Journal of Geriatric Oncology 15 (2024) 101683

Contents lists available at ScienceDirect

Journal of Geriatric Oncology

journal homepage: www.elsevier.com/locate/jgo

Research Paper

Hospital use and cancer treatment by age and socioeconomic status in the last year of life: A Norwegian population-based study of patients dying of cancer

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ARTICLE INFO

Keywords:
Geriatric oncology
Hospitalizations
Cancer
End of life
Socioeconomic status
Comorbidity
Epidemiological data
Registry data
Health disparity

ABSTRACT

Introduction: Cancer is the leading cause of death in Norway. In this nationwide study we describe the number and causes of hospital admissions and treatment in the final year of life for patients who died of cancer, as well as the associations to age and socioeconomic status (SES).

Materials and Methods: From nationwide registries covering 2010–2014, we identified all patients who were diagnosed with cancer 12–60 months before death and had cancer as their reported cause of death. We examined the number of overnight hospital stays, causes of admission, and treatment (chemotherapy, radiotherapy, surgical procedures) offered during the last year of life by individual (age, sex, comorbidity), cancer (type, stage, months since diagnosis), and socioeconomic variables (co-residential status, income, education).

Results: The analytical sample included 17,669 patients; 8,247 (47%) were female, mean age was 71.7 years (standard deviation 13.7). At diagnosis, 31% had metastatic disease, while 29% had an intermediate or high comorbidity burden.

Altogether, 94% were hospitalized during their final year, 82% at least twice, and 33% six times or more. Patients spent a median of 23 days in hospital (interquartile range 11–41), and altogether 38% died there. Younger age, bladder and ovarian cancer, not living alone, and higher income were associated with having ≥6 hospitalizations. Cancer-related diagnoses were the main causes of hospitalizations (65%), followed by infections (11%).

Around 51% had ≥1 chemotherapy episode, with large variations according to patient age and SES; patients who were younger, did not live alone, had high education, and high income received more chemotherapy. Radiotherapy was received by 15% and declined with age, and the variation according to SES characteristics was minor. Of the 12,940 patients with a cancer type where surgery is a main treatment modality, only 835 (6%) underwent surgical procedures for their primary tumor in the last year of life.

Discussion: Most patients who die of cancer are hospitalized multiple times during the last year of life. Hospitalizations and treatment decline with advancing age. Living alone and having low income is associated with fewer hospitalizations and less chemotherapy treatment. Whether this indicates over- or undertreatment across various groups warrants further exploration.

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https://doi.org/10.1016/j.jgo.2023.101683
Received 12 December 2022; Received in revised form 10 July 2023; Accepted 1 December 2023
Available online 7 December 2023

Table 1
Sociodemographic data and hospitalizations.

		Number of hospitalizations (row proportion)			
	Total	**0–1**	**2–3**	**4–5**	**6 or more**
	n =	*n* =	*n* =	*n* =	*n* =
Number of patients	17,669	3120	4802	3990	5757
Age at death, years, grouped	**N**				
0–49	*n* = 1117	0.08	0.17	0.21	0.57
50–59	*n* = 1989	0.09	0.21	0.25	0.46
60–69	*n* = 4444	0.09	0.26	0.24	0.41
70–79	*n* = 4653	0.15	0.28	0.25	0.32
80–89	*n* = 4387	0.28	0.33	0.20	0.19
90+	*n* = 1079	0.48	0.31	0.13	0.08
Sex					
Female	*n* = 8247	0.18	0.27	0.22	0.32
Male	*n* = 9422	0.17	0.27	0.23	0.33
Comorbidity index 1 year prior to death					
no admission	*n* = 1061	0.36	0.28	0.19	0.16
	n =				
CCI = 0	11,518	0.16	0.28	0.23	0.34
CCI = 1–2	*n* = 3512	0.16	0.27	0.22	0.36
CCI ≥ 3	*n* = 1578	0.25	0.24	0.21	0.29
Multiple cancers					
	n =				
No	13,886	0.17	0.27	0.22	0.33
Yes	*n* = 3783	0.20	0.27	0.23	0.30
Cancer stage at diagnosis					
	n =				
Non-metastatic	12,231	0.19	0.27	0.23	0.32
Metastatic	*n* = 5438	0.15	0.27	0.23	0.35
Cancer site					
Lung	*n* = 2777	0.16	0.31	0.24	0.29
Colorectal cancer	*n* = 3199	0.22	0.29	0.21	0.28
Prostate	*n* = 1882	0.24	0.29	0.22	0.25
Breast	*n* = 1230	0.24	0.28	0.22	0.26
Pancreatic	*n* = 526	0.12	0.26	0.26	0.35
Brain	*n* = 547	0.15	0.27	0.27	0.31
Bladder	*n* = 669	0.14	0.22	0.20	0.44
Ovarian	*n* = 646	0.08	0.21	0.23	0.48
Uterine	*n* = 387	0.18	0.27	0.23	0.32
Kidney	*n* = 412	0.14	0.26	0.22	0.37
Gastric	*n* = 530	0.14	0.25	0.26	0.36
Myeloma	*n* = 490	0.12	0.25	0.29	0.33
Other	*n* = 4374	0.16	0.25	0.21	0.38
Marital status					
Never-married	*n* = 1836	0.18	0.26	0.20	0.37
Married	*n* = 9409	0.14	0.26	0.24	0.36
Widowed	*n* = 3949	0.30	0.31	0.20	0.20
Divorced/sep	*n* = 2457	0.14	0.25	0.23	0.37
Missing	n = 18				
Household members					
	n =				
>1	11,146	0.13	0.26	0.24	0.37
1 (alone)	*n* = 6523	0.25	0.29	0.20	0.25
Individual income					
Lowest quartile	*n* = 4329	0.20	0.27	0.22	0.31
Quartile 2	*n* = 4332	0.19	0.27	0.22	0.32
Quartile 3	*n* = 4464	0.17	0.27	0.22	0.34
Highest quartile	*n* = 4544	0.16	0.27	0.24	0.33
Education					
High	*n* = 5964	0.13	0.26	0.24	0.37
	n =				
Low	11,705	0.20	0.28	0.22	0.30
Place of death					
Hospital	*n* = 6752	0.09	0.26	0.24	0.41
Nursing home	*n* = 8318	0.23	0.28	0.22	0.27
Home	*n* = 2426	0.24	0.26	0.20	0.30
Other/missing	*n* = 173				

Abbreviation: CCI; Charlson comorbidity index.

1. Introduction

Cancer is now the leading cause of death in Norway, as in many other Western countries. Older age is the most important predictor for developing cancer. With the projected increase in life expectancy and survivorship from cancer, cancer care comprises a large and increasing proportion of health care [1,2]. Hospitalizations are costly, and knowledge about hospital use in the last year of life for patients with cancer is crucial to planning future resource needs [3–5]. Available treatments for cancer also progress quickly. In Norway, oncological treatment is offered through the public healthcare system. Cancer treatment often necessitates hospitalizations, and there are no out-of-pocket costs for hospital admissions. Observational studies show that hospital-based services are heavily used at the end-of-life in patients with cancer, but as most studies do not provide complete population data and detailed information about causes of hospital admissions, there is limited knowledge about the journey of the patient with cancer during the last year of the disease [3,4,6]. In particular, information about the relative importance of comorbidity and cancer for hospitalizations in the last year is lacking. It is also unclear to what extent age and socioeconomic status (SES) influence hospitalizations and treatment in the last year of life in the cancer setting. On the one hand, older patients with comorbidity, in addition to cancer, may need more hospital treatment for other conditions. On the other hand, older patients are more frequently cared for primarily in the community setting.

