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Proximity to public transportation and incidence of depression risk among older adults: A three-year longitudinal analysis from the Japan Gerontological evaluation study

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ABSTRACT

Objective: Depression in older adults has been associated with environmental factors, such as green spaces and walkable neighborhoods; however, evidence on the relationship between proximity to public transportation and mental health is scarce. This multi-municipality longitudinal study examined the association between proximity to public transportation and risk of depression among older adults and considered car usage.

Methods: We analyzed data from 4947 functionally independent adults, aged 65 years and older who resided in 25 municipalities across Japan. Data were obtained via the Japan Gerontological Evaluation Study in 2016 and 2019. We assessed depression over three years in older adults without depression at baseline via the Geriatric Depression Scale-15. We subjectively and objectively measured their proximity to public transportation. Logistic regression analyses were performed, adjusted for covariates, with analyses stratified by car usage.

Results: Of the participants, 9.76 % developed depression over a three-year period. Those without car usage and with reported lack of proximal public transport exhibited a higher incidence of depression (OR = 1.60, 95 %CI: 1.05–2.42) compared with those who had better access. No significant association was observed in the car user group. Furthermore, no significant association was observed in the analysis that used objective measures with Geographic Information System (GIS) data.

Conclusion: Subjective limited access to public transport was significantly associated with the risk of depression among older adults without car usage. Hence, improving and maintaining transportation infrastructure may mitigate the risk of depression.

1. Introduction

Depression in older adults, a major public health issue, has been linked to an increased risk of dementia (Diniz et al., 2013), frailty (Vaughan et al., 2015), and mortality (World Health Organization, 2017). Approximately 7 % of older adults worldwide suffer from depression (World Health Organization, 2017). With the proportion of older adults expected to double between 2020 and 2050 (World Health Organization, 2023), the number of those with depression and related health impairments is also anticipated to increase. Accordingly, in addition to traditional individual approaches, such as medication and counseling, preventive environmental interventions are becoming increasingly important (Rautio et al., 2018). Various environmental factors affect mental health, such as population density, pollution, noise,

Abbreviations and acronyms: JAGES, The Japan Gerontological evaluation study; GDS, Geriatric depression scale; GIS, Geographic information system; IADL, Instrumental activities of daily living; TMIG-IC, Tokyo metropolitan Institute of Gerontology Index of competence; MI, Multiple imputation; OR, Odds ratio; CI, Confidence interval; MaaS, Mobility as a service.

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housing type, and green spaces (Núñez-González et al., 2020). A systematic review reported that walkable neighborhoods were associated with reduced depressive symptoms among older adults (Julien et al., 2012).

In Japan, the proportion of traffic accidents caused by older adults is rising annually (National Police Agency Traffic Bureau, 2024). Furthermore, although voluntary surrender of driving licenses is encouraged, cessation of driving can lead to decreased frequency of going out (Marottoli et al., 2000) and double the risk of long-term care needs (Hirai et al., 2020). Those who stop driving tend to use alternative transportation methods, such as trains and buses (Liddle et al., 2014). Conversely, older adults who do not live near public transportation have less walking time (Barnett et al., 2017) and social participation (Levasseur et al., 2015), which could potentially lead to depression. Prior research indicated that older adults who lived far from their nearest bus stop had poorer mental health (Chiatti et al., 2017). Additionally, higher noise levels have been reported in areas near stations or bus stops (Gershon et al., 2006), with noise increasing the risk of depression and anxiety (Gong et al., 2022). Furthermore, station areas can become crowded, with a study suggesting a positive correlation between crowding and stress (Zhang et al., 2023). Such factors can negatively impact mental health; hence, proximity to public transportation may be an important environmental factor that affects the risk of depression in older adults.

However, evidence on the relationship between proximity to public transportation and mental health among older adults is scarce. In addition, previous studies have several limitations. First, active individuals may have underestimated self-reported distance to the nearest bus stop. Second, one cross-sectional study could not eliminate the possibility of reverse causality (Chiatti et al., 2017). Third, the narrow range in one study could limit generalizability (Eibich et al., 2016).

