Title: Effect of Home-Visit Nursing Agencies and the Number of Nurses per Agency on Home Death Rates in Japan: A Panel Data Study from 2016 to 2022

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Conflicts of interest

The authors declare no conflicts of interest regarding the publication of this study.

Ethics statement

This study was conducted using publicly available data, and no ethical approval was required.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT-4o (developed by OpenAI) to assist in the translation from Japanese to English and to improve the readability of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Abstract

This study examined the effects of increasing home-visit nursing agencies and nurses per agency on home death rates in Japan, considering the growing demand for end-of-life care. Publicly available data from 1,741 municipalities from 2016 to 2022 were analyzed using Pooled Ordinary Least Squares, Fixed-Effects, and Random-Effects models. Covariates such as population density, proportion of the older population, household size, number of hospitals, and home clinics were included. The Fixed-Effects model showed that each additional home-visit nursing agency increased the home death rate by 0.06% ($p = .010$), and each additional nurse per agency increased it by 0.11% ($p = .001$). Expanding the workforce within existing agencies may have a greater impact on home deaths than merely increasing the number of agencies. Future research should consider factors like family caregiving capacity and regional healthcare practices to improve home-based end-of-life care strategies.

Keywords: Older adults, Home care nursing, End-of-life care, home death, home-visit nursing agencies

Introduction

Japan's rapidly aging population has led to growing demand for end-of-life care. A national survey conducted by The Nippon Foundation in 2021 reported that nearly 60% of older individuals and their families preferred home-based deaths. [1] However, only 17.4% of deaths in older adults occur at home, indicating a gap between preferences and the reality of end-of-life care. [2] This gap suggests the need for enhanced support systems that facilitate home-based deaths among patients who wish to stay in their communities. Several factors may contribute to this gap, including limited access to home-based care in certain regions, cultural attitudes towards institutional care, and uneven distribution of healthcare resources across municipalities. [3-5]

In response, the Japanese government has implemented policies promoting the expansion of home-visit nursing services, which are critical for supporting home-based care and helping older individuals maintain their quality of life in their preferred settings. [6] Since the introduction of the long-term care insurance system in the year 2000, the number of home-visit nursing agencies has increased substantially, reflecting the government's commitment to enhance community-based healthcare services. [6] These agencies are essential for providing continuous medical

and nursing care, especially to older individuals near the end of their lives. [7]

Although the relationship between healthcare resources and home death rates has been previously investigated, the specific role of home-visit nursing agencies in influencing home deaths remains underexplored. [3] Studies such as those by Morioka et al. have highlighted the importance of healthcare resources, including home-visit nursing agencies, in supporting home-based deaths. [4] Although these studies provided valuable insights into the relationship between healthcare resources and home deaths, the specific impact of the growth and size of home-visit nursing agencies on home death rates over time has not yet been fully examined. Thus, there is a need for additional research to better understand how healthcare resources align with end-of-life preferences.

Previous research has made important contributions by identifying factors such as population density, household structure, and access to healthcare resources that influence home deaths. However, while healthcare resources have been broadly examined, the specific role of home-visit nursing agencies—an essential component of community-based end-of-life care—has not been sufficiently explored. [8,9] In particular, little is known about how the availability and scale of these agencies affect the likelihood of dying at home, despite a growing number of such agencies in

Japan. [3,10] This represents a critical research gap, especially considering that older individuals prefer to spend their final days at home. Understanding these dynamics is important for improving strategies to reduce home deaths and support individuals' preferences for home-based end-of-life care. [11,12]

To address this research gap, this study aimed to (1) investigate the effect of the increase in home-visit nursing agencies over this period on home death rates and (2) examine how the size of these agencies influences home death rates. Our results can help provide a clear understanding of how healthcare resources can be optimized to support home-based end-of-life care in Japan.

Materials & Methods

Data Source

We used publicly available panel data from the Ministry of Health, Labor, and Welfare covering the period from 2016 to 2022. [13] By accounting for temporal changes, panel data analysis provided a distinct advantage over cross-sectional studies in previous research, as it allows for a clearer inference of causal relationships while considering time-varying effects. This dataset enables an analysis of how changes in the number and size of home-visit nursing agencies

influence home death rates.

