# Use of healthcare services at the end of life in decedents compared to their surviving counterparts: A case-control study among adults born before 1946 in Friuli Venezia Giulia

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## Abstract

### Background

There is a heterogeneous literature on healthcare utilization patterns at the end of life. The objective of this study is to examine the impact of closeness to death on the utilization of acute hospital-based healthcare services and some primary healthcare services and compare differences in gender, age groups and major causes of death disease specific mortality.

### Methods

A matched case-control study, nested in a cohort of 411,812 subjects, linked to administrative databases was conducted. All subjects were residents in the Friuli Venezia Giulia Region (Italy), born before 1946, alive in January 2000 and were followed up to December 2014. Overall, 158,571 decedents/cases were matched by gender and year of birth to one control, alive at least one year after their matched case's death (index-date). Hospital admissions, emergency department visits, drug prescriptions, specialist visits and laboratory tests that occurred 365 days before death/index-date, have been evaluated. Odds Ratios (ORs) for healthcare utilization were estimated through conditional regression models, further adjusted for Charlson Comorbidity Index and stratified by gender, age groups and major causes of death.

### Results

Decedents were significantly more likely of having at least one hospital admission (OR 7.0, 6.9–7.1), emergency department visit (OR 5.2, 5.1–5.3), drug prescription (OR 2.8, 2.7–2.9), specialist visit (OR 1.4, 1.4–1.4) and laboratory test (OR 2.7, 2.6–2.7) than their matched surviving counterparts. The ORs were generally lower in the oldest age group (95

+) than in the youngest (55–74). Healthcare utilization did not vary by sex, but was higher in subjects who died of cancer.

## Conclusion

Closeness to death appeared to be strongly associated with healthcare utilization in adult/ elderly subjects. The risk seems to be greater among younger age groups than older ones, especially for acute based services. Reducing acute healthcare at the EOL represents an important issue to improve the quality of life in proximity to death.

## Introduction

Elderly individuals, aged 65 or above, sum up to 15% of the European population [1], but are estimated to contribute to around 30% and 50% of the total healthcare expenditure in Western countries [2]. With a rapidly aging population, a better understanding of healthcare demand in the elderly is becoming crucial to guide healthcare expenditure and policy-making.

Several studies have tried to identify the determinants of healthcare among older adults, but they have arrived to contradictory conclusions. According to some authors, increased health-care service use, is a pure consequence of ageing [3,4], that is associated to an increase in comorbidities [5, 6].

On the other hand, Zweifel et al. asserted that this conclusion might actually be a"red her-ring" [7]. According to their analyses, in fact, proximity to death (or end of life period—EOL) is the actual responsible of high healthcare costs and this is phenomenon is greater in older people, simply because they are closer to death than the majority of younger individuals. Despite there being other studies that supported this last interpretation [8,9], a study by How-don and Rice, suggested that proximity to death is itself a 'red herring' that acts as proxy for morbidity [10].

Other researchers found that both proximity to death and age play a role in shaping health-care costs [11,12].

Overall, there is a certain heterogeneity in literature, on definitions and research objectives concerning healthcare utilization at the EOL. For instance, the timeframe of the EOL itself is not univocal as it ranges from a few months [13–15], to several years before death [16–20]. Furthermore, most studies on healthcare at the EOL, focused on its costs [21–24] and only a limited number considered utilization itself [9,19]. Some studies are concentrated exclusively on decedents that died of specific diseases, such as cancer [25–27] or patients affected by COPD and lung cancer [23], or Alzheimer's disease [28] and many other conditions.

Throughout these studies, different types of healthcare services have been evaluated. Some studies have investigated only primary healthcare service use [11,15,29], while others focused exclusively on acute healthcare use [17,18,30]. To the best of our knowledge, only few papers considered both acute and long-term care and/or primary care services among decedents and compared it with matching survivors [9,19,31]. According to the abovementioned studies, in the period preceding death, younger-old individuals are more likely to access acute care ser-vices compared to older age groups [9,19]. Younger-old decedents compared to survivors, have also shown to have a higher risk of accessing acute care than older decedents [9]. Results concerning primary care use, on the other hand, appear to be contrasting. Nevertheless, none of the identified literature includes acute hospital-based services, along with drug prescriptions

and relevant outpatient services, namely laboratory tests and specialist visits, with a matched case-control study design.

The aim of this study is therefore to explore patterns of healthcare utilization (HCU) of both acute hospital-based services (hospitalizations and emergency department visits) and primary healthcare services (drug prescriptions, diagnostic tests and specialist visits), among people aged 55 and above, resident in North Eastern Italy, during their EOL period and to compare it, on an individual level (one-to-one), with that of surviving subjects, matched by age and gender. We will also estimate whether those patterns were or not modified by gender, class ages and major causes of death

## Methods

### Setting and study population

Italy has a tax-based National Health Service (NHS) system, which provides universal coverage, like in most European countries. The NHS delivers healthcare free or upon co-payment to all Italian and European Union citizens. This is granted to all subjects who have the right to access NHS care, regardless of income. Healthcare in the Italian NHS, is significantly decentralized to the Regions, which have a vast autonomy in the administration and organization of healthcare in their own territory. Data concerning healthcare utilization is recorded at a Regional level, for all residents assisted by the NHS, even when patients access healthcare services outside the Region where they reside.

This study was conducted in the Region of Friuli Venezia Giulia, Italy, with a total population of about 1.2 million. This Region has an automated centralized system developed in the '80s with the objective of systematically collecting and pooling data on healthcare funded by the National Health Service using a unique anonymous ID regional code.

### Definition of the cohort

A matched case-control design, nested in a cohort, linked to administrative data, was adopted. The original cohort included 411,812 subjects born before 1946 and alive in January 2000, resident in the Friuli Venezia Giulia Region, followed-up from January 2001 to December 2014. Data on the population derives from the **Health Population register** that contains demographic information on all residents in the Region, who have the right to be assisted by the NHS.

All the subjects who died in the follow-up period (cases-decedents) were matched by gender and year of birth to one control (survivor) who was alive at least one year after the counterpart's death. The purpose was to ensure same age and gender distribution in decedents and survivors.

By adopting a SAS macro [32] through an iterative process, all cases were identified from the cohort. In the same population, for each case, all possible controls were identified, according to the following criteria: having the same gender, year of birth and being alive at least 12 months after the matching case's death. Among the controls, there could be subjects identified as cases in the following years (the same way as cases could have been eligible to be controls for a previous case). One control for each case was randomly selected. This way, each control was assigned a date to end the follow-up (index date), that corresponded to the date of death of the matched case.

At the end of the iterative loop, 158,611 cases have been identified and 158,571 of them had a matching counterpart. Only 40 decedents did not have a matched control and were eliminated from the study.

## Healthcare use

The databases used, concerned both acute hospital-based services and primary care services. Acute hospital-based service databases consisted of: **hospital admissions (HA),** which hold information collected during any episode of inpatient care, within or outside the Region, with up to six diagnostic codes (according to the International Classification of Diseases Ninth Revision—ICD-IX), recorded at discharge; **emergency department (ED)** visits, which hold data on patients that accessed an emergency department, with the specific triage color tag (from green to black color tags, with the addition of white tags for subjects that would have not require an ED visit). Primary care services consisted of databases on: **drug prescriptions (DP)** where all dispensations of NHS-reimbursable drugs are registered (coded by the Anatomical Therapeutic Chemical -ATC- code); **ambulatory care service database** which holds outpatient visits for diagnostic, therapeutic or rehabilitation services, that was further divided in **specialist visits (SV)** and **laboratory tests (LT)**. These Regional registries were linked to the cases and controls using the anonymized ID number, in order to detect all the events that occurred 365 days before the index date (case's date of death).

All HAs that presented "death" as discharge modality, have been eliminated. All ED visits with black triage codes (patient dead at admission to the ED) and all ED visits that subsequently led to a hospitalization where the patient died have also been removed.

## Statistical analyses

The first analyses evaluated the proportion of cases and controls that used anyone of the five types of healthcare services at least once (any vs none). Secondly, the use of each healthcare service was considered as categorical variable (quartiles of utilization) defining specific cut-off through the quartiles of utilization among controls

The analyses were performed on the entire study population and stratified by gender, age groups (55–74, 75–84, 85–94, 95+ years old) and major causes of death (neoplasms, circulatory disease, respiratory diseases) of cases. The age among cases was calculated at the date of death. The corresponding age among controls was calculated at the as the index_date, namely the date when the matching control died. When stratifying by age, 4678 paired couples of cases and controls—9356 subjects–(2.95% of the sampled population) have been eliminated, because they belonged to different age classes, since they were matched by year of birth, but the age was calculated at the date of death/index date.

