

RESEARCH ARTICLE

Sociodemographic and clinical factors for non-hospital deaths among cancer patients: A nationwide population-based cohort study

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Abstract

Background

Factors associated with place of death inform policies with respect to allocating end-of-life care resources and tailoring supportive measures.

Objective

To determine factors associated with non-hospital deaths among cancer patients.

Design

Retrospective cohort study of cancer decedents, examining factors associated with non-hospital deaths using multinomial logistic regression with hospital deaths as the reference category.

Setting/subjects

Cancer patients (n = 15254) in Singapore who died during the study period from January 1, 2012 till December 31, 2105 at home, acute hospital, long-term care (LTC) or hospice were included.

Results

Increasing age (categories ≥ 65 years: RRR 1.25–2.61), female (RRR 1.40; 95% CI 1.28–1.52), Malays (RRR 1.67; 95% CI 1.47–1.89), Brain malignancy (RRR 1.92; 95% CI 1.15–3.23), metastatic disease (RRR 1.33–2.01) and home palliative care (RRR 2.11; 95% CI 1.95–2.29) were associated with higher risk of home deaths. Patients with low socioeconomic status were more likely to have hospice or LTC deaths: those living in smaller housing

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types had higher risk of dying in hospice (1–4 rooms apartment: RRR 1.13–3.17) or LTC (1–5 rooms apartment: RRR 1.36–4.11); and those with Medifund usage had higher risk of dying in LTC (RRR 1.74; 95% CI 1.36–2.21). Patients with haematological malignancies had increased risk of dying in hospital (categories of haematological subtypes: RRR 0.06–0.87).

Conclusions

We found key sociodemographic and clinical factors associated with non-hospital deaths in cancer patients. More can be done to enable patients to die in the community and with dignity rather than in a hospital.

Introduction

Cancer is a leading cause of death globally, accounting for an estimated 9.6 million deaths in 2018. [1] A large proportion of cancer deaths occur in hospitals for many developed countries. [2,3] Similar to global trends, cancer incidence is on the rise in Singapore; with cancer accounting for 30% of total population mortality. [4,5] Additionally, more than 50% of cancer decedents die in Singapore hospitals, [6,7] despite a majority patient preference for home deaths. [8–12]

Respecting preferences in terms of place of care and death is important. [13] Good cancer care includes a consideration of a patient's needs, goals and preferences throughout their course of illness. [14] Respecting such preferences may provide better holistic well-being, increased peace and less intense grief for families. [15,16] Studies done in Singapore profiling end-of-life care preferences suggest most cancer patients prefer to die at home. [8–10,17] Such preferences remain relatively stable over trajectory of illness. [18]

Place of death is also a recognised quality indicator for end-of-life care. [19] Dying from cancer in hospitals is considered overly aggressive end-of-life care. [20–23] Costs for aggressive end-of-life care are substantially higher, driven by heavy dependence on hospitalizations. [24–28] Local data in Singapore suggests that hospitalizations are the largest driver of healthcare spending for oncology care. [29]

To develop services that effectively reduce hospital deaths, reduce costs and support dying in patients' preferred place, understanding factors associated with non-hospital deaths in cancer patients is needed. These factors inform public health policies with respect to allocation of end-of-life care resources and tailoring supportive measures.

A systematic review of Western countries found 17 factors associated with place of death. Six factors were strongly associated with home deaths: low functional status, patient preferences for home death, use of home care, intensity of home care, living with relatives and extended family support. Conversely, non-solid tumours, ethnic minorities, previous admissions to hospitals and areas with greater hospital provision were associated with hospital deaths. [30] Literature specific to Asia suggest that marital status, poor functional status, having multidisciplinary home palliative care, lower caregiver burden and patient and family preferences increased the likelihood of dying at home. [31–35] Within Singapore, factors found to be associated with home death include age, female gender, Malay ethnicity, receipt of home palliative care, having a caregiver, non-cancer diagnosis, fewer prior hospitalizations and a preference for home death. [6,7,36]

While a recent systematic review concluded that low socioeconomic status increased the odds of hospital deaths, this conclusion was weaker for Asian countries due to a lack of published studies within this region. [37] To the best of our knowledge, local literature defining cancer specific risk factors for hospital deaths is also currently lacking; and remains critical in future identification of patients with unmet needs.

To meet the gap in literature, the primary objective of this study was to explore the influence of socioeconomic factors and clinical factors on places of death. We used the US National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) categorisation of cancer types to increase granularity in examining cancer types. [38]

Methods

Setting, study design and participants

Cancer care in Singapore is predominantly provided within tertiary public institutions through a mixture of government subsidies, compulsory savings, compulsory national health-care insurance and a state-provided "safety net". [39] In recent years, to improve care across the cancer continuum, there have been increasing efforts to transition care to the community by empowering and increasing resources to community hospice providers. [40]

A retrospective national cohort study was conducted using state-wide administrative data of inpatient admissions, financial claims from the Ministry of Health (MOH) and death records from the Singapore Registry of Births and Deaths. [41]

Singapore residents who were discharged alive from hospital with a primary discharge diagnosis of cancer based on International Classification of Diseases codes (ICD-10-AM:C00-C96) between January 1, 2012 and December 31, 2015, and a recorded death in the national death registry by December 31, 2015 were included in this study. Patients with unnatural deaths at sites such as roads (e.g. traffic accidents), ground floor of residential apartment blocks and reservoirs (possibly suicides) were excluded from the study (n = 52).

The STROBE guidelines were used for the reporting of this observational study. [42]

Dependant variable

Place of death was as recorded in the patient's death certificate and categorised as hospital, home, hospice and long-term care facilities (LTC)

Independent variables

Socioeconomic variables were defined by three different aspects. First, we examined housing subsidy via mapping residential postal codes to housing type. Housing type (categorised by level of housing subsidy, ranging from private / non-subsidized housing, to intermediate subsidy with restrictions on resale and rental, to maximal subsidy, non-market housing) correlates with income status due to the public subsidized housing system in Singapore where income ceilings determine housing type eligibility. [43–45] Second, we calculated average monthly household income per capita percentiles based on the eligibility cut-off tiers for subsidized primary care under the Community Health Assist Scheme (CHAS). [46,47] Third, financial data on inpatient admissions paid from the government Medical Endowment Scheme (Medifund) was used. Medifund is a discretionary government-funded safety net to help the neediest Singaporeans with high post-subsidy inpatient bills, and takes into consideration the applicant's financial, health and social circumstances. [48]

Clinical information was extracted from discharge diagnoses (age, gender, ethnicity, cancer sites, comorbidities) and admission records (length of stay, discharge disposition). We

categorised ethnicity as Chinese, Malay, Indian and Others in accordance with the national approach towards racial categories. [49] Comorbid burden was computed using the Charlson Comorbidity Index (CCI). [50] Primary cancer sites were grouped by two-digit ICD-10-CM codes according to the SEER codes for cancers deemed to be single site primaries. [38] Metastases were grouped by three-digit SEER codes into brain, bone, lymph node, lung, liver, other gastrointestinal and other metastases. Status of home palliative care involvement was obtained from MOH Agency for Integrated Care records. [51]

The only variables with missing data were housing type (416, 2.72%) and ethnicity (144, 0.94%). Patients with missing variables were included in the analysis as “missing category”.