The main dataset, containing information on home-visit nursing agencies and home clinics, was sourced from the Ministry of Health, Labour, and Welfare. [13] Demographic and household data were obtained from the National Statistics Bureau's e-Stat database, [14] while municipal-level income data were collected from the Ministry of Internal Affairs and Communications. [15]

Study Population and Variables

We analyzed data from all 1,741 municipalities in Japan between 2019 and 2022. Of these, 24 municipalities were excluded from the analysis because home death data were unavailable. While the reasons for this absence are unclear, one possible factor could be that no deaths occurred in these municipalities in 2021, or the data may not have been recorded for some reason.

The dependent variable was the proportion of deaths occurring at home, which was defined as the percentage of deaths occurring at home in each municipality. The independent variables included the number of home-visit nursing agencies and nurses per agency. Control variables, including population density, proportion of older population, household size (population/number of households), number of

hospitals, number of home clinics, and average income tax amounts, were incorporated to account for confounding factors.

Statistical Analysis

Descriptive statistics, including the mean and standard deviation of all variables, were calculated for each year. This includes population, older population, number of households, population density, home-visit nursing agencies, home-visit nurses, number of hospitals, number of home clinics, home deaths, and average income tax.

Three regression models were used to examine the relationship between the number and size of home-visit nursing agencies and home death rates [16]: the Pooled Ordinary Least Squares (OLS) Model, which assumes no variation across municipalities; Fixed-Effects Model, which accounts for unobserved time-invariant differences across municipalities; and Random-Effects Model, which assumes that the unobserved factors affecting each municipality are uncorrelated with the independent variables.

For comparative tests, an F-test was used to compare the fixed-effects model with the pooled OLS model, and the Breusch-Pagan Lagrange multiplier (LM) test was used to compare the random-effects model with the pooled OLS model.

Additionally, the Hausman Test was used to compare the fixed- and random-effects models. The analyses were conducted using Python (version 3.11.2) with the following libraries: pandas, numpy, linear models, state models, and scipy. Analysis was conducted at a significance level of 5%.

Ethical Considerations

This study used publicly available anonymized data. No ethical approval or informed consent was obtained from any patient. Measures were implemented to ensure data integrity and confidentiality throughout the analysis.

Results

Descriptive Statistics

The descriptive statistics for each variable from 2019 to 2022 are provided in Table 1. During this period, the number of home-visit nursing agencies and nurses increased, accompanied by an increase in the home death rate from 11.4% in 2019 to 14.4% in 2022. Other variables, including the population, proportion of older population, and average income tax, remained consistent throughout the study period.

Effect of the Number of Home-Visit Nursing Agencies on Home Death Rates

The regression results examining the effect of the number of home-visit nursing agencies on home death rates are shown in Table 2. The analysis included pooled OLS, fixed-effects, and random-effects models. Statistical tests indicated that the fixed-effects model was most suitable (Table 3).

In the fixed-effects model, the number of home-visit nursing agencies showed a significant positive association with home death rates ($\beta = 0.06$, $p = .010$). Among the covariates, the proportion of the older population showed a significant positive association ($\beta = 120.83$, $p < .001$). Furthermore, population density ($\beta = 0.00$, $p = .016$) was observed to have a positive and statistically significant effect on home death rates. However, household size ($\beta = 0.04$, $p = .857$) and number of hospitals ($\beta = -0.22$, $p = .320$) did not show statistical significance.

Effect of Nurses per Home-Visit Nursing Agency on Home Death Rates

Table 2 shows the results of the analysis of the number of nurses per home visit nursing agency and their effect on home death rates across the three models tested. The fixed-effects model determined through statistical tests was chosen as the best

fit (Table 3).

In the fixed-effects model, the number of nurses per home-visit nursing agency had a significant, positive effect on home death rates ($\beta = 0.11$, $p = .001$). Other significant covariates included the proportion of the older population ($\beta = 117.87$, $p < .001$) and population density ($\beta = 0.00$, $p = .017$), both contributing positively to the home death rates. Household size ($\beta = 0.06$, $p = .768$) and number of hospitals ($\beta = -0.30$, $p = .170$), however, did not show statistical significance.

Discussion

In this study, we examined the influence of the number of home-visit nursing agencies and the number of nurses per agency on home death rates across Japanese municipalities from 2019 to 2022. The findings indicate that although both variables have a significant influence on home death rates, their relative contributions vary.