Conditional binomial regression models were used to estimate Odds Ratios (ORs) with 95% confidence intervals (CI) for the use of each healthcare service (as dichotomous and categorical variables), among the one-to-one matched case-control pairs. Analyses were further adjusted by Charlson Comorbidity Index [33]. The Charlson Comorbidity Index was calculated by using the ICD-IX coded primary diagnosis of hospital discharge records, from the 12 months before date of death/index date. The index is calculated by summing the weights (1 to 6) assigned to a list of 17 medical conditions that have led to a hospital admission. The so obtained index has been divided in four categories: 0, 1 or 2, 3 or 4, and 5 or more.

## Results

Overall, 317,142 individuals, composed of 158,571 decedents and an equal amount of matched controls were included in the study. The distribution by gender, age, comorbidity index and cause of death is shown in Table 1. Out of all the pairs, 44.70% were men and 55.30% women. The majority of subjects belonged to the age groups 75–84 (34.23%) and 85–94 (37.05%). The Charlson Comorbidity Index varied among cases and controls, with decedents having more comorbidities than survivors. The major causes of death were related to diseases of the

**Table 1. Characteristics of the cases (decedents) and matched controls (survivors).**

| Variable | Cases (n = 158,571) | Control (n = 158,571) |
|---|---|---|
| Gender | | |
|   Male | 70877 (44.70) | 70877 (44.70) |
|   Female | 87694 (55.30) | 87694 (55.30) |
| Age at the "Index_date" | | |
|   55–74 | 32533 (20.51) | 32620 (20.57) |
|   75–84 | 54282 (34.23) | 54371 (34.29) |
|   85–94 | 58743 (37.05) | 58618 (36.97) |
|   95+ | 13013 (8.21) | 12962 (8.17) |
| Comorbidity Index | | |
|   0 | 95797 (60.41) | 147733 (93.16) |
|   1–2 | 50055 (31.57) | 10246 (6.46) |
|   3–4 | 6186 (3.90) | 472 (0.30) |
|   $\geq$5 | 6533 (4.12) | 120 (0.08) |
| Cause of Death ICD IX code | | |
|   Infectious and Parasitic Diseases 001–139 | 2180 (1.37) | // |
|   Neoplasms 140–239 | 46219 (29.15) | |
|   Endocrine, Nutritional and Metabolic Diseases 240–279 | 3816 (2.41) | |
|   Diseases of the Blood 280–289 | 607 (0.38) | |
|   Mental Disorders 290–319 | 4258 (2.69) | |
|   Diseases of the Nervous System 320–389 | 3769 (2.38) | |
|   Diseases of the Circulatory System 390–459 | 62341 (39.31) | |
|   Diseases of the Respiratory System 460–519 | 14906 (9.40) | |
|   Diseases of the Digestive System 520–579 | 7406 (4.67) | |
|   Diseases of the Genitourinary System 580–629 | 2483 (1.57) | |
|   Diseases of the Skin 680–709 | 211 (0.13) | |
|   Diseases of the Musculoskeletal System 710–739 | 1168 (0.74) | |
|   Symptoms, Signs, and Ill-defined Conditions 780–799 | 4758 (3.00) | |
|   Injury 800–999 | 3831 (2.42) | |
|   Without Causes | 613 (0.39) | |

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circulatory system (39.31%), followed by neoplasms (29.15%) and diseases of the respiratory system (9.40%).

Healthcare utilization during the one-year study period, among cases and controls, stratified by gender, is shown in Table 2.

Healthcare utilization among decedents compared to survivors was higher with a statistical significance, especially regarding hospital admissions (OR = 7; 95% CI 6.9–7.1) and emergency department visits (OR = 5.2; 95% CI 5.1–5.3), while in a less extent for drug prescriptions (OR = 2.8; 95% CI 2.7–2.9), laboratory tests (OR = 2.7; 95% CI 2.6–2.7) and specialist visits (OR = 1.4; 95% CI 1.4–1.4). Decedents were significantly more likely than their matching controls, to have a higher number of each service utilization, across all considered quartiles of utilization (p-trend <0.001).

Odds Ratios adjusted for Charlson Comorbidity Index decreased in value, while keeping the same trends and statistical significance as the non-adjusted ones, except for specialist visits (OR = 1.1; 95% CI. 1.1–1.1).

Patterns of utilization were relatively similar among male and female individuals, although the risks of HCU among the female decedents compared to their matched controls were always lower than males, especially for drug prescriptions, with the exception of laboratory tests.

**Table 2. Healthcare utilization during the last year of life by gender; Odds Ratios (OR) and 95% Confidence Intervals (CI) from conditional logistic regression for cases (decedents) and matched controls (survivors).**

| | Male (n = 141754) | | | | Female (n = 175388) | | | | Total (n = 317142) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cases | Controls | | | Cases | Controls | | | Cases | Controls | | |
| | % | % | OR (95% CI) | adjOR (95% CI) | % | % | OR (95% CI) | adjOR (95% CI) | % | % | OR (95% ICI) | adjOR (95% CI) |
| Hospitalization admission | | | | | | | | | | | | |
| At least one HA | 66.23 | 20.43 | 7.5 (7.3–7.7) | 4.0 (3.9–4.2) | 58.92 | 17.75 | 6.6 (6.4–6.8) | 4.0 (3.9–4.1) | 62.19 | 18.95 | 7.0 (6.9–7.1) | 4.0 (3.9–4.1) |
| Total HA by classes | | | | | | | | | | | | |
| 0 | 33.77 | 79.57 | 1 | 1 | 41.08 | 82.25 | 1 | 1 | 37.81 | 81.05 | 1 | 1 |
| 1 | 26.80 | 14.13 | 4.4 (4.2–4.5) | 3.2 (3.1–3.3) | 28.56 | 12.92 | 4.4 (4.3–4.6) | 3.3 (3.2–3.4) | 27.77 | 13.46 | 4.4 (4.3–4.5) | 3.3 (3.2–3.4) |
| 2 | 17.50 | 4.22 | 9.7 (9.2–10.2) | 5.8 (5.4–6.1) | 15.48 | 3.43 | 8.9 (8.5–9.4) | 5.5 (5.2–5.8) | 16.38 | 3.78 | 9.3 (9.0–9.6) | 5.6 (5.4–5.9) |
| 3+ | 21.94 | 2.09 | 24.0 (22.5–25.6) | 11.4 (10.6–12.3) | 14.87 | 1.40 | 20.6 (19.3–22.0) | 10.1 (9.4–10.9) | 18.03 | 1.71 | 22.3 (21.3–23.4) | 10.8 (10.3–11.4) |
| Emergency department visits | | | | | | | | | | | | |
| At least one ED | 65.07 | 25.40 | 5.68 (5.5–5.8) | 3.5 (3.4–3.6) | 61.79 | 25.46 | 4.9 (4.8–5.0) | 3.2 (3.1–3.2) | 63.26 | 25.43 | 5.2 (5.1–5.3) | 3.3 (3.2–3.4) |
| Total ED by classes | | | | | | | | | | | | |
| 0 | 34.93 | 74.60 | 1 | 1 | 38.21 | 74.54 | 1 | 1 | 36.74 | 74.57 | 1 | 1 |
| 1 | 26.07 | 16.50 | 3.5 (3.4–3.6) | 2.6 (2.5–2.7) | 27.27 | 16.62 | 3.3 (3.2–3.4) | 2.5 (2.4–2.6) | 26.73 | 16.57 | 3.3 (3.3–3.4) | 2.5 (2.5–2.6) |
| 2+ | 38.99 | 8.91 | 9.8 (9.5–10.2) | 5.2 (5.0–5.4) | 34.53 | 8.83 | 8.0 (7.7–8.2) | 4.5 (4.3–4.7) | 36.52 | 8.87 | 8.7 (8.5–9.0) | 4.8 (4.7–4.9) |
| Drug prescriptions | | | | | | | | | | | | |
| At least one DP | 95.59 | 86.33 | 3.5 (3.3–3.7) | 2.4 (2.3–2.4) | 93.30 | 85.37 | 2.4 (2.4–2.5) | 1.9 (1.8–2.0) | 94.32 | 85.80 | 2.8 (2.7–2.9) | 2.1 (2.0–2.1) |
| Total DP by classes | | | | | | | | | | | | |
| 0–4 | 10.63 | 24.50 | 1 | 1 | 15.59 | 25.57 | 1 | 1 | 13.37 | 25.09 | 1 | 1 |
| 5–15 | 16.10 | 22.66 | 1.7 (1.6–1.8) | 1.4 (1.7–1.8) | 19.26 | 24.67 | 1.3 (1.3–1.3) | 1.2 (1.1–1.2) | 17.85 | 23.78 | 1.4 (1.4–1.5) | 1.3 (1.2–1.3) |
| 16–31 | 23.41 | 24.05 | 2.4 (2.3–2.5) | 1.4 (1.4–2.8) | 24.79 | 25.25 | 1.6 (1.6–1.7) | 1.3 (1.3–1.4) | 24.17 | 24.72 | 1.9 (1.9–1.9) | 1.5 (1.5–1.5) |
| 32+ | 49.86 | 28.79 | 4.3 (4.2–4.5) | 2.7 (2.6–2.8) | 40.36 | 24.50 | 2.8 (2.8–2.9) | 2.0 (1.9–2.0) | 44.60 | 26.42 | 3.4 (3.3–3.5) | 2.2 (2.2–1.3) |
| Specialist visits | | | | | | | | | | | | |
| At least one SV | 63.64 | 53.27 | 1.6 (1.5–1.6) | 1.2 (1.1–1.2) | 47.05 | 41.63 | 1.3 (1.3–1.3) | 1.0 (1.0–1.0) | 54.46 | 46.84 | 1.4 (1.4–1.4) | 1.1 (1.1–1.1) |
| Total SV by classes | | | | | | | | | | | | |
| 0 | 36.36 | 46.73 | 1 | 1 | 52.95 | 58.37 | 1 | 1 | 45.54 | 53.16 | 1 | 1 |
| 1 | 17.48 | 18.64 | 1.2 (1.2–1.3) | 1.1 (1.0–1.1) | 16.91 | 17.09 | 1.1 (1.1–1.1) | 1.0 (1.0–1.0) | 17.16 | 17.78 | 1.2 (1.1–1.2) | 1.0 (1.0–1.0) |
| 2 | 10.83 | 11.24 | 1.3 (1.2–1.3) | 1.0 (1.0–1.1) | 8.57 | 8.37 | 1.2 (1.1–1.2) | 1.0 (0.9–1.0) | 9.58 | 9.66 | 1.2 (1.2–1.2) | 1.0 (1.0–1.0) |
| 3+ | 35.32 | 23.40 | 2.0 (2.0–2.1) | 1.3 (1.3–1.4) | 21.57 | 16.17 | 1.5 (1.5–1.6) | 1.1 (1.0–1.1) | 27.72 | 19.40 | 1.7 (1.7–1.8) | 1.2 (1.2–1.2) |
| Laboratory tests | | | | | | | | | | | | |
| At least one LT | 83.10 | 65.92 | 2.6 (2.6–2.7) | 1.9 (1.9–2.0) | 78.09 | 58.16 | 2.7 (2.6–2.7) | 2.1 (2.1–2.2) | 80.33 | 61.63 | 2.7 (2.6–2.7) | 2.0 (2.0–2.1) |
| Total LT by classes | | | | | | | | | | | | |