Therefore, studies encompassing multiple municipalities, including diverse urban and rural areas, are required to explore the relationship between proximity to public transportation and mental health. Furthermore, studies employing objective measures of proximity to public transportation are necessary to address the limitations of self-reported data. Thus, conducting longitudinal studies could further help observe the onset of depression and eliminate the possibility of reverse causality. In addition, studies should also consider the availability of a car. Older adults who have stopped driving, do not have access to a vehicle, or are distant from public transport could be more susceptible to depression (Edwards et al., 2009).

This study conducted a longitudinal analysis across multiple municipalities and focused on the relationship between the risk of depression in older adults and their proximity to public transportation, such as train stations or bus stops. We differentiated between individuals based on their access to a car and employed both subjective and objective measures to assess their proximity to public transportation.

2. Methods

2.1. Study design

This three-year longitudinal study used data from the Japan Gerontological Evaluation Study (JAGES) (Kondo, 2016). A self-reported postal survey administered in 2016 targeted 28,858 functionally independent older adults aged 65 years and older who resided in 25 municipalities. Responses were received from 20,281 participants (response rate: 70.3 %) (Fig. 1). The 25 municipalities included a diverse range of areas from urban to rural regions in Japan. Respondents were followed up for three years, which resulted in a sample of 9081 individuals (follow-up rate: 44.8 %).

Subsequently, we excluded individuals who did not respond to the 15-item Geriatric Depression Scale (GDS-15) (Yesavage and Sheikh, 1986), were depressed (GDS score of ≥5 points), or were undergoing treatment for depression as of 2016. We further excluded individuals who were not independent in their activities of daily living, did not respond to caregiving certification questions, did not answer the transportation method question, or had missing residential information. Additionally, individuals with inconsistencies in their age and gender between 2016 and 2019 and those who had lived in their current residence for <3 years or did not provide residential information as of 2019 were excluded. Hence, 4134 individuals were excluded.

Consequently, the final analysis included 4947 older adults, with an average age of 73 years (50.8 % men). Average follow-up period was three years.

2.2. Measurements

2.2.1. Dependent variable

The dependent variable was depression status, as of 2019, as determined via the GDS-15. A score of ≥5 was considered indicative of

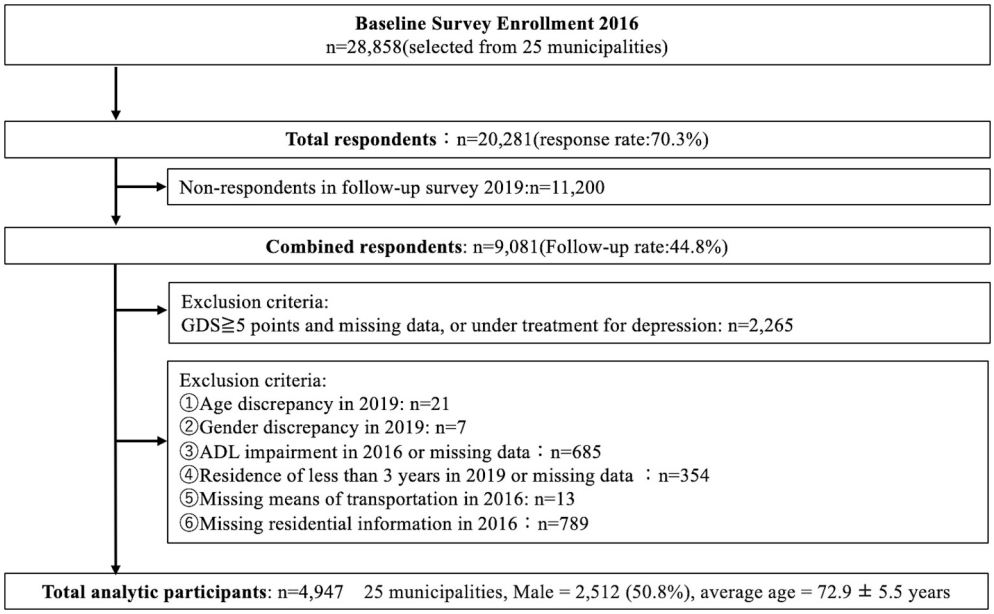

Fig. 1. Participant flow and exclusion criteria in the longitudinal study among older adults, Japan, 2016–2019.

depression. The GDS-15 was a self-administered assessment that used a simple "yes/no" format, and the total score ranged from 0 to 15 points. Its validity and reliability have been confirmed in older adults (Yesavage and Sheikh, 1986). We defined participants who scored ≥5 on the GDS-15 in 2019 as having developed depression during the follow-up period.