Statistical analysis

Differences in mean of continuous variable by places of death were compared using Analysis of Variance. Corresponding differences in categorical variable were compared using chi-square test or Fisher's exact test, as appropriate. Multivariable multinomial logistic regression analyses were used to estimate relative risk ratios (RRR) to examine the association between places of death and various covariates. Hospital death was used as the reference category and all independent variables listed above were included as covariates in the model. Sixty-six predictors were tested which was below the maximum number of predictors that could be fitted given total sample size and number of responses in each place of death category. [52] Model diagnostics were performed in which Wald tests were used to examine whether places of death categories could be combined, and spearman correlations were used to identify potential multicollinearity between independent variables. Sensitivity analyses were performed to examine the impact of outliers.

STATA version 13.0 (StataCorp) was used to perform statistical analysis. A two-sided $p < 0.05$ was considered statistically significant.

Research ethics and patient consent

This study was approved by SingHealth Central Institutional Review Board (CIRB Ref No: 2017/2908). Research and analysis were done on deidentified data. Waiver of requirement for informed consent was granted.

Results

A total of 15254 decedents met the study eligibility criteria and were analysed. Within this cohort, 6.69% passing away in LTC, 14.38% in a hospice, 33.14% at home, and 45.79% in hospital. Mean (SD) age was 68 (13.6) years, majority were Chinese (81.05%) and 56.29% were male. Lung (21.40%), liver (9.39%), colon (9.37%), breast (7.28%) and stomach (6.14%) made up the top five solid organ malignancies, while 6.85% had haematological malignancies. Thirty-two percent received home palliative care before their deaths.

Table 1 and S1 Table summarises the distribution of each independent variable by places of death. Variables with small cell counts were reported as < 5 to respect confidentiality of patients. There were distinct differences in sociodemographic characteristics of decedents by places of death. Decedents who passed away at hospital and hospice were younger than those who died at home and LTC. Malays and decedents who had home palliative care were more likely to pass away at home, while decedents with lower socioeconomic status (Medifund, $< 20^{\text{th}}$ income percentile, living in 1–2 room apartments) were less likely to do so.

The results from our multinomial logistic regression model are presented in Table 2. Sensitivity analyses excluding outliers made no appreciable differences to the estimates of the model.

Table 1. Sociodemographic and clinical characteristics of decedents by place of death.

Variable	No. (%)				P value
	Hospital	Home	Hospice	LTC	
Total	6985 (100.0)	5055 (100.0)	2194 (100.0)	1020 (100.0)	
Gender					
Male	4150 (59.41)	2543 (50.31)	1347 (61.39)	547 (53.63)	<0.001
Female	2835 (40.59)	2512 (49.69)	847 (38.61)	473 (46.37)	
Age, years					
<17	35 (0.50)	16 (0.32)	1 (0.05)	0 (0)	<0.001
17–34	118 (1.69)	44 (0.87)	18 (0.82)	2 (0.20)	
35–44	238 (3.41)	128 (2.53)	64 (2.92)	11 (1.08)	
45–54	848 (12.14)	430 (8.51)	242 (11.03)	86 (8.43)	
55–64	1756 (25.14)	1034 (20.45)	553 (25.21)	221 (21.67)	
65–74	1906 (27.29)	1286 (25.44)	614 (27.99)	274 (26.86)	
75–84	1567 (22.43)	1428 (28.25)	518 (23.61)	280 (27.45)	
≥85	517 (7.40)	689 (13.63)	184 (8.39)	146 (14.31)	
Mean (SD)	66.3 (13.7)	70.2 (13.6)	67.7 (12.7)	71.0 (12.2)	<0.001
Race					
Chinese	5565 (79.67)	3930 (77.74)	1973 (89.93)	896 (87.84)	<0.001
Indian	322 (4.61)	174 (3.44)	63 (2.87)	27 (2.65)	
Malay	678 (9.71)	647 (12.80)	88 (4.01)	54 (5.29)	
Others	345 (4.94)	260 (5.14)	55 (2.51)	34 (3.33)	
Missing	75 (1.07)	44 (0.87)	15 (0.68)	9 (0.88)	
CCI score					
0	3350 (47.96)	2318 (45.86)	1131 (51.55)	467 (45.78)	<0.001
1	1392 (19.93)	1129 (22.33)	436 (19.87)	196 (19.22)	
2	693 (9.92)	503 (9.95)	220 (10.03)	109 (10.69)	
3	489 (7.00)	373 (7.38)	155 (7.06)	77 (7.55)	
≥4	1061 (15.19)	732 (14.48)	252 (11.49)	171 (16.76)	
Medifund Use					
Yes	453 (6.49)	214 (4.23)	164 (7.47)	116 (11.37)	<0.001
No	6532 (93.51)	4841 (95.77)	2030 (92.53)	904 (88.63)	
CHAS Income Percentile					
<20th percentile	1983 (28.39)	1409 (27.87)	745 (33.96)	367 (35.98)	<0.001
20th–50th percentile	355 (5.08)	266 (5.26)	106 (4.83)	56 (5.49)	
>50th percentile	4647 (66.53)	3380 (66.86)	1343 (61.21)	597 (58.53)	
Housing Subsidy					
1–2 Room Apartment	331 (4.74)	187 (3.70)	233 (10.62)	130 (12.75)	<0.001
3 Room Apartment	1982 (28.38)	1351 (26.73)	743 (33.87)	287 (28.14)	
4 Room Apartment	2194 (31.41)	1655 (32.74)	608 (27.71)	280 (27.45)	
5 Room/Executive Apartment	1449 (20.74)	1171 (23.17)	351 (16.00)	169 (16.57)	
Private Housing ^a	836 (11.97)	612 (12.11)	193 (8.80)	78 (7.65)	
Missing	193 (2.76)	79 (1.56)	66 (3.01)	76 (7.45)	
Mean Length of Stay of Index Admission (SD), days	10.1 (13.6)	9.9 (12.1)	13.4 (16.2)	14.0 (21.5)	
Final Deposition of Index Admission					
Discharged	5989 (85.74)	4411 (87.26)	1541 (70.24)	606 (59.41)	<0.001
Transferred ^b	606 (8.68)	410 (8.11)	152 (6.93)	89 (8.73)	
Others ^c	390 (5.58)	234 (4.63)	501 (22.84)	325 (31.86)	
Home Palliative Care Involvement					