*(Continued)*

**Table 2.** (Continued)

| | Male (n = 141754) | | | | Female (n = 175388) | | | | Total (n = 317142) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cases | Controls | | | Cases | Controls | | | Cases | Controls | | |
| | % | % | OR (95% CI) | adjOR (95% CI) | % | % | OR (95% CI) | adjOR (95% CI) | % | % | OR (95% ICI) | adjOR (95% CI) |
| 0 | 16.90 | 34.08 | 1 | 1 | 21.91 | 41.84 | 1 | 1 | 19.67 | 38.37 | 1 | 1 |
| 1–2 | 16.89 | 22.44 | 1.6 (1.5–1.6) | 1.4 (1.3–1.4) | 21.15 | 23.71 | 1.8 (1.7–1.8) | 1.6 (1.6–1.7) | 19.25 | 23.14 | 1.7 (1.6–1.7) | 1.5 (1.5–1.5) |
| 3–4 | 15.82 | 18.40 | 1.8 (1.8–1.9) | 1.5 (1.5–1.6) | 16.85 | 16.30 | 2.1 (2.0–2.2) | 1.8 (1.8–1.9) | 16.39 | 17.24 | 2.0 (2.0–2.0) | 1.7 (1.7–1.7) |
| 5+ | 50.39 | 25.08 | 4.4 (4.3–4.5) | 2.8 (2.7–2.9) | 40.08 | 18.14 | 4.7 (4.5–4.8) | 3.2 (3.1–3.3) | 44.69 | 21.24 | 4.6 (4.5–4.7) | 3.1 (3.0–3.1) |

adj: adjustment for Charlson Comorbidity Index.

Table 3 describes HCU stratified by age groups. The rate of decedents who were hospitalized at least once, decreased with age, reaching the lowest value in the very elderly (from 70% among the 55–75 age group to 45% among the 95+), with more stays and days per stay during hospitalizations among younger decedents (21.9 days among 55–75 vs 7.9 days among 95+, data not shown in the tables). Similar patterns were seen for specialist visits, with a marked reduction in the utilization, with the increase of age (from 72% to 25%).

Compared to survivors, the amount of hospital admissions among cases was markedly higher in the youngest age group (OR = 12.8; 95% CI 12.1–13.4) than the oldest one (OR = 4.7; 95% CI 4.4–5.1). The utilization of emergency departments followed a similar pattern, that is more stable in the youngest age group (OR = 7.1; 95% CI 6.8–7.4), with a decrease in the 95+ group (OR = 4.3; 95% CI 4.1–4.6). When primary care services (drug prescriptions, specialist visits, laboratory tests) are considered, the risks of utilization among cases and controls did not show a clear age-related pattern, with higher odds in the youngest and in the oldest age groups. Comorbidity adjusted ORs have shown a greater reduction, especially among the younger age groups.

Table 4 describes HCU stratified by the major causes of death. People who died from neoplasms, compared to their matched controls, had the highest risks of utilization of healthcare services, out of all the major causes of death considered in the analyses. No major differences were observed among subjects who died from cardiovascular or respiratory diseases.

Cases that died from cancer, compared to their survivors, showed highest risks of HCU. This was especially evident when considering the non-adjusted risk of having at least one hospital based acute healthcare service (HA OR = 17.5; 95% CI 16.7–18.4; ED OR = 8.1; 95% CI 7.8–8.4). ORs decreased when the analyses were performed, adjusting for comorbidities (HA OR = 5.9 95% CI 5.6–6.3; ED OR = 3.8 95% CI 3.7–4.0).

## Discussion

This study compared patterns of healthcare utilization among decedents in their last year of life and survivors, during the same period, in a large cohort of participants aged 55 years and older in the Friuli Venezia Giulia Region, Italy. The objective was to assess how age, proximity to death, sex and the major causes of death, influence the utilization of acute and primary care services. The results found, suggest that closeness to death is strongly associated to HCU in adults/elderly, but its influence varies between age groups and major causes of death. Since relatively few papers have studied healthcare utilization among decedents and survivors, we