2.2.2. Independent variable

The independent variable was proximity to train stations or bus stops, measured via both subjective and objective methods. The subjective scale was based on a baseline questionnaire item, "How many train or subway stations or bus stops are within walking distance (10–15 minutes) from your home?" We categorized the responses into five options: "many," "some," "few," "none," and "do not know." Responses of "many" and "some" were classified as "present," while "few" and "none" were classified as "absent." Responses of "do not know" were treated as missing values.

An objective scale measured the road network distance from the representative point of the registered Chocho-aza data (regional classification within a municipality in Japan) (Association for Promotion of Infrastructure Geospatial Information Distribution, 2022) to the nearest train station or bus stop as the continuous variable. Geographic Information System (GIS) data for stations and bus stops were obtained from the National Land Numerical Information (Ministry of Land, Infrastructure, Transport and Tourism, 2024) via 2016 and 2012 data for stations and bus stops, respectively. Distances were calculated using ArcGIS Pro version 3.0 (Esri, Redlands, CA, USA) and expressed in kilometers.

2.2.3. Covariates

Covariates were developed based on prior studies on transportation and health (Eibich et al., 2016; Tsunoda et al., 2012; Zhang et al., 2018). We adjusted for baseline age, gender, equivalent income, years of education, employment, marital, diseases under treatment, living-alone status, car usage, and population density, as well as Instrumental Activities of Daily Living (IADL), which were related to the ability to recognize one's neighborhood environment. Population density was used as a categorical variable for the three quintiles. Diseases under treatment included stroke, osteoporosis, hypertension, diabetes, trauma/fractures/arthritis, respiratory diseases, and heart diseases (Woods and Moshang, 2005). The Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC) was used as the IADL index (Koyano et al., 1991) and included IADL as a subitem; an IADL score of <13 indicated non-independence in higher life functions (Miyazawa et al., 2021). Car usage was determined based on a baseline questionnaire item that enquired regarding the modes of transportation used for going out. Furthermore, those who drove themselves or were being driven were considered to have car access.

2.3. Statistical analysis

First, we checked the distribution of participants' characteristics by subjective proximity to public transportation and car usage status. Subsequently, we calculated descriptive statistics for distance to the train stations and bus stops by depression onset and car usage status. We performed multiple imputation (MI) on the participants and conducted logistic regression analyses, adjusted for covariates. We calculated the odds ratios (OR) and 95 % confidence intervals (CI) for new cases of depression in 2019. MI addressed the missing data in the explanatory variables, dependent variables, and covariates. It was conducted via the MVN method to generate 20 datasets. We also conducted analyses stratified according to car usage. To examine the pathway that connected proximity to public transportation with depression, we conducted sensitivity analyses that included variables assumed to be intermediate factors, such as walking time, social participation, and availability of fresh food stores within walking distance (le Cessie et al., 2011). All statistical analyses were performed using STATA version 17 (StataCorp, College Station, TX, USA).

2.4. Ethics approval

This study was approved by the ethical committee of the National Center for Geriatrics and Gerontology (No. 992 and 1274–2), Chiba University (No. 2493 and 3442) and Japan Gerontological Evaluation Study Association (No. 2019–01). All procedures followed the principles set by the Declaration of Helsinki and its future amendments.

3. Results

Table 1 presents the distribution of each variable according to the subjective proximity to public transport and car usage status. Of the 4947 participants, 483 (9.76 %) were classified as having depression after three years. Furthermore, 4015 (81.16 %) used a car, while 932 (18.84 %) did not. Compared with those with car access, a higher proportion of individuals without car access developed depression (GDS-15 score of ≥5) by 2019 and were older adults (aged 75 years or older), women, those with lower incomes, shorter educational backgrounds, unemployed, and those bereaved, separated, or living alone. Additionally, older adults without car access often lived in areas with high population density and frequently reported they had a train station or bus stop within walking distance. Overall, a higher proportion of people who had an equivalent income of ≤1.99-million-yen, shorter education, and resided in areas with lower population density reported they had no train or bus stops nearby. In the non-car usage group, 9.98 % among those with access to train or bus stops nearby developed depression compared with 16.49 % among those without. In the car usage group, 8.89 % of those with access to trains or bus stops developed depression compared with 9.58 % of those without. Difference in depression was greater in the non-car group than that in the car group. Regarding the means of going out other than by car, those who reported having a train station or bus stop within walking distance were more likely to use them (Table S1).

