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Impact of COVID-19 on place of death for disease-related causes: a population-based study in Nanchang, China

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Little is known about the place of death at the regional level in China. Furthermore, the impact of COVID-19 on the place of death remains unclear. We aimed to examine the place of death before and during COVID-19 in Nanchang, China, focusing on changes in home death across different causes, to determine whether these changes were disproportionately experienced among patients with different diseases. Using data from the National Death Registration System, Nanchang, China, this population-based, observational study examined all non-accidental deaths from 1 January 2014 to 31 December 2019 (pre-COVID-19), and 25 January 2020 to 31 December 2022 (during COVID-19). Modified Poisson regression models were employed to assess the association between underlying cause of death and home death, and interaction terms added to evaluate changes over periods. We used R version 4.2.2 for all analyses. The analysis included 198,383 deaths, with a median age of 78 years (IQR: 66–85); 58.2% were male and 41.8% were female. Home deaths rose from 72.7% pre-COVID-19 to 75.6% during COVID-19 ($p < 0.0007$). Before COVID-19, patients with renal failure (adjusted PR 0.74 [95% CI, 0.67–0.81]), liver disease (0.81 [0.76–0.86]), and hematological cancer (0.88 [0.84–0.92]) were less likely to die at home compared to those with solid cancer. During COVID-19, these disparities diminished, with a significant increase in home deaths among renal failure (1.32 [1.19–1.48]), liver disease (1.19 [1.10–1.29]), and hematological cancer (1.12 [1.05–1.20]). The majority of non-accidental deaths occurred at home, with a notable rise during COVID-19, underscoring the urgent need to strengthen community- and home-based end-of-life care services. Although home death rates for patients with renal failure, liver disease, and hematological cancer were lower before COVID-19, they increased significantly during the pandemic, highlighting disparities in end-of-life care that necessitate targeted improvements.

Keywords Palliative care, End-of-life care, Place of death, Cause of death, COVID-19

Place of death is considered and used as an outcome measure for end-of-life care, and dying in a place of one's preference contributes to a higher quality of end-of-life care[1]. Studies from high-income countries suggested that most people preferred to die at home[2,3]. Similar results were found for terminal-stage patients in China[4,5]. Providing palliative care could increase the odds of home death, and good quality dying at home requires high-quality care and support from the community[6,7]. However, palliative care development varies worldwide. In most areas of China, the end-of-life healthcare system is still in its infancy, with limited palliative and hospice care services. For example, hospice care is provided mainly in inpatient settings rather than at home or in the community[7].

China is a developing country with a large population in the world, with uneven economic development, and cultural differences in different regions. Therefore, the demand and availability of end-of-life care may vary significantly. Developed cities like Beijing and Shanghai, have implemented community-based end-of-life care systems with all community health centers providing end-of-life care services, and this measure increased the odds of dying in hospitals[8]. But for some of the ethnic minorities like the Yi population in Yunnan, the lower probability of hospital death was affected by cultural background and traditional customs[9]. To date, reporting on

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the place of death at the regional level in China remains limited, and this information is important for developing end-of-life care policies consistent with geographic culture and economic levels.

During the COVID-19 pandemic, Lopes et al. observed an increase in the proportion of home deaths in high-income countries. However, in Bulgaria and Uganda, the proportion of home deaths declined, and the reasons behind this phenomenon remain unclear[10]. Additionally, research in Zambia found that, throughout different phases of the pandemic, the number of deaths occurring in the community consistently exceeded those in the facility[11]. Despite these findings, the dynamics of death places in low- and middle-income countries remain insufficiently studied. In China, hospital deaths declined[12], but little is known about deaths occurring at home during COVID-19 and how they differed from pre-COVID-19. Although studies have shown that the COVID-19 pandemic was associated with an increase in home deaths among cancer patients and a reduction in the provision of specialist palliative care at the end of life[13], it remains unclear whether it has exacerbated inequalities in place of death among patients with different diseases.

Therefore, this study aimed to examine the place of death before and during COVID-19 in Nanchang, China, focusing on changes in home death for different causes of death, to determine whether these changes were disproportionately experienced among patients with different diseases.

Methods

Study design and data source

A population-based, observational study was conducted using 2014 to 2022 data from the National Death Registration System, Nanchang, China. The data included the decedents' age of death, sex, marital status, education, personal identity, settlement, place of death, and underlying causes of death. The underlying causes of death were recorded using the tenth edition of the International Classification of Diseases (ICD-10) codes. The Nanchang National Death Registration System has covered the entire population since 2013, and the Nanchang Center for Disease Prevention and Control regularly conducted underreporting investigations to ensure data quality[14]. This research was approved by the Research Ethics Committee of Nanchang University - BioMedicine, approval number NCUREC202406004. As this research was based on retrospective fully anonymized administrative data, the Research Ethics Committee of Nanchang University - BioMedicine waived the requirement for informed consent. All research was performed in accordance with relevant guidelines and regulations.

