Saharan Africa, including South Africa, despite the high prevalence of sensory impairment in the region. Findings are mixed, influenced by variations in sensory impairment measurement (objective vs. self-reported), reverse causality considerations, and cognitive assessment methods.
2. **Interpretation**: In this rural South African population, both vision and hearing impairments are linked to an increased risk of dementia. Distance vision impairment alone is associated with mild cognitive impairment. Older adults with combined impairments in distance vision, near vision, and hearing had the highest dementia risk.
3. **Future directions**: To address reverse causality, future studies should examine how sensory impairment affects longitudinal changes in cognition. Additionally, research should explore whether sensory interventions improve cognition and reduce dementia risk.

2.4 | Sensory impairment measurement

Hearing and vision were assessed during the HAALSI-HCAP Wave 1 (2019–2020). Hearing was screened using the handheld Siemens HearCheck Screener, a tool suitable for nonclinical settings. While not as comprehensive as pure-tone audiometry,[40] it can detect at least moderately severe hearing loss per World Heslth Organization (WHO) criteria,[41] with high accuracy.[42,43] It has been used in other population-base aging studies, such as the English Longitudinal Study of Aging (ELSA).[44]

Trained HAALSI-HCAP nurses conducted hearing assessments in the quietest area of participants' homes. The test included two sequences of three tones:1000 Hertz (Hz) at 55, 35, and 20 decibels hearing level (dB HL), and 3000 Hz at 75, 55, and 35 dB HL, respectively. Participants reported the number of tones heard in each ear. For our analysis, we defined hearing impairment as the inability to successfully detect all six tones, using the better-hearing ear for analysis, following common practice.[26,45] We also treated hearing function as

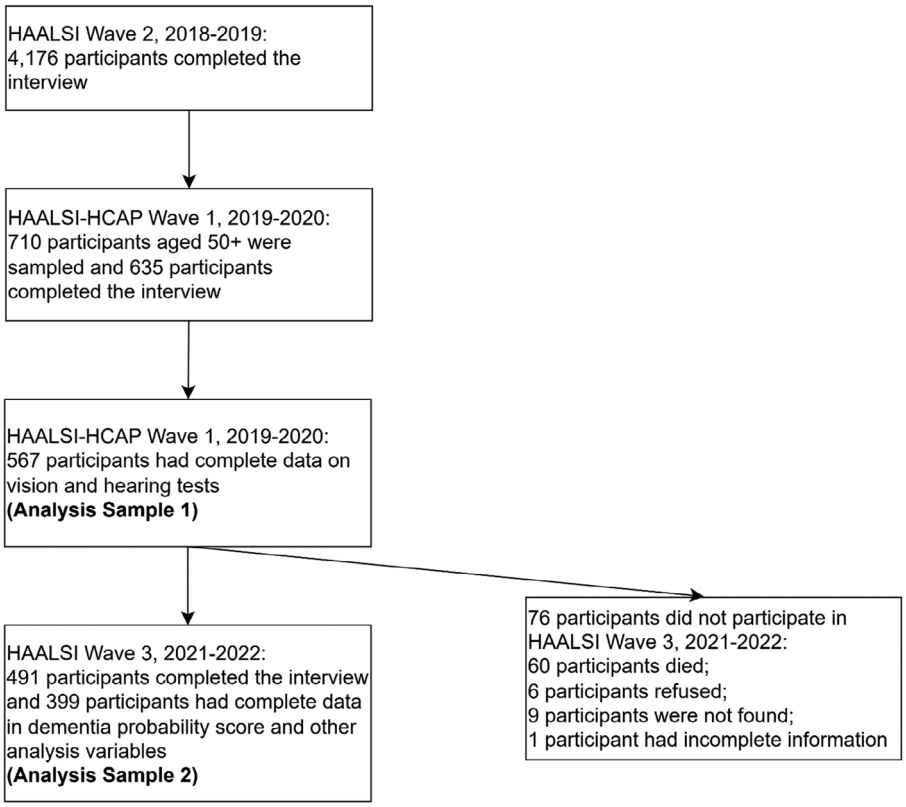


FIGURE 1 Study sample flow chart.

a continuous variable, using a reversed tone score (range 0–6), with higher scores indicating greater impairment.