In the palliative setting, without hope of cure, extensive oncological treatment with side effects and frequent hospitalizations to prolong life can be burdensome. Nevertheless, being hospitalized means having access to cancer and palliative care specialists across several disciplines and may therefore be welcomed. Furthermore, only in retrospect does it become clear when the last year of life has begun.

Epidemiological register data have the advantage of being complete on a population-level, and include factors related to SES such as co-residential status, income, and educational level. Previous research has shown that SES accounts for a substantial amount of variation in population health outcomes [7]. As population-based data enable us to uncover heterogeneity in treatment according to age, comorbidities and SES, such data may provide an indication of patient groups who receive too much or too little treatment, and therefore provide directions for smaller scale patient-oriented research to ensure optimal treatment provision across diverse groups [4].

Against this backdrop, the aim of this nationwide study was to quantify hospital stays in the last year of life and causes of hospital admissions, and explore the hypothesis that older patients with cancer experience fewer hospitalizations than their younger counterparts, but that specialist care is extensive even for older patients [8]. It is worth mentioning that in Norway, all palliative care is integrated into existing structures of public health care, and hospices are therefore rare [9]. This study also sought to explore the influence of SES on hospitalizations and cancer treatment, although a priori hypotheses are less clear. From a resource perspective, one might expect SES to be positively associated with the amount of care, such that the presence of household members, higher income, and higher education are linked to more hospitalizations and treatment [10,11]. On the other hand, the need for care might be higher among patients with cancer with fewer resources, thus resulting in more frequent and longer hospitalizations [12]. Due to comprehensive national registry data in Norway, we can investigate all hospitalizations and their underlying causes at the individual level, along with the use of chemo- and radiotherapy, surgical procedures, and aggressive care (i.e., dialysis, ventilatory support, intensive care, feeding tube insertion) in relation to age, comorbidity, cancer characteristics, and SES.

Table 2
Logistic regression model presenting odds ratios of ≥6 hospitalizations, receiving chemotherapy and radiotherapy in the last year of life, not including interaction terms.

	≥ 6 hospitalizations			Chemotherapy			Radiotherapy		
Age at death, years, grouped	OR	95% CI		OR	95% CI		OR	95% CI	
<50	1			1			1		
50–59	0.63	0.54	0.73	0.93	0.78	1.13	0.97	0.81	1.17
60–69	0.47	0.41	0.54	0.70	0.59	0.83	0.85	0.72	1.00
70–79	0.32	0.28	0.37	0.36	0.30	0.42	0.61	0.51	0.73
80–89	0.15	0.13	0.18	0.07	0.06	0.08	0.42	0.35	0.51
90+	0.06	0.05	0.08	0.01	0.01	0.02	0.17	0.12	0.24
Sex									
Female	1			1			1		
Male	1.0	0.92	1.08	0.98	0.90	1.06	**1.16**	1.05	1.28
Comorbidity index 1 year prior to death									
no admission	1								
CCI = 0	**1.76**	1.47	2.10	**3.16**	2.64	3.79	0.90	0.74	1.10
CCI = 1–2	**2.26**	1.87	2.72	**2.05**	1.69	2.49	0.71	0.57	0.88
CCI = 3+	**2.03**	1.65	2.50	**1.23**	0.99	1.54	0.54	0.42	0.69
Months since cancer diagnosis									
12–23 months	1			1			1		
24–60 months	0.88	0.82	0.94	0.66	0.62	0.72	0.76	0.70	0.83
Cancer stage at diagnosis	N/S						N/S		
Non-metastatic				1					
Metastatic				1.8	1.62	1.92			
Cancer site (ref. no cancer at site)									
Lung	0.57	0.51	0.63	**1.46**	1.31	1.62	**1.43**	1.27	1.61
Colorectal	0.71	0.64	0.78	**2.17**	1.95	2.42	0.53	0.46	0.61
Prostate	0.86	0.75	0.98	N/S			**1.27**	1.09	1.49
Breast	0.57	0.49	0.66	**1.54**	1.31	1.82	**1.23**	1.04	1.48
Pancreatic	0.72	0.59	0.87	**3.03**	2.39	3.85	0.34	0.24	0.48
Brain	0.41	0.33	0.49	0.28	0.23	0.34	0.52	0.40	0.67
Bladder	**2.02**	1.70	2.40	N/S			**1.31**	1.04	1.64
Ovarian	**1.36**	1.14	1.63	**3.58**	2.78	4.61	0.33	0.23	0.46
Uterine	N/S			**1.56**	1.21	2.02	N/S		
Myeloma	N/S			**5.29**	4.17	6.72	N/S		
Kidney	N/S			0.22	0.17	0.28	N/S		
Gastric	N/S			**1.36**	1.10	1.68	0.40	0.31	0.52
Household members									
>1	1			1			1		
1 (alone)	0.80	0.74	0.86	0.61	0.56	0.66	0.77	0.70	0.85
Individual income							N/S		
Lowest quartile	1			1					
Quartile 2	1.04	0.95	1.15	1.03	0.93	1.14			
Quartile 3	**1.19**	1.08	1.30	**1.15**	1.04	1.28			
Highest quartile	**1.12**	1.02	1.23	**1.38**	1.23	1.54			
Education	N/S						N/S		
Low				1					
High				**1.15**	1.06	1.28			
Log likelihood	−10,212.09			−8776.66			−6917.35		
Likelihood ratio chi-square	1880.55(df22), $p < 0.00$			6932.38(df26), $p < 0.00$			856.72(df21), $p < 0.00$		
Pseudo R^2	0.08			0.28			0.06		

Abbreviations: OR: odds ratio; CI: confidence interval; CCI: Charlson comorbidity index. Higher ORs in bold.
$n = 17{,}669$.

2. Material and Methods

2.1. Study Design and Cohort Selection

In Norway, with a population of 5.5 million, specialized health care services are tax financed, and hospital treatment is free of charge. This was a population-based retrospective study of a cohort of all patients in Norway who had a recent cancer (12–60 months before death) in their medical history and died between January 1, 2010 and December 31, 2014.

2.2. Data Sources and Linkage

We used the Cancer Registry of Norway (CRN) to identify index cases of patients with a cancer diagnosis in their history. The CRN is a population-based cancer registry with high quality, comparability, completeness, and validity. The completeness is approximately 99% when all cancer diagnoses are considered [13]. All Norwegian citizens have a personal identification number. Using encrypted personal identification numbers, index cases from the CRN were linked to the Norwegian Patient Registry (NPR), which contains diagnostic and procedure information of all discharges and outpatient contacts from public hospitals for residents of Norway. Information on comorbidity one year prior to death was also derived from this register. We linked the index cases to The Cause of Death Registry (DAAR) to obtain information on all deaths and reported causes of death, as well as to population registries from Statistics Norway (SSB), from which we obtained proxy measures of patient SES.