Study population

The period from January 1, 2014, to December 31, 2019, was classified as pre-COVID-19, whereas January 25, 2020, to December 31, 2022, was categorized as during COVID-19. All non-accidental deaths during these periods were included. The selection of January 25, 2020, as the start date of the COVID-19 period was based on the fact that Jiangxi Province activated a Level 1 public health emergency response mechanism (the highest-level response for major public health emergencies) and implemented a series of prevention and control measures on January 24, 2020[15]. The focus on non-accidental deaths is driven by the fact that these are the deaths that could have potentially benefited from palliative and end-of-life care planning. Non-accidental deaths in this study refer to all deaths caused by natural causes, defined according to ICD-10 codes. The following are excluded: Injury, poisoning and certain other consequences of external causes (S00-T98), External causes of morbidity and mortality (V01-Y98), Factors influencing health status and contact with health services (Z00-Z99), Codes for special purposes (U00-U99)[16].

Variables

The place of death in the Nanchang National Death Registration System includes six categories: home, hospital, on the way to the hospital, nursing home, others, and unknown. The study outcome was home death. Non-home deaths were categorized into two groups: hospital (including on the way to hospital), and others (including nursing home). Deaths occurring on the way to the hospital were classified under the hospital category because both scenarios reflect healthcare facility-related deaths and the intention to receive medical care. The number of deaths occurring in nursing home was 922, accounting for only 0.46% of the total sample. Therefore, nursing home deaths were grouped under the "others" category to avoid data sparsity issues. The main explanatory variable was the underlying cause of death. According to the classification suggested by Murtagh et al.,[17] a non-external cause of death included the following ICD-10 codes: heart disease (I00-I52), cerebrovascular disease (I60-I69), respiratory disease (J40-J47, J96), renal failure (N17-N19), liver disease (K70-K77), neurological disease (F01, F03, G30, G10, G12.2, G20, G23.1, G35, G90.3), hematological cancer (C81-C96), solid cancer (C00-C97 excluding C81-C96), others (A00-R99 excluding above codes). The contextual sociodemographic variables included age of death (0–44, 45–64, 65–84, and 85 years or more), sex (male or female), marital status (unmarried, married, widowed, divorced and unknown), education (junior high school and below, senior high school or college and above), personal identity (child or student, agricultural-related personnel, retired, employed and unemployed), settlement (urban or rural). Detailed variable definitions and coding schemes are provided in Table S1.

Statistical analysis

Places of death before and during COVID-19 were described using count and percentage. Home death proportions were plotted by year. Cases with missing values were excluded (Fig. S1). Modified Poisson regression models assessed the association between underlying cause of death and home death, with interaction terms included to analyze changes over time. We measured associations using prevalence ratio (PR), a measure of relative risk estimated from multivariate models, to avoid overestimation linked to odds ratio[18]. A two-tailed p-value of < 0.05 was considered statistically significant. Data analysis in this study was conducted using R (version 4.2.2,

R Core Team, 2022). Data processing was primarily performed using the tidyverse and dplyr packages, while descriptive statistical analysis was conducted with the furniture package. Multicollinearity was assessed using the vif function from the car package. Poisson regression models were built using the glm function, with standard errors corrected using the sandwich package. Figures were created using Microsoft Excel 2021. The R codes used in this study are provided in Supplementary R Code.

Results

Between 2014 and 2022 in Nanchang, 198,383 people died from non-accidental causes. Among them, 146,502 (73.8% [95% CI, 73.7–74.0]) died at home, while 49,669 (25.0% [95% CI, 24.8–25.2]) died in hospital and 2,212 (1.1% [95% CI, 1.1–1.2]) died elsewhere. Annual home deaths increased from 12,252 in 2014 to 23,737 in 2022. The proportion of home deaths rose from 68.3% in 2014 to 77.6% in 2022 (Fig. 1). Before COVID-19, 119,095 decedents were recorded, with home being the leading place of death (72.7%). During COVID-19, 79,288 decedents were included, with an increased proportion of home deaths (75.6%, $p < 0.0007$). The proportion of home deaths increased for people under 45 years old (from 38.9 to 52.8%), unmarried people (from 28.3 to 46.7%), and children or students (from 23.6 to 39.3%). Solid cancer (26.7%) was the leading common cause of death pre-COVID-19, while cardiovascular disease (26.3%) was the most common cause of death during COVID-19. The proportion of home deaths increased for patients with renal failure (from 47.1 to 67.8%), liver disease (from 52.3 to 70.6%), and hematological cancer (from 49.2 to 59.5%; Table 1).

Before COVID-19, compared to those who died from solid cancer, patients who died from renal failure (adjusted PR 0.74 [95% CI, 0.67–0.81]), liver disease (adjusted PR 0.81 [95% CI, 0.76–0.86]), and hematological cancer (adjusted PR 0.88 [95% CI, 0.84–0.92]) had a lower chance of home death. During COVID-19, patients who died from renal failure (adjusted PR 0.98 [95% CI, 0.93–1.03]), liver disease (adjusted PR 0.96 [95% CI, 0.91–1.01]), and hematological cancer (adjusted PR 0.95 [95% CI, 0.91–1.00]) did not identify significant disparities in the likelihood of home death compared to those who died from solid cancer (Table 2). Compared to pre-COVID-19, the differences in the likelihood of dying at home among various age and gender groups during COVID-19 have narrowed, but the difference in the likelihood of dying at home for widowed individuals (compared to married individuals) has increased. The differences in the likelihood of dying at home have also increased for individuals with lower levels of education (compared to those with higher education) and unemployed individuals (compared to employed individuals) compared to pre-COVID-19 (Table 2).