Visual acuity in HAALSI-HCAP was assessed using the "Tumbling E" logMAR chart, displayed on the Computer-Assisted Personal Interviewing (CAPI) screen. Designed for low-literacy populations, the chart features Es in varying orientations and sizes. Participants identified the direction of the E's "opening" from 2.5 m (distance vision) and 50 cm (near vision), using their usual corrective lenses if needed. Each eye was evaluated separately, and acuity was scored based on the smallest line where at least 60% of Es[9] were correctly identified. The better-seeing eye was used for analysis.[46] In line with the definitions outlined by the World Health Organization and the US American Academy of Ophthalmology,[46] we used a visual acuity threshold worse than 20/40 for both distance and near vision to classify participants with vision impairment. In addition, we measured more levels of vision impairment, by adopting the approach used in a prior study from India,[47] which classified both distance and near vision impairment according to WHO[48] definitions: normal visual acuity (≥20/40), mild (< 20/40 to 20/60), and moderate/severe or blind (< 20/60). We combined moderate, severe impairment and blindness into a single category due to small sample sizes in severe vision impairment and blindness.

2.5 | Covariates

We also included a set of covariates associated with both sensory impairment and cognitive impairment, including dementia. These covariates were measured in HAALSI Wave 2, prior to the assessment of sensory function and dementia outcomes. The selected covariates encompass sociodemographic factors, health behaviors, and comorbidities, including sex, age, presence of cataracts, use of glasses, education level, household wealth, smoking status, diabetes, hypertension, heart disease, stroke, and depressive symptoms. Household wealth was assessed using quintiles derived from an asset index, which accounted for ownership of key assets, including housing materials, electricity, piped water, vehicles, and technological goods.[49] Health conditions such as diabetes, hypertension, heart disease, and stroke were determined based on a combination of clinical diagnoses and self-reported data. Depressive symptoms were evaluated using the 20-item Center for Epidemiologic Studies Depression Scale (CES-D), a widely used measure for assessing depressive affect and related symptoms.[50]

2.6 | Analysis strategy

Based on Analysis Sample 1, we employed a set of multinomial logistic regression models on dementia and mild cognitive impairment outcomes, with the "normal" status as the reference group. Our primary objective was to investigate the relationship between cognitive impairment and three key sensory impairments: distance vision impairment, near vision impairment, and hearing impairment. To assess the impact of different groups of confounding factors, we adjusted them step by step. Model 1 included these three sensory exposures while controlling for potential confounding variables such as sex, age, the

presence of cataracts, and whether participants wore glasses. In Model 2, we extended our analysis by introducing additional control variables, specifically education level, household wealth, and smoking status. Subsequently, in Model 3, we additionally controlled for comorbidities, including conditions such as diabetes, hypertension, heart disease, stroke, and depressive symptoms. For each regression, odds ratios (ORs) and 95% confidence intervals (CIs) were reported. All tests were two-sided, with a significance level set at 0.05.

Because ORs can be difficult to interpret, especially when comparing groups, we supplemented the regression results with predicted probabilities of dementia to improve interpretability. Specifically, we used post-estimation margins to estimate the average predicted probability of dementia under specific combinations of sensory impairment. For example, we set all participants to have impaired distance and near vision and hearing loss, while retaining their observed values for all other covariates. Using the estimated coefficients from Model 3, we calculated each participant's predicted probability of dementia under these conditions and then averaged across the sample. This approach yields an interpretable estimate of dementia risk for the study population under a given scenario of sensory impairment, allowing for clearer comparisons of dementia risk across different sensory impairment groups, independent of other sociodemographic and health-related factors. Sensory impairment and dementia diagnosis were assessed simultaneously, raising the possibility of reverse causality—where impaired cognition or dementia may influence sensory impairment. To mitigate this, we examined the association of sensory impairment variables measured in HAALSI-HCAP Wave 1 with dementia probability score at HAALSI Wave 3, two years after. Based on Analysis Sample 2, we applied an ordinary linear regression on the dementia probability score at HAALSI Wave 3, adjusting for the same covariates as in Model 3 above. To further mitigate reverse causality, we excluded those who were diagnosed with dementia at HAALSI-HCAP Wave 1 and repeated the analysis among those without dementia (normal cognition or MCI).

To assess the robustness of our findings, we conducted two sensitivity analyses using alternative measures of sensory function. First, we combined distance and near vision impairment into a single measure of any vision impairment. Second, we explored potential dose-response relationships by using categorical vision impairment and continuous hearing impairment measures. Statistical analyses were conducted using STATA 18 (StataCorp LLC).