2.3. Classification of Variables

2.3.1. Main Outcome Measures

Hospitalizations were defined as overnight stays in hospital and were calculated from NPR. To categorize the main reported cause of hospitalizations, ICD10-codes from NPR were used. Hospitalizations were grouped into cancer-related hospitalizations (primary diagnosis was

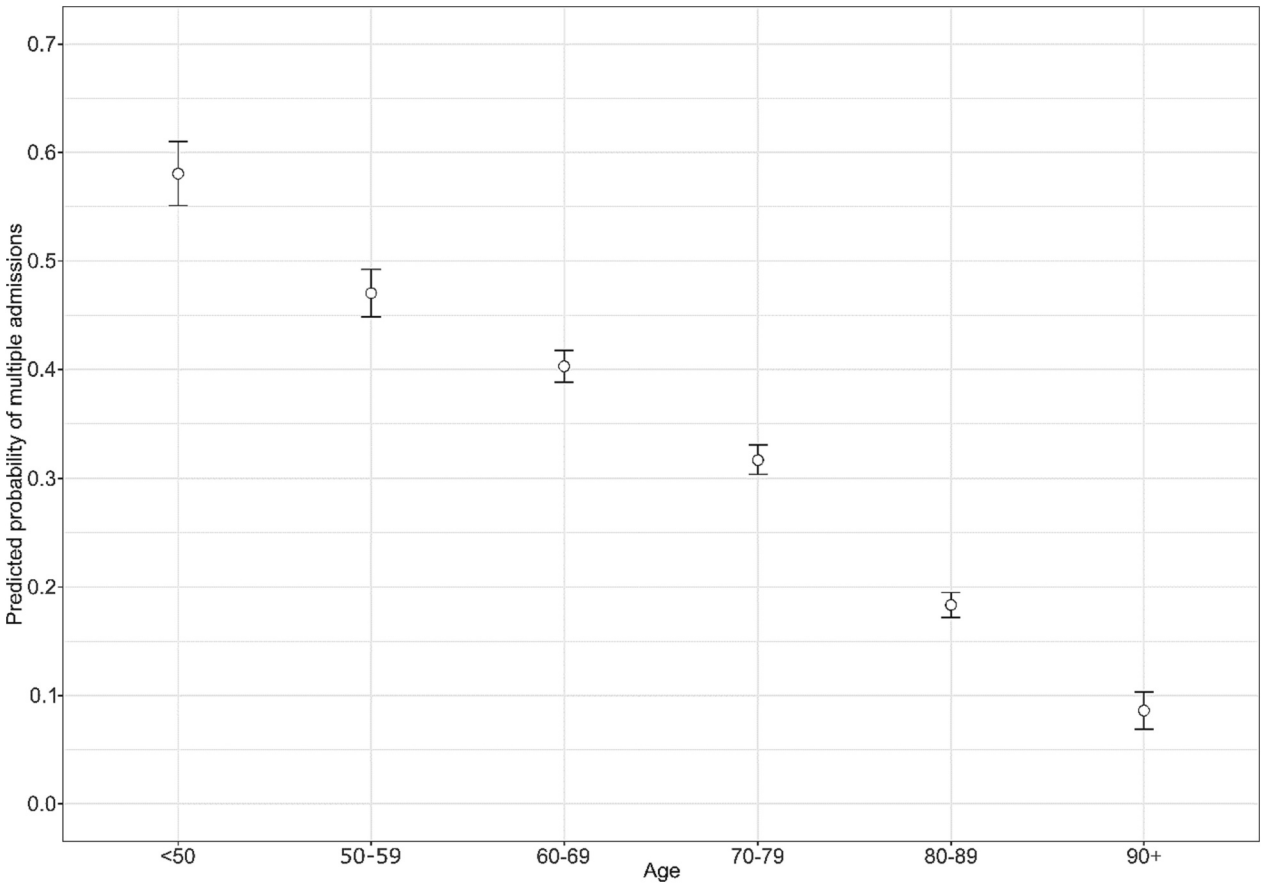


Fig. 1. a. Predicted probability of multiple admissions (six or more) by age.
b. Predicted probability of multiple admissions (six or more): Co-residential status and low income by age.

either a cancer diagnosis or palliative care, chemotherapy, or radiotherapy use), heart disease, lung disease, cerebrovascular disease, infections, kidney disease, vascular disease, hematological disease, digestive disease, hip fracture, or other. Details of the classification can be found in the Appendix (A1). The variable "surgical procedure" was calculated by searching for specific surgical procedure codes (resections and other tumor-related procedures) from Norwegian Codes for Surgical Procedures (NCSP) related to the 11 most common cancer types in the sample where surgery may be required, namely lung, colorectal, prostate, breast, pancreatic, bladder, brain, ovarian, uterine, kidney, and gastric cancer, based on all hospital stays for individual patients. We searched for codes for procedures related to the primary tumor, not metastatic sites. Use of chemotherapy and radiotherapy is recorded in NPR with specific ICD10-codes, and the results refer to patients having $\geq$1 treatment episode in their last year. In addition, we constructed the variable "aggressive treatment" by using codes for dialysis, intensive care admission, respiratory support, and the insertion of a feeding tube. Details of the codes used can be found in the Appendix (A1).

2.3.2. Independent Variables

Age, sex, date of diagnosis, type of cancer, stage of cancer at diagnosis (metastatic versus non-metastatic), and date of death were available in the CRN. When patients had multiple cancers diagnosed throughout life, we used the date and type of the last non-skin cancer diagnosis before death in the analyses. Comorbidity (other diseases than cancer) was calculated using a version of the Charlson Comorbidity Index (CCI) adapted to national patient registries, and categorized into four groups: no hospital admissions (CCI = −1); low (CCI = 0); intermediate (CCI = 1–2); and high (CCI $\geq$ 3) [14]. The following socio-economic characteristics were obtained from SSB: educational attainment (lower = $\leq$12 years or higher = 13 or more years) at year of diagnosis; co-residential status (living alone = yes or no, with the latter defined as there being only one person in the household) one year prior to death; individual income quartile (categorized by sex, age group, and year) one year prior to diagnosis; and household income quartile (categorised by age group and year) one year prior to diagnosis. Place and cause of death were captured from DAAR.

2.4. Statistical Analyses

In addition to providing descriptive statistics for the overall cohort, we focused specifically on multiple hospitalizations (defined as six or more) as this was reflected in approximately one third of patients. We employed binary logistic regression and used multiple hospitalizations, chemotherapy, and radiotherapy use as dichotomous outcome variables. Our main independent variable of interest was patient age at death (<50, 50–59, 60–69, 70–79, 80–89, 90+ years). Our models also accounted for the type and stage of cancer at diagnosis, multiple cancers, time since diagnosis, comorbidity, as well as socio-economic and demographic characteristics (sex, marital status, co-residential status, educational attainment, individual and household income). To assess possible moderation effects, we included several two-way interaction terms between age and the different SES variables, with predicted probabilities pertaining to statistically significant interaction effects plotted in order to visualize how the age effect varies across different SES groupings (full tabulated results of the interaction models are available upon request). Margins plots demonstrating the predicted probability of multiple admissions by age for bladder cancer, breast