**Table 3. Healthcare utilization during the last year of life by age groups; Odds Ratios (OR) and 95% Confidence Intervals (CI) from conditional logistic regression for cases (decedents) and matched controls (survivors).**

| | Age 55–74 (n = 63764) | | | | Age 75–84 (n = 105118) | | | | Age 85–94 (n = 114072) | | | | Age 95+ (n = 24832) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cases | Controls | | | Cases | Controls | | | Cases | Controls | | | Cases | Controls | | |
| | % | % | OR (95% CI) | adjOR (95% IC) | % | % | OR (95% CI) | adjOR (95% CI) | % | % | OR (95% CI) | adjOR (95% CI) | % | % | OR (95% CI) | adjOR (95% CI) |
| **Hospitalization admission** | | | | | | | | | | | | | | | | |
| At least one HA | 69.90 | 15.12 | 12.8 (12.1–13.4) | 4.8 (4.5–5.1) | 66.16 | 19.90 | 7.4 (7.7–8.2) | 4.2 (4.0–4.3) | 58.05 | 20.90 | 5.2 (5.0–5.4) | 3.6 (3.5–3.8) | 44.97 | 15.18 | 4.7 (4.4–5.1) | 3.9 (3.6–4.2) |
| **Total HA by classes** | | | | | | | | | | | | | | | | |
| 0 | 30.10 | 84.88 | 1 | 1 | 33.84 | 80.10 | 1 | 1 | 41.95 | 79.10 | 1 | 1 | 55.03 | 84.82 | 1 | 1 |
| 1 | 23.53 | 10.76 | 6.0 (5.7–6.4) | 3.6 (3.4–3.8) | 27.94 | 13.69 | 4.9 (4.7–5.1) | 3.4 (3.2–3.5) | 30.24 | 15.12 | 3.7 (3.6–3.9) | 3.1 (3.0–3.2) | 27.05 | 11.36 | 3.8 (3.5–4.1) | 3.5 (3.2–3.8) |
| 2 | 17.73 | 2.96 | 16.8 (15.3–18.4) | 7.0 (6.3–7.8) | 17.53 | 4.19 | 10.0 (9.4–10.6) | 5.5 (5.2–5.9) | 15.61 | 4.05 | 7.2 (6.8–7.6) | 5.2 (4.9–5.5) | 11.27 | 2.79 | 6.5 (5.7–7.4) | 5.5 (4.7–6.3) |
| 3+ | 28.64 | 1.41 | 55.6 (49.4–62.6) | 16.6 (14.5–18.9) | 20.69 | 2.02 | 24.3 (22.5–26.2) | 10.8 (9.9–11.8) | 12.20 | 1.72 | 13.3 (12.4–14.4) | 8.3 (7.7–9.1) | 6.65 | 1.03 | 10.3 (8.4–12.5) | 7.9 (6.3–9.8) |
| **Emergency department visits** | | | | | | | | | | | | | | | | |
| At least one ED | 61.65 | 19.24 | 7.1 (6.8–7.4) | 3.7 (3.5–3.9) | 65.79 | 25.67 | 5.8 (5.6–6.0) | 3.5 (3.3–3.6) | 63.46 | 29.10 | 4.3 (4.2–4.5) | 3.1 (3.0–3.2) | 55.63 | 22.91 | 4.3 (4.1–4.6) | 3.5 (3.3–3.8) |
| **Total ED by classes** | | | | | | | | | | | | | | | | |
| 0 | 38.35 | 80.76 | 1 | 1 | 34.21 | 74.33 | 1 | 1 | 36.54 | 70.90 | 1 | 1 | 44.37 | 77.09 | 1 | 1 |
| 1 | 25.72 | 13.51 | 4.2 (4.0–4.4) | 2.8 (2.6–2.9) | 26.55 | 16.83 | 3.5 (3.4–3.7) | 2.6 (2.5–2.7) | 27.32 | 18.38 | 2.9 (2.8–3.0) | 2.4 (2.3–2.5) | 27.35 | 14.55 | 3.4 (3.1–3.6) | 3.0 (2.8–3.2) |
| 2+ | 35.93 | 5.72 | 14.0 (13.1–15.0) | 5.9 (5.5–6.3) | 39.24 | 8.85 | 10.2 (9.8–10.7) | 5.3 (5.1–5.6) | 36.14 | 10.72 | 6.7 (6.5–7.0) | 4.4 (4.2–4.6) | 28.28 | 8.35 | 6.0 (5.5–6.6) | 4.6 (4.8–5.0) |
| **Drug prescriptions** | | | | | | | | | | | | | | | | |
| At least one DP | 94.56 | 84.11 | 3.3 (3.1–3.5) | 1.9 (1.7–2.0) | 95.84 | 90.72 | 2.4 (2.2–2.5) | 1.6 (1.5–1.7) | 93.98 | 86.89 | 2.4 (2.3–2.5) | 1.9 (1.8–2.0) | 88.85 | 63.84 | 4.6 (4.3–5.0) | 4.1 (3.8–4.4) |
| **Total DP by classes** | | | | | | | | | | | | | | | | |
| 0–4 | 12.28 | 32.38 | 1 | 1 | 10.24 | 18.73 | 1 | 1 | 14.58 | 22.50 | 1 | 1 | 23.88 | 46.13 | 1 | 1 |
| 5–15 | 18.00 | 28.32 | 1.8 (1.7–1.9) | 1.3 (1.2–1.4) | 16.21 | 24.20 | 1.2 (1.2–1.3) | 1.0 (1.0–2.1) | 18.21 | 22.01 | 1.3 (1.2–1.3) | 1.2 (1.1–1.2) | 22.72 | 18.63 | 2.3 (2.2–2.6) | 2.2 (2.1–2.4) |
| 16–31 | 24.35 | 22.30 | 3.1 (2.9–3.3) | 2.0 (1.8–2.1) | 24.17 | 26.92 | 1.7 (1.6–1.7) | 1.3 (1.2–1.3) | 24.09 | 25.34 | 1.5 (1.4–1.5) | 1.3 (1.2–1.3) | 23.99 | 18.36 | 2.6 (2.4–2.8) | 2.3 (2.1–2.5) |
| 32+ | 45.37 | 17.00 | 7.8 (7.4–8.2) | 3.9 (3.6–4.1) | 49.38 | 30.15 | 3.1 (3.0–3.2) | 2.0 (1.9–2.1) | 43.11 | 30.15 | 2.3 (2.2–2.4) | 1.7 (1.7–1.8) | 29.41 | 16.89 | 3.5 (3.2–3.7) | 2.9 (2.7–3.1) |
| **Specialist visits** | | | | | | | | | | | | | | | | |

*(Continued)*

**Table 3.** (Continued)

| | Age 55–74 (n = 63764) | | | | Age 75–84 (n = 105118) | | | | Age 85–94 (n = 114072) | | | | Age 95+ (n = 24832) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cases | Controls | | | Cases | Controls | | | Cases | Controls | | | Cases | Controls | | |
| | % | % | OR (95% CI) | adjOR (95% IC) | % | % | OR (95% CI) | adjOR (95% CI) | % | % | OR (95% CI) | adjOR (95% CI) | % | % | OR (95% CI) | adjOR (95% CI) |
| At least one SV | 72.34 | 52.37 | 2.4 (2.3–2.5) | 1.5 (1.5–1.6) | 63.16 | 57.51 | 1.3 (1.2–1.3) | 1.0 (0.9–1.0) | 43.01 | 40.24 | 1.1 (1.1–1.2) | 1.0 (0.9–1.0) | 25.05 | 17.44 | 1.6 (1.5–1.7) | 1.4 (1.3–1.5) |
| Total SV by classes | | | | | | | | | | | | | | | | |
| 0 | 27.66 | 47.63 | 1 | 1 | 36.84 | 42.49 | 1 | 1 | 56.99 | 59.76 | 1 | 1 | 74.95 | 82.56 | 1 | 1 |
| 1 | 14.98 | 18.66 | 1.4 (1.3–1.5) | 1.1 (1.1–1.2) | 17.95 | 18.99 | 1.1 (1.1–1.1) | 1.0 (0.9–1.0) | 18.53 | 17.93 | 1.1 (1.0–1.1) | 1.0 (0.9–1.0) | 13.41 | 10.08 | 1.5 (1.4–1.6) | 1.4 (1.3–1.5) |
| 2 | 10.20 | 10.27 | 1.8 (1.7–1.9) | 1.2 (1.1–1.3) | 11.17 | 11.97 | 1.1 (1.0–1.1) | 0.9 (0.8–0.9) | 8.75 | 8.46 | 1.1 (1.1–1.1) | 1.0 (0.9–1.0) | 5.02 | 3.41 | 1.7 (1.5–1.9) | 1.4 (1.3–1.6) |
| 3+ | 47.15 | 23.44 | 3.5 (3.4–3.7) | 2.0 (1.9–2.1) | 34.04 | 26.55 | 1.5 (1.5–1.5) | 1.0 (1.0–1.1) | 15.73 | 13.85 | 1.2 (1.2–1.3) | 0.9 (0.9–1.0) | 6.62 | 3.95 | 1.9 (1.7–2.1) | 1.5 (1.4–1.7) |
| Laboratory tests | | | | | | | | | | | | | | | | |
| At least one LT | 85.31 | 66.10 | 3.0 (2.9–3.1) | 1.8 (1.7–1.9) | 84.35 | 69.28 | 2.4 (2.4–2.5) | 1.8 (1.7–1.8) | 76.95 | 57.36 | 2.5 (2.5–2.6) | 2.1 (2.1–2.2) | 66.17 | 37.03 | 3.4 (3.2–3.6) | 3.0 (2.6–3.2) |
| Total LT by classes | | | | | | | | | | | | | | | | |
| 0 | 14.69 | 33.90 | 1 | 1 | 15.65 | 30.72 | 1 | 1 | 23.05 | 42.64 | 1 | 1 | 33.83 | 62.97 | 1 | 1 |
| 1–2 | 13.50 | 24.15 | 1.3 (1.2–1.4) | 1.0 (1.0–1.1) | 16.72 | 23.16 | 1.4 (1.4–1.5) | 1.2 (1.2–1.3) | 22.79 | 23.41 | 1.8 (1.8–1.9) | 1.7 (1.6–1.7) | 28.14 | 19.14 | 2.8 (2.6–3.0) | 2.6 (2.4–2.8) |
| 3–4 | 13.74 | 19.43 | 1.7 (1.6–1.8) | 1.2 (1.1–1.3) | 16.24 | 19.40 | 1.7 (1.6–1.8) | 1.4 (1.3–1.5) | 17.98 | 15.66 | 2.2 (2.1–2.3) | 1.9 (1.8–2.0) | 16.59 | 9.81 | 3.2 (2.9–3.5) | 2.9 (2.6–3.1) |
| 5+ | 58.07 | 22.52 | 6.2 (5.9–6.5) | 3.1 (2.9–3.3) | 51.38 | 26.73 | 4.0 (3.8–4.1) | 2.6 (2.5–2.7) | 36.18 | 18.30 | 3.8 (3.7–4.0) | 2.9 (2.8–3.0) | 21.44 | 8.09 | 5.0 (4.6–5.5) | 4.3 (3.9–4.7) |

