

ORIGINAL ARTICLE



Potential overtreatment in end-of-life care in adults 65 years or older dying from cancer: applying quality indicators on nationwide registries

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ABSTRACT

Background: Quality indicators are frequently used to measure the quality of care at the end of life. Whether quality indicators of potential *overtreatment* (i.e., when the risks outweigh the benefits) at the end of life can be reliably applied to routinely collected data remains uncertain. This study aimed to identify quality indicators of overtreatment at the end of life in the published literature and to investigate their tentative prevalence among older adults dying with solid cancer.

Materials and methods: Retrospective cohort study of decedents including all older adults (≥ 65 years) who died with solid cancer between 1 January 2013 and 31 December 2015 ($n = 54,177$) in Sweden. Individual data from the National Cause of Death Register were linked with data from the Total Population Register, the National Patient Register, and the Swedish Prescribed Drug Register. Quality indicators were applied for the last one and three months of life.

Results: From a total of 145 quality indicators of overtreatment identified in the literature, 82 (57%) were potentially operationalisable with routine administrative and healthcare data in Sweden. Unidentifiable procedures and hospital drug treatments were the reason for non-operationalisability in 52% of the excluded indicators. Among the 82 operationalisable indicators, 67 measured overlapping concepts. Based on the remaining 15 unique indicators, we tentatively estimated that overall, about one-third of decedents received at least one treatment or procedure indicative of 'potential overtreatment' during their last month of life.

Conclusion: Almost half of the published overtreatment indicators could not be measured in routine administrative and healthcare data in Sweden due to a lack of means to capture the care procedure. Our tentative estimates suggest that potential overtreatment might affect one-third of cancer decedents near death. However, quality indicators of potential overtreatment for specific use in routinely collected data should be developed and validated.

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Introduction

At the end of life, survival-centred goals of care should ideally shift to comfort- and quality of life-oriented care according to patient preferences, also among persons with cancer [1]. Yet non-beneficial treatments have been reported to be as prevalent as 33–38% near death [2]. Treatments can be considered as overtreatment '*in the absence of a clear medical basis for use or when the benefit of therapy does not outweigh risks*' [3,4]. Another definition suggests that overtreatment is when patients, particularly vulnerable older people, would overall benefit from less intensive care [5]. As there is no general consensus on what *exactly* constitutes overtreatment, in the context of this article we broadly use both of these definitions of overtreatment incorporating also several closely related terms such as aggressive-,

non-beneficial-, questionable-, futile-, excessive-, low-value-, unwanted- and unnecessary care.

One approach to measure these broad aspects of overtreatment is to use quality indicators. Quality indicators are considered a valid approach to measure the quality of care at the population level, especially at the end of life [6]. However, most quality indicators for persons dying with cancer have been designed in the US and Canada to be used in the clinical setting and do not specifically target aspects of overtreatment [7]. It remains unclear how well quality indicators of overtreatment can be applied to routinely collected administrative data in Europe.

Persons dying with cancer are at an increased risk of overtreatment at the end of life [8–10]. Their care is often characterised by excessive use of anticancer agents (e.g., intravenous chemotherapy) [11,12], life-sustaining procedures

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(e.g., mechanical ventilation, surgery) [2], frequent transitions (e.g., non-elective hospital admissions) [13,14], and preventative treatments (i.e., drugs with longer time to benefit than the patient's remaining life expectancy) [15,16]. These potentially non-beneficial treatments and hospital transitions threaten the quality of care near death, especially for an older, vulnerable cancer patient. To systematise the measures of end-of-life cancer care quality, Henson et al. compiled a list of published quality indicators in 2019 [7]. However, this list did not consider applicability to routinely collected administrative data, but it contains a shortlist of indicators recommended for use. Notably, De Schreye et al. have developed [17] and measured [18] a list of quality indicators for end-of-life cancer care specifically for administrative data in Belgium, but it has not yet been used in other countries. In Sweden, the palliative care guidelines include quality indicators for end of life [19], but these are intended for the Register of Palliative Care where not all deaths (66 and 87% of all deaths and cancer deaths in 2015, respectively) are reported [20].