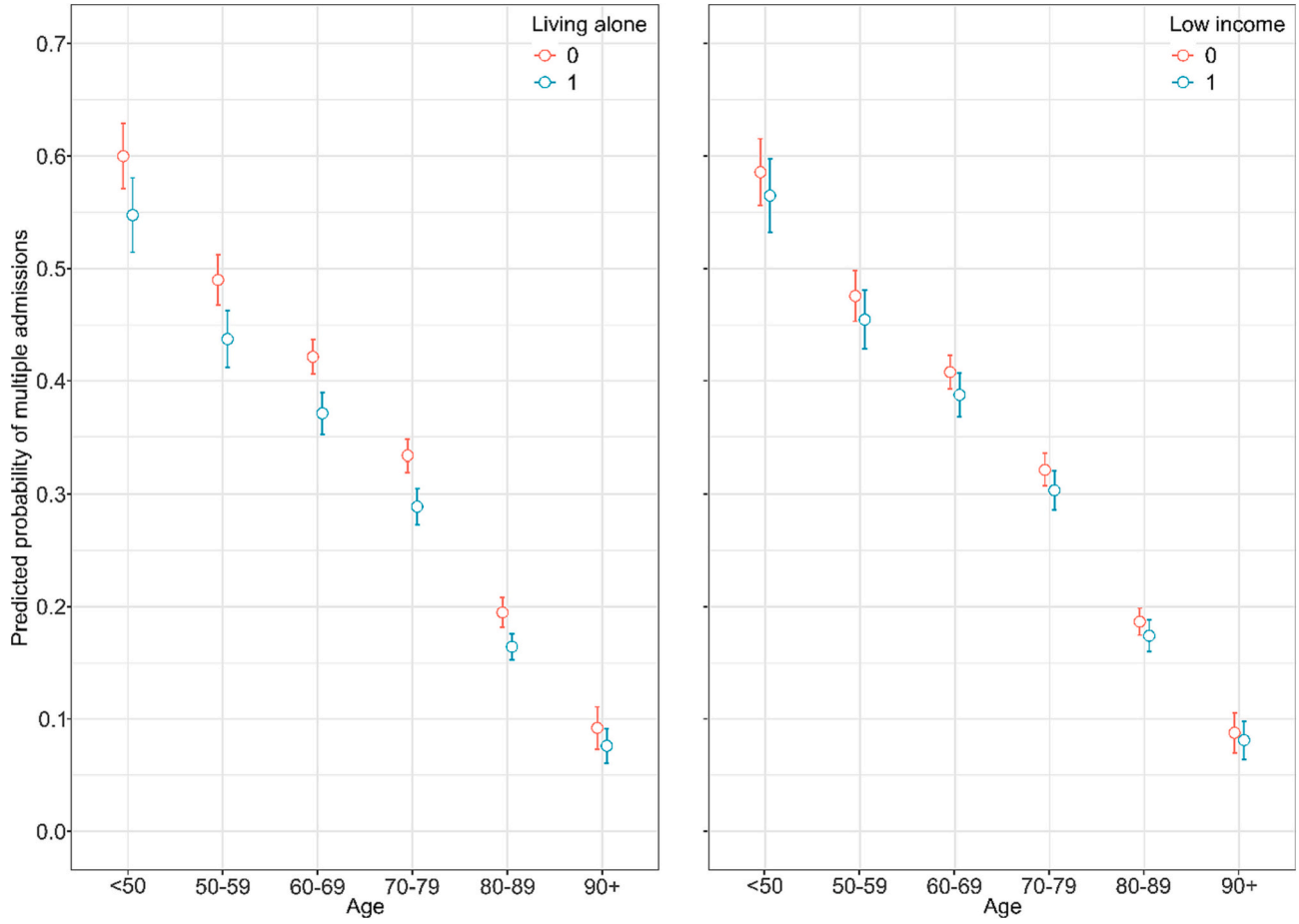


Fig. 1. (*continued*).

cancer, colorectal cancer, lung cancer, and ovarian cancer are also included in the Appendix (A2).

To examine the reported main diagnoses for the hospital stays, we categorized admissions into four groups according to diagnostic information. We also wanted to study the pattern of hospitalizations in relation to cancer, and classified information based on all admissions into three subgroups: no hospitalization; one or more cancer-related hospitalizations, and only non-cancer-related hospitalizations.

We used a Sankey flow diagram to visualize pathways according to age, number of hospitalizations, and place of death. The Sankey flow diagram includes nodes and arcs, and the arc flows from its source node to target nodes. The plot displays the size of the flows from each category, left to right.

All statistical analyses were performed in Stata, version 16.

2.5. Ethics

The study was approved by the Regional Committee for Medical and Health Research Ethics in North Norway (2016/2312/REK nord).

3. Results

3.1. Descriptive Statistics

Overall, 101,705 patients with cancer died between 2010 and 2014. We restricted this cohort to patients who were diagnosed with cancer within 12–60 months of death and had at least 12 months observation time prior to death, a total of 25,180 patients. Of these, 17,669 (70%) had cancer as their reported cause of death, and they comprised the final analytical cohort. Patient characteristics are presented in Table 1. The mean age was 71.7 years (standard deviation [SD] 13.7), and 47% were female. At diagnosis, 31% had metastatic disease. The median time since diagnosis was 25 months (interquartile range [IQR] 18–38). Altogether 21% had multiple cancer diagnoses. The most frequent cancer types were colorectal, lung, prostate, and breast. Most patients had comorbidity group CCI = 0 (65%), while 6% had CCI = -1, 20% had CCI = 1–2, and 9% had CCI ≥3. The most common place of death was nursing homes (47%), while 38% died in hospital and 14% at home. In terms of SES, 37% lived alone, 53% were married, 22% were widowed, and 34% had higher education.

3.2. Hospitalizations During the Last Year of Life

3.2.1. No Hospitalizations

A total of 1,136 (6%) patients were not hospitalized during their last year of life. These patients were older (median 84 years), and while 71% died in nursing homes, a relatively large share died at home (24%).

3.2.2. Non-Cancer-Related Hospitalizations

Patients who only had non-cancer-related hospitalizations totaled 2,126 (12%). These patients were older (median 82 years), spent a median of 11 (IQR 5–22) days in hospital, and while 58% died in nursing homes, 28% died in hospitals. Patients with only non-cancer-related hospitalizations had a higher burden of comorbidities than patients with only cancer-related hospitalizations.

3.2.3. Patients with Six or More Hospitalizations

A total of 5,757 (33%) patients had six or more hospitalizations. Table 1 shows the number of hospitalizations according to age, sex, comorbidity, cancer characteristics, marital status, co-residential status,