(Continued)

Table 1. (Continued)

Variable	No. (%)				P value
	Hospital	Home	Hospice	LTC	
Yes	1872 (26.80)	2187 (43.26)	579 (26.39)	274 (26.86)	<0.001
No	5113 (73.20)	2868 (56.74)	1615 (73.61)	746 (73.14)	

Abbreviations: LTC, Long-Term Care Facilities; CCI, Charlson Comorbidity Index excluding cancer; Medifund, Medical Endowment Fund Scheme; CHAS, Community Health Assist Scheme.

a Included condominiums and landed properties

b To another tertiary healthcare institution

c Discharged against advice or abscondment

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Home death vs hospital death

Independent factors associated with higher risks of dying at home than in hospitals were increasing age, females, Malay and Other ethnicities, receipt of home palliative care, being non-Medifund aided and having less comorbidities. (Table 2)

Hospice death vs hospital death

Independent factors associated with higher risks of dying in hospice than hospitals were Chinese, having fewer comorbidities, living in smaller subsidized housing types and being discharged against advice or abscondment during index hospitalisation. (Table 2)

Long-Term Care (LTC) death vs hospital death

Independent factors associated with higher risks of dying in LTC than hospitals were older age, females, Chinese, Medifund recipients, living in smaller subsidized housing types and being transferred to another tertiary institute, discharged against advice or absconded during index hospitalisation. (Table 2)

Cancer-specific risk factors for hospital deaths and out-of-hospital deaths

Patients with solid organ tumours such as Breast, Prostate, Lung and other rarer sites had increased risk of dying in hospitals rather than home or hospice. Most haematological malignancies had higher risk for dying in hospital.

Primary brain malignancy and having metastatic cancer (e.g. brain metastases, bone metastases) were associated with increased risk for out-of-hospital deaths. (Table 2)

Discussion

In this study, a large proportion of cancer patients (45.64%) died in hospitals while only 33.03% died at home and 21.07% in LTC/hospice. Like previous local studies, we confirm older age, female, Malay ethnicity and home palliative care involvement to be associated with home deaths. [6,7] Additionally, we found that primary brain cancer, metastatic disease and non-Medifund patients were more likely to die at home.

From our analysis, low SES patients (smaller housing types, Medifund recipients) were more likely to pass away in LTC or hospices rather than hospitals. Being discharged against advice or abscondment from hospital, which we classify as high-risk behaviours with possible underlying social and financial needs, was also strongly associated with LTC and hospice deaths. This contrasts with a recent systematic review that included studies mostly from the

Table 2. Association of places of death with sociodemographic and clinical characteristics.

Variable	Relative Risk Ratio (95% CI)					
	Base category for places of death in multinomial logistic model = Hospital					
	Home	P value	Hospice	P value	LTC	P value
Gender (ref: Male)						
Female	1.40 (1.28–1.52)	<0.001	0.95 (0.84–1.07)	0.378	1.27 (1.08–1.49)	0.005
Age, years (ref: 55–64)						
< 17	0.65 (0.33–1.27)	0.207	0.09 (0.01–0.70)	0.021	*	-
17–34	0.57 (0.39–0.84)	0.005	0.61 (0.35–1.06)	0.078	0.18 (0.04–0.74)	0.017
35–44	0.82 (0.64–1.04)	0.102	1.02 (0.75–1.39)	0.911	0.41 (0.22–0.77)	0.006
45–54	0.76 (0.66–0.88)	<0.001	0.93 (0.78–1.12)	0.462	0.77 (0.59–1.01)	0.061
65–74	1.25 (1.12–1.39)	<0.001	1.01 (0.87–1.16)	0.943	1.15 (0.94–1.40)	0.174
75–84	1.77 (1.58–1.98)	<0.001	1.00 (0.89–1.17)	0.990	1.39 (1.13–1.71)	0.002
≥85	2.61 (2.24–3.03)	<0.001	1.06 (0.85–1.31)	0.604	1.97 (1.51–2.56)	<0.001
Race (ref: Chinese)						
Indian	0.88 (0.72–1.07)	0.199	0.60 (0.45–0.80)	<0.001	0.49 (0.32–0.74)	0.001
Malay	1.67 (1.47–1.89)	<0.001	0.35 (0.28–0.45)	<0.001	0.49 (0.36–0.66)	<0.001
Others	1.24 (1.04–1.48)	0.016	0.50 (0.37–0.67)	<0.001	0.60 (0.41–0.88)	0.009
CCI score (ref: 0)						
1	1.09 (0.99–1.21)	0.091	0.90 (0.78–1.03)	0.116	0.90 (0.74–1.08)	0.261
2	0.93 (0.81–1.06)	0.279	0.88 (0.73–1.05)	0.142	0.93 (0.73–1.18)	0.528
3	0.96 (0.82–1.12)	0.563	0.89 (0.72–1.09)	0.258	0.91 (0.69–1.20)	0.499
≥ 4	0.86 (0.76–0.97)	0.012	0.67 (0.56–0.79)	<0.001	0.89 (0.72–1.10)	0.275
Medifund Use (ref: No)						
Yes	0.69 (0.58–0.83)	<0.001	1.10 (0.90–1.35)	0.348	1.74 (1.36–2.21)	<0.001
CHAS Income Percentile (ref: > 50th percentile)						
20th - 50th percentile	0.95 (0.80–1.13)	0.559	0.99 (0.78–1.25)	0.924	1.22 (0.89–1.66)	0.209
< 20th percentile	0.92 (0.84–1.01)	0.065	1.06 (0.94–1.19)	0.332	1.05 (0.90–1.24)	0.512
Housing Type (ref: Private Housing ^a)						
1–2 Room Apartment	0.83 (0.66–1.03)	0.091	3.17 (2.48–4.05)	<0.001	4.11 (2.96–5.72)	<0.001
3 Room Apartment	0.95 (0.83–1.09)	0.488	1.65 (1.37–2.00)	<0.001	1.52 (1.15–2.00)	0.003
4 Room Apartment	1.07 (0.94–1.22)	0.301	1.23 (1.02–1.49)	0.031	1.44 (1.09–1.89)	0.009
5 Room/Executive Apartment	1.11 (0.97–1.27)	0.147	1.13 (0.92–1.39)	0.236	1.36 (1.02–1.82)	0.037
Length of Stay of Index Admission (per day increase)						
	1.00 (1.00–1.00)	0.939	1.01 (1.00–1.01)	<0.001	1.00 (1.00–1.01)	0.033
Final Disposition of Index Admission(ref: Discharged)						
Transferred ^b	1.00 (0.86–1.15)	0.951	0.93 (0.77–1.13)	0.484	1.50 (1.17–1.92)	0.002
Others ^c	0.83 (0.70–0.99)	0.043	4.28 (3.66–5.01)	<0.001	6.57 (5.45–7.93)	<0.001
Home Palliative Care (ref: No)						
Yes	2.11 (1.95–2.29)	<0.001	1.09 (0.97–1.22)	0.143	1.23 (1.05–1.44)	0.011
Primary Cancer Site ^d						
Other Head and Neck	0.49 (0.22–1.08)	0.076	0.49 (0.19–1.27)	0.142	1.68 (0.57–4.94)	0.348
Tongue	0.51 (0.26–1.00)	0.052	0.73 (0.34–1.56)	0.421	0.77 (0.25–2.34)	0.648
Oropharynx [⊗]	0.52 (0.21–1.32)	0.169	0.50 (0.17–1.47)	0.206	1.11 (0.30–4.16)	0.879
Nasopharynx	0.92 (0.57–1.48)	0.719	0.61 (0.32–1.16)	0.132	0.69 (0.28–1.69)	0.423
Hypopharynx [⊗]	0.97 (0.45–2.11)	0.945	0.65 (0.25–1.73)	0.392	0.19 (0.02–1.64)	0.131
Oesophagus	0.66 (0.41–1.08)	0.098	0.40 (0.20–0.78)	0.007	0.72 (0.30–1.71)	0.454
Stomach	0.93 (0.61–1.43)	0.755	0.57 (0.32–1.02)	0.060	0.79 (0.36–1.71)	0.545
Small Intestine	0.44 (0.22–0.86)	0.016	0.28 (0.10–0.77)	0.014	0.82 (0.25–2.67)	0.745
Colon	0.76 (0.50–1.15)	0.195	0.55 (0.31–0.98)	0.043	0.75 (0.35–1.59)	0.450