Quality indicators assessed using nationwide administrative data represent an efficient way to compare patterns of cancer management within and across countries [21]. However, several challenges exist for comparing administrative data across areas, such as opportunistic coding for financial benefits, data availability, inaccurate coding and lack of risk-adjustment in across-country comparisons [22]. So far, the results reported for end-of-life cancer care quality indicators measured in administrative data have yielded heterogeneous results across countries [21]. For example, a Belgian study reported that 17% of cancer decedents received chemotherapy in the last month of life [18] compared with 12% in Denmark [23], and 10% in Germany [24]. It is unclear whether these differences are due to coding or treatment practices. In Sweden, the prevalence of overtreatment among older adults dying with cancer has not yet been measured in nationwide register data, possibly because drugs used at hospitals are not systematically recorded.

The overarching goal of this study was to investigate how well universal quality indicators of broadly defined potential overtreatment in older cancer patients can be measured in Swedish nationwide administrative and healthcare data and shed light on methodological challenges. To that end, we identified quality indicators that broadly target overtreatment in end-of-life cancer care published until August 2020. First, we assessed how many of these indicators can be applied to nationwide register data in Sweden. Second, we presented a tentative prevalence of potential overtreatment among Swedish older adults dying with solid cancer.

Methods

Identification of quality indicators of overtreatment at the end-of-life cancer care

We identified quality indicators of end-of-life cancer care from a 2019 systematic review by Henson and colleagues [7]. We updated their list of quality indicators by applying their search algorithm and inclusion criteria (Supplementary

eFigure 1) to identify recently published quality indicators for end-of-life cancer patients until August 2020. From the complete list of identified quality indicators, we selected those potentially implying that the benefits of care provided might not outweigh its risks, namely overtreatment indicators defined in a broad sense. We restricted these indicators to include only those that refer to medications, procedures and hospital transitions, similar to the work of De Schreye et al. [17,18].

We subsequently assessed the possibility of applying these indicators on routinely collected administrative and healthcare data in Sweden. We excluded the indicators deemed not operationalisable because they incorporated procedures, specific in-hospital drug treatments, hospital transitions or time frames that cannot be captured in the data. Lastly, we classified the operationalisable indicators into three different categories: (1) cancer-specific treatments, (2) hospital transitions and place of death, and finally (3) potentially futile treatments not specific to cancer. Further details together with the complete list of excluded quality indicators are provided in the online [Supplementary Material](#) (eText 1, eTable 1-2).

Data sources

We used routinely collected administrative and healthcare data with national coverage in Sweden. Data from the National Cause of Death Register were linked at the individual level using pseudonymised identifiers in the National Patient Register, the Swedish Prescribed Drug Register, the Total Population Register, and the Swedish Register of Education. The content of each register is summarised in [Supplementary eTable 3](#).

Study design and population

We applied the potentially operationalisable quality indicators in a retrospective cohort study of decedents. We identified all older adults (age ≥ 65 years) who died with solid cancer between 1 January 2013 and 31 December 2015 ($n = 55,391$) which was the most recent available data to us. We included decedents with either solid cancer reported as the underlying cause of death (obtained from the death certificate data) or solid cancer reported as both a contributing cause of death and as a hospital diagnosis in the last two years of life (International Statistical Classification of Diseases and Related Health Problems, Tenth Revision [ICD-10], codes C00–C80, excluding C77–C79). We did not include patients younger than 65 years or those with haematological malignancies (ICD-10 codes C81–C95) in the study to select a homogenous population. Individuals with haematological malignancies may experience a rapid functional decline near the end of life that makes the survival predictions even more unreliable than for solid cancer patients. In addition, they have a potential for cure until late in the disease trajectory that differentiates them from patients dying of solid cancer [25]. Furthermore, the current quality measures may be