adj: adjustment for Charlson Comorbidity Index.

considered results also from studies that focused on healthcare costs. We assume that, considering each healthcare service separately, expenditure may be considered as a proxy of healthcare utilization even if there are, especially among acute healthcare services, important differences in costs [34].

Acute healthcare services play a large role in patient care at the end of life: 62% of dying patients receive hospital care and 63% access the ED at least once during the EOL. Decedents have higher risks of being hospitalized, compared to age-sex matched controls (HA OR = 7, ED OR = 5.2) and tend to be hospitalized longer (mean/median length of stay of: cases = 16.3/8 days, controls = 2.3/0 days).

In addition, the percentage of hospitalized subjects, in the last year of life, declines with the increase of age at death. A greater portion of younger-old decedents was admitted to the hospital, compared to the oldest-old. Furthermore, decedents aged 95 and above showed a marked reduction in the frequency of ED visits as oppose to other decedents. These results are

**Table 4. Healthcare utilization during the last year of life by major causes of death; Odds Ratios (OR) and 95% Confidence Intervals (CI) from conditional logistic regression for cases (decedents) and matched controls (survivors).**

| | Cancer (n = 92438) | | | | Cardiovascular diseases (n = 124682) | | | | Respiratory diseases (n = 29812) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cases | Controls | | | Cases | Controls | | | Cases | Controls | | |
| | % | % | OR (95% CI) | adj OR (95% CI) | % | % | OR (95% CI) | adjOR (95% CI) | % | % | OR (95% CI) | adjOR (95% CI) |
| Hospitalization admission | | | | | | | | | | | | |
| At least one HA | 79.79 | 18.15 | 17.5 (16.7–18.4) | 5.9 (5.6–6.3) | 53.84 | 19.48 | 4.9 (4.7–5.0) | 3.1 (3.0–3.2) | 59.35 | 19.48 | 5.9 (5.5–6.3) | 4.7 (4.4–5.0) |
| Total HA by classes | | | | | | | | | | | | |
| 0 | 20.21 | 81.85 | 1 | 1 | 46.16 | 80.52 | 1 | 1 | 40.65 | 80.52 | 1 | 1 |
| 1 | 29.27 | 12.76 | 9.1 (8.6–9.6) | 4.6 (4.3–4.9) | 27.02 | 13.94 | 3.4 (3.3–3.5) | 2.6 (2.6–2.7) | 28.14 | 13.75 | 3.7 (3.7–4.3) | 3.7 (3.4–4.0) |
| 2 | 21.75 | 3.66 | 24.2 (22.5–26.1) | 8.6 (7.9–9.3) | 13.80 | 3.82 | 6.4 (6.0–6.7) | 4.2 (3.9–4.4) | 15.64 | 4.00 | 7.6 (6.8–8.4) | 6.7 (5.9–7.5) |
| 3+ | 28.78 | 1.73 | 65.4 (59.5–72.0) | 17.0 (15.3–19.0) | 13.02 | 1.71 | 13.4 (12.5–14.4) | 7.3 (6.7–7.9) | 15.56 | 1.74 | 17.0 (14.7–19.6) | 14.3 (12.2–16.8) |
| Emergency department visits | | | | | | | | | | | | |
| At least one ED | 70.40 | 24.01 | 8.1 (7.8–8.4) | 3.8 (3.7–4.0) | 58.99 | 26.08 | 4.2 (4.1–4.3) | 2.9 (2.8–2.9) | 64.27 | 26.63 | 4.9 (4.7–5.2) | 3.8 (3.5–4.0) |
| Total ED by classes | | | | | | | | | | | | |
| 0 | 29.60 | 75.99 | 1 | 1 | 41.01 | 73.92 | 1 | 1 | 35.73 | 73.37 | 1 | 1 |
| 1 | 27.74 | 16.06 | 4.7 (4.5–4.9) | 2.8 (2.7–3.0) | 26.01 | 16.79 | 2.9 (2.8–3.0) | 2.3 (2.2–2.4) | 26.57 | 17.13 | 3.2 (3.0–3.4) | 2.8 (2.6–3.0) |
| 2+ | 42.67 | 7.95 | 15.0 (14.2–15.8) | 5.9 (5.6–6.3) | 32.98 | 9.29 | 6.7 (6.5–7.0) | 4.1 (3.9–4.2) | 37.70 | 9.49 | 8.1 (7.5–8.7) | 5.8 (5.3–6.2) |
| Drug prescriptions | | | | | | | | | | | | |
| At least one DP | 97.40 | 86.98 | 5.6 (5.3–6.0) | 3.3 (3.0–3.5) | 93.83 | 85.09 | 2.7 (2.6–2.7) | 2.2 (2.1–2.3) | 94.06 | 85.90 | 2.7 (2.5–2.9) | 2.2 (2.1–2.5) |
| Total DP by classes | | | | | | | | | | | | |
| 0–4 | 8.00 | 24.99 | 1 | 1 | 14.13 | 25.43 | 1 | 1 | 14.27 | 23.97 | 1 | 1 |
| 5–15 | 17.45 | 25.07 | 2.2 (2.1–2.3) | 1.7 (1.6–1.8) | 17.42 | 23.55 | 1.4 (1.3–1.4) | 1.3 (1.2–1.3) | 16.90 | 21.86 | 1.3 (1.2–1.4) | 1.2 (1.1–1.3) |
| 16–31 | 26.75 | 24.57 | 3.5 (3.4–3.7) | 2.3 (2.1–2.4) | 23.49 | 24.74 | 1.8 (1.7–1.8) | 1.5 (1.5–1.6) | 21.13 | 24.88 | 1.5 (1.4–1.6) | 1.3 (1.2–1.4) |
| 32+ | 47.80 | 25.36 | 6.4 (6.1–6.7) | 3.3 (3.1–3.5) | 44.97 | 26.28 | 3.3 (3.2–3.4) | 2.5 (2.4–2.5) | 47.71 | 29.29 | 2.9 (2.7–3.1) | 2.2 (2.1–2.4) |
| Specialist visits | | | | | | | | | | | | |
| At least one SV | 73.81 | 52.02 | 2.7 (2.6–2.8) | 2.0 (1.9–2.1) | 46.39 | 43.85 | 1.1 (1.1–1.2) | 0.9 (0.9–1.0) | 46.89 | 45.48 | 1.1 (1.0–1.1) | 0.9 (0.9–1.0) |
| Total SV by classes | | | | | | | | | | | | |
| 0 | 26.19 | 47.98 | 1 | 1 | 53.61 | 56.15 | 1 | 1 | 53.11 | 54.52 | 1 | 1 |
| 1 | 16.17 | 18.59 | 1.7 (1.6–1.7) | 1.4 (1.4–1.5) | 17.88 | 17.30 | 1.1 (1.1–1.1) | 1.0 (1.0–1.0) | 17.91 | 17.58 | 1.1 (1.0–1.1) | 1.0 (0.9–1.1) |
| 2 | 10.98 | 10.66 | 2.0 (1.9–2.1) | 1.6 (1.5–1.7) | 9.09 | 8.97 | 1.1 (1.0–1.1) | 0.9 (0.9–1.0) | 9.45 | 9.90 | 1.0 (0.9–1.1) | 0.9 (0.8–1.0) |
| 3+ | 46.66 | 22.77 | 4.0–3.9–4.2) | 2.7 (2.6–2.8) | 19.42 | 17.58 | 1.2 (1.1–1.2) | 0.9 (0.9–0.9) | 19.54 | 17.99 | 1.1 (1.1–1.2) | 0.9 (0.9–1.0) |
| Laboratory tests | | | | | | | | | | | | |
| At least one LT | 91.96 | 65.24 | 6.4 (6.1–6.7) | 4.5 (4.2–4.7) | 74.63 | 59.65 | 2.0 (2.0–2.1) | 1.7 (1.7–1.7) | 77.47 | 60.71 | 2.3 (2.2–2.4) | 2.0 (1.9–2.1) |
| Total LT by classes | | | | | | | | | | | | |