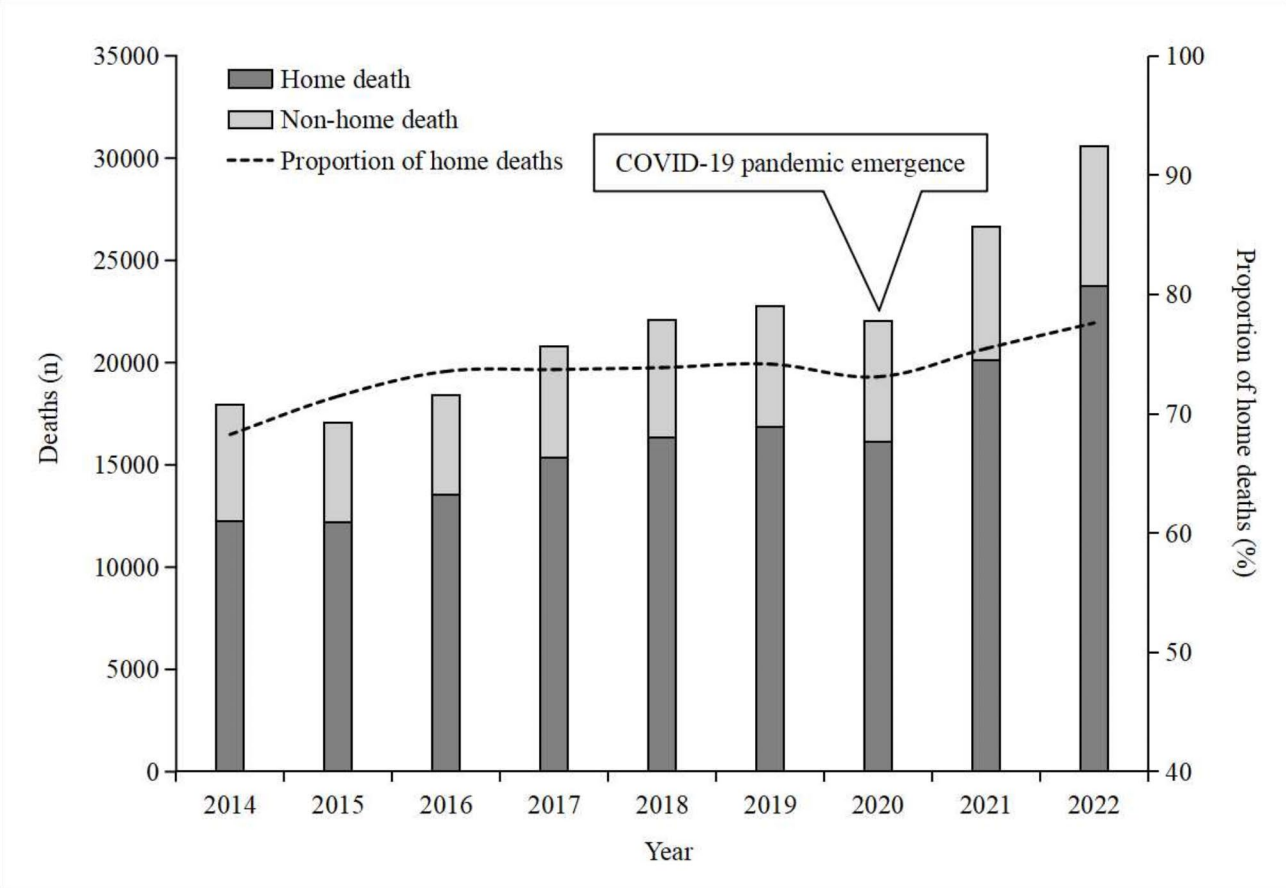

Fig. 1. Number of deaths and proportion of home deaths in Nanchang 2014–2022.