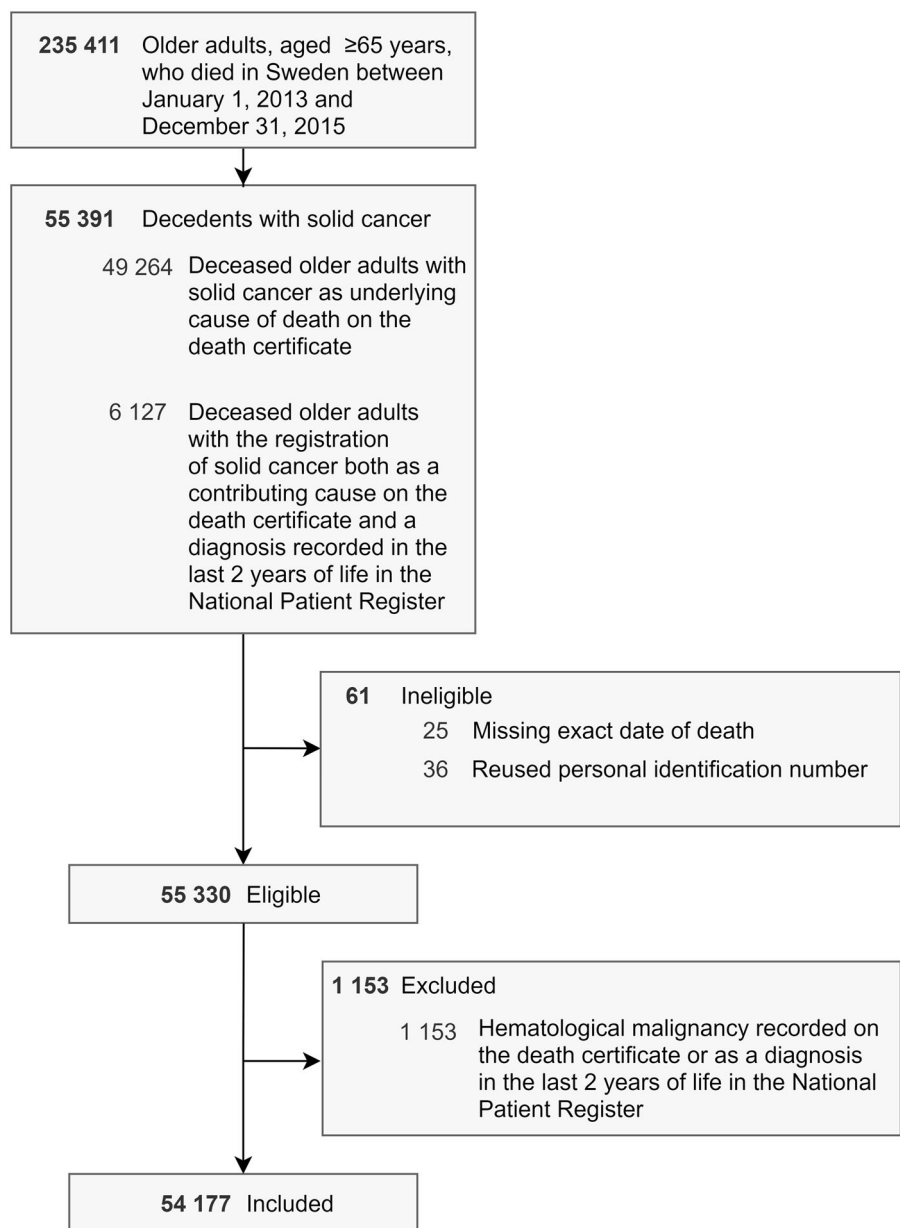


Figure 1. Flowchart of the study population selection.

inappropriate to identify potential overtreatment in patients with haematological malignancies [26].

To avoid including older adults with unconfirmed malignancies or individuals who were not identified as cancer patients prior to their death, we excluded decedents with cancer mentioned as a contributing cause of death but with no cancer diagnosis reported in the National Patient Register, as well as those whose cancer diagnosis was reported during a hospital stay but not as one of the causes of death (Figure 1). We further excluded individuals whose exact date of death was unknown ($n=25$), those whose unique personal identifier had been re-allocated to another person ($n=36$), and those with a concomitant haematological malignancy (ICD-10 codes C81–C95; $n=1,153$). Details about the identification of the study

population are provided in [Supplementary eFigure 2–3](#) and [eTable 4–5](#).