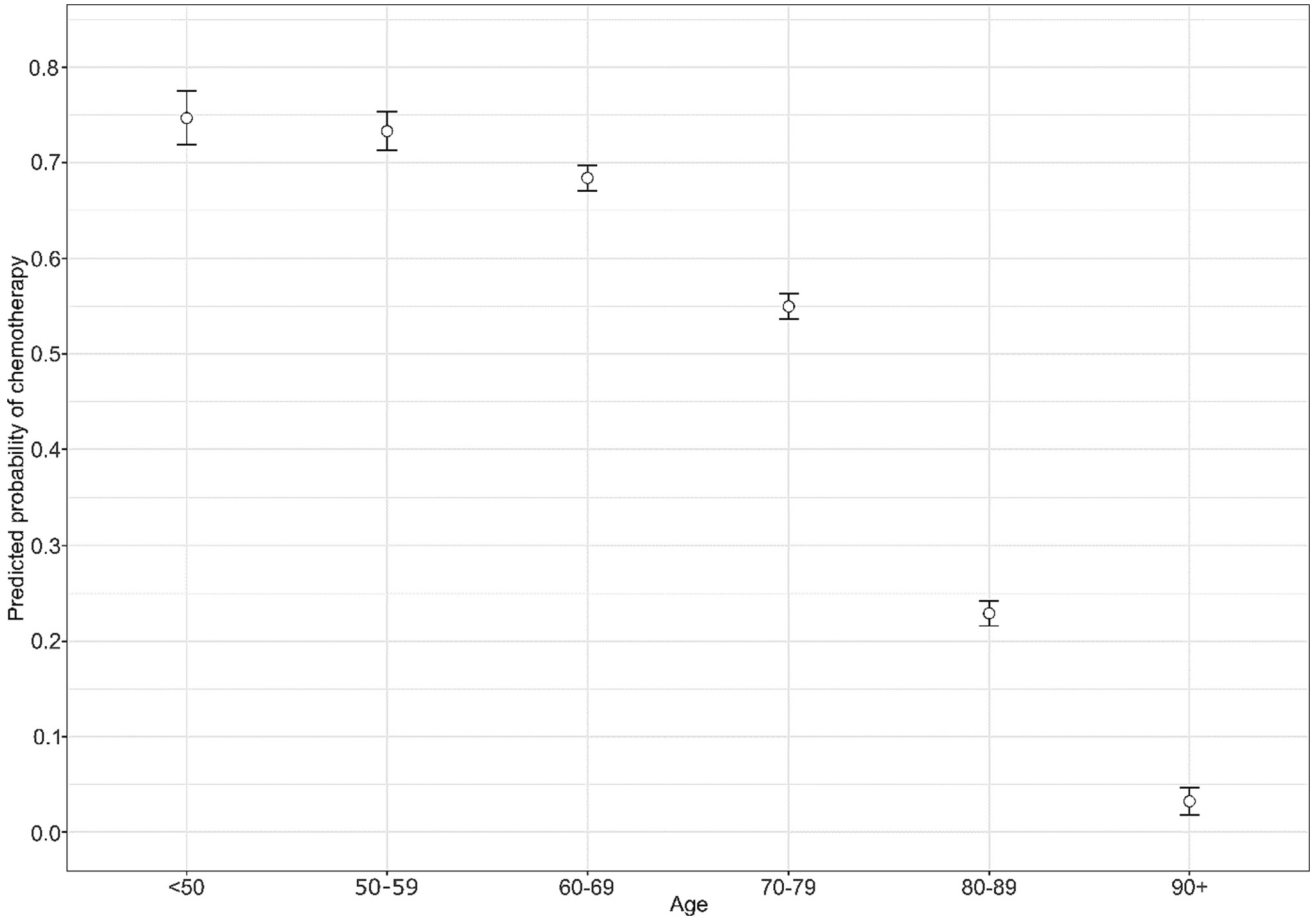


Fig. 2. a. Predicted probability of receiving chemotherapy by age.
b. Predicted probability of receiving chemotherapy: co-residential status, income quartiles and higher education by age.

individual income, education, and place of death. Independent predictors of six or more hospitalizations, chemotherapy, and radiotherapy use are presented in Table 2. Figs. 1a and 1b show the predicted probability of having six or more hospitalizations by age, age by co-residential status, and age by income.

3.2.4. *Hospitalizations Due to Cancer*

The total number of hospitalizations in the sample was 82,549. Cancer was reported as the main cause for 65% of hospital admissions, followed by infections (11%); see Appendix (A3). At least one hospitalization due to cancer was observed for 82%. Of these patients, 35% had *only* cancer-related admissions. Patients with at least one cancer-related hospitalization were younger (median 71 years), spent a median of 27 (IQR 15–46) days in hospital, and a similar share died in hospitals (42%) as in nursing homes (44%). Patients with cancer-related admissions generally had a lower comorbidity burden (27% had CCI $\geq$1).

3.2.5. *Cancer Treatment and Aggressive Care During the Last Year of Life*

Chemotherapy treatment was received by 51% of patients in their final year, while radiotherapy was received by 15%. Predicted probabilities of receiving chemotherapy by age are presented in Fig. 2a. Younger patients had far higher probabilities of receiving chemotherapy than older patients, particularly those aged over 80 (i.e., 75% probability for those aged <50 versus 23% for those aged 80–89). Fig. 2b presents variations in the predicted probability of receiving chemotherapy by age across different SES groupings. While the same decline by age is observed across the different SES groupings, we see clear variations in the propensity to receive chemotherapy between the SES groups. Broadly speaking, the predicted probability of receiving chemotherapy was higher for those who had high education, high income, and who did not live alone. For the oldest age groups (90+), the predicted probability of receiving chemotherapy was extremely low and variations between SES groups were trivial.

Radiotherapy use also declined with age (Fig. 3a) but there were fewer moderating effects of SES. Indeed, only co-residential status was found to have a significant interaction with age, with the results showing that living alone was associated with a lower probability of receiving radiotherapy treatment only in the older age groups (i.e., 60+) (see Fig. 3b). Of the 12,940 patients with a cancer type where surgery was a main treatment modality, 6% underwent surgical procedures in their last year, and the largest proportions were observed for bladder cancer. The effect of age was less pronounced for surgical procedures. Fig. 4 displays hospitalizations and treatment according to age. Only 922 patients (<4%) received respiratory support, dialysis, intensive care unit admission, or feeding tube insertion.

3.2.6. *Patients Dying in Hospital and Trajectories in the Last Year of Life*

A total of 6752 (38%) patients died in hospital, and their median age was 68 years. For the last hospital admission, 76% were admitted from home, while 17% were admitted from another hospital department. "Home" may include nursing homes, for instance for older individuals who are residing permanently in a long-term care facility. Most patients who died in hospital (65%) had four or more hospitalizations, indicating a burdensome disease trajectory. Fig. 5 shows the trajectory in the last year according to age, number of hospitalizations, and place of death.