	Pre-COVID-19				During COVID-19			
			Non-home				Non-home	
	Total	Home	Hospital	Others	Total	Home	Hospital	Others
Total	119,095	86,533 (72.7%)	31,260 (26.2%)	1302 (1.1%)	79,288	59,969 (75.6%)	18,409 (23.2%)	910 (1.1%)
Age								
0–44	7657 (6.4%)	2978 (38.9%)	4480 (58.5%)	199 (2.6%)	3012 (3.8%)	1589 (52.8%)	1322 (43.9%)	101 (3.4%)
45–64	20,962 (17.6%)	13,660 (65.2%)	6982 (33.3%)	320 (1.5%)	12,252 (15.5%)	8381 (68.4%)	3670 (30%)	201 (1.6%)
65–84	61,197 (51.4%)	46,101 (75.3%)	14,554 (23.8%)	542 (0.9%)	39,380 (49.7%)	30,263 (76.8%)	8746 (22.2%)	371 (0.9%)
85+	29,279 (24.6%)	23,794 (81.3%)	5244 (17.9%)	241 (0.8%)	24,644 (31.1%)	19,736 (80.1%)	4671 (19%)	237 (1%)
Sex								
Male	69,958 (58.7%)	49,078 (70.2%)	19,992 (28.6%)	888 (1.3%)	45,498 (57.4%)	33,334 (73.3%)	11,586 (25.5%)	578 (1.3%)
Female	49,137 (41.3%)	37,455 (76.2%)	11,268 (22.9%)	414 (0.8%)	33,790 (42.6%)	26,635 (78.8%)	6823 (20.2%)	332 (1%)
Marital status								
Unmarried	4318 (3.6%)	1222 (28.3%)	2934 (67.9%)	162 (3.8%)	2032 (2.6%)	948 (46.7%)	988 (48.6%)	96 (4.7%)
Married	93,088 (78.2%)	67,462 (72.5%)	24,772 (26.6%)	854 (0.9%)	60,166 (75.9%)	44,845 (74.5%)	14,757 (24.5%)	564 (0.9%)
Widowed	19,854 (16.7%)	16,685 (84%)	2943 (14.8%)	226 (1.1%)	14,971 (18.9%)	12,618 (84.3%)	2140 (14.3%)	213 (1.4%)
Divorced	790 (0.7%)	381 (48.2%)	384 (48.6%)	25 (3.2%)	652 (0.8%)	344 (52.8%)	280 (42.9%)	28 (4.3%)
Unknown	1045 (0.9%)	783 (74.9%)	227 (21.7%)	35 (3.3%)	1467 (1.9%)	1214 (82.8%)	244 (16.6%)	[a]
Education								
Junior high school and below	100,679 (84.5%)	78,953 (78.4%)	20,667 (20.5%)	1059(1.1%)	69,709 (87.9%)	56,271 (80.7%)	12,718 (18.2%)	720 (1%)
Senior high school	12,545 (10.5%)	5567 (44.4%)	6813 (54.3%)	165 (1.3%)	6158 (7.8%)	2626 (42.6%)	3406 (55.3%)	126 (2%)
College and above	5871 (4.9%)	2013 (34.3%)	3780 (64.4%)	78 (1.3%)	3421 (4.3%)	1072 (31.3%)	2285 (66.8%)	64 (1.9%)
Personal identity								
Child or student	3833 (3.2%)	906 (23.6%)	2823 (73.6%)	104 (2.7%)	1215 (1.5%)	478 (39.3%)	684 (56.3%)	53 (4.4%)
Agricultural-related personnel	60,062 (50.4%)	54,103 (90.1%)	5418 (9%)	541 (0.9%)	40,561 (51.2%)	37,030 (91.3%)	3237 (8%)	294 (0.7%)
Retired	26,760 (22.5%)	14,929 (55.8%)	11,565 (43.2%)	266 (1%)	19,001 (24%)	10,853 (57.1%)	7885 (41.5%)	263 (1.4%)
Employed	22,861 (19.2%)	12,777 (55.9%)	9747 (42.6%)	337 (1.5%)	13,867 (17.5%)	8134 (58.7%)	5486 (39.6%)	247 (1.8%)
Unemployed	5579 (4.7%)	3818 (68.4%)	1707 (30.6%)	54 (1%)	4644 (5.9%)	3474 (74.8%)	1117 (24.1%)	53 (1.1%)
Settlement								
Urban	37,555 (31.5%)	21,893 (58.3%)	15,314 (40.8%)	348 (0.9%)	23,997 (30.3%)	14,014 (58.4%)	9634 (40.1%)	349 (1.5%)
Rural	81,540 (68.5%)	64,640 (79.3%)	15,946 (19.6%)	954 (1.2%)	55,291 (69.7%)	45,955 (83.1%)	8775 (15.9%)	561 (1%)
Underlying cause of death								
Cerebrovascular disease	25,532 (21.4%)	20,725 (81.2%)	4483 (17.6%)	324 (1.3%)	18,435 (23.3%)	14,865 (80.6%)	3332 (18.1%)	238 (1.3%)
Heart disease	25,929 (21.8%)	20,011 (77.2%)	5533 (21.3%)	385 (1.5%)	20,820 (26.3%)	16,501 (79.3%)	3984 (19.1%)	335 (1.6%)
Respiratory disease	13,626 (11.4%)	11,006 (80.8%)	2502 (18.4%)	118 (0.9%)	6613 (8.3%)	5306 (80.2%)	1259 (19%)	48 (0.7%)
Solid cancer	31,818 (26.7%)	22,558 (70.9%)	9099 (28.6%)	161 (0.5%)	19,210 (24.2%)	13,970 (72.7%)	5148 (26.8%)	92 (0.5%)
Hematological cancer	1619 (1.4%)	797 (49.2%)	816 (50.4%)	[a]	908 (1.1%)	540 (59.5%)	361 (39.8%)	[a]
Liver disease	881 (0.7%)	461 (52.3%)	412 (46.8%)	[a]	558 (0.7%)	394 (70.6%)	160 (28.7%)	[a]
Renal failure	395 (0.3%)	186 (47.1%)	206 (52.2%)	[a]	521 (0.7%)	353 (67.8%)	162 (31.1%)	[a]
Neurological disease	662 (0.6%)	531 (80.2%)	122 (18.4%)	[a]	547 (0.7%)	431 (78.8%)	105 (19.2%)	11 (2%)
Others	18,633 (15.6%)	10,258 (55.1%)	8087 (43.4%)	288 (1.5%)	11,676 (14.7%)	7609 (65.2%)	3898 (33.4%)	169 (1.4%)