Patient-level characteristics

Sex and age at death were extracted from the Cause of Death Register. We extracted marital status ('married', 'single/divorced', 'widowed') from the Swedish Total Population Register. Education was defined as the lifetime highest attained educational level, and was categorised into 'primary', 'secondary', and 'tertiary' education based on the ISCED-97 classification system [27] using the Swedish Register of Education. We estimated the Hospital Frailty Risk Score [28] based on the data captured in the National

Patient Register during the period ranging from 5 years to 3 months before death ([Supplementary eTable 6](#)). We defined primary cancer diagnosis using ICD-10 codes from the underlying cause of death ('Head or neck' [C00–C14], 'Digestive tract' [C15–C26], 'Respiratory tract' [C30–C39], 'Melanoma' [C43–C44], 'Breast' [C50], 'Female genital organs' [C51–C58], 'Male genital organs' [C60–C63], 'Urinary tract' [C64–C68], 'Other' [C40–C41, C45–C49, or C69–C80], 'Multiple Primary Tumours' [reported only for the decedents who did not have solid cancer listed in the underlying cause of death but had more than one solid cancer listed among their contributing causes of death]).

Quality indicators of potential overtreatment

Quality indicators consist of explicitly defined numerators and denominators, or calculations [6,29–31]. The numerator is the number of patients that fulfil the pre-set criteria (e.g., receiving a given treatment deemed potentially inappropriate), while the denominator is the number of patients in the population under study (e.g., excluding individuals for whom this treatment would be appropriate) [32]. The codes used to calculate the numerator and denominator for each quality indicator in this study are available in [Supplementary eTable 7–14](#). They were selected in consultation with classification experts from the National Board of Health and Welfare.

Statistical analysis

We calculated the prevalence of each quality indicators separately as a proof of concept. The denominator was allowed to vary between quality indicators to only include the population potentially eligible for treatments, according to the original denominator. For time-specific quality indicators, we calculated the prevalence for two distinct periods (the last month of life, and the last three months before death) that align well with previous studies published in the end-of-life care literature [33]. Furthermore, we calculated the overall and category-specific prevalence of overtreatment using only those indicators that were estimated for the last month of life.

We calculated the overall and the category specific proportion of people fulfilling ≥ 1 overtreatment quality indicator stratified by primary cancer site and age groups. The rationale for these sensitivity analyses was to investigate the potential variation in end-of-life overtreatment patterns across cancer sites and age groups [15,34]. In post-hoc sensitivity analyses, we excluded decedents with acute and potentially unexpected causes of death by using a previously published algorithm ([Supplementary eTable 15](#)) [15]. We further restricted the study population to decedents whose solid cancer diagnosis should be known by the care team and thus their death were likely expected. We excluded decedents who were identified with solid cancer only reported as the contributing cause of death or solid cancer recorded only as the underlying cause of death (without a solid cancer hospital diagnosis in the last two years of life). Lastly, we excluded decedents whose first solid cancer diagnosis was recorded close to (3 months) death. These

restrictions of the study population was done to ascertain that the decedents were perceived to be at the end-of-life by the treating physicians. All analyses were performed with SAS software version 9.4 and R statistical software version 3.6.1.

Reporting guidelines and ethical approval

The present study was reported in keeping with the RECORD guidelines ([Supplementary eTable 16](#)) and was approved by the Regional Ethical Review Board in Stockholm (dnr: 2016/1001-31/4).

Results

Identification of quality indicators of overtreatment

We identified 354 quality indicators for end-of-life cancer care, of which 145 (41%) pertained specifically to overtreatment. Of these, 82 (57%) were deemed operationalisable with nationwide Swedish administrative data. Reasons for non-operationalisability included unidentifiable procedures/hospital drug treatments (52%), care transitions/visits not captured in the data (24%), too short time period for evaluation (e.g., drug treatments in last 3 days of life) (21%), or other (4%), see [Supplementary eTable 2](#). Among the 82 indicators of overtreatment selected for this study, 13 (16%) were focussed on cancer-specific treatments, 32 (39%) were related to hospital transitions and places of death, and 37 (45%) on potentially futile non-cancer specific treatments ([Supplementary eFigure 4](#)). Many quality indicators were overlapping (e.g., targeting the same procedure). We present 15 unique quality indicators, with reference to overlapping indicators. The complete list of quality indicators is included in [Supplementary eTable 1](#).

Patient characteristics

Out of 55,391 decedents with solid cancer who died at the age of 65 years or older in Sweden between 1 January 2013 and 31 December 2015, we included 54,177 (97.8%) individuals with no concomitant haematological malignancy. The majority (91.4% of included decedents) had an inpatient or specialised care admission related to their solid cancer in the last two years of life. The median age was 79.9 years (IQR 73.1–86.3), 54.5% were men ([Table 1](#)), and 13.6% had a high hospital frailty risk score. The most common primary cancers were located in the digestive tract (32.6%), respiratory tract (17.3%), and male genital organs (16.5%).