*(Continued)*

**Table 4.** (Continued)

| | Cancer (n = 92438) | | | | Cardiovascular diseases (n = 124682) | | | | Respiratory diseases (n = 29812) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cases | Controls | | | Cases | Controls | | | Cases | Controls | | |
| | % | % | OR (95% CI) | adj OR (95% CI) | % | % | OR (95% CI) | adjOR (95% CI) | % | % | OR (95% CI) | adjOR (95% CI) |
| 0 | 8.04 | 34.76 | 1 | 1 | 25.37 | 40.35 | 1 | 1 | 22.53 | 39.29 | 1 | 1 |
| 1–2 | 12.66 | 22.99 | 2.5 (2.4–2.6) | 2.1 (2.0–2.2) | 21.86 | 23.55 | 1.5 (1.5–1.6) | 1.4 (1.3–1.4) | 23.14 | 22.89 | 1.8 (1.7–1.9) | 1.7 (1.6–1.8) |
| 3–4 | 14.38 | 18.43 | 3.7 (3.5–3.9) | 3.0 (2.8–3.2) | 17.12 | 16.45 | 1.7 (1.7–1.8) | 1.5 (1.5–1.6) | 18.09 | 16.91 | 2.0 (1.8–2.1) | 1.8 (1.7–2.0) |
| 5+ | 64.92 | 23.82 | 13.6 (12.9–14.4) | 8.4 (7.9–9.0) | 35.65 | 19.65 | 3.1 (3.0–3.2) | 2.3 (2.2–2.4) | 36.25 | 20.92 | 3.3 (3.1–3.5) | 2.6 (2.4–2.8) |

adj: adjustment for Charlson Comorbidity Index.

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consistent with those of other studies. Different studies, also showed how older age was associated with a lower frequency of acute hospital-based healthcare assistance, in the period preceding death [17,18,30]. This could be related to the fact that subjects in the oldest age group are often living in an institution and are therefore less likely to require hospital-based services. Another possible explanation may be that aggressiveness of medical care decreases with the increase of age. Some evidence suggested an increase in the use of healthcare in younger individuals already one year before the date of death, while in older individuals, the increase would occur only 4 months before death [9]. Therefore, by analyzing a one-year period before the index date, younger decedents could have a longer period of increased risk of hospital-based healthcare service utilization, with greater chances of being admitted to the hospital, more than once.

The high use of hospital-based services (HA and ED) at the EOL could be an indicator of a low quality of life in proximity to death. The worsening of clinical conditions that often precedes death, can indeed lead to an increase need of hospital-based healthcare assistance. Anyway, assessing the need of these services in the EOL, goes beyond the objectives of this study. Nevertheless, Gill et al suggested, by means of an observational study on individuals aged 70 years or above, during their last year of life, that acute illnesses and injuries leading to hospital admission play an important role in a disabling process, that leads to recurrent hospitalizations in more than half the decedents. For those patients, to enhance restorative interventions in the subacute, palliative care approach, home-care and outpatient setting should be considered [35]. Several studies showed that hospitalizations at the EOL can be potentially preventable [14,36]. Since EOL expenditures are driven largely by an increase in inpatient hospital costs [34], efforts should focus on reducing hospitalizations [37]. Hospital-at-home or in day-care services might be an alternative solution to hospitalizations, in certain situations [38]. This is also true, when considering elder patients,—not necessarily at the EOL—that are characterized by high frailty, which is responsible of the delivery of an important amount of acute healthcare services, which might often not be appropriate for this specific subgroup [39]. In Italy, a study conducted in the Regions of Emilia Romagna and Veneto seems to suggest that well-integrated palliative care approach can be effective in further reducing the percentage of patients who spend many days in hospital and/or undergo frequent and inappropriate changes of their care setting during the last month of life [40]. Those results were confirmed by other studies in patients with cancer, conducted in the same geographical areas [25,41]. These results underline how enhancing palliative care and reducing hospitalization during the EOL period were associated with an increase in patient and family satisfaction [41]. In Israel, Bentur et al had

observed how the costs associated with the last 6 months of life in patients with metastatic can-
cer were lower for those who received acute care in addition to regular community care [13].
Without an extensive support network, there may be an increase in hospital-based services,
used as "service substitutions" [16]. Since 55% of the individuals included in this study have
died in hospital structures, all acute hospital-based services that were associated with the death
of the patient, were excluded from analyses, to avoid imbalances due to the high frequency of
this final contact.

Primary care as well, is an important determinant of healthcare assistance in the last year
before death, with 87% of cases receiving more than five drug prescriptions, 54% requiring at
least one specialist visit and 80% having at least one laboratory test. Controls, in contrast, had
respectively: 75%, 47% and 62%. It has been estimated that these three services combined, rep-
resent almost 30% of healthcare expenditure in Italy [11]. These healthcare services also
showed a progressively increasing trend of use in the EOL, although here age seems to play a
more marginal role. Closeness to death is in fact associated with an increased use of primary
care services. This pattern remains relatively constant across all ages, except for a slight U-
shaped trend in drug prescriptions. Consistently with this finding, Moore et al, showed how
proximity to death, rather than age itself, drives prescription expenditure in the population
aged 70 or more [15]. Among decedents, the use of specialist visits and laboratory tests in the
EOL showed a marked reduction with the increase of age. Pot et al showed a similar decrease
of specialist visits with the increase of age among decedents aged 55 or above [19]. A possible
cause, might be attributable to frailty markers such as poor cognitive ability [42], low educa-
tional level and low social support among the extremely elderly subjects, that may hamper
access to appropriate care [19].

On the other hand, long-term-care use, which has not been analyzed in this work, has been
found to increase in the last years of life [29]. Further studies are required to evaluate the dif-
ferent patterns in long-term care utilization, as oppose to primary care.

Another finding was that the risk of healthcare utilization among female decedents, com-
pared to their matched controls were always lower than males', especially for drug prescrip-
tions, with the exception of laboratory tests. Other studies have shown lower hospital costs
respectively for elderly [43] and decedent women, compared to men [44]. Further studies are
needed to investigate whether healthcare assistance and needs in elderly woman are related to
gender disparity or to true differences in healthcare needs, in the EOL, between men and
women.

Specific causes of death, showed strong differences in HCU patterns, concerning both acute
and primary care services. These were in fact consistently higher for patients dying from can-
cer, compared to those that died from cardiovascular and respiratory diseases. These findings
are consistent with those from previous international studies on HCU in the EOL for cancer
deaths, compared to all other causes of death [16]. A possible explanation may be that some of
these diseases have a sudden clinical presentation (e.g. stroke, myocardial infarction and pneu-
monia), leading to a less intense healthcare service consumption. On the other hand, cancer
has a longer course and requires more accesses to healthcare services. However, this does not
explain the reduced likelihood of hospitalization for people who died due to chronic diseases
(e.g. chronic obstructive pulmonary disease, heart failure). Another study noted a pattern of
decreasing medical expenditure, frequency of hospital admission and utilization of intensive
care units, with the increase of age, for all cause of death except cancer [45].

Considering the advanced age of the subjects that were analyzed, comorbidities are an
important and frequent determinant of health, but they also play a relevant role in modifying
life expectancy among younger individuals [46]. When adjusting the results from our analyses,
according to the Charlson Comorbidity Index, the Odds Ratios decreased, with a sensible

reduction among the younger decedents and the cancer patients. This is explainable, considering that comorbidities have a key role in defining the amount of healthcare services that an individual requires and have a great influence on survival.