Table 1. Number and place of deaths before and during COVID-19 in Nanchang. Data are n (%). [a]Values censored to prevent the identification of cells contained < 10 patients because of data use agreements.

Both before and during COVID-19, increased age (45 years or older) was associated with a higher chance of home death. People who were widowed (vs. married), agricultural-related personnel, unemployed (vs. employed), and those with lower education were more likely to die at home. The interaction terms indicated that, compared to those who died from solid cancer, the increase in the proportion of home deaths during COVID-19 was more pronounced among patients with renal failure, with a 1.32-fold greater increase (adjusted PR 1.32 [95% CI 1.19–1.48]). Patients with liver disease experienced a 1.19-fold greater increase (adjusted PR 1.19 [95% CI 1.10–1.29]), and those with hematological cancer had a 1.12-fold greater increase (adjusted PR 1.12 [95% CI 1.05–1.20]). These findings suggest that the impact of COVID-19 on the proportion of home deaths varied significantly by underlying cause of death (Table 3).

Discussion

In this population-based study, home remained the most common place of death for patients. The differences in the place of death among patients who died from various diseases changed during COVID-19. Before

	Pre-COVID-19		During COVID-19	
	Unadjusted PR	Adjusted PR	Unadjusted PR	Adjusted PR
Underlying cause of death (ref: soild cancer)				
Cerebrovascular disease	1.14 (1.13–1.16)	1.06 (1.05–1.07)	1.11 (1.10–1.12)	1.05 (1.04–1.06)
Heart disease	1.09 (1.08–1.10)	1.01 (1.01–1.02)	1.09 (1.08–1.10)	1.04 (1.03–1.05)
Neurological disease	1.13 (1.09–1.18)	1.11 (1.08–1.16)	1.08 (1.04–1.13)	1.12 (1.07–1.16)
Hematological cancer	0.69 (0.66–0.73)	0.88 (0.84–0.92)	0.82 (0.77–0.86)	0.95 (0.91–1.00)
Respiratory disease	1.14 (1.13–1.15)	1.03 (1.02–1.04)	1.10 (1.09–1.12)	1.01 (1.00–1.02)
Liver disease	0.74 (0.69–0.79)	0.81 (0.76–0.86)	0.97 (0.92–1.03)	0.96 (0.91–1.01)
Renal failure	0.66 (0.60–0.74)	0.74 (0.67–0.81)	0.93 (0.88–0.99)	0.98 (0.93–1.03)
Others	0.78 (0.77–0.79)	0.88 (0.86–0.89)	0.90 (0.88–0.91)	0.93 (0.92–0.95)
Age (ref: 0–44)				
45–64	1.68 (1.63–1.73)	1.11 (1.08–1.15)	1.30 (1.25–1.34)	1.01 (0.98–1.05)
65–84	1.94 (1.88–1.99)	1.21 (1.18–1.25)	1.46 (1.41–1.51)	1.07 (1.03–1.10)
85+	2.09 (2.03–2.15)	1.25 (1.22–1.28)	1.52 (1.47–1.57)	1.07 (1.03–1.11)
Sex (ref: male)				
Female	1.09 (1.08–1.09)	1.01 (1.01–1.02)	1.08 (1.07–1.08)	1.00 (0.99–1.01)
Marital status (ref: married)				
Unmarried	0.39 (0.37–0.41)	0.67 (0.63–0.71)	0.63 (0.60–0.66)	0.77 (0.73–0.80)
Widowed	1.16 (1.15–1.17)	1.06 (1.05–1.06)	1.13 (1.12–1.14)	1.09 (1.08–1.10)
Divorced	0.67 (0.62–0.72)	0.77 (0.73–0.82)	0.71 (0.66–0.76)	0.89 (0.83–0.95)
Unknown	1.03 (1.00-1.07)	1.07 (1.04–1.11)	1.11 (1.08–1.14)	1.13 (1.10–1.16)
Education (ref: college and above)				
Senior high school	2.29 (2.21–2.37)	1.26 (1.21–1.31)	2.58 (2.45–2.71)	1.31 (1.24–1.39)
Junior high school and below	1.29 (1.24–1.35)	1.77 (1.71–1.83)	1.36 (1.28–1.44)	1.98 (1.89–2.08)
Personal identity (ref: employed)				
Child or student	0.42 (0.40–0.45)	0.75 (0.70–0.81)	0.67 (0.62–0.72)	0.91 (0.84–0.99)
Agricultural-related personnel	1.61 (1.59–1.63)	1.50 (1.48–1.52)	1.56 (1.53–1.58)	1.38 (1.36–1.40)
Retired	1.00 (0.98–1.01)	0.95 (0.94–0.97)	0.97 (0.96–0.99)	0.98 (0.97–1.00)
Unemployed	1.22 (1.20–1.25)	1.13 (1.11–1.16)	1.28 (1.25–1.30)	1.17 (1.14–1.19)
Settlement (ref: urban)				
Rural	1.36 (1.35–1.37)	0.88 (0.87–0.90)	1.42 (1.41–1.44)	1.03 (1.01–1.04)