Prevalence of overtreatment

Overall, 36.9% ($n = 19,980$) of cancer decedents received at least one treatment or had one hospital transition indicative of potential overtreatment during the last month of life. The proportions of older patients who received different types of care belonging to one, two and three categories of potential overtreatment were 26.3, 9.4, and 1.2%, respectively.

Table 1. Characteristics of people aged ≥ 65 years who died with solid cancer in Sweden, 2013–2015.

Decedents, No.	Overall (n = 54,177)
Sex, No. (%)	
Men	29,528 (54.5%)
Women	24,649 (45.5%)
Age at time of death	
Median (P ₂₅ –P ₇₅), years	79.9 (73.1–86.3)
No. (%)	
65–74 years	17,153 (31.7%)
75–84 years	20,709 (38.2%)
85–94 years	15,003 (27.7%)
95 years and older	1312 (2.4%)
Marital status	
Married	24,185 (44.6%)
Single/divorced	13,714 (25.3%)
Widowed	16,276 (30.0%)
Missing	2 (0.0%)
Level of education, No. (%)	
Primary	21,909 (40.4%)
Secondary	23,672 (43.7%)
Tertiary	7771 (14.3%)
Missing	825 (1.5%)
Hospital Frailty Risk Score	
Median (P ₂₅ –P ₇₅)	2.90 (0.40–6.70)
No. (%)	
Low	35,719 (65.9%)
Moderate	11,103 (20.5%)
High	7355 (13.6%)
Primary cancer diagnosis (ICD-10)	
Head or neck (C00–C14)	737 (1.4%)
Digestive tract (C15–C26)	17,654 (32.6%)
Respiratory tract (C30–C39)	9370 (17.3%)
Melanoma (C43–C44)	1408 (2.6%)
Breast (C50)	3489 (6.4%)
Female genital organs (C51–C58)	2966 (5.5%)
Male genital organs (C60–C63)	8961 (16.5%)
Urinary tract (C64–C68)	3912 (7.2%)
Other (C40–C41, C45–C49, or C69–C80)	5392 (10.0%)
Multiple primary tumours	288 (0.5%)

Regarding cancer-specific treatments, 27.0% ($n = 14,622$) of the decedents received one or more treatment that suggest potential overtreatment during the last month of life (Table 2). Overall, 2.7% of decedents received chemotherapy during their last month of life. Of those who received chemotherapy during their last year of life, 8.0% initiated new chemotherapy during their last month of life. Almost one-fourth of decedents received at least one surgical or diagnostic procedure, and 1.4% had a nomenclature code indicative of tube or intravenous feeding during their last month of life.

Concerning hospital transitions indicators, 9.4% ($n = 5,082$) of the decedents experienced a hospital transition during the last month that may have amounted to overtreatment. The proportion of decedents who had more than one emergency room visit during their last month of life was 7.2%. Almost half (49%) of cancer decedents died in hospitals, and patients spent more than one-third of the last month (35% of the available days) at the hospital.

As for potentially futile non-cancer specific treatments, the prevalence of blood transfusion was 9.2%, port-a-cath 1.2%, new anti-depressant treatment 2.0% and cardiopulmonary resuscitation 0.3% during the last month of life. One-third of decedents aged 75 years or older ($n = 12,463$) were exposed to potentially inadequate drug initiation or continuation during their last three months of life.

The stratified sensitivity analysis showed that the prevalence of patients with at least one indicator of potential overtreatment during the last month of life varied by primary cancer type between 28.4% (breast) and 41.2% (female genital organ cancer). Decedents with primary cancer located in the male genital organ (30.0%) and melanoma (30.3%) were exposed to treatments suggesting overtreatment less than the average, while patients with head and neck (37.2%), urinary tract (37.9%), respiratory tract (38.4%) and digestive tract (41.2%) cancers more than the average. In the age-stratified analysis, the prevalence of potential overtreatment was higher in younger age groups; the prevalence gradually decreased from 45.0% in the 65 to 74 year age group to 19.6% in the 95 years and older group (Supplementary eTable 17). The post-hoc analysis showed that excluding decedents with acute and potentially unexpected cause of death ($n = 949$; 1.8% of total study population) did not meaningfully change our results. However, when we applied a restrictive criteria and removed decedents identified *via* their contributing causes of death ($n = 5,759$; 10.6% of total) or who had solid cancer recorded only in the underlying cause of death ($n = 4,653$; 8.6% of total) or had their first solid cancer diagnosis recorded close to (3 months) death ($n = 10,583$, 19.5% of total), the prevalence of potential overtreatment decreased to 33.9% during the last month of life (Supplementary eTable 18).