3 | RESULTS

Among the study sample, participants with dementia or MCI were significantly older than those with normal cognitive function (Table 1). Over 60% of cognitively healthy participants were younger than 70, whereas more than 60% of those with MCI or dementia were older than 70. Sex disparities were evident, as women were disproportionately diagnosed with MCI or dementia. Educational attainment also differed substantially; individuals with cognitive impairment had notably higher prevalence of no formal schooling compared to their cognitively healthy counterparts. Similarly, lower household wealth was more prevalent among those with MCI or dementia, indicating a socioeconomic gradient in cognitive health. In terms of lifestyle behaviors, smoking habits showed little variation across cognitive groups, with over 80% of participants in all categories reporting they had never smoked. However, health conditions varied significantly. Diabetes was more prevalent among those with MCI, while hypertension was more common in participants with normal cognition or MCI. On the other hand, those with dementia exhibited higher rates of heart disease, stroke, and depressive symptoms. Clear gradients emerged in sensory impairment, with dramatically higher prevalence among those with dementia: 50% had distance vision impairment, 90% near vision impairment, and 70% reported hearing loss. Even among those with normal cognition, 56% had near vision impairment, and 36% experienced hearing loss. Additionally, individuals with dementia had a higher likelihood of undergoing cataract surgery, yet the use of corrective eyewear remained strikingly low (only 3.5%–8.2%), despite the widespread vision impairment in this population.

Among the sensory impairments examined, only distance vision impairment was significantly associated with MCI compared to normal cognition (Table 2). Participants with distance vision impairment had 2.48 times higher odds of MCI (95% CI: 1.32–4.68) relative to those with normal vision. Notably, this association remained stable even after adjusting for additional covariates. In contrast, neither near vision impairment nor hearing impairment showed a significant association with MCI. However, all three types of sensory impairment were significantly linked to an increased risk of dementia. Individuals with distance vision impairment had twice the odds of dementia (OR: 2.01, 95% CI: 1.02–3.97) compared to those with normal cognition. The association was even stronger for near vision impairment, with affected individuals having 4.17 times higher odds of dementia (95% CI: 1.81–9.60). Similarly, hearing impairment was linked to a 2.51-fold increase in dementia risk (95% CI: 1.36–4.66). Furthermore, the associations between near vision or hearing impairment and dementia became more pronounced as additional covariates were included.

Figure 2 shows the average predicted probability of dementia under different sensory impairment scenarios. If no participants had hearing or vision impairment, the probability was 0.05 (95% CI: 0.01–0.08). This increased with single sensory impairment, particularly for near vision impairment only (0.18, 95% CI: 0.11–0.24). The probability rose further with multiple impairments, particularly driven by near vision impairment and hearing impairment, reaching a peak of 0.34 (95% CI: 0.24–0.43) when all three impairments were present—nearly seven times higher than in the absence of any sensory impairment.

Sensory impairment also predicted higher dementia probability score 2 years after, as shown in Table 3. Both near vision impairment and hearing impairment remained significantly associated with a higher probability of dementia score two years later (Table 3). Among participants without dementia, only hearing impairment remained associated with a higher probability of dementia over a 2-year period (0.021, 95% CI: 0.002–0.04), representing 23.3% increase relative to the average dementia probability score of 0.09 among individuals with normal cognition (Table 1). The associations between vision

TABLE 1 Descriptive characteristics of study sample.