Table 2 presents the depression onset and the distance to train stations and bus stops by car usage status. The full results of the descriptive statistics for each variable and the distance to train stations and bus stops are available in the supplementary material (Table S2). Distance to the nearest train station and bus stop was greater in the car user group (3.02 ± 4.08 km and 0.53 ± 0.71 km, respectively) compared with the non-car user group (1.87 ± 2.49 km and 0.37 ± 0.55 km, respectively). Among the car users, distance to the train station was greater for those who developed depression (3.16 km) compared with those who did not (2.97 km). In the non-car user group, this trend was similar; individuals who were depressed reported greater distance (1.95 km) compared with individuals who were not depressed (1.86 km). No notable difference was observed in the distance to bus stops regarding depression onset.

Table 3 presents the results of logistic regression analysis for MI. Full results are available in the supplementary material (Tables S3 and 4). In the analysis that used subjective measures as explanatory variables, no significant association was observed between the presence of train or bus stops within walking distance and risk of developing depression after three years for the entire sample. In the non-car user group, the risk of developing depression was 1.60 times higher (95 % CI: 1.05–2.42) for those who reported no access to train or bus stops compared with those who did. No significant association was observed in the car user group. In the analyses that used objective measures as explanatory variables, no significant association was observed in either the entire sample or stratified analyses.

Sensitivity analysis in the non-car user group, independently adjusted for the three additional variables of walking time, social participation, and availability of fresh food stores within walking distance, revealed that the odds ratios decreased in all. Furthermore, the significant associations disappeared in availability of fresh food stores (Table S5).

Table 1
Participants' characteristics according to subjective proximity to public transport and car usage status among older adults, Japan, 2016–2019.