Descriptive Statistics

During the study period, Japan experienced a decrease in the population size alongside an increase in its older adult population (Table 1). While this demographic trend is important, it is the development of comprehensive healthcare systems,

including but not limited to home-visit nursing, that will likely play a significant role in increasing home death rates from 11.4% in 2019 to 14.4% in 2022. The government introduced various initiatives to improve medical infrastructure, such as the enhancement of advanced care planning, regional comprehensive care, and access to home-visit nursing services. [17] These efforts have contributed to more effective support for home-based end-of-life care. However, further analysis is required to assess how these healthcare improvements directly influence home mortality rates.

Effect of the Number of Home-Visit Nursing Agencies on Home Death Rates

The regression analysis showed a significant positive relationship between the number of home-visit nursing agencies and home death rates. Statistical tests confirmed that the fixed-effects model best captured this relationship, with each additional home-visit nursing agency increasing the home death rate by 0.06%. This finding is consistent with previous research highlighting the importance of healthcare access in influencing the place of death. [3, 4, 18] For instance, Morioka et al. (2018) demonstrated a link between healthcare resources such as nursing agencies and home deaths across Japan. [4] In the report by Ikeda et al., regions with a higher

density of home-visit clinics (OR: 2.14, 95% CI: 1.12-3.15) and home-visit nursing agencies (OR: 2.19, 95% CI: 0.99-3.39) showed a significant increase in home death rates, while regions with a higher density of hospitals had lower home death rates (OR: -3.93, 95% CI: -7.45 to -0.40). [3] However, the relatively small effect size observed in this study suggests that simply increasing the number of agencies may not be sufficient to substantially increase home death rates.

Moreover, the proportion of the older population was strongly associated with higher home death rates in the fixed-effects model, further emphasizing that the older population demands greater end-of-life care services, including home-visit nursing. [19, 20] Ishikawa et al. reported that older individuals tended to express a stronger preference for dying at home, which may explain the association between regions with older populations and higher rates of home deaths. [21] Variables such as household size and the number of hospitals did not significantly contribute to home death rates. This implies that other factors, such as community-based support systems or the coordination of home and hospital care, may play a more crucial role in influencing end-of-life care locations. [22] The lack of significance of household size suggests that familial support is less decisive than professional healthcare services. Furthermore, calculating household size as the population per household

may have resulted in more relevant indicators such as single-person or elderly-only households being overlooked, which could have had a stronger impact on home death rates.

Effect of Nurses per Home-Visit Nursing Agency on Home Death Rates

The number of nurses per home-visit nursing agency was positively associated with home death rates, with the fixed-effects model indicating that adding one nurse per agency resulted in a 0.11% increase in home death rates. In municipalities with an average of 8.5 agencies (Table 1), increasing the total number of nurses by approximately seven to eight per municipality could have a more substantial impact on home death rates compared to adding one new agency. This finding suggests that increasing the workforce of existing agencies may be more effective in improving home-based care. [23]

These findings align with those of previous studies, suggesting that larger healthcare teams, including more nurses, improve the quality and availability of home care services. [11, 12] An increase in the number of home-visit nurses enables agencies to offer round-the-clock care and emergency services that are essential for adequate end-of-life care. The ability to respond promptly to patients' needs ensures

that end-of-life care can be managed effectively at home, including pain management and other complex medical needs. [12, 24] Additionally, efforts to evaluate and enhance the quality of home-visit nursing services are progressing in Japan, with discussions on quality indicators that assess various aspects, such as care structure, process, and outcomes. [25, 26] Such initiatives are critical for improving overall healthcare system performance and addressing broader challenges. Moreover, simply increasing the number of home-visit nursing agencies would be insufficient. Ensuring that these agencies meet the diverse and complex needs of patients is equally critical. This includes the capability to provide specialized care for those with complex medical conditions and ensure ongoing training and support for staff. [27] Research has shown that improving both the quantity and quality of home-visit nursing services is essential for delivering effective patient-centered care. Therefore, future strategies should focus on expanding the number of agencies and enhancing their capacity to address a wider range of patient needs, which will be the key to improving outcomes in home-based care. [12, 25, 26]

Strength, Limitations, and Future Directions

This study had several strengths and limitations. One strength of this study is the

use of panel data, which allows for the observation of changes over time and provides a stronger basis for inferring relationships than cross-sectional designs. Furthermore, by adjusting for key covariates such as income levels, an often-underexplored area in previous research, this study offers a more comprehensive understanding of the factors influencing home death rates.