(Continued)

Table 2. (Continued)

Variable	Relative Risk Ratio (95% CI)					
	Base category for places of death in multinomial logistic model = Hospital					
	Home	P value	Hospice	P value	LTC	P value
Rectosigmoid	0.81 (0.51–1.29)	0.378	0.60 (0.32–1.12)	0.110	0.77 (0.33–1.78)	0.541
Rectum	0.75 (0.48–1.17)	0.204	0.69 (0.38–1.26)	0.223	1.16 (0.53–2.57)	0.709
Anus ^{&}	1.60 (0.63–4.04)	0.324	2.26 (0.78–6.52)	0.132	2.83 (0.69–11.61)	0.148
Liver	0.84 (0.56–1.28)	0.426	0.55 (0.31–0.98)	0.042	0.79 (0.37–1.68)	0.534
Biliary	0.90 (0.56–1.45)	0.664	0.51 (0.26–1.00)	0.050	0.44 (0.17–1.15)	0.095
Pancreas	0.82 (0.53–1.26)	0.354	0.60 (0.33–1.08)	0.089	0.73 (0.33–1.61)	0.430
Other Facial	1.03 (0.48–2.18)	0.947	0.50 (0.15–1.39)	0.165	1.53 (0.46–5.12)	0.490
Larynx	0.60 (0.31–1.14)	0.118	0.53 (0.24–1.17)	0.117	0.76 (0.26–2.18)	0.611
Trachea and Lung	0.61 (0.41–0.92)	0.018	0.54 (0.31–0.94)	0.030	0.73 (0.35–1.53)	0.406
Thymus, Heart, Mediastinum ^{&}	0.30 (0.12–0.75)	0.011	0.15 (0.03–0.69)	0.015	1.21 (0.33–4.48)	0.771
Bone ^{&}	1.70 (0.73–3.98)	0.219	0.66 (0.18–2.44)	0.537	1.38 (0.24–7.92)	0.718
Skin	0.55 (0.32–0.96)	0.037	0.38 (0.17–0.83)	0.015	0.52 (0.18–1.47)	0.214
Mesothelioma, pleura	0.65 (0.34–1.26)	0.199	1.02 (0.46–2.28)	0.959	1.43 (0.49–4.18)	0.510
Other soft tissue, Sarcoma ^{&}	0.59 (0.30–1.16)	0.125	0.85 (0.38–1.91)	0.696	0.51 (0.13–2.08)	0.347
Retroperitoneum ^{&}	1.35 (0.67–2.76)	0.403	0.95 (0.35–2.58)	0.920	0.38 (0.04–3.27)	0.379
Breast	0.58 (0.38–0.89)	0.013	0.43 (0.24–0.78)	0.006	0.88 (0.41–1.90)	0.754
Female Genital ^{&}	0.67 (0.31–1.45)	0.307	0.63 (0.21–1.93)	0.416	0.90 (0.22–3.66)	0.878
Cervix	0.83 (0.50–1.36)	0.459	0.76 (0.38–1.49)	0.419	1.44 (0.60–3.43)	0.415
Uterus	0.61 (0.37–1.02)	0.058	0.51 (0.25–1.05)	0.066	1.41 (0.60–3.33)	0.435
Ovary	0.64 (0.40–1.01)	0.056	0.64 (0.34–1.22)	0.174	0.97 (0.42–2.25)	0.951
Male Genital ^{&}	0.66 (0.25–1.75)	0.402	0.98 (0.35–2.74)	0.973	1.08 (0.21–5.73)	0.925
Prostate	0.57 (0.36–0.91)	0.017	0.49 (0.26–0.92)	0.027	0.66 (0.29–1.49)	0.315
Kidney and Ureter	0.74 (0.47–1.16)	0.194	0.57 (0.31–1.06)	0.075	0.80 (0.35–1.80)	0.584
Bladder	0.71 (0.43–1.18)	0.187	0.44 (0.22–0.90)	0.025	0.91 (0.37–2.23)	0.834
Brain, Spine	1.92 (1.15–3.23)	0.013	1.71 (0.87–3.36)	0.118	2.52 (1.02–6.18)	0.044
Thyroid ^{&}	0.78 (0.41–1.50)	0.463	0.54 (0.21–1.37)	0.193	0.16 (0.02–1.37)	0.094
Adrenal and Endocrine ^{&}	1.43 (0.55–3.71)	0.463	1.22 (0.37–4.08)	0.744	*	-
Other misc. malignancies	1.42 (0.73–2.77)	0.300	1.81 (0.81–4.01)	0.147	1.38 (0.43–4.46)	0.586
Unspecified Site	0.85 (0.55–1.32)	0.462	0.60 (0.33–1.10)	0.102	0.61 (0.27–1.41)	0.248
Hodgkin's Disease ^{&}	0.23 (0.05–1.15)	0.074	*	-	*	-
Follicular NHL (nodular) ^{&}	0.87 (0.36–2.13)	0.760	0.16 (0.02–1.32)	0.088	0.44 (0.05–3.89)	0.462
Diffuse NHL	0.57 (0.35–0.92)	0.022	0.41 (0.21–0.81)	0.010	0.76 (0.32–1.81)	0.532
Peripheral and cutaneous TCL ^{&}	0.27 (0.11–0.63)	0.003	0.18 (0.05–0.58)	0.004	0.63 (0.17–2.31)	0.488
Other and unspecified NHL	0.41 (0.22–0.76)	0.004	0.18 (0.07–0.49)	0.001	0.42 (0.13–1.35)	0.145
Misc IPD ^{&}	0.74 (0.36–1.54)	0.422	0.45 (0.16–1.24)	0.122	0.14 (0.02–1.23)	0.076
Multiple myeloma and MPCN ^{&}	0.28 (0.15–0.50)	<0.001	0.13 (0.05–0.36)	<0.001	0.06 (0.01–0.48)	0.008
Lymphoid leukaemia ^{&}	0.28 (0.13–0.61)	0.001	*	-	0.11 (0.01–0.95)	0.045
Myeloid leukaemia	0.35 (0.21–0.59)	<0.001	0.15 (0.07–0.33)	<0.001	0.22 (0.07–0.66)	0.007
More than one primary site	1.57 (1.09–2.25)	0.014	1.47 (0.90–2.39)	0.125	1.29 (0.66–2.52)	0.456
Secondary Cancer Site ^d						
Lymph node metastases	0.99 (0.82–1.20)	0.897	1.33 (1.02–1.72)	0.032	1.13 (0.80–1.60)	0.486