Table 2. Prevalence ratios (95% CI) of variables associated with home deaths (vs. non-home deaths) before and during COVID-19. PR = prevalence ratio. ref = reference. CI = confidence interval.

COVID-19, compared to those who died from solid cancer, patients who died from renal failure, liver disease, and hematological cancer were less likely to die at home. During COVID-19, no significant disparities in the likelihood of home death were identified among patients who died from these three conditions and those who died from solid cancer. The proportion of home deaths increased during COVID-19, but this increase was not consistent across different underlying causes of death. Patients with renal failure, liver disease, and hematological cancer had a greater increase in the proportion of home deaths than other diseases, indicating a disproportionate impact on end-of-life care for these conditions.

Our study revealed that the proportion of home deaths increased during COVID-19, which was consistent with findings from other regions[10]. The observed trend may be attributed to several factors. Hospital visiting restrictions and changes in the use of acute hospital services discouraged admissions[19,20]. Specifically, some facilities were repurposed as COVID-19 treatment centers, while others scaled down non-emergency services[21], severely limiting care continuity for chronically ill patients. Additionally, the heightened perception of hospitals as high-risk environments for infection led patients to avoid hospital settings[22]. Compounding this fear, widespread COVID-19 myths, including exaggerated claims about hospital transmission risks, further deterred timely care-seeking[23]. Due to systemic and psychosocial constraints, patients faced reduced access to facilities while harboring amplified reluctance to utilize available services.

Before the COVID-19 pandemic, due to the development of home-based end-of-life care, the place of death in many high-income countries shifted from hospitals to homes, with the home death rate increasing year by year[24]. The pandemic further accelerated this trend. However, in China, the impact of the pandemic on home death rates was less pronounced. Before COVID-19, China exhibited a persistently high baseline proportion of home deaths[25], a phenomenon consistent with our research findings. On the one hand, influenced by cultural values and the idea of returning to one's roots, people are more likely to choose to die at home. At the same time, disparities in healthcare access, especially in rural areas, along with the limited availability of institutional hospice facilities, have reinforced this trend. Financial barriers to prolonged hospital care further exacerbate

	Unadjusted PR	95%CI	Adjusted PR	95%CI
Underlying cause of death interaction with period (ref: pre-COVID-19 and soild cancer)				
Cerebrovascular disease # During COVID-19	0.97	0.95–0.98	0.99	0.97-1.00
Heart disease # During COVID-19	1.00	0.99–1.02	1.01	1.00-1.03
Respiratory disease # During COVID-19	0.97	0.95–0.99	0.97	0.95–0.98
Hematological cancer # During COVID-19	1.18	1.09–1.29	1.12	1.05–1.20
Liver disease # During COVID-19	1.32	1.21–1.43	1.19	1.10–1.29
Renal failure # During COVID-19	1.40	1.24–1.58	1.32	1.19–1.48
Neurological disease # During COVID-19	0.96	0.90–1.02	0.97	0.92–1.03
Others # During COVID-19	1.15	1.13–1.18	1.07	1.05–1.09
Underlying cause of death (ref: solid cancer)				
Cerebrovascular disease	1.13	1.12–1.14	1.06	1.05–1.07
Heart disease	1.09	1.08–1.10	1.02	1.01–1.03
Respiratory disease	1.13	1.12–1.14	1.04	1.03–1.05
Hematological cancer	0.74	0.71–0.77	0.87	0.83–0.91
Liver disease	0.83	0.80–0.87	0.81	0.76–0.86
Renal failure	0.82	0.78–0.87	0.74	0.67–0.81
Neurological disease	1.11	1.08–1.14	1.13	1.09–1.17
Others	0.82	0.81–0.83	0.87	0.86–0.88
Period (ref: pre-COVID-19)				
During COVID-19	1.04	1.04–1.05	1.01	1.00-1.02
Age (ref: 0–44)				
45–64	1.55	1.51–1.59	1.08	1.06–1.10
65–84	1.77	1.73–1.81	1.16	1.14–1.19
85+	1.89	1.84–1.93	1.18	1.16–1.21
Sex (ref: male)				
Female	1.08	1.08–1.09	1.01	1.00-1.01
Marital status (ref: married)				
Unmarried	0.47	0.45–0.48	0.71	0.68–0.74
Widowed	1.15	1.14–1.15	1.07	1.06–1.08
Divorced	0.69	0.65–0.72	0.82	0.79–0.86
Unknown	1.08	1.06–1.11	1.10	1.08–1.12
Education (ref: college and above)				
Senior high school	1.32	1.28–1.36	1.28	1.23–1.32
Junior high school and below	2.39	2.32–2.46	1.84	1.78–1.89
Personal identity (ref: employed)				
Agricultural-related personnel	1.59	1.58–1.61	1.44	1.43–1.46
Retired	0.99	0.98-1.00	0.96	0.95–0.97
Unemployed	1.25	1.23–1.27	1.15	1.14–1.17
Child or student	0.48	0.46–0.50	0.77	0.73–0.82
Settlement (ref: urban)				
Rural	1.39	1.38–1.40	0.94	0.93–0.95