	With Car use				Without Car use				Total
	With station or bus stop	Without station or bus stop	Station or bus unknown	Total	With station or bus stop	Without station or bus stop	Station or bus unknown	Total	
	(n = 1845)	(n = 1556)	(n = 614)	(n = 4015)	(n = 621)	(n = 194)	(n = 117)	(n = 932)	(n = 4947)
GDS in 2019(n,%)									
≤ 4 points	1498(81.2)	1237(79.5)	489(79.6)	3224(80.3)	470(75.7)	133(68.6)	86(73.5)	689(73.9)	3913(79.1)
≥ 5 points	164(8.9)	149(9.6)	64(10.4)	377(9.4)	62(10.0)	32(16.5)	12(10.3)	106(11.4)	483(9.8)
Missing	183(9.9)	170(10.9)	61(9.9)	414(10.3)	89(14.3)	29(15.0)	19(16.2)	137(14.7)	551(11.1)
Age(n,%)									
65–74 years old	1267(68.7)	1034(66.5)	419(68.2)	2720(67.8)	321(51.7)	103(53.1)	59(50.4)	483(51.8)	3203(64.7)
≥ 75 years	578(31.3)	522(33.6)	195(31.8)	1295(32.3)	300(48.3)	91(46.9)	58(49.6)	449(48.2)	1744(35.3)
Gender(n,%)									
Male	1058(57.3)	834(53.6)	289(47.1)	2181(54.3)	234(37.7)	64(33.0)	33(28.2)	331(35.5)	2512(50.8)
Female	787(42.7)	722(46.4)	325(52.9)	1834(45.7)	387(62.3)	130(67.0)	84(71.8)	601(64.5)	2435(49.2)
Equivalent income(n,%)*									
Low	549(29.8)	565(36.3)	210(34.2)	1324(33.0)	243(39.1)	99(51.0)	44(37.6)	386(41.4)	1710(34.6)
Middle	823(44.6)	578(37.2)	232(37.8)	1633(40.7)	238(38.3)	43(22.2)	34(29.1)	315(33.8)	1948(39.4)
High	265(14.4)	171(11.0)	70(11.4)	506(12.6)	55(8.9)	16(8.3)	8(6.8)	79(8.5)	585(11.8)
Missing	208(11.3)	242(15.6)	102(16.6)	552(13.8)	85(13.7)	36(18.6)	31(26.5)	152(16.3)	704(14.2)
Education(n,%)									
≤ 9 years	306(16.6)	385(24.7)	144(23.5)	835(20.8)	142(22.9)	81(41.8)	34(29.1)	257(27.6)	1092(22.1)
>10 years	1519(82.1)	1158(74.4)	468(76.2)	3145(78.3)	476(76.7)	110(56.7)	82(70.1)	668(71.7)	3813(77.1)
Other/missing	20(1.1)	13(0.8)	2(0.3)	35(0.9)	3(0.5)	3(1.6)	1(0.9)	7(0.8)	42(0.8)
Employment(n,%)									
Employed	576(31.2)	482(31.0)	175(28.5)	1233(30.7)	138(22.2)	40(20.6)	22(18.8)	200(21.5)	1433(29.0)
Not employed	1128(61.1)	954(61.3)	390(63.5)	2472(61.6)	409(65.9)	124(63.9)	73(62.4)	606(65.0)	3078(62.2)
Missing	141(7.6)	120(7.7)	49(8.0)	310(7.7)	74(11.9)	30(15.5)	22(18.8)	126(13.5)	436(8.8)
Marital status(n,%)									
Married	1558(84.4)	1306(83.9)	481(78.3)	3345(83.3)	393(63.3)	121(62.4)	70(59.8)	584(62.7)	3929(79.4)
Widowed	215(11.7)	195(12.5)	101(16.5)	511(12.7)	140(22.5)	48(24.7)	30(25.6)	218(23.4)	729(14.7)
Divorced	44(2.4)	25(1.6)	15(2.4)	84(2.1)	49(7.9)	17(8.8)	4(3.4)	70(7.5)	154(3.1)
Single	21(1.1)	19(1.2)	14(2.3)	54(1.3)	35(5.6)	7(3.6)	11(9.4)	53(5.7)	107(2.2)
Missing	7(0.4)	11(0.7)	3(0.5)	21(0.5)	4(0.6)	1(0.5)	2(1.7)	7(0.8)	28(0.6)
Diseases under treatment(n,%)									
Present	1407(76.3)	1212(77.9)	454(73.9)	3073(76.5)	467(75.2)	152(78.4)	88(75.2)	707(75.9)	3780(76.4)
Absent	392(21.3)	312(20.1)	144(23.5)	848(21.1)	135(21.7)	36(18.6)	28(23.9)	199(21.4)	1047(21.2)
Missing	46(2.5)	32(2.1)	16(2.6)	94(2.3)	19(3.1)	6(3.1)	1(0.9)	26(2.8)	120(2.4)
IADL(n,%)									
Independent	1714(92.9)	1443(92.7)	568(92.5)	3725(92.8)	597(96.1)	178(91.8)	113(96.6)	888(95.3)	4613(93.2)
Dependent	110(6.0)	93(6.0)	40(6.5)	243(6.1)	19(3.1)	16(8.3)	3(2.6)	38(4.1)	281(5.7)
Missing	21(1.1)	20(1.3)	6(1.0)	47(1.2)	5(0.8)	0(0)	1(0.9)	6(0.6)	53(1.1)
Living alone status(n,%)									
Living alone	153(8.3)	129(8.3)	63(10.3)	345(8.6)	147(23.7)	45(23.2)	28(23.9)	220(23.6)	565(11.4)
Living with others	1652(89.5)	1365(87.7)	530(86.3)	3547(88.3)	451(72.6)	140(72.2)	81(69.2)	672(72.1)	4219(85.3)
Missing	40(2.2)	62(4.0)	21(3.4)	123(3.1)	23(3.7)	9(4.6)	8(6.8)	40(4.3)	163(3.3)
Population density(n,%)									
Low	381(20.7)	912(58.6)	243(39.6)	1536(38.3)	35(5.6)	59(30.4)	23(19.7)	117(12.6)	1653(33.4)
Middle	664(36.0)	508(32.7)	261(42.5)	1433(35.7)	164(26.4)	64(33.0)	31(26.5)	259(27.8)	1692(34.2)
High	800(45.4)	136(8.7)	110(17.9)	1046(26.1)	422(68.0)	71(36.6)	63(53.9)	556(59.7)	1602(32.4)

Note. *Equivalent income for low, middle, and high are ≤¥1,99, ¥2–3.99, and ≥ ¥4 million, respectively.