Lung metastases	1.16 (0.96–1.40)	0.133	1.49 (1.15–1.94)	0.002	1.13 (0.80–1.60)	0.483
Gastrointestinal Metastases	1.33 (1.08–1.64)	0.008	1.30 (0.98–1.74)	0.073	1.07 (0.72–1.58)	0.748
Liver metastases	1.37 (1.14–1.64)	0.001	1.78 (1.38–2.28)	<0.001	1.14 (0.81–1.59)	0.455
Bone metastases	1.25 (1.03–1.51)	0.021	1.46 (1.13–1.88)	0.004	1.54 (1.10–2.16)	0.011

(Continued)

Table 2. (Continued)

Variable	Relative Risk Ratio (95% CI)					
	Base category for places of death in multinomial logistic model = Hospital					
	Home	P value	Hospice	P value	LTC	P value
Brain metastases	2.01 (1.62–2.49)	< 0.001	2.53 (1.91–3.34)	< 0.001	1.86 (1.28–2.70)	0.001
Other metastases	1.00 (0.87–1.16)	0.986	1.07 (0.89–1.28)	0.487	1.03 (0.80–1.33)	0.455
More than one secondary site	0.94 (0.81–1.09)	0.408	0.77 (0.62–0.95)	0.013	0.89 (0.68–1.17)	0.408

Abbreviations: LTC, Long-Term Care Facilities; ref, reference category; CCI, Charlson Comorbidity Index excluding cancer; Medifund, Medical Endowment Fund Scheme; CHAS, Community Health Assist Scheme; NHL, non-Hodgkin's lymphoma; TCL: T-cell lymphomas; misc, miscellaneous; IPD, immunoproliferative diseases; MPCN, malignant plasma cell neoplasms.

a Included condominiums and landed properties

b To another tertiary healthcare institution

c Discharged against advice or abscondment

d Refer to Table 1 for the ICD-10-CM topography codes for each category of cancer site

*Not estimable as there were no decedent in the category

Note: RRR estimates in bold are significantly different from value 1 ($p < 0.05$).

& Caution with interpretation due to low cell counts

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US, Canada and Europe suggesting that low socioeconomic position is a risk factor for hospital deaths. [37] We hypothesize that within Singapore's healthcare system, early transfers to LTC or hospice were taking place for low SES patients when they lose the ability to self-care, resulting in higher proportions of death within these institutions. [53] While palliative care services are routinely provided within hospices, many LTC facilities are still unable to provide good quality palliative care services due to manpower and resource constraints and lack of training [40] Palliative care provision has to be strengthened within LTC to meet the needs of the socially disadvantaged who are more likely to die in such facilities. [54–56]

We found home palliative care involvement to be associated with increased likelihood of home or LTC deaths. This concurs with meta-analysis evidence that home palliative care increases the likelihood of dying at home. [57] Our findings reaffirm ongoing national efforts in improving capacity of community palliative care to meet the needs of patients and facilitating out-of-hospital-deaths. [40]

We found positive association between haematological malignancies and dying in hospital, echoing findings from studies done by western counterparts. [30,58–60] Additionally, this association remained strongly significant for almost all types of haematological malignancies. We postulate this is due to characteristics of underlying disease and treatment, including uncertain trajectories, indistinct transitions, prognostic difficulties and difficult symptoms (e.g. overwhelming sepsis, symptomatic anaemia, etc). [61] Referrals to palliative care occur less frequently for patients with haematological malignancies and often late in the disease trajectory, with many still undergoing aggressive treatment. [62] More research is needed to improve end-of-life outcomes for this group of patients.