Italy has the largest proportion of elderly in Europe, with more than one fifth of its residents, aged 65 years or above, at the beginning of 2015 (Eurostat http://ec.europa.eu/eurostat/data/database). This portion is expected to increase as the so-called "baby boom" cohort (those born between 1945 and 1964) ages progressively (Italian National Institute of Statistics [ISTAT], 2011). Despite this particular demographic conformation, there is limited knowledge about healthcare utilization in older age groups, in relation to the use at the EOL, in this country [11,39]. Atella and colleagues have analyzed for first in Italy primary healthcare expenditure, showing a faster increase in the healthcare costs as individuals approach the six-month period before death [11].

## Strengths and limitations of this study

To the best of our knowledge, this is the only article that compares the utilization among decedents and survivors, of acute hospital-based services, drug prescriptions, specialist's visits and laboratory tests, in different age groups. All of the three studies [9,19,31] that showed the greatest similarities with ours, are not completely comparable. McGrail and coauthors studied the costs between decedents and survivors and does not focus on utilization itself. Forma and Pot analyzed long-term care and therefore include different sources from the ones used in this study. Our analysis distinguished the extremely elderly ($\geq$95) in age stratification, as only few studies before have done [18,47,48]. Another advantage of this work is the use of regional, population-based databases, since the healthcare administrative data used for the analyses, comes from the entire Region of Friuli Venezia Giulia. This study has included in the analyses of risk of healthcare utilization, specialist visits, that have been scarcely evaluated in previous works [11,31]. This source could be used more broadly in future studies.

A limit of this study was that the overlook on primary care was not complete, since data regarding general practitioners' visits are not collected systematically in the Region. Information on long-term care facilities and connected services (home assistance, home nursing, palliative care) were not included in the analyses, although they could provide a better understanding of institutionalized EOL periods and how this modifies the utilization of healthcare services (especially acute ones) mainly among the eldest. This goes beyond the objective of this study, but it could be considered in future works. Due to these limitations, it was also not possible to incorporate information regarding the place of death. That said, a European report has shown that only about 2% of the population aged 65 years or above, in Italy, is residing in long-term care facilities. This is in contrast with most European countries, where this percentage is greater than 5% [49]. Another limit is that the Charlson Comorbidity Index was calculated only by means of hospital discharge records. This served as a proxy for comorbidity, due to a lack of individual information on chronic conditions. Considering the possible incompleteness of said adjustment, greater attention has been given, throughout the article, to the value of unadjusted odds ratios.

## Conclusions

In conclusion, proximity to death is strongly associated to healthcare utilization in subjects aged 55 or above, but its influence varies between age groups and kind of service considered. Our results confirm that there is high use of acute hospital-based services in the last year of life, more markedly present in the younger-old. Further studies are needed to better understand how acute hospital-based healthcare use is influenced by the access to other primary and

long-term-care services. A more complete overview on comorbidities could also help comprehend some other aspects influencing this complex phenomenon. Reducing the access to acute healthcare services is particularly important in an ageing population to improve the quality of life in proximity to death, with a consequent cost containment.

## Author Contributions

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## References

1. Liddle R, Lerais F. A CONSULTATION PAPER FROM THE BUREAU OF EUROPEAN POLICY ADVISERS EUROPE'S SOCIAL REALITY.: 56.

2. Jacobzone S. Ageing and the Challenges of New Technologies: Can OECD Social and Healthcare Systems Provide for the Future? Geneva Papers on Risk and Insurance—Issues and Practice. 2003; 28: 254–274. https://doi.org/10.1111/1468-0440.00222

3. Dormont B, Grignon M, Huber H. Health expenditure growth: reassessing the threat of ageing. Health Econ. 2006; 15: 947–963. https://doi.org/10.1002/hec.1165 PMID: 16958079

4. Westerhout WMT. Does Ageing Call for a Reform of the Health Care Sector? CESifo Economic Studies. 2006; 52: 1–31. https://doi.org/10.1093/cesifo/ifj001

5. Bähler C, Huber CA, Brüngger B, Reich O. Multimorbidity, health care utilization and costs in an elderly community-dwelling population: a claims data based observational study. BMC Health Serv Res. 2015; 15: 23. https://doi.org/10.1186/s12913-015-0698-2 PMID: 25609174

6. Dagli RJ, Sharma A. Polypharmacy: A Global Risk Factor for Elderly People. J Int Oral Health. 2014; 6: i–ii.

7. Zweifel P, Felder S, Meiers M. Ageing of population and health care expenditure: a red herring? Health Econ. 1999; 8: 485–496. PMID: 10544314

8. Seshamani M, Gray A. Ageing and health-care expenditure: the red herring argument revisited. Health Economics. 2004; 13: 303–314. https://doi.org/10.1002/hec.826 PMID: 15067669

9. Forma L, Rissanen P, Aaltonen M, Raitanen J, Jylha M. Age and closeness of death as determinants of health and social care utilization: a case-control study. The European Journal of Public Health. 2009; 19: 313–318. https://doi.org/10.1093/eurpub/ckp028 PMID: 19286838

10. Howdon D, Rice N. Health care expenditures, age, proximity to death and morbidity: Implications for an ageing population. J Health Econ. 2018; 57: 60–74. https://doi.org/10.1016/j.jhealeco.2017.11.001 PMID: 29182935

11. Atella V, Conti V. The effect of age and time to death on primary care costs: The Italian experience. Social Science & Medicine. 2014; 114: 10–17. https://doi.org/10.1016/j.socscimed.2014.05.029 PMID: 24908170

12. Yang Z, Norton EC, Stearns SC. Longevity and health care expenditures: the real reasons older people spend more. J Gerontol B Psychol Sci Soc Sci. 2003; 58: S2–10. PMID: 12496303

13. Bentur N, Resnizky S, Balicer R, Eilat-Tsanani T. Utilization and Cost of Services in the Last 6 Months of Life of Patients With Cancer—With and Without Home Hospice Care. American Journal of Hospice and Palliative Medicine®. 2014; 31: 723–725. https://doi.org/10.1177/1049909113499604 PMID: 23928076

14. Tran B, Falster MO, Girosi F, Jorm L. Relationship between use of general practice and healthcare costs at the end of life: a data linkage study in New South Wales, Australia. BMJ Open. 2016; 6: e009410. https://doi.org/10.1136/bmjopen-2015-009410 PMID: 26743704

15. Moore PV, Bennett K, Normand C. Counting the time lived, the time left or illness? Age, proximity to death, morbidity and prescribing expenditures. Social Science & Medicine. 2017; 184: 1–14. https://doi.org/10.1016/j.socscimed.2017.04.038 PMID: 28482276

16. Rosenwax LK, McNamara BA, Murray K, McCabe RJ, Aoun SM, Currow DC. Hospital and emergency department use in the last year of life: a baseline for future modifications to end-of-life care. 2011; 194: 4.

17. Ishizaki T, Shimmei M, Fukuda H, Oh E-H, Shimada C, Wakui T, et al. Cumulative number of hospital bed days among older adults in the last year of life: A retrospective cohort study: Hospital bed days in the end of life. Geriatrics & Gerontology International. 2017; 17: 737–743. https://doi.org/10.1111/ggi.12777 PMID: 27215376

18. Goldsbury DE, O'Connell DL, Girgis A, Wilkinson A, Phillips JL, Davidson PM, et al. Acute hospital-based services used by adults during the last year of life in New South Wales, Australia: a population-based retrospective cohort study. BMC Health Services Research. 2015; 15. https://doi.org/10.1186/s12913-015-1202-8 PMID: 26637373

19. Pot AM, Portrait F, Visser G, Puts M, van Groenou MIB, Deeg DJ. Utilization of acute and long-term care in the last year of life: comparison with survivors in a population-based study. BMC Health Services Research. 2009; 9. https://doi.org/10.1186/1472-6963-9-139 PMID: 19656358

20. Bird CE, Shugarman LR, Lynn J. Age and Gender Differences in Health Care Utilization and Spending for Medicare Beneficiaries in Their Last Years of Life. Journal of Palliative Medicine. 2002; 5: 705–712. https://doi.org/10.1089/109662102320880525 PMID: 12572969

21. Bekelman JE, Halpern SD, Blankart CR, Bynum JP, Cohen J, Fowler R, 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. https://doi.org/10.1001/jama.2015.18603 PMID: 26784775

