Long-term health-care utilisation in older patients with cancer and the association with the Geriatric 8 screening tool: a retrospective analysis using linked clinical and population-based data in Belgium

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Summary

Background Little evidence is available on the long-term health-care utilisation of older patients with cancer and whether this is associated with geriatric screening results. We aimed to evaluate long-term health-care utilisation among older patients after cancer diagnosis and the association with baseline Geriatric 8 (G8) screening results.

Methods For this retrospective analysis, we included data from three cohort studies for patients (aged ≥70 years) with a new cancer diagnosis who underwent G8 screening between Oct 19, 2009 and Feb 27, 2015, and who survived more than 3 months after G8 screening. The clinical data were linked to cancer registry and health-care reimbursement data for long-term follow-up. The occurrence of outcomes (inpatient hospital admissions, emergency department visits, use of intensive care, contacts with general practitioner [GP], contacts with a specialist, use of home care, and nursing home admissions) was assessed in the 3 years after G8 screening. We assessed the association between outcomes and baseline G8 score (normal score [>14] or abnormal [≤14]) using adjusted rate ratios (aRRs) calculated from Poisson regression and using cumulative incidence calculated as a time-to-event analysis with the Kaplan-Meier method.

Findings 7556 patients had a new cancer diagnosis, of whom 6391 patients (median age 77 years [IQR 74–82]) met inclusion criteria and were included. 4110 (64·3%) of 6391 patients had an abnormal baseline G8 score (≤14 of 17 points). In the first 3 months after G8 screening, health-care utilisation peaked and then decreased over time, with the exception of GP contacts and home care days, which remained high throughout the 3-year follow-up period. Compared with patients with a normal baseline G8 score, patients with an abnormal baseline G8 score had more hospital admissions (aRR 1·20 [95% CI 1·15–1·25]; p<0·0001), hospital days (1·66 [1·64–1·68]; p<0·0001), emergency department visits (1·42 [1·34–1·52]; p<0·0001), intensive care days (1·49 [1·39–1·60]; p<0·0001), general practitioner contacts (1·19 [1·17–1·20]; p<0·0001), home care days (1·59 [1·58–1·60]; p<0·0001), and nursing home admissions (16·7% *vs* 3·1%; p<0·0001) in the 3-year follow-up period. At 3 years, of the 2281 patients with a normal baseline G8 score, 1421 (62·3%) continued to live at home independently and 503 (22·0%) had died. Of the 4110 patients with an abnormal baseline G8 score, 1057 (25·7%) continued to live at home independently and 2191 (53·3%) had died.

Interpretation An abnormal G8 score at cancer diagnosis was associated with increased health-care utilisation in the subsequent 3 years among patients who survived longer than 3 months.

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Introduction

The global population is ageing and cancer incidence increases with age, thus the burden of cancer in older populations is high and is expected to keep rising globally.[1]

Management of older patients with cancer is often particularly