Parameter	Normal (*N* = 280)	MCI (*N* = 170)	Dementia (*N* = 117)	Total (*N* = 567)
Sex				
Male	117 (41.8%)	59 (34.7%)	40 (34.2%)	216 (38.1%)
Female	163 (58.2%)	111 (65.3%)	77 (65.8%)	351 (61.9%)
Age groups, years				
< 60	107 (38.2%)	20 (11.8%)	5 (4.3%)	132 (23.3%)
60-69	97 (34.6%)	44 (25.9%)	19 (16.2%)	160 (28.2%)
70-79	54 (19.3%)	54 (31.8%)	40 (34.2%)	148 (26.1%)
> 79	22 (7.9%)	52 (30.6%)	53 (45.3%)	127 (22.4%)
Education level				
No formal education	101 (36.1%)	120 (70.6%)	95 (81.9%)	316 (55.8%)
Some primary (1-7 years) or more	179 (63.9%)	50 (29.4%)	21 (18.1%)	250 (44.2%)
Household wealth index				
Q1	38 (13.6%)	62 (36.5%)	32 (27.4%)	132 (23.3%)
Q2	51 (18.2%)	35 (20.6%)	26 (22.2%)	112 (19.8%)
Q3	59 (21.1%)	26 (15.3%)	26 (22.2%)	111 (19.6%)
Q4	69 (24.6%)	21 (12.4%)	17 (14.5%)	107 (18.9%)
Q5	63 (22.5%)	26 (15.3%)	16 (13.7%)	105 (18.5%)
Smoking status				
Never	247 (88.5%)	140 (83.3%)	100 (86.2%)	487 (86.5%)
Former	16 (5.7%)	14 (8.3%)	7 (6.0%)	37 (6.6%)
Current	16 (5.7%)	14 (8.3%)	9 (7.8%)	39 (6.9%)
Diabetes				
No	243 (88.7%)	134 (81.7%)	97 (85.8%)	474 (86.0%)
Yes	31 (11.3%)	30 (18.3%)	16 (14.2%)	77 (14.0%)
Hypertension				
No	183 (69.6%)	103 (67.8%)	88 (80.7%)	374 (71.4%)
Yes	80 (30.4%)	49 (32.2%)	21 (19.3%)	150 (28.6%)
Heart disease				
No	274 (97.9%)	167 (98.2%)	114 (97.4%)	555 (97.9%)
Yes	6 (2.1%)	3 (1.8%)	3 (2.6%)	12 (2.1%)
Stroke				
No	272 (97.5%)	164 (97.6%)	107 (92.2%)	543 (96.4%)
Yes	7 (2.5%)	4 (2.4%)	9 (7.8%)	20 (3.6%)
Mean number of CES-D depressive symptoms (SD)	13.86 (9.37)	15.14 (9.60)	18.04 (9.58)	15.08 (9.60)
Distance vision				
Not impaired	240 (85.7%)	108 (63.5%)	59 (50.4%)	407 (71.8%)
Impaired	40 (14.3%)	62 (36.5%)	58 (49.6%)	160 (28.2%)
Near vision				
Not impaired	122 (43.6%)	66 (38.8%)	12 (10.3%)	200 (35.3%)
Impaired	158 (56.4%)	104 (61.2%)	105 (89.7%)	367 (64.7%)
Hearing function				
Not impaired	178 (63.6%)	89 (52.4%)	35 (29.9%)	302 (53.3%)
Impaired	102 (36.4%)	81 (47.6%)	82 (70.1%)	265 (46.7%)

(Continues)

TABLE 1 (Continued)

Parameter	Normal (*N* = 280)	MCI (*N* = 170)	Dementia (*N* = 117)	Total (*N* = 567)
Ever had cataract				
No	259 (92.5%)	151 (88.8%)	95 (81.2%)	505 (89.1%)
Yes, no surgery	17 (6.1%)	13 (7.6%)	20 (17.1%)	50 (8.8%)
Yes, surgery	4 (1.4%)	6 (3.5%)	2 (1.7%)	12 (2.1%)
Wear glass				
No	257 (91.8%)	164 (96.5%)	109 (93.2%)	530 (93.5%)
Yes	23 (8.2%)	6 (3.5%)	8 (6.8%)	37 (6.5%)
Mean probability of dementia in wave 3 (SD)	0.09 (0.06)	0.15 (0.12)	0.24 (0.19)	0.13 (0.12)

Abbreviations: CES-D, Center for Epidemiologic Studies Depression Scale; MCI, mild cognitive impairment; SD, standard deviation.

TABLE 2 Multinomial logistic regression results in the associations of distance vision, near vision, or hearing impairment with mild cognitive impairment and dementia (*N* = 567).