Discussion

Main findings

In this study, we found that almost half of the overtreatment indicators identified in the literature could not be measured with Swedish administrative data due to a lack of means to capture the care procedure. Furthermore, many quality indicators were overlapping and measured similar concepts. Based on the 15 non-overlapping quality indicators that could be measured in Swedish administrative data, we tentatively estimated that about one-third of older cancer decedents were exposed to potential overtreatment during their last month of life. We found some variation according to primary cancer site, whilst the prevalence decreased with older age. Future studies should further validate how well these clinical quality indicators are captured in administrative data. However, the relatively high prevalence of overtreatment estimated in this study align well with 33–38% reported from clinical studies on non-beneficial treatments at the end of life [2].

The main challenge of measuring overtreatment in administrative data is the lack of information on whether the treatment, procedure or hospital transition was clinically inappropriate, as the intention of care, life expectancy, patient's functional status, patients' preferences and interrelation between physicians and patients are not recorded [7,38]. Therefore, most register-based studies using quality indicators, including ours, have no means of assessing whether the end-of-life care decisions were actually appropriate or not; hence the use of the phrase *potential overtreatment* in our study. Furthermore, differences might exist in how well the measured

Table 2. Quality indicators of overtreatment at the end-of-life care for all people aged ≥ 65 years who died from cancer in Sweden, 2013–2015.

Numerator (No. of people who died with solid cancer who received/had ...)	Denominator (No. of people who died with solid cancer ...)	No. of similar indicators	No. of months before death until death		
			Not specified	1 (%)	3(%)
Cancer-specific treatments				27.0 ^a	–
Tube feeding or intravenous feeding [17]	N = 36,523 (people with gastro-intestinal cancer excluded)	–	–	1.4	2.2
One or more chemotherapy (antineoplastic) treatments	N = 54,177	8 [17,35–41]	–	2.7	8.1
New chemotherapy (antineoplastic) regimen ^b	N = 8,893 (people who did not receive chemotherapy before excluded)	2 [35,36,42]	–	8.0	26.7
Surgical and invasive diagnostic procedures ^c	N = 54,177	2 [17,42]	–	24.6	43.0
Hospital transitions and place of death				9.4 ^a	–
More than one emergency room visit	N = 54,177	9 [17,35–38,41,43]	–	7.2	31.7
More than one hospitalisation	N = 54,177	6 [17,35–41]	–	9.4	39.6
Calculation: Non-general practitioner visits in last six months averaged across all cases with at least three non-general practitioner visits*	N = 34,274	5 [37,38,43]	7.7	–	–
Died in hospitals*	N = 54,177	7 [17,35–42,44]	49.0%	–	–
Calculation: per cent of days spent at home versus hospital*	–	5 [37,38,42–44]	–	65.1	78.3
Potentially futile non-cancer specific treatments				12.3 ^a	–
Blood transfusion(s) [17]	N = 54,177	–	–	9.2	15.6
Port-a-Cath installed [17]	N = 54,177	–	–	1.2	2.8
Initiation of a new anti-depressant treatment [17]	N = 54,177	–	–	2.0	5.0
Cardiopulmonary resuscitation performed [42]	N = 54,177	–	–	0.3	0.3
Continued the use of often inadequate drugs* ^d [45]	N = 37,024 (people < 75 years of age excluded)	–	–	–	24.3
Initiated the use of often inadequate drugs* ^d [45]	N = 37,024 (people < 75 years of age excluded)	–	–	–	12.8

^aOvertreatment group-level quality indicators were aggregated for 1 month only not to overinflate the prevalence of overtreatment as the lookback period is extended.

^bThe operationalisation of “new chemotherapy” is reported in [Supplementary eTable 11](#).

^cThe ten most common surgical and invasive diagnostic procedures are included in [Supplementary eTable 19](#).