Table 2
Participants' characteristics by depression onset status and average distance to the train stations and bus stops, stratified by car usage status among older adults, Japan, 2016–2019.

	With Car use			Without Car use			Total
	n	Mean (SD) Station	Bus stop	n	Mean (SD) Station	Bus stop	n(%)
GDS in 2019							
≤ 4 points	3224	3.0(4.0)	0.5(0.6)	689	1.9(2.4)	0.4(0.6)	3913(79.1)
≥ 5 points	377	3.2(4.3)	0.5(0.6)	106	2.0(2.6)	0.4(0.3)	483(9.8)
Missing	414	3.3(4.3)	0.7(1.2)	137	1.8(2.7)	0.4(0.4)	551(11.1)
Total	4947	3.0(4.1)	0.5(0.7)	932	1.9(2.5)	0.4(0.6)	4947(100)

Note. All distances in kilometers.

4. Discussion

We explored the relationship between proximity to public transportation and the onset of depression in older adults via both subjective and objective measures. Furthermore, we compared car-user and non-car-user groups. Our findings revealed no significant association across the entire sample. However, a major distinction emerged when stratified based on car usage. Among older adults who did not use cars, those who reported a lack of train stations or bus stops within walking distance exhibited a significantly higher risk of developing depression after three years. However, this association was not observed in the analyses that used objective measures as independent variables.

In the non-car user group, 62.8 % and 67.7 % took a train and bus, respectively, which were more than those with cars (39.1 % and 28.6 %, respectively), as indicated in Table S1. Hence, significant results in the non-car user group could be attributed to their reliance on alternative mode of transportation, which likely made them more sensitive to the effects of proximity to these facilities. In contrast, those with car access were less influenced by proximity to public transportation. This study found no significant associations via objective measures, which was consistent with the results of a previous study that found significant results only for self-reported access to public transportation (Eibich et al., 2016). Several studies reported the discrepancy between objective and subjective measures of built environments (Roda et al., 2016) (Tani et al., 2018).

This possibly explains the discrepancy that perceived built environment may better reflect the availability of transportation than objective distance. A well-perceived neighborhood environment can influence walking motivation and behavior (Rhodes et al., 2006) and promote healthy behaviors that can prevent depression (Liu et al., 2022). Additionally, more frequent public transit service increased use (Djurhuus et al., 2014), which suggested that stops with a lower frequency and convenience may be less well-perceived. Therefore, a subjective scale that included availability of transportation would have yielded better results. Another factor may be the physical barriers that were overlooked in the objective measures, such as street areas or slopes, which were not considered in the GIS network distances. Therefore, subjective measures may better assess actual access (Tani et al., 2018).

The pathway linking proximity to public transportation to depression could involve increased walking time, bustling environment around the stations, and enhanced social participation. Prior research (Barnett et al., 2017) indicated that better access to public transportation increased walking time. Furthermore, approximately one-third of public transportation users engaged in more than 30 min of daily physical activity by just walking to and from transit stops (Besser and Dannenberg, 2005). A study revealed that walking mitigated depressive symptoms (Craft and Perna, 2004).

Stations attract numerous users, and many commercial facilities tend to be located in front of them (Yukio, 1994). Commercial facilities create station fronts where bustling activity is likely to occur, which can increase social interaction (Kim and Park, 2018). Social interaction could prevent depression (Misawa and Kondo, 2019), and social participation could reduce the risk of depression (Shiba et al., 2021). In our analysis of the association between subjective proximity to public transportation and depression in the non-car user group, we additionally adjusted for three variables assumed to be intermediate factors: walking time, social participation, and availability of fresh food stores, which related to proximity to the commercial facilities. The odds ratio subsequently reduced (Table S5), which suggested that these factors could partly explain the observed association.