Lastly, ethnicity was associated with place of death, suggesting that unmeasured sociocultural differences in perspectives influence utilization of hospice/LTC facilities. Malays were more likely to die at home, congruent with previous studies, possibly due to strong family and intergenerational support as well as religious beliefs. [63,64] In contrast, Indian and "other" (non-Chinese, non-Malay, non-Indian) minority ethnicities, compared to the Chinese, were more likely to die in hospital than in hospice or LTC. Additional studies with qualitative methodology may shed further light on this finding.

Strengths and limitations

A key strength of our study is the linkage of nation-wide clinical data with socioeconomic profiles and healthcare utilization data. Analysing place of death outcomes as a multiclass problem prevents oversimplification to a binary outcome of “hospital” vs “others” as individuals may prefer to die in other settings and understanding the factors influencing each is important. Additionally, only a small percentage of our cohort had missing data.

One key limitation was the inability to capture important variables such as patient preferences for place of death, acute hospital utilization at end-of-life, cancer stage at death, health and function trajectories and additional socioeconomic variables such as employment status, education level and caregiver burden. As this study was limited to public hospitals, we could not capture those who received treatment solely in private centres. However, majority of healthcare in Singapore is provided by public hospitals so the effect may be minimal. [65] While some of the patients in our study may have died of other unrelated causes, this was mitigated by adjustment for comorbidity index at the time of index admission. Moreover, 91.26% of our cohort passed away from cancer as primary cause of death.

Finally, due to cancer epidemiology and the relatively small population in Singapore, the rarer cancers (e.g. bone, anus, female and male genital, Hodgkin’s disease) had low counts and hence the related statistics must be interpreted with caution.

Implications and generalisability

Results from our study suggest directions for future studies and healthcare policies. Firstly, low SES patients are more likely to die in LTC or hospice than hospitals. Provision of good quality palliative care should expand towards LTC to meet the needs of socially disadvantaged patients who are more likely to die in such facilities. Secondly, patients on home palliative care were more likely to pass away at home or in LTC, reaffirming efforts on improving capacity of community palliative care to meet the needs of patients and facilitating out-of-hospital-deaths. Thirdly, if patients with haematological cancers are more likely to pass away in hospitals, then it is essential that adequate care is available within the hospital setting. Additionally, research is needed on their care preferences, reasons for hospital deaths and mitigation strategies if home death is preferred by these patients.

Considering the similarity of some of our study findings to international studies, the findings may be generalizable to other urban settings. However, culture and system-specific factors found in our study highlight the complexities of place of death.

Conclusion

We found in this study key sociodemographic and clinical factors associated with non-hospital deaths among cancer patients. We believe our findings have implications for future policy making. High-risk groups for dying in hospitals may benefit from targeted models of care while better support can be tailored for those who pass away out of hospitals.

Supporting information

S1 Table. Cancer sites of decedents by place of death.
(DOCX)

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References

1. WHO Media centre (2018) Cancer: Fact sheet, <https://www.who.int/news-room/fact-sheets/detail/cancer> (accessed 10 May 2019).
2. Bekelman JE, Halpern SD, Blankart CR, et al. Comparison of Site of Death, Health Care Utilization, and Hospital Expenditures for Patients Dying With Cancer in 7 Developed Countries. *JAMA* 2016; 315: 272–283. <https://doi.org/10.1001/jama.2015.18603> PMID: 26784775
3. Cohen J, Pivodic L, Miccinesi G, et al. International study of the place of death of people with cancer: a population-level comparison of 14 countries across 4 continents using death certificate data. *Br J Cancer* 2015; 113: 1397–1404. <https://doi.org/10.1038/bjc.2015.312> PMID: 26325102
4. Cancer Registry—National Registry Of Diseases Office, <https://www.nrdo.gov.sg/publications/cancer> (accessed 14 September 2018).
5. Number of Deaths and Top 10 Principal Causes. Data.gov.sg, https://data.gov.sg/dataset/principal-causes-of-death?resource_id%3D98d62914-67a3-47c8-bd7a-310fb3b07a0f (accessed 14 September 2018).
6. Hong CY, Chow KY, Poulouse J, et al. Place of death and its determinants for patients with cancer in Singapore: an analysis of data from the Singapore Cancer Registry, 2000–2009. *J Palliat Med* 2011; 14: 1128–1134. <https://doi.org/10.1089/jpm.2011.0092> PMID: 21966990
7. Tan WS, Bajpai R, Low CK, et al. Individual, clinical and system factors associated with the place of death: A linked national database study. *PLOS ONE* 2019; 14: e0215566. <https://doi.org/10.1371/journal.pone.0215566> PMID: 30998764
8. Finkelstein EA, Bilger M, Flynn TN, et al. Preferences for end-of-life care among community-dwelling older adults and patients with advanced cancer: A discrete choice experiment. *Health Policy Amst Neth* 2015; 119: 1482–1489.
9. Malhotra C, Farooqui MA, Kanesvaran R, et al. Comparison of preferences for end-of-life care among patients with advanced cancer and their caregivers: A discrete choice experiment. *Palliat Med* 2015; 29: 842–850. <https://doi.org/10.1177/0269216315578803> PMID: 25805740
10. Lee A, Pang WS. Preferred place of death—a local study of cancer patients and their relatives. *Singapore Med J* 1998; 39: 447–450. PMID: 9885706