Nevertheless, this study had several limitations. First, the observational design limits the ability to draw definitive causal inferences. However, using panel data from multiple years (2019-2022) and adjusting for key covariates, we aim to mitigate this issue and strengthen the validity of our results. The use of fixed-effects modeling helped control for unobserved, time-invariant factors within municipalities, further reducing potential confounding factors. [28]

A second limitation is the exclusion of municipalities with no reported deaths, which may have introduced selection bias. Although this exclusion was necessary owing to the lack of data, it may have affected the results. Additionally, unmeasured variables, such as family support structures or regional healthcare practices, may have influenced home death rates but were not included in the analysis. Additionally, the exclusion of variables related to family caregiving capacity and regional healthcare practices may have influenced home death rates. [29-31] Future

studies should incorporate these factors to provide a more comprehensive understanding of the end-of-life care determinants.

Finally, the generalizability of our findings may be limited to Japan due to its unique healthcare system and cultural attitudes towards end-of-life care. Nevertheless, the use of a nationwide dataset and control for multiple relevant variables allows for the provision of useful insights into the relationship between home-visit nursing resources and home deaths. Future studies should explore the impact of cultural attitudes towards death and dying in different regions or countries, comparing how home-visit nursing services are utilized in diverse cultural contexts. Additionally, longitudinal data that include family caregiving dynamics can offer deeper insights into the factors driving home death rates.

Conclusion

This study suggests that increasing the number of nurses per home-visit nursing agency may be more effective in enhancing home-based end-of-life care than simply expanding the number of agencies. Strengthening the capacity of existing agencies can better address the complex needs of an aging population, potentially enabling more individuals to receive end-of-life care at home.

These findings have implications for healthcare policy, indicating that resource allocation should prioritize workforce expansion within current agencies. Future research should explore cultural attitudes, family support, and regional healthcare practices to better understand factors influencing home death rates.

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Table 1. Descriptive Statistics: Demographic, Healthcare Resources, and Economic Data across 1,741 Municipalities (2019-2022)

	Population (n)		Older poplation (n)		Household (n)		Population density (people/km2)		Home-visit nursing agency (n)	
Year	average	SD	average	SD	average	SD	average	SD	average	SD
2019	71669.4	183448.9	20111.5	46791.8	32737.8	90099.8	1294.5	4312.0	6.7	21.1
2020	71379.3	183595.5	20279.9	47217.2	32067.9	91648.9	1293.4	4321.4	7.1	22.5
2021	71133.1	183844.1	20437.6	47597.2	33230.8	92044.0	1292.1	4327.0	7.8	25.1
2022	70777.5	183621.2	20525.8	47805.9	34325.7	95915.0	1288.2	4320.1	8.5	27.8
	Home-visit nurse (n)		Hospital (n)		Home Clinic (n)		Home death (%)		Average income tax amount (Japanese Yen)	
2019	34.7	115.5	4.8	12.5	8.2	27.9	11.4	4.9	101058.5	29018.4
2020	37.8	128.0	4.8	12.5	8.3	28.3	13.0	6.1	101087.1	28094.2
2021	42.8	149.0	4.8	12.4	8.5	29.0	14.4	6.1	99467.2	27196.4
2022	66.3	235.8	4.7	12.3	8.7	29.6	14.4	5.9	102603.2	32544.1

SD: standard deviation

Table 2. Regression Analysis Results: Home-Visit Nursing Agencies and Nurses per Agency