Table 3. Prevalence ratios (95% CI) of variables associated with home deaths (vs. non-home deaths) and the interactions between period (pre-COVID-19 and during COVID-19) and underlying cause of death. PR = prevalence ratio. ref = reference. CI = confidence interval.

these challenges[26]. Consequently, although the COVID-19 pandemic was severe and strict containment measures were implemented, the relative increase in home death rates in China was less pronounced than in Western nations. This subdued growth can be attributed to the already high pre-pandemic baseline of home deaths, which left limited room for dramatic shifts. These findings underscore the need for policies that enhance community-based palliative care services and strengthen support for home-based end-of-life care. Targeted interventions should include training programs for home caregivers, developing crisis-responsive protocols for home death management, and implementing equitable reimbursement mechanisms to alleviate financial barriers to both institutional and home-based end-of-life care.

Our study also found that during COVID-19, children and young adults were significantly affected in their use of medical services. A study showed that during COVID-19, age differences in the increase of home deaths were inconsistent across countries. The increase in home death was higher in those aged 18–49 years in 12/28 countries and in those aged 80 + years in 11/28 countries[10]. This may be due to country differences

in how age relates to the place of death[27]. In China, younger individuals are more likely to die in hospitals rather than at home[25], thus the impact of COVID-19 significantly increased the proportion of home deaths among children and young adults. In addition, we found increased differences in the likelihood of dying at home with lower educational levels (compared to those with higher education) and the unemployed (compared to the employed) during COVID-19. This suggests that inequalities in accessing end-of-life care services among different socioeconomic groups have widened. A study in the United Kingdom similarly found that COVID-19 exacerbated a previously described socioeconomic inequality in place of death[28]. However, it is worth noting that the study in the United Kingdom found that people living in less deprived areas experienced a greater increase in home deaths than those living in more deprived areas. In contrast, our study indicates that within our research population, individuals with lower socioeconomic status saw a more significant increase in the proportion of home deaths. While these results may seem contradictory on the surface, both phenomena fundamentally reflect the exacerbation of structural healthcare inequalities caused by the pandemic. This divergence likely stems from contextual differences in healthcare system organization and baseline inequality patterns. In the case of the United Kingdom, for those living in more deprived areas, factors such as poor housing conditions and limited access to community-based support services may have contributed to the observed trends, making it more difficult for individuals to receive adequate end-of-life care at home[29]. In China, regional healthcare resource imbalances may have pushed vulnerable groups toward involuntary home deaths through disruptions in chronic disease management and financial barriers to hospital admission. Both scenarios ultimately underscore how systemic vulnerabilities become magnified during health crises, though their manifestations vary across welfare regimes[30]. This contrast highlights the need for context-specific analyses of health equity dynamics, as similar pandemic stressors may produce opposed outcomes in different health system architectures. More research is needed to understand different populations' access to healthcare services during COVID-19. Targeted strategies should include strengthening community palliative care networks, improving financial assistance programs for vulnerable populations, and ensuring equitable distribution of healthcare resources to mitigate the disproportionate impact of future public health crises.

Before COVID-19, compared to those who died from solid cancer, patients who died from renal failure, liver disease, and hematological cancer were less likely to die at home, consistent with studies in high-income countries[24,31,32]. Terminal-stage patients with renal failure, liver disease, and hematological cancer are often admitted urgently due to severe symptom burden and complex comorbidities, which increase patient burden and discomfort as well as health care costs[33]. Elderly hospitalized patients may experience prolonged hospitalization, greater use of life-sustaining interventions, and decreased survival[34]. Additionally, during hospitalization, patients and their families may be faced with difficult decisions about high-risk treatments without adequate communication about prognosis or advance care planning. Therefore, terminal-stage patients often have a great need for palliative care. Palliative care can provide support with symptom management, advanced care planning, and psychological support and education for both patients and their families[35]. However, with the complex and unpredictable disease trajectories of patients with these diseases, identifying the optimal timing and setting for early palliative care involvement is still a major challenge[36–38]. During COVID-19, the proportion of home deaths among patients with renal failure, liver disease, and hematological cancer increased significantly. On the one hand, these patients may be more susceptible to COVID-19 infection and face more severe outcomes if infected, so they avoid visiting hospitals to reduce the risk of infection[39–41]. On the other hand, during COVID-19, medical resources were reallocated to respond to COVID-19, making it difficult for some non-COVID-19 patients to obtain necessary medical care[42]. For patients with renal failure, liver disease, and hematological cancer, this reallocation of resources severely impacted their treatment plans. In the dual context of the pandemic and the lack of home-based palliative care, the end-of-life quality for these patients is severely compromised, warranting further investigation. Future researches are needed to enhance understanding of the end-of-life care needs of patients with liver disease, renal failure, and hematological cancer and the optimal end-of-life care delivery models for these populations, especially under circumstances like a pandemic when healthcare services are under significant strain.