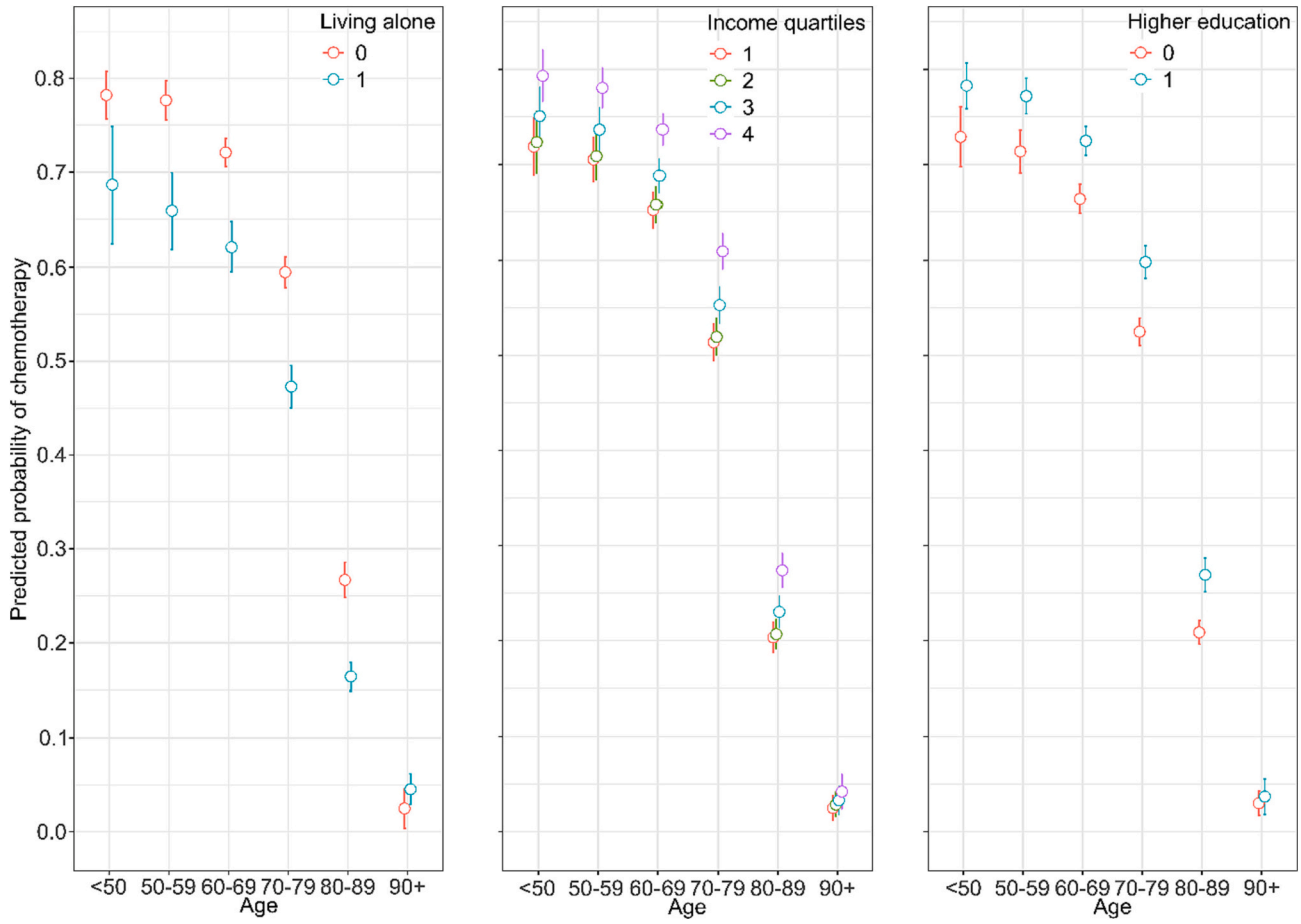


Fig. 2. (*continued*).

The older age group (80–89 years and 90+ years) had a higher percentage of patients with few hospitalizations, and those with 0–1 hospitalizations mostly died in nursing homes.

4. Discussion

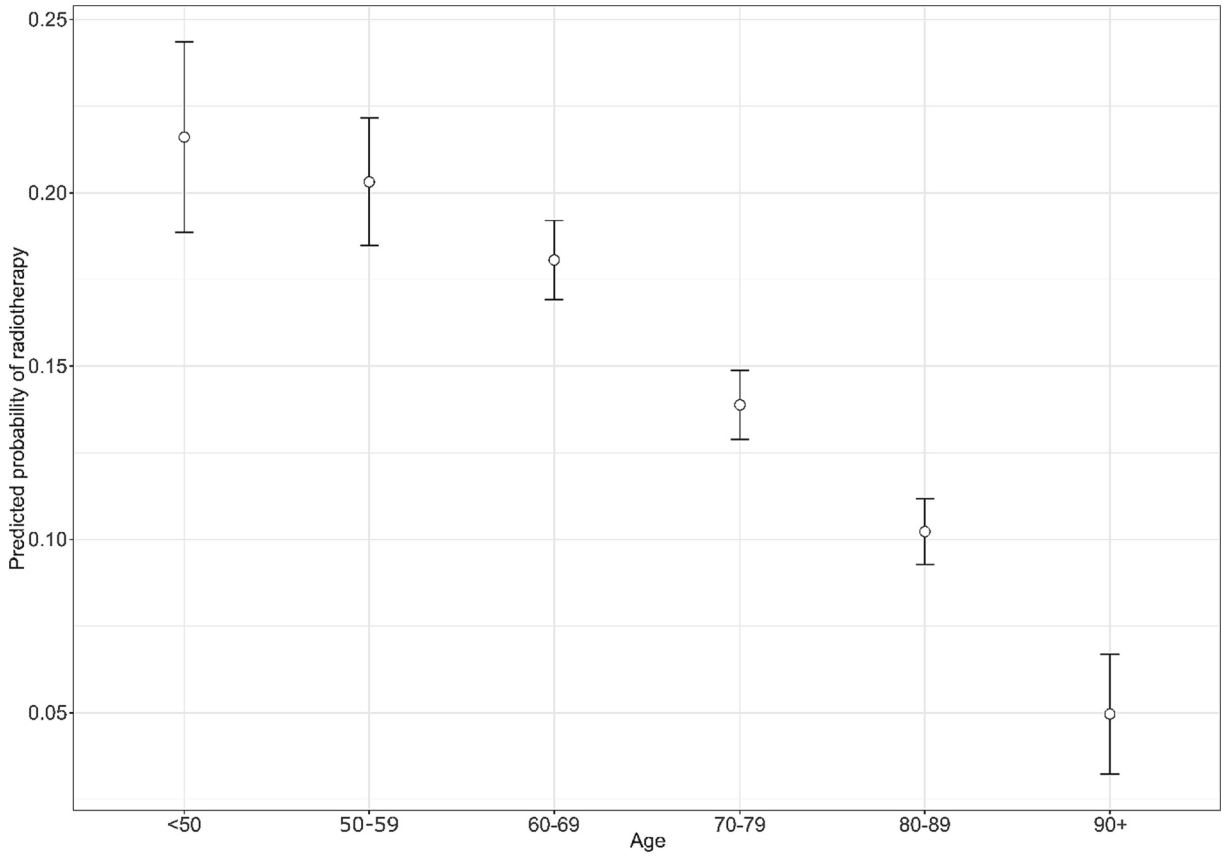
In our population-based cohort of patients with cancer who died, the majority experienced multiple hospitalizations in their final year, and cancer was the most frequent cause of hospital admission. In total, 33% of patients were hospitalized six times or more. The most common cancer-specific treatment received was chemotherapy, followed by radiotherapy and surgical procedures. However, substantial variation in both hospitalizations and treatment were observed according to patient age and SES.

Hospitalizations due to cancer may be caused by cancer treatment, complications of cancer and its treatment, palliative care needs, or diagnostic procedures. As the numbers of patients with cancer and cancer survivors increase [15], partly due to the aging of the population, our findings indicate an increased need for hospital beds and specialists involved in cancer care in the future. It is worth noticing that as many as 65% of admissions were caused by cancer-related diagnoses. Available treatment for cancer develops rapidly, both in curative and palliative settings and for patients of all ages. As patients survive longer, we expect that more patients will need treatment and care in the specialized health care system. Hospitalizations already contribute considerably to the high costs of cancer care; in Norway, about 90% of costs in cancer care are attributed to the specialized health care system, and the majority of costs (55%) are due to hospitalizations [16].

The main causes of hospitalizations reinforce the need for beds in oncology services: most patients, 82%, had at least one cancer-related hospitalization. These patients were younger and had less comorbidity than patients with only non-cancer-related hospitalizations. Patients with other causes of hospitalizations are more likely to be seen by internists and other non-cancer-specialists, and with cancer being reported as their cause of death, one may question whether these older patients with multimorbidity received adequate attention to their cancer disease. Cancer is becoming the primary cause of death in Western societies, and the increasing age and complexity of patients increases the need for collaboration between specialists in all parts of the health care system.

The variation in hospitalizations by age and SES, including by co-residential status and income, is worth discussing. We observe far lower probabilities for hospitalizations in the older age groups in our adjusted models. Our results are consistent with previous research [8,17,18]. The findings regarding SES, however, are partly in contrast with previous research, although results differ according to the given health care system and geographical area [17]. In a systematic review from 2020 about health expenditure at end of life (not limited to death from cancer) and SES, SES was found to be significantly correlated with end of life expenditure; contrary to our findings, adjusting for comorbidities showed that low SES was associated with higher total and hospital expenditure [12]. It is worth noting that most studies were from the US, a country without universal healthcare and with a different organization of palliative care as compared to Norway.