^dFor example: vitamin D, calcium supplements, osteoporosis drugs, antidiemetic drugs, etc. The complete list of individual quality indicators of continuation and initiation of often inadequate drugs with the corresponding ATC codes are reported in the [Supplementary eTables 20–21](#). These quality indicators were reported only for three months before death, as was done in the original publication.

*Quality indicator contributing neither to overtreatment category level prevalence nor the overall overtreatment prevalence measured in the last month of life.

quality indicators approximate the *actual* prevalence due to potential variation in registration practices and general under-reporting of procedure codes (e.g., chemotherapy).

What this study adds

Overall, there are several quality indicators for cancer care at the end of life, but many are overlapping, too unspecific or not possible to measure using administrative data. Furthermore, few focuses specifically on older people. From the quality indicators list of De Schreye et al. [17], developed for measuring end-of-life cancer care quality using administrative data, we considered 16 out of 26 as overtreatment indicators. Only 10 out of 16 could be operationalised using Swedish administrative data due to data limitations (e.g., missing hospital drugs, lines of chemotherapy). Nonetheless, quality indicators offer great potential to measure variations in the quality of care across regions, care providers, and nations [46]. The current study might offer a starting point to create a core set of agreed indicators to measure potential

overtreatment in different health care settings. Although, the indicators should be adjusted or stratified for factors across and outside the healthcare system in future comparative studies (e.g., patient age, cancer type, palliative care models) [31,47].

Cancer-specific treatments, such as surgical and invasive diagnostic procedures, contributed most to the prevalence of overtreatment in our study, corroborating results from earlier studies suggesting that cancer care tend to be prioritised at the end of life [8–10]. For certain indicators, we found similar (e.g., ‘tube feeding or intravenous feeding’ 1.4 vs 1.3% reported in Belgium [18]) and for others lower prevalence estimates than in previous studies. For example, we found that only $\approx 3\%$ of older adults with solid cancer received chemotherapy in the last month of life in Sweden, which is considerably lower than findings based on administrative data in Germany (10%) [24], Belgium [18] (17%) or Denmark (16%) [23]. Although the focus on older people in our study might explain some of these differences. Notably, a study in northern Sweden conducted on clinical data also found higher proportions (13%) of patients with epithelial cancer

using chemotherapy at the end of life [48]. Measuring chemotherapy use based on Swedish national register data is hampered because hospital drugs are not captured. We mainly used procedure codes, which are generally underreported according to the Swedish National Patient Register, to capture in-hospital chemotherapy administration, and Anatomical Therapeutic Chemical codes to capture chemotherapy treatments dispensed in community pharmacies. Therefore, the observed low proportion of chemotherapy use suggests that it can only be partially measured using Swedish nationwide register data. This supports the notion that quality indicators should be selected with caution and with careful consideration of the limitations of the data source at hand.

Hospital transitions and place of death are commonly measured using national registers [21,49], because they are recorded with high completeness in many countries (e.g., 99% of all somatic and psychiatric hospital discharges are registered in Sweden [50]). We found similar results for hospital transitions and place of death as in previous studies conducted in comparable health care settings. For example, in our study population, the prevalence of in-hospital death was 49%, which is similar to estimates in another Swedish study reporting a prevalence of 51% across all cancer deaths [51]. A shortcoming of the Swedish National Patient Register is that transitions to specialised palliative in-hospital units, where patients receive high quality of care [52], are not reliably recorded. Thus, we had no means of separating these types of admission from hospitalisation. This dampens the interpretability of end-of-life hospital transition results, because specialised palliative care unit admissions might be regarded as appropriate. [18]

For the quality indicators of potentially futile non-cancer specific treatments that we measured using procedure codes (e.g., blood transfusion, port-a-cath) we obtained similar estimates as those reported by De Schreye et al. using administrative data [18]. As of yet, no validation study was conducted on the Swedish procedure codes in an end-of-life setting, thereby the possibility of under- or overreporting is unconfirmed, but we suspect underreporting based on our estimates. Quality indicators constructed solely using drug-specific codes, such as the Morin indicators [45,53], are likely registered reliably in the Swedish Prescribed Drug Register [54,55]. Nevertheless, these results are expected to be underestimated because drugs administered during hospitalisation or from nursing home drug storerooms (in the case of a few nursing homes with such facilities) are not included.