22. Brameld KJ, Holman CD, Bass AJ, Codde JP, Rouse IL. Hospitalisation of the elderly during the last year of life: an application of record linkage in Western Australia 1985–1994. Journal of Epidemiology & Community Health. 1998; 52: 740–744. https://doi.org/10.1136/jech.52.11.740

23. Goodridge D, Lawson J, Duggleby W, Marciniuk D, Rennie D, Stang M. Health care utilization of patients with chronic obstructive pulmonary disease and lung cancer in the last 12 months of life. Respiratory Medicine. 2008; 102: 885–891. https://doi.org/10.1016/j.rmed.2008.01.007 PMID: 18313278

24. Howard M, Chalifoux M, Tanuseputro P. Does Primary Care Model Effect Healthcare at the End of Life? A Population-Based Retrospective Cohort Study. Journal of Palliative Medicine. 2017; 20: 344–351. https://doi.org/10.1089/jpm.2016.0283 PMID: 27893954

25. Pellizzari M, Rolfini M, Ferroni E, Savioli V, Gennaro N, Schievano E, et al. Intensity of integrated cancer palliative care plans and end-of-life acute medical hospitalisation among cancer patient in Northern Italy. European Journal of Cancer Care. 2018; 27: e12742. https://doi.org/10.1111/ecc.12742 PMID: 28809459

26. Lyngaa T, Christiansen CF, Nielsen H, Neergaard MA, Jensen AB, Laut KG, et al. Intensive care at the end of life in patients dying due to non-cancer chronic diseases versus cancer: a nationwide study in Denmark. Critical Care. 2015; 19. https://doi.org/10.1186/s13054-015-1124-1 PMID: 26597917

27. Reeve E, Moriarty F, Nahas R, Turner JP, Kouladjian O'Donnell L, Hilmer SN. A narrative review of the safety concerns of deprescribing in older adults and strategies to mitigate potential harms. Expert Opin Drug Saf. 2018; 17: 39–49. https://doi.org/10.1080/14740338.2018.1397625 PMID: 29072544

28. Forma L, Rissanen P, Aaltonen M, Raitanen J, Jylhä M. Dementia as a determinant of social and health service use in the last two years of life 1996–2003. BMC Geriatrics. 2011; 11. https://doi.org/10.1186/1471-2318-11-14 PMID: 21470395

29. Forma L, Aaltonen M, Pulkki J, Raitanen J, Rissanen P, Jylhä M. Long-term care is increasingly concentrated in the last years of life: a change from 2000 to 2011. European Journal of Public Health. 2017; 27: 665–669. https://doi.org/10.1093/eurpub/ckw260 PMID: 28339763

30. Calver J, Bulsara M, Boldy D. In-patient hospital use in the last years of life: a Western Australian population-based study. Australian and New Zealand Journal of Public Health. 2006; 30: 143–146. https://doi.org/10.1111/j.1467-842X.2006.tb00107.x PMID: 16681335

31. McGrail K. Age, costs of acute and long-term care and proximity to death: evidence for 1987–88 and 1994–95 in British Columbia. Age and Ageing. 2000; 29: 249–253. https://doi.org/10.1093/ageing/29.3.249 PMID: 10855908

32. Matthews RS, Brill IK. 152–30: SAS® Programs to Select Controls for Matched Case-Control Studies.: 9.

33. D'Hoore W, Bouckaert A, Tilquin C. Practical considerations on the use of the charlson comorbidity index with administrative data bases. Journal of Clinical Epidemiology. 1996; 49: 1429–1433. https://doi.org/10.1016/S0895-4356(96)00271-5 PMID: 8991959

**34.** Tanuseputro P, Wodchis WP, Fowler R, Walker P, Bai YQ, Bronskill SE, et al. The Health Care Cost of Dying: A Population-Based Retrospective Cohort Study of the Last Year of Life in Ontario, Canada. Räisänen SHeditor. PLOS ONE. 2015; 10: e0121759. https://doi.org/10.1371/journal.pone.0121759 PMID: 25811195

**35.** Gill TM, Gahbauer EA, Han L, Allore HG. The role of intervening hospital admissions on trajectories of disability in the last year of life: prospective cohort study of older people. BMJ. 2015; 350: h2361–h2361. https://doi.org/10.1136/bmj.h2361 PMID: 25995357

**36.** Kronman AC, Ash AS, Freund KM, Hanchate A, Emanuel EJ. Can primary care visits reduce hospital utilization among Medicare beneficiaries at the end of life? J Gen Intern Med. 2008; 23: 1330–1335. https://doi.org/10.1007/s11606-008-0638-5 PMID: 18506545

**37.** Van den Block L, Deschepper R, Drieskens K, Bauwens S, Bilsen J, Bossuyt N, et al. Hospitalisations at the end of life: using a sentinel surveillance network to study hospital use and associated patient, disease and healthcare factors. BMC Health Services Research. 2007; 7. https://doi.org/10.1186/1472-6963-7-69 PMID: 17488520

**38.** Sewo Sampaio PY, Sampaio RAC, Yamada M, Arai H. Comparison of frailty between users and nonusers of a day care center using the Kihon Checklist in Brazil. Journal of Clinical Gerontology and Geriatrics. 2014; 5: 82–85. https://doi.org/10.1016/j.jcgg.2014.02.005

**39.** Legramante JM, Morciano L, Lucaroni F, Gilardi F, Caredda E, Pesaresi A, et al. Frequent Use of Emergency Departments by the Elderly Population When Continuing Care Is Not Well Established. Bugiardini R, editor. PLOS ONE. 2016; 11: e0165939. https://doi.org/10.1371/journal.pone.0165939 PMID: 27973563

**40.** Casotto V, Rolfini M, Ferroni E, Savioli V, Gennaro N, Avossa F, et al. End-of-Life Place of Care, Health Care Settings, and Health Care Transitions Among Cancer Patients: Impact of an Integrated Cancer Palliative Care Plan. Journal of Pain and Symptom Management. 2017; 54: 167–175. https://doi.org/10.1016/j.jpainsymman.2017.04.004 PMID: 28479411

**41.** Louis DZ, Hegarty SE, Leoni M, De Palma R, Varga S, Melotti R. Variation in Hospital Utilization at the end of Life for Patients with Cancer in the Emilia-Romagna Region of Italy. Tumori Journal. 2016; 102: 614–620. https://doi.org/10.5301/tj.5000544 PMID: 27514312

**42.** Jakobsson E, Bergh I, Öhlén J, Odén A, Gaston-Johansson F. Utilization of health-care services at the end-of-life. Health Policy. 2007; 82: 276–287. https://doi.org/10.1016/j.healthpol.2006.10.003 PMID: 17097757

**43.** Gabriele S, Cislaghi C, Costantini F, Innocenti F, Lepore V, Raitano M, et al. Demographic factors and health expenditure profiles by age: the case of Italy.: 33.

**44.** Brockmann H. Why is less money spent on health care for the elderly than for the rest of the population? Health care rationing in German hospitals. Soc Sci Med. 2002; 55: 593–608. PMID: 12188466

**45.** Levinsky NG, Yu W, Ash A, Moskowitz M, Gazelle G, Saynina O, et al. Influence of Age on Medicare Expenditures and Medical Care in the Last Year of Life.: 7.

**46.** Mariotto AB, Wang Z, Klabunde CN, Cho H, Das B, Feuer EJ. Life tables adjusted for comorbidity more accurately estimate noncancer survival for recently diagnosed cancer patients. Journal of Clinical Epidemiology. 2013; 66: 1376–1385. https://doi.org/10.1016/j.jclinepi.2013.07.002 PMID: 24035494

**47.** Geue C, Briggs A, Lewsey J, Lorgelly P. Population ageing and healthcare expenditure projections: new evidence from a time to death approach. The European Journal of Health Economics. 2014; 15: 885–896. https://doi.org/10.1007/s10198-013-0543-7 PMID: 24292437

**48.** Moorin R, Gibson D, Holman D, Hendrie D. The contribution of age and time-to-death on health care expenditure for out-of-hospital services. Journal of Health Services Research & Policy. 2012; 17: 197–205. https://doi.org/10.1258/jhsrp.2012.011130 PMID: 23038709

**49.** Frogatt K, Arrue B, Edwards M, Finne-Soveri H, Morbey H, Payne S, et al. Palliative care systems and current practices in long term care facilities in Europe. PACE—comparing the effectiveness of PAlliative CarE for older people in long-term care facilities in Europ; 2017 Jan p. 99.