	Pooled OLS Medol					Fixed Effects Medel					Randem Effects Medel				
	Estimate	SE	95%CI	T-stat	p-value	Estimate	SE	95%CI	T-stat	p-value	Estimate	SE	95%CI	T-stat	p-value
(By home-visit agency count)															
Intercept	19.80	0.83	[18.18, 21.41]	23.99	< .001	-34.28	3.74	[-41.61, -26.95]	-9.17	< .001	18.39	1.01	[16.40, 20.37]	18.17	< .001
Nubmer of home-visit nursing agencies	0.06	0.01	[0.04, 0.09]	5.72	< .001	0.06	0.02	[0.01 0.10]	2.58	.010	0.10	0.01	[0.07, 0.13]	7.36	< .001
Population density	0.00	0.00	[0.00, 0.00]	7.12	< .001	0.00	0.00	[0.00, 0.01]	2.41	.016	0.00	0.00	[0.00, 0.00]	4.88	< .001
Proportion of elderly population	-19.39	1.08	[-21.51, -17.28]	-17.97	< .001	120.83	6.29	[108.50, 133.16]	19.22	< .001	-13.57	1.65	[-16.81, -10.33]	-8.21	< .001
Households size	-0.96	0.19	[-1.33, -0.60]	-5.17	< .001	0.04	0.21	[-0.37, 0.45]	0.18	.857	1.15	0.18	[-1.51, -0.79]	-6.27	< .001
Number of hospitals	-0.10	0.01	[-0.124, -0.08]	-8.40	< .001	-0.22	0.22	[-0.64, 0.21]	-0.99	.320	-0.13	0.02	[-0.16, -0.09]	-7.28	< .001
Number of home clinic	-0.01	0.01	[-0.02, 0.01]	-1.09	.269	0.17	0.06	[0.05, 0.30]	2.78	.006	-0.02	0.01	[-0.04, -0.00]	-2.20	.028
Average income tax amount	0.00	0.00	[0.00, 0.00]	7.94	< .001	0.00	0.00	[0.00, 0.00]	-1.27	.205	0.00	0.00	[0.00, 0.00]	5.37	< .001
(By nurse count)															
Intercept	17.63	0.86	[15.95, 19.30]	20.62	< .001	-33.54	3.75	[-40.89, -26.19]	-8.95	< .001	16.08	1.0349	[14.06, 18.11]	15.541	< .001
Number of nurses per agency	0.21	0.02	[0.16, 0.25]	9.26	< .001	0.11	0.03	[0.04, 0.17]	3.23	.001	0.26	0.03	[0.21, 0.31]	10.09	< .001
Population density	0.00	0.00	[0.00, 0.00]	7.47	< .001	0.00	0.00	[0.00, 0.01]	2.40	.017	0.00	0.00	[0.00, 0.00]	5.23	< .001
Proportion of elderly population	-16.28	1.13	[-18.49, -14.07]	-14.43	< .001	117.87	6.39	[105.33, 130.40]	18.44	< .001	-10.49	1.67	[-13.77, -7.22]	-6.28	< .001
Households size	-0.88	0.19	[-1.24, -0.52]	-4.75	< .001	0.06	0.21	[-0.35, 0.47]	0.29	.768	-1.03	0.18	]-1.39, -0.67]	-5.63	< .001
Number of hospitals	-0.07	0.01	[-0.08, -0.05]	-6.87	< .001	-0.30	0.22	[-0.11, -0.05]	-1.37	.170	-0.08	0.02	[-0.106, -0.05]	-4.85	< .001
Number of home clinic	0.03	0.00	[0.02, 0.04]	6.33	< .001	0.26	0.05	[0.17, 0.35]	5.73	< 0.001	0.03	0.01	[0.02, 0.05]	4.92	< 0.001
Average income tax amount	0.00	0.00	[0.00, 0.00]	8.27	< .001	0.00	0.00	[0.00, 0.00]	-1.47	0.1429	0.00	0.00	[0.00, 0.00]	5.23	< .001

SE: standard error. T-stat: t-statistic. Pooled OLS Models: Pooled Ordinary Least Squares Model

Table 3. Model Comparison Tests: Fixed Effects vs. Random Effects and Pooled OLS

Model	Test	Purpose	Statistic	P-value	Interpretation
By home-visit agency count	F-test	Fixed effect VS Pooled OLS	2027.8	< .001	Fixed effects preferred
	Lagrange Multiplier test	Randam effects VS Pooled OLS	52.1	< .001	Random effects preferred
	Hausman test	Fixed effect VS Random effencts	538.0	<.001	Fixed effects preferred
By nurse count	F-test	Fixed effect VS Pooled OLS	2007.1	< .001	Fixed effects preferred
	Lagrange Multiplier test	Randam effects VS Pooled OLS	128.6	< .001	Random effects preferred
	Hausman test	Fixed effect VS Random effencts	503.5	< .001	Fixed effects preferred

Degrees of freedom: 7.

F-statistic: Evaluates the overall significance of the model by comparing the variance explained by the regression model to the unexplained variance. Lagrange Multiplier (LM) statistic: A test statistic used to determine whether random effects are present in the model. A significant LM statistic indicates that the random effects model is preferred over the pooled OLS model. Hausman statistic: Tests whether a fixed-effects or random-effects model is more appropriate by comparing the estimates from both models.