Sensory impairment variables	Model 1	Model 2	Model 3
Mild cognitive impairment versus normal			
Distance vision impaired	2.21** (1.30, 3.78)	2.22** (1.27, 3.88)	2.48** (1.32, 4.68)
Near vision impaired	0.73 (0.47, 1.15)	0.76 (0.47, 1.23)	0.61 (0.36, 1.05)
Hearing impaired	1.02 (0.66, 1.59)	1.21 (0.76, 1.93)	1.33 (0.79, 2.21)
Dementia versus normal			
Distance vision impaired	1.95* (1.08, 3.53)	1.98* (1.06, 3.69)	2.01* (1.02, 3.97)
Near vision impaired	3.27** (1.62, 6.61)	3.41** (1.63, 7.15)	4.17** (1.81, 9.60)
Hearing impaired	2.04** (1.20, 3.47)	2.53** (1.43, 4.48)	2.51** (1.36, 4.66)

Note: Odds ratios and the 95% confidence intervals in parentheses. In addition to the sensory impairment measures, Model 1 includes sex, age, the presence of cataracts, and whether participants wore glasses. Model 2: Model 1 + education level, household wealth, and smoking status. Model 3: Model 2 + diabetes, hypertension, heart disease, stroke, and depressive symptoms.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

impairment and predicted dementia probability score decreased and became not statistically significant. But the overall trend suggests that sensory impairments were positively linked to a higher dementia probability score two years after sensory assessment.

Table S1 presents sensory impairment measures with greater detail across multiple categories. The associations between sensory impairment and cognitive outcomes remained robust across alternative measures of impairment (Tables S2–S5). Distance vision impairment showed a particularly strong association with MCI, which was attenuated when vision measures were combined (Table S2). Evidence for a dose-response relationship between sensory impairments and cognitive outcomes is limited. Only more severe levels of distance vision impairment show a stronger association with MCI. In contrast, greater severity of hearing impairment—as indicated by an increased number of tones not heard—was linearly associated with higher risks of MCI, dementia, and elevated dementia probability scores two years later (Tables S4,S5).

4 | DISCUSSION

In a region with scarce prior research—both within South Africa and across Sub-Saharan Africa,[16,51] this study is among the first to examine the associations of both vision and hearing impairments with dementia and cognitive impairment in South Africa. To our knowledge, prior to this study, only the WHO Study on global AGEing and adult health (SAGE) study[16] had investigated the association of vision impairment with cognitive impairment among older adults from six LMICs, including South Africa.

Our findings on vision or hearing impairment associated with greater risks of dementia and cognitive impairment are consistent with previous systematic review and meta-analysis studies.[11,14,15] Most previous studies on vision impairment and cognition did not distinguish between distance and near vision impairments. This is often because they relied on self-reported data, which typically focus on how vision problems affect daily activities—such as recognizing faces from a