11. Tan WS, Bajpai R, Ho AHY, et al. Retrospective cohort analysis of real-life decisions about end-of-life care preferences in a Southeast Asian country. *BMJ Open*; 9. Epub ahead of print 3 February 2019. <https://doi.org/10.1136/bmjopen-2018-024662> PMID: 30782914
12. *Blackbox Research. Lien Foundation Survey on Death Attitudes 2014*, http://lienfoundation.org/sites/default/files/Death%20survey%20Presser%20Final%20-%20Combined_0.pdf.
13. Davies E, Higginson I (eds). *The Solid Facts: Palliative Care*. World Health Organization, <http://www.euro.who.int/en/publications/abstracts/palliative-care.-the-solid-facts> (2004).
14. Peppercorn JM, Smith TJ, Helft PR, et al. American society of clinical oncology statement: toward individualized care for patients with advanced cancer. *J Clin Oncol Off J Am Soc Clin Oncol* 2011; 29: 755–760.
15. Higginson IJ, Sarmento VP, Calanzani N, et al. Dying at home—is it better: a narrative appraisal of the state of the science. *Palliat Med* 2013; 27: 918–924. <https://doi.org/10.1177/0269216313487940> PMID: 23698451
16. Gomes B, Calanzani N, Koffman J, et al. Is dying in hospital better than home in incurable cancer and what factors influence this? A population-based study. *BMC Med* 2015; 13: 235. <https://doi.org/10.1186/s12916-015-0466-5> PMID: 26449231
17. Tan WS, Bajpai R, Ho AHY, et al. Retrospective cohort analysis of real-life decisions about end-of-life care preferences in a Southeast Asian country. *BMJ Open* 2019; 9: e024662. <https://doi.org/10.1136/bmjopen-2018-024662> PMID: 30782914
18. Gomes B, Calanzani N, Gysels M, et al. Heterogeneity and changes in preferences for dying at home: a systematic review. *BMC Palliat Care* 2013; 12: 7. <https://doi.org/10.1186/1472-684X-12-7> PMID: 23414145
19. Earle CC, Park ER, Lai B, et al. Identifying potential indicators of the quality of end-of-life cancer care from administrative data. *J Clin Oncol Off J Am Soc Clin Oncol* 2003; 21: 1133–1138.
20. Earle CC, Neville BA, Landrum MB, et al. Trends in the Aggressiveness of Cancer Care Near the End of Life. *J Clin Oncol* 2004; 22: 315–321. <https://doi.org/10.1200/JCO.2004.08.136> PMID: 14722041
21. Earle CC, Neville BA, Landrum MB, et al. Evaluating claims-based indicators of the intensity of end-of-life cancer care. *Int J Qual Health Care* 2005; 17: 505–509. <https://doi.org/10.1093/intqhc/mzi061> PMID: 15985505
22. Earle CC, Landrum MB, Souza JM, et al. Aggressiveness of Cancer Care Near the End of Life: Is It a Quality-of-Care Issue? *J Clin Oncol* 2008; 26: 3860–3866. <https://doi.org/10.1200/JCO.2007.15.8253> PMID: 18688053
23. Ho TH, Barbera L, Saskin R, et al. Trends in the Aggressiveness of End-of-Life Cancer Care in the Universal Health Care System of Ontario, Canada. *J Clin Oncol* 2011; 29: 1587–1591. <https://doi.org/10.1200/JCO.2010.31.9897> PMID: 21402603
24. Tanuseputro P, Wodchis WP, Fowler R, et al. The Health Care Cost of Dying: A Population-Based Retrospective Cohort Study of the Last Year of Life in Ontario, Canada. *PLoS ONE*; 10. Epub ahead of print 26 March 2015. <https://doi.org/10.1371/journal.pone.0121759> PMID: 25811195
25. Chastek B, Harley C, Kallich J, et al. Health Care Costs for Patients With Cancer at the End of Life. *J Oncol Pract* 2012; 8: 75s–80s. <https://doi.org/10.1200/JOP.2011.000469> PMID: 23598848
26. Mariotto AB, Robin Yabroff K, Shao Y, et al. Projections of the Cost of Cancer Care in the United States: 2010–2020. *JNCI J Natl Cancer Inst* 2011; 103: 117–128. <https://doi.org/10.1093/jnci/djq495> PMID: 21228314
27. Bremner KE, Krahn MD, Warren JL, et al. An international comparison of costs of end-of-life care for advanced lung cancer patients using health administrative data. *Palliat Med* 2015; 29: 918–928. <https://doi.org/10.1177/0269216315596505> PMID: 26330452
28. Cheung MC, Earle CC, Rangrej J, et al. Impact of aggressive management and palliative care on cancer costs in the final month of life. *Cancer* 2015; 121: 3307–3315. <https://doi.org/10.1002/cncr.29485> PMID: 26031241
29. Yan S, Kwan YH, Thumboo J, et al. Characteristics and Health Care Utilization of Different Segments of a Multiethnic Asian Population in Singapore. *JAMA Netw Open* 2019; 2: e1910878. <https://doi.org/10.1001/jamanetworkopen.2019.10878> PMID: 31490539
30. Gomes B, Higginson IJ. Factors influencing death at home in terminally ill patients with cancer: systematic review. *BMJ* 2006; 332: 515–521. <https://doi.org/10.1136/bmj.38740.614954.55> PMID: 16467346
31. Fukui S, Fujita J, Tsujimura M, et al. Late referrals to home palliative care service affecting death at home in advanced cancer patients in Japan: a nationwide survey. *Ann Oncol Off J Eur Soc Med Oncol* 2011; 22: 2113–2120.