From a research perspective, our results emphasise the need to develop and validate quality indicators for older adults that are applicable to administrative data. In addition, data on the intention of care and patients' preferences should be collected. However, researchers should strive for a balance between patient-centred quality indicators and feasibility to measure indicators in available data. From a public health perspective, our findings suggest that stakeholders should introduce interventions that optimise the use of curative treatments and hospital transitions at the end of life. Ensuring that patients spend their last stage of life according

to their stated preferences and avoiding the risks of worsened quality of life is among the highest priorities of palliative care [1]. From a health economic perspective, our results indicate a potential for better use of available health care resources.

Strengths and limitations

To the best of our knowledge, this is the first Swedish study to assess the applicability of internationally developed end-of-life quality indicators of overtreatment in an older solid cancer population with near 100% coverage. Strengths of our study included the nationwide population-based setting that reduces the risk of sampling bias and includes hard to reach patient populations. However, several limitations need mentioning. First, an inherent weakness of employing administrative data is that random errors in measuring quality indicators might be present. Second, differences in coding practices including inaccuracies, deliberately opportunistic coding and variations across time and care settings, which cannot be controlled by statistical analysis, might have led to over or underestimations. Third, the Swedish Prescribed Drug register collects data regarding drug dispensing and not actual consumption. Fourth, the Swedish National Cancer Register was not used for the study population identification because these data were unavailable to us, although it is unlikely that it would have largely influenced our results due to potential underreporting within this register [56]. Fifth, patients' treatment preference, functional status and intention of care are unavailable in the employed register data; thus, the presented estimates of potential overtreatment should be interpreted with caution. A procedure classified as potential overtreatment (e.g. insertion of chest drain) may have been appropriate given the complex clinical situation of the patient.[57] Sixth, the applied retrospective ('mortality follow-back') study design potentially underestimates the prognostic uncertainty that the care teams experience near the end of life.[58] Clinicians might not have been able to anticipate the exact time of death and could have overestimated remaining life expectancy that might have led to treatment decisions we deemed as potential overtreatment. [59,60] Seventh, our data is limited to years 2013-2015 and patients aged 65 years or older that might not represent the latest treatment practices (e.g., clinical decision-making based on chronological age) and available therapy options (e.g., immunotherapy). Eighth, we used a broad definition of potential overtreatment that includes a wide range of treatments (e.g., from chemotherapy to initiation of inadequate drugs such as vitamin D). Some might not be regarded as potential overtreatment when the lookback period is extended to three months, but we reported this period similarly to previous research. [18] We did not rank the indicators in priority order. We believe that this important task should be based on rigorous scientific methods incorporating the views by experts in cancer care, administrative data and end-users. We deem that all included indicators have potential elements linked to providing "care in the absence of a clear medical basis for use or when the benefit of therapy does not outweigh risks" [3,4] Lastly, our tentative prevalence of overtreatment needs to be

validated, and may only be generalisable to regions with healthcare systems similar to that in Sweden.

Conclusion

Many quality indicators of overtreatment at the end of life were not operationalisable and challenging to measure using nationwide administrative data. Nonetheless, quality indicators of overtreatment provide an inexpensive and policy-relevant way to monitor and improve the quality of end-of-life care. Based on nationwide register data, our tentative findings indicate that potential overtreatment at the end of life affected about one-third of older patients with solid cancer. Further research is needed to develop and validate quality indicators of overtreatment for older cancer patients based on administrative data that can be used across healthcare settings and countries.

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Ethical approval

The study was approved by the Regional Ethical Review Board in Stockholm (dnr: 2016/1001-31/4).

Author contributions

MS, KJ, LM conceived and designed the study. MS performed the statistical analysis, interpreted the data, drafted, and critically revised the manuscript. JWW, LM, ACL, ML and KJ interpreted the data and critically revised the manuscript. KJ obtained funding and acquired the data. KJ and JWW provided supervision. KJ is the guarantors of the study and data integrity. All authors gave approval for the final version of the manuscript and agree to be accountable for all aspects of the work.

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Data availability statement

Data may be obtained from a third party and are not publicly available. Clinical data cannot be made publicly available because of privacy

issues. However, additional results and aggregated findings are available in the [supplementary files](#).

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