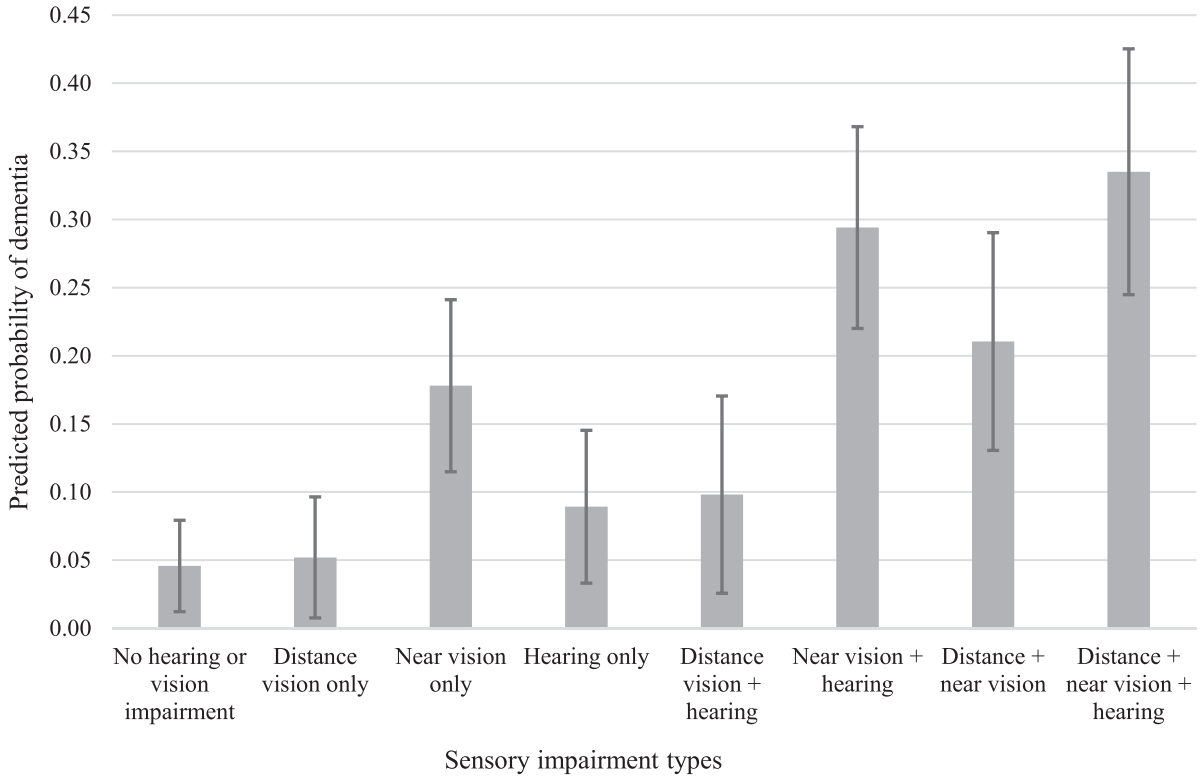


FIGURE 2 Average predicted probability of dementia by different types of sensory impairment. *Note*: Error bars represent 95% confidence intervals. Results were derived from Model 3 in Table 2 that compared relative risks of dementia against normal cognitive function. In addition to vision and hearing measurement, the model adjusted sex, age category, presence of cataracts, glasses use, education level, household wealth, smoking status, diabetes, hypertension, heart disease, stroke, and depressive symptoms.

TABLE 3 Linear regression results on the associations of distance vision, near vision, or hearing impairment with predicted probability of dementia score at HAALSI Wave 3 (2021-2022).

	Analysis samples	
Sensory impairment variables	**Among all respondents from HAALSI HCAP Wave 1 (*N* = 399)**	**Only among respondents without dementia at HAALSI HCAP Wave 1 (*N* = 335)**
Distance vision impaired	0.026 (−0.003, 0.056)	0.009 (−0.017, 0.034)
Near vision impaired	0.026* (0.002, 0.049)	0.007 (−0.011, 0.026)
Hearing impaired	0.033** (0.010, 0.056)	0.021* (0.002, 0.040)

Note: Results were based on linear regressions. The 95% confidence intervals were provided in parentheses. Among 567 HAALSI HCAP Wave 1 participants who have no missing in diagnosis and sensory impairment, 491 (86.6%) of them completed HAALSI Wave 3 interviews and 444 of them had predicted probability of dementia score. After excluding participants with missingness in covariates and outcomes, 399 cases remained, and 335 of them were without dementia in HAALSI-HCAP Wave 1. We used a linear regression on probability of dementia score and controlled covariates used in Model 3 of Table 2: sex, age, the presence of cataracts, whether participants wore glasses, education level, household wealth, smoking status, diabetes, hypertension, heart disease, stroke, and depressive symptoms.

Abbreviations: HAALSI HCAP, Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community in South Africa Harmonized Cognitive Assessment Protocol.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

distance or reading a book—making it difficult to differentiate between distance and near vision impairment.[20,22,25,28] Other studies limited their assessment to objective measures of distance vision only.[17,27,52] Among the few prior studies that examined both distance and near vision impairments, the focus was solely on cognitive outcomes rather than clinical dementia.[16,53,54] This study added evidence that both distance and near vision impairment were independently associated with greater dementia risks. In addition, we observed an association

between distance vision impairment and MCI but no association of near vision impairment with MCI. In contrast, the earlier study with South African samples[16] reported that distance vision impairment alone was not associated with MCI, while near vision impairment, with or without distance vision impairment, was associated with MCI.[16] Both studies used the "Tumbling E" logMAR chart to examine visual acuity. Differences in sample size and how vision impairment was classified may explain this discrepancy. The previous study had a much larger sample size, providing greater power to detect associations, and assessed the combined vision impairments, whereas we analyzed distance and near vision separately based on a much smaller sample size. Additionally, previous studies pooled data across multiple LMICs, potentially obscuring country-specific variations. Our findings that distance vision impairment was associated with both MCI and dementia, whereas near vision impairment was not associated with MCI, may reflect a greater reliance on distance vision in daily life among our study population. Participants were from rural South Africa and generally had little or no formal education.[33] In this context, individuals are more likely to engage in activities that depend on distance vision—such as agricultural work and outdoor navigation—and are less likely to engage in reading or screen-based tasks that rely on near vision.