32. Nakamura S, Kuzuya M, Funaki Y, et al. Factors influencing death at home in terminally ill cancer patients. *Geriatr Gerontol Int* 2010; 10: 154–160. <https://doi.org/10.1111/j.1447-0594.2009.00570.x> PMID: 20446929
33. Tang ST, Huang E-W, Liu T-W, et al. Propensity for home death among Taiwanese cancer decedents in 2001–2006, determined by services received at end of life. *J Pain Symptom Manage* 2010; 40: 566–574. <https://doi.org/10.1016/j.jpainsymman.2010.01.020> PMID: 20580525
34. Fukui S, Fukui N, Kawagoe H. Predictors of place of death for Japanese patients with advanced-stage malignant disease in home care settings: a nationwide survey. *Cancer* 2004; 101: 421–429. <https://doi.org/10.1002/cncr.20383> PMID: 15241842
35. Place of death and the differences in patient quality of death and dying and caregiver burden.—PubMed—NCBI, <https://www.ncbi.nlm.nih.gov/pubmed/25534381> (accessed 25 February 2020).
36. Lee YS, Akhileswaran R, Ong EHM, et al. Clinical and Socio-Demographic Predictors of Home Hospice Patients Dying at Home: A Retrospective Analysis of Hospice Care Association's Database in Singapore. *J Pain Symptom Manage* 2017; 53: 1035–1041. <https://doi.org/10.1016/j.jpainsymman.2017.01.008> PMID: 28196785
37. Davies JM, Sleeman KE, Leniz J, et al. Socioeconomic position and use of healthcare in the last year of life: A systematic review and meta-analysis. *PLOS Med* 2019; 16: e1002782. <https://doi.org/10.1371/journal.pmed.1002782> PMID: 31013279
38. Topography Codes from ICD-O-2 and ICD-O-3 | SEER Training, https://training.seer.cancer.gov/arc_neoplasms/codes.html (accessed 24 June 2019).
39. Lim J. Sustainable Health Care Financing: The Singapore Experience. *Glob Policy* 2017; 8: 103–109.
40. Yvonne A, Christopher G. Leaving Well- End-of-Life Policies in Singapore, https://lkyspp.nus.edu.sg/docs/default-source/ips/ips-exchange-series_no-13_leaving-well-end-of-life-polices-in-singapore_web.pdf (July 2019, accessed 6 August 2019).
41. Ministry of Health. Costs and financing., <https://www.moh.gov.sg/cost-financing/healthcare-schemes-subsidies/medisave> (accessed 24 June 2019).
42. von Elm E, Altman DG, Egger M, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ* 2007; 335: 806–808. <https://doi.org/10.1136/bmj.39335.541782.AD> PMID: 17947786
43. Wong TH, Skanthakumar T, Nadkarni N, et al. Survival of patients with head and neck squamous cell carcinoma by housing subsidy in a tiered public housing system. *Cancer* 2017; 123: 1998–2005. <https://doi.org/10.1002/cncr.30557> PMID: 28135397
44. Homepage—Housing & Development Board (HDB), <https://www.hdb.gov.sg/cs/infoweb/homepage> (accessed 29 June 2019).
45. Low LL, Wah W, Ng MJ, et al. Housing as a Social Determinant of Health in Singapore and Its Association with Readmission Risk and Increased Utilization of Hospital Services. *Front Public Health*; 4. Epub ahead of print 2016. <https://doi.org/10.3389/fpubh.2016.00109> PMID: 27303662
46. M810361—Key Indicators On Household Income From Work Among Resident Employed Households, Annual | SingStat Table Builder, <https://www.tablebuilder.singstat.gov.sg/publicfacing/createDataTable.action?refId=12307> (accessed 26 June 2019).
47. CHAS Subsidies, <https://www.chas.sg/content.aspx?id=636> (accessed 26 June 2019).
48. MediFund, <https://www.moh.gov.sg/cost-financing/healthcare-schemes-subsidies/medifund> (accessed 26 June 2019).
49. Siddique S. The Phenomenology of Ethnicity: A Singapore Case-Study. *Sojourn J Soc Issues Southeast Asia* 1990; 5: 35–62.
50. Klabunde CN, Potosky AL, Legler JM, et al. Development of a comorbidity index using physician claims data. *J Clin Epidemiol* 2000; 53: 1258–1267. [https://doi.org/10.1016/s0895-4356\(00\)00256-0](https://doi.org/10.1016/s0895-4356(00)00256-0) PMID: 11146273
51. Ministry of Health Agency for Integrated Care, <http://www.gov.sg/sgdi/ministries/moh/departments/aic> (accessed 24 June 2019).
52. Harrell F. *Regression Modeling Strategies: With Applications to Linear Models, Logistic Regression, and Survival Analysis*. New York: Springer-Verlag, <https://www.springer.com/gp/book/9781441929181> (2001, accessed 29 July 2019).
53. Barclay JS, Kuchibhatla M, Tulskey JA, et al. Association of Hospice Patients' Income and Care Level With Place of Death. *JAMA Intern Med* 2013; 173: 450–456. <https://doi.org/10.1001/jamainternmed.2013.2773> PMID: 23420383

54. Ng CWL, Cheong S, Govinda Raj A, et al. End-of-life care preferences of nursing home residents: Results of a cross-sectional study. *Palliat Med* 2016; 30: 843–853. <https://doi.org/10.1177/0269216316634242> PMID: 26962065
55. Sussman T, Kaasalainen S, Mintzberg S, et al. Broadening End-of-Life Comfort to Improve Palliative Care Practices in Long Term Care. *Can J Aging Rev Can Vieil* 2017; 36: 306–317.
56. Teo W-SK, Raj AG, Tan WS, et al. Economic impact analysis of an end-of-life programme for nursing home residents. *Palliat Med* 2014; 28: 430–437. <https://doi.org/10.1177/0269216314526270> PMID: 24651709
57. Gomes B, Calanzani N, Curiale V, et al. Effectiveness and cost-effectiveness of home palliative care services for adults with advanced illness and their caregivers. *Cochrane Database Syst Rev* 2013; CD007760. <https://doi.org/10.1002/14651858.CD007760.pub2> PMID: 23744578
58. Howell DA, Roman E, Cox H, et al. Destined to die in hospital? Systematic review and meta-analysis of place of death in haematological malignancy. *BMC Palliat Care* 2010; 9: 9. <https://doi.org/10.1186/1472-684X-9-9> PMID: 20515452
59. Cohen J, Houttekier D, Onwuteaka-Philipsen B, et al. Which patients with cancer die at home? A study of six European countries using death certificate data. *J Clin Oncol Off J Am Soc Clin Oncol* 2010; 28: 2267–2273.
60. Howell DA, Wang H-I, Smith AG, et al. Place of death in haematological malignancy: variations by disease sub-type and time from diagnosis to death. *BMC Palliat Care* 2013; 12: 42. <https://doi.org/10.1186/1472-684X-12-42> PMID: 24245578
61. McCaughan D, Roman E, Smith AG, et al. Determinants of hospital death in haematological cancers: findings from a qualitative study. *BMJ Support Palliat Care* 2018; 8: 78–86. <https://doi.org/10.1136/bmjspcare-2016-001289> PMID: 28663341
62. Moreno-Alonso D, Porta-Sales J, Monforte-Royo C, et al. Palliative care in patients with haematological neoplasms: An integrative systematic review. *Palliat Med* 2018; 32: 79–105. <https://doi.org/10.1177/0269216317735246> PMID: 29130387
63. Gubhaju B, Chan A, Østbye T. Intergenerational support to and from older Singaporeans. In: *Family and Population Changes in Singapore*. London: Routledge, 2018. Epub ahead of print 17 April 2018. <https://doi.org/10.4324/9781351109871-6>
64. General Household Survey 2015. *Base*, <http://www.singstat.gov.sg/publications/ghs/ghs2015> (accessed 29 June 2019).
65. Singapore Health Facts. *Base*, <http://www.singstat.gov.sg/find-data/search-by-theme/society/health/latest-data> (accessed 30 June 2019).