In Japan, decline in public transportation users owing to a population decrease in rural areas has led to financial challenges for bus operators. Approximately 99 % are running at a loss, with continued discontinuation of train and bus routes (Ministry of Land, Infrastructure, Transport and Tourism, 2021). Therefore, some municipalities, such as Matsumoto, a core city in Japan, have been promoting the integration of routes and increasing the number of bus services. Such reorganization can reduce the loss-making bus routes among multiple operators while also building consensus among residents (Matsumoto City, 2024). This study provides evidence to consider when discussing and deciding on discontinuation and reorganization. Consideration that depression in older adults can lead to dementia, frailty, and increased mortality is necessary. If maintaining train and bus routes is unfeasible, introducing new mobility systems, such as on-demand buses, Neighborhood Electric Vehicles, or Mobility as a Service (MaaS) may be necessary for ensuring access to transportation. Previous studies in Japan reported that the installation of Neighborhood Electric Vehicles, known as Green Slow Mobility, improved users' going out frequency, social connections, and mental health (Tamura et al., 2023).

A strength of this study was being one of the few longitudinal studies to demonstrate the association between access to public transportation and depression that utilized samples from multiple municipalities. Furthermore, we examined the association by car availability and used both subjective and objective measures of proximity to train stations and

Table 3
Logistic regression analysis of depression onset and subjective and objective proximity to train stations and bus stops among older adults, Japan, 2016–2019.

		With Car use(n = 4015)			Without Car use(n = 932)			Total(n = 4947)		
		n	OR	95 %CI	n	OR	95 %CI	n	OR	95 %CI
Subjective	Station or bus stop Absent (ref. present)	4015	0.98	0.79–1.23	932	1.60	1.05–2.42	4947	1.11	0.91–1.35
Objective	Station(km)	4015	0.99	0.96–1.02	932	0.99	0.91–1.08	4947	0.99	0.97–1.02
	Bus stop(km)	4015	0.94	0.80–1.11	932	0.93	0.56–1.54	4947	0.95	0.82–1.10

Note. Models adjusted for age, gender, equivalent income, education, employment status, marital status, diseases under treatment, IADL, living alone status, population density, and car usage.

bus stops.

However, this study has several limitations. First, we may not have fully adjusted for walkability, which could have influenced the association between proximity to public transportation and depression. However, we adjusted for population density as a proxy variable instead of walkability. Second, conflation of "stations and bus stops" in the subjective scale without distinct categorization could pose a problem. Third, some discrepancies in bus stop data did not align with the survey year. Fourth, potential unmeasured confounders, such as air pollution (Borroni et al., 2022), purpose of public transportation use (Marques et al., 2020), and frequency of public transportation services, present further challenges. Future research should explore how proximity to stations and bus stops influences depression and include factors not measured in this study, such as the purpose of using public transportation, air pollution, and convenience of public transport. Additionally, future studies should investigate whether improving the environment for alternative modes of transportation can alleviate the increased risk of depression in cases of inadequate access to train stations and bus stops.

5. Conclusion

This longitudinal study revealed a significantly higher risk of depression three years after baseline among older adults who reported no car use and train or bus station within walking distance. Our findings suggest that improving access to stations and bus stops for older adults who cannot use cars may reduce their risk of developing depression. Maintaining such access may also help mitigate an increase in the risk of depression. This study highlights the need to consider environmental factors, such as proximity to public transportation, in strategies that aim to combat depression among older adults. This research direction could provide further insights into practical strategies for reducing the risk of depression among older adults, particularly in areas with limited public transportation.

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CRediT authorship contribution statement

Kazuki Matsumoto: Methodology, Formal analysis, Conceptualization, Writing – original draft. **Masamichi Hanazato:** Supervision, Methodology, Conceptualization, Writing – review & editing. **Yu-Ru Chen:** Methodology, Conceptualization, Writing – review & editing. **Yoko Matsuoka:** Methodology, Conceptualization, Writing – review & editing. **Yuta Mori:** Methodology, Conceptualization, Writing – review & editing. **Hiroaki Yoshida:** Methodology, Conceptualization, Writing – review & editing. **Katsunori Kondo:** Supervision, Methodology, Funding acquisition, Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

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