Intuitively, six or more hospitalizations in the last year of life indicates a high burden for the individual patient. Independent predictors of experiencing multiple admissions were a younger age, comorbidity, having bladder or ovarian cancer, and not living alone. As only patients diagnosed with cancer 12–60 months before death were included, we assume that most cancer-related hospitalizations were due to treatment, complications, or palliative care instead of diagnostic procedures.



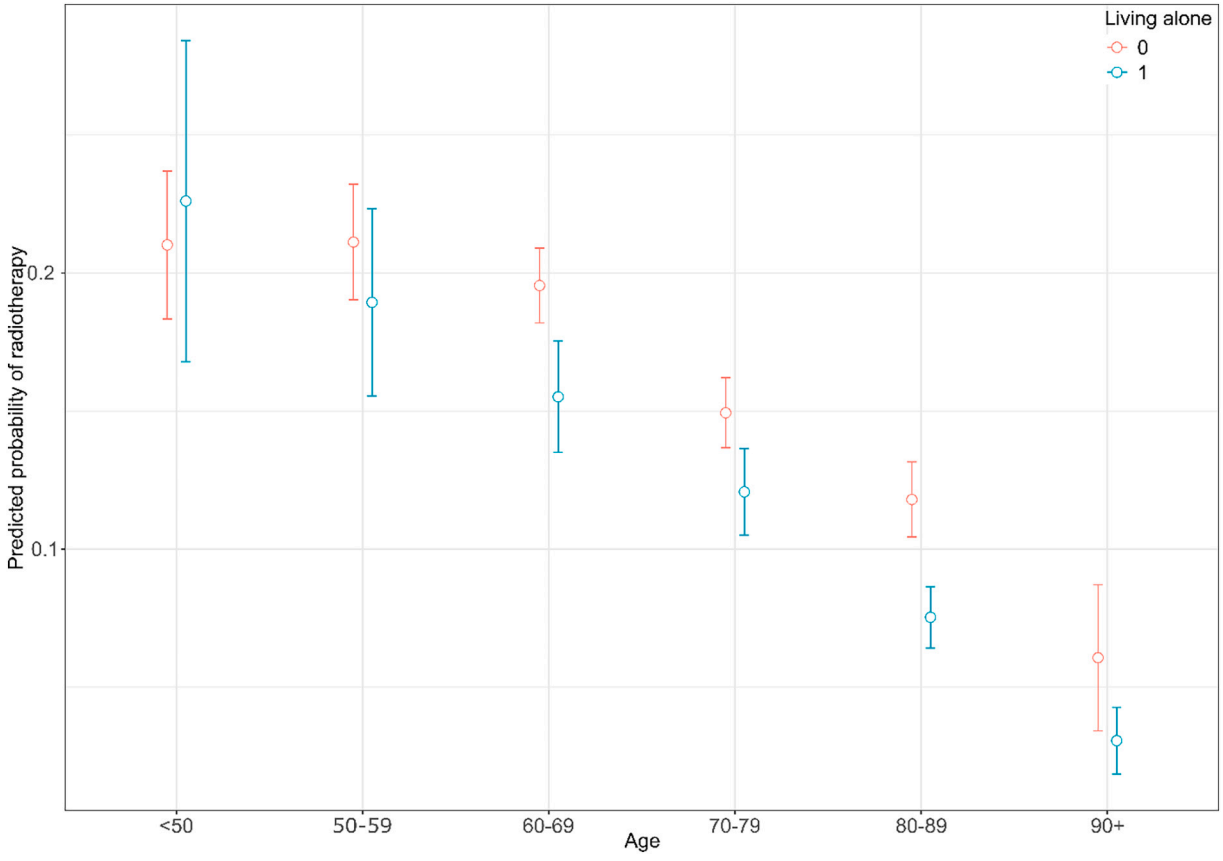


Fig. 3. a. Predicted probability of receiving radiotherapy by age.
b. Predicted probability of receiving radiotherapy: age by co-residential status.

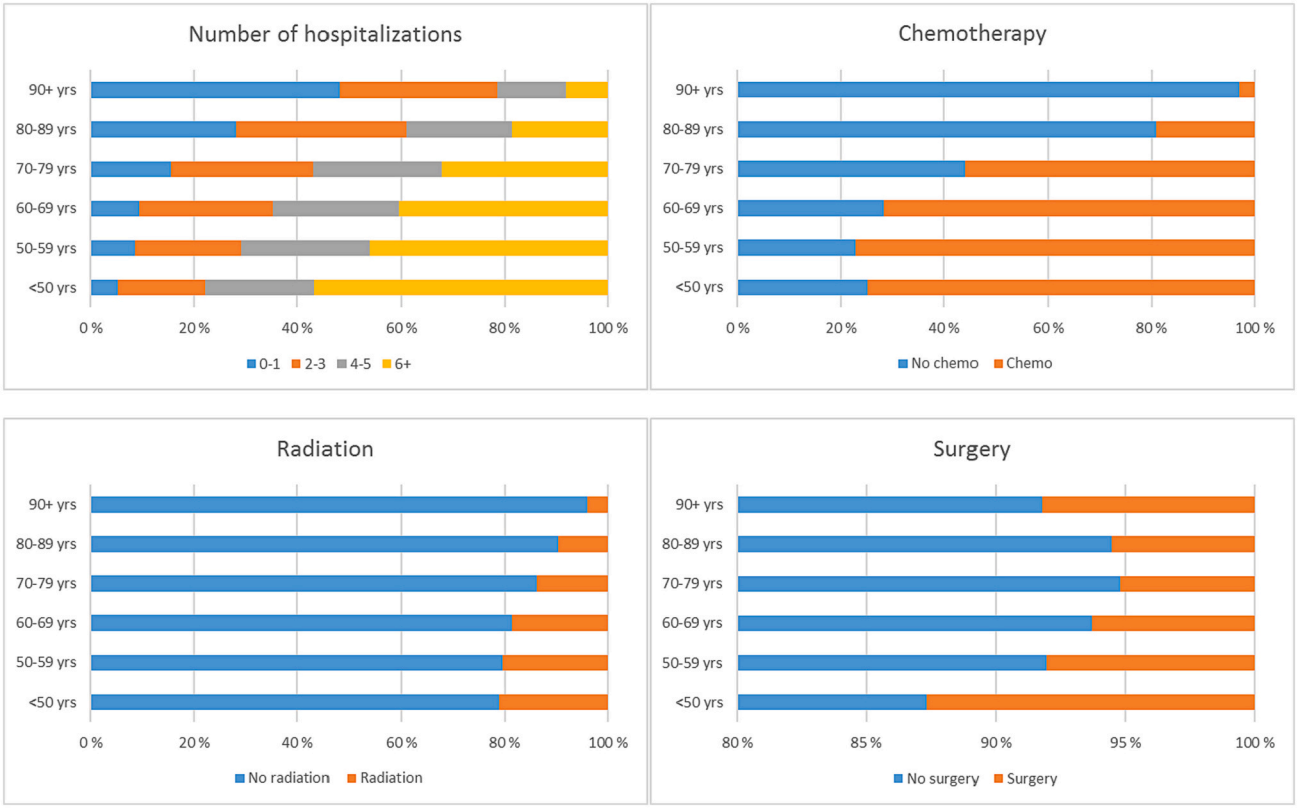


Fig. 4. Hospitalizations and treatment uptake by age.