Moreover, distance vision impairment may reflect a longer duration of vision problems. While near vision impairment typically arises in older age due to age-related loss of lens elasticity (presbyopia), distance vision impairment is often caused by uncorrected refractive errors that commonly begin in childhood or adolescence.[9] As shown in Table 1, few participants wore corrective lenses, despite a high prevalence of vision impairment. This suggests that individuals with distance vision impairment may have experienced reduced cognitive stimulation from a young age, potentially resulting in lower cognitive reserve and worse cognitive outcomes later in life. In contrast, near vision impairment emerges later in life and may have less impact on early-stage cognitive decline.

This study also finds that sensory impairment—particularly hearing impairment—is associated with increased dementia risk over the longer term, as shown in Table 3. This temporal relationship helps mitigate concerns about reverse causality, given that the dementia probability score was measured two years after the sensory assessments. Compared to vision impairment, the association between hearing impairment and dementia risk appears more robust: hearing impairment remained significantly associated with dementia probability even after excluding individuals with dementia at baseline, whereas the association with near vision impairment did not. These findings suggest that hearing impairment may serve as an early risk factor for cognitive decline. However, the relatively short 2-year follow-up period may have limited our ability to detect longer-term associations between vision impairment and dementia risk.

Due to the scope of the current study, this study did not examine the mechanisms linking sensory impairment and cognitive function in later life. The literature shows that hearing and vision impairments may share common pathways that contribute to cognitive decline,[55] including shared underlying etiologies (e.g., vascular disease), increased cognitive load from sensory deprivation, and reduced cognitive stimulation due to social isolation and decreased activity. White matter hyperintensities, markers of cerebrovascular disease, are observed in individuals with hearing loss or dementia.[56] There are also overlapping neuropathological processes in the retina and brain.[14] Future analysis is needed to verify and explore more potential pathways.

This study has several limitations. First, we assessed vision and hearing function at a single time point and lacked information on the duration and underlying causes of sensory impairments. For example, common causes of vision impairment such as uncorrected refractive error, diabetic retinopathy, or glaucoma[57] were not identified. Without distinguishing between preventable, treatable, or irreversible causes of vision loss, the public health implications of our findings might be compromised, as it remains unclear which impairments could be effectively addressed through interventions like eyeglasses, surgery, or chronic disease management. Second, the short two-year follow-up period may not fully address the concern of reverse causality and may have limited our ability to detect longer-term associations between sensory impairment and cognitive decline. Most previous studies have followed participants for five or more years,[17,52] allowing for a more comprehensive assessment of incident dementia risk. Third, there may be unmeasured confounders that influence both sensory impairment and cognitive function, such as occupational history.[58,59] The majority of HAALSI participants were unemployed, and available data on occupation were limited,[32] which prevented us from adequately examining its potential confounding effects. Other limitations include the relatively small sample size and the high prevalence of near vision impairment among individuals with dementia—approximately 90%, as well as relatively low prevalence of distance vision impairment—which reduced the precision of our estimates.

Overall, the findings of this study have significant public health implications. Based on our calculation shown in Figure 2, removing vision and hearing impairment would substantially reduce dementia risk at the population level. We observed a high prevalence of vision and hearing impairments, yet the uptake of corrective lenses and hearing aids was strikingly low. Providing assistive devices or interventions for sensory impairments (e.g., hearing aids, cochlear implants, prism lenses, cataract surgery) may support cognitive function, slow cognitive decline, and enhance quality of life for both older adults and caregivers, though evidence remains mixed.[5,60] However, a recent randomized controlled trial found that hearing aids had a strong protective effect on cognition in individuals at high risk of dementia, such as those who are older, smoke more, have lower education levels, live alone, or have diabetes and hypertension.[61] Additionally, older adults with depression or social disengagement are more vulnerable to cognitive decline associated with sensory impairment. Promoting social engagement may help mitigate this risk.[17,62]

In summary, this study underscores the critical role of sensory impairment in dementia risk among older adults in rural South Africa. Our findings highlight the need for targeted interventions to improve vision and hearing function as part of dementia prevention strategies. Future research should explore the long-term cognitive benefits of sensory interventions and examine potential biological mechanisms linking sensory impairment to dementia in LMIC populations.

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CONFLICT OF INTEREST STATEMENT

The authors report no conflicts of interest. Author disclosures are available in the supporting information.

CONSENT STATEMENT

Written or verbally informed consent was obtained from all study participants.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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