Compared to those who died from solid cancer, patients who died from heart disease, cerebrovascular disease, and neurological diseases had a higher chance of home death, which was stable both before and during COVID-19. For patients with sudden cerebrovascular and cardiovascular events, the limited time to access emergency care can lead to a higher chance of dying at home[43]. This continues to be a widespread concern. On the other hand, these diseases may progress more slowly in some cases, requiring long-term management and care, which gives patients and families time to adjust to the condition and consider the ultimate place of care and death[25]. In China, traditional cultural values influence patients' preference for dying at home[44]. According to previous research[45], despite the rapid expansion of hospital beds per capita and increased hospital admission rates, more than one-third of hospitalized terminal-stage participants were discharged to home within 7 days before death. In the context of the high proportion of home deaths, traditional family informal care is far from meeting the needs of physical comfort and emotional support, and the end-of-life quality of home death is worrying. Further researches are required to explore the needs of patients dying at home and improve the satisfaction of end-of-life care.

Our study provides valuable information about the place of death for various diseases, which helps us better understand the utilization of healthcare services for terminal-stage patients over different periods. Accordingly, how to deal with this information is important and policy should be designed to enable people to die in their preferred location and to ensure that high-quality care is available in the places in which a large percentage of the population dies. In reality, where patients die does not necessarily indicate whether care was appropriate or the outcome was good or bad. On one hand, if a patient chooses to die at home, healthcare professionals need to fulfill their needs and provide quality care. On the other hand, if medical issues necessitate treatment in a hospital and this aligns with the patient's best interests, they should have the opportunity to receive care and

treatment in the hospital, regardless of whether they ultimately die there. To address disparities in healthcare access among different disease groups, policies should prioritize expanding home-based palliative care services, enhancing hospital-based end-of-life care coordination, and integrating palliative care into treatment plans at an appropriate stage. Additionally, resource allocation strategies should be tailored to the distinct needs of patients with varying disease trajectories, ensuring equitable access to high-quality care in both home and hospital settings, especially during public health crises like COVID-19.

To our knowledge, this is the first study to examine changes in the place of death among patients with various diseases before and during COVID-19. However, there are limitations. First, our analysis lacked detailed clinical records, such as medical history, care trajectories, and healthcare utilization patterns. Moreover, it did not include crucial data on patients' explicit preferences regarding their preferred place of death. This gap leaves uncertainty about whether the observed increase in home deaths reflects deliberate patient choice or was driven by external constraints such as pandemic-related hospital access restrictions. Furthermore, our study does not provide information on the quality of home-based end-of-life care, including the availability of palliative care services. Without these data, we cannot assess whether patients who died at home received adequate support. Moreover, the use of death registry data presents several inherent limitations. First, potential misclassification of death locations may affect the accuracy of our findings, as the recorded place of death may not always reflect the actual circumstances, particularly in cases where deaths occurred during emergency transfers or at unregistered care facilities. Second, underreporting may occur, particularly for deaths in nursing homes, where reporting systems may be less standardized. However, as this study primarily focuses on home deaths, the impact of such underreporting is likely minimal. In the future, as more comprehensive data become available, nursing homes should be examined separately as a distinct place of death. A more detailed and nuanced analysis of trends in death locations could help identify important differences in end-of-life care experiences across different settings. Additionally, although missing data in death records could lead to biased estimations of trends in place of death, the proportion of missing data in this study was low (0.65%) and was addressed through case-wise deletion, making it unlikely to introduce substantial bias. These limitations underscore the need for more comprehensive data collection efforts that integrate clinical and social care records to enhance our understanding of end-of-life care patterns during public health crises.

Conclusion

Most non-accidental deaths occurred at home, with a notable rise in home deaths during COVID-19, highlighting the urgent need to develop community- and/or home-based end-of-life care services. The chance of home death for patients with renal failure, liver disease, and hematological cancer was lower but increased significantly during COVID-19, indicating a disproportionate impact on end-of-life care utilization for these conditions that require focused improvement.

Data availability

The data that support the findings of this study are available from Nanchang Center for Disease Prevention and Control but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. The data used and analysed during the current study available from the corresponding author on reasonable request.

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Author contributions

Huiting Chen was responsible for research design, data processing, data analysis, and manuscript writing. Yibing Fan was responsible for data collection and contributed to data processing. Hao Wu and Yu Cao provided technical support and suggestions for method improvement. Fanyan Zeng and Hui Liu contributed to data processing. Wei Gao supervised the overall study, contributed to research design, finalized the manuscript framework, and revised the final draft. All authors reviewed the manuscript.

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Competing interests
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