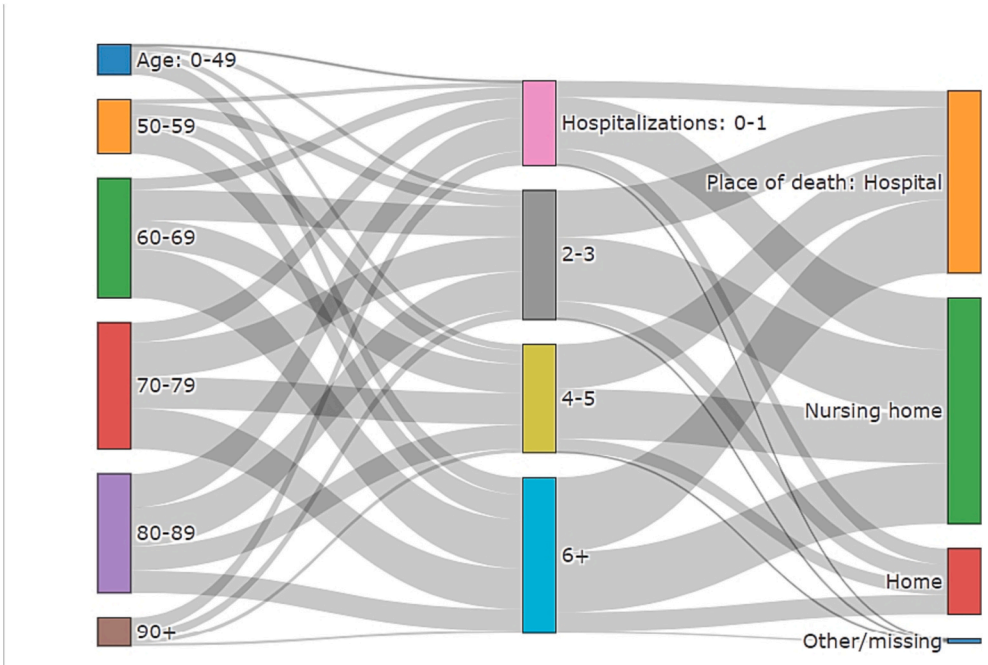


Fig. 5. Sankey diagram showing pathway in last year of life according to age, number of hospitalizations, and place of death.

Hospitalizations are often distressing, and interrupt time spent at home. Multiple hospitalizations may represent poor-quality care if they are not aligned with patient preferences [17]. On the other hand, admittance to hospital may secure access to cancer specialists and specialized palliative care, especially in Norway where hospices are rare [9]. Such factors may bring relief and a sense of security to patients and their caregivers. We have previously shown how higher age and lower SES are associated with a lower use of specialized palliative care in a similar

population [9]. In Norway, a much larger proportion of patients die in hospitals compared to most other developed countries [19]. Nevertheless, the large variations according to age and SES remain unexplained from a clinical point of view and warrant further study. In Norway, as in most European countries, health insurance status is not an issue due to the universal nature of health care. Still, our data show that patients with high SES receive more specialized care. Hospitalizations are costly, and future efforts to reduce hospitalizations should ideally target patients at higher risk. It is worth exploring whether efforts to strengthen cancer care in the community may prevent hospitalizations. To reflect the broader picture, future studies should also include patient preferences and measure whether hospital care is goal-concordant [20].

Our descriptive data about any chemotherapy and radiotherapy use in the last year of life show a marked decline with age, most evidently for chemotherapy. This result is well-known from previous studies [6,21], and may be partly explained by an unfavorable risk-benefit ratio for older patients with a higher risk of side-effects. However, many patients between 80 and 85 years are robust and may benefit from chemotherapy. Additionally, patient preferences may play a role, as most older patients report that they are not willing to trade their functional status for living longer [22]. The effects of income, co-residential status, and educational attainment on chemotherapy use are much more pronounced than their effects on radiotherapy use. A possible explanation is that social vulnerability makes oncologists more cautious when prescribing chemotherapy due to toxicity concerns, but this hurdle can be amended by increasing community care. For clinical practice, these data should be a reminder to devote more attention to patients with a poor SES. For radiotherapy, the limited use in older patients is concerning because radiotherapy is often used with palliative intent during the last year of life. The effect of SES on cancer treatment variables and outcomes has been shown previously for brain tumor resections, lung cancer, and bladder cancer, and raises concerns about undertreatment in deprived populations [23–25].

For surgical procedures a few details are worth noting. Few patients underwent procedures in their final year, partly because we excluded patients who were diagnosed with cancer less than one year before death, and we only looked at procedures related to the primary tumor. However, for patients with bladder cancer, as many as 34% underwent surgical procedures. This also includes trans-urethral procedures. Patients with bladder cancer experience a particularly high treatment burden due to symptoms and complications. Many of these patients are older, with a median age of 82 years in our sample, and 40% have an intermediate or high comorbidity burden. We therefore think that bladder cancer may represent an area of expansion for geriatric oncology and palliative care.

Our study has several limitations. The data date back to 2010–2014. However, they remain relevant to illustrate the high use of specialized health care in patients dying of cancer, especially since our data capture the entire population of Norway (i.e., avoid small sample issues and non-representativeness). Moreover, no major organizational changes to end-of-life-care have been implemented in the last 10 years in Norway, at least not on a structural level, and there are no indications that the effect of age and SES variables have substantively changed in the intervening years. Even though registry data are extensive and provide details at the individual level, they do not include data regarding functional status, which we know influences treatment decisions. Furthermore, patient preferences are not included. Additionally, our cohort includes patients with all cancer types and stages and is therefore very heterogeneous. For example, while some patients had zero hospitalizations in their last year of life, other patients had >200 overnight stays. The treatment variables are broad and refer to at least one episode of receiving the treatment, while the treatment intent is not captured and may have changed over the course of their last year. The reported cause of death is not necessarily accurate, as the cause of death is less certain for older patients and the rate of autopsy in Norway is only about 10–12%. We did repeat the analyses for all causes of death, and the results did not change. For the treatment variables, distance to the hospital may be a confounding factor as certain regions of Norway are very sparsely populated, resulting in long travel times to healthcare facilities, especially for more rural patients. However, transport costs are free of charge, limiting this impact.

In conclusion, most patients with cancer reported as the cause of death experience multiple hospitalizations in the last year of life, and cancer is the most frequent cause of hospital admissions. Hospitalizations and treatment decline with advancing age. Living alone and having low income is associated with fewer hospitalizations and less chemotherapy treatment. Whether this indicates over- or undertreatment across various social groups warrants further exploration.

Funding Acknowledgement

This study was funded by a research grant from South-Eastern Norway Regional Health Authority (to SR).

Disclaimer

Data from the Norwegian Patient Registry has been used in this publication. The interpretation and reporting of these data are the sole responsibility of the authors, and no endorsement by the Norwegian Patient Registry is intended nor should be inferred.

Author Contributions

Study concepts: SR, AS, MS, BM, AN
Study design: SR, AS, MS, BM
Data acquisition: SR
Quality control of data: SR, AS
Data analysis and interpretation: SR, AS, MS, MJT, BM, AN
Statistical analysis: SR, AS, MJT
Manuscript preparation: SR
Manuscript editing: All authors
Manuscript review: All authors

Declaration of Competing Interest

Authors report no conflicts of interest.

Appendix A. Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jgo.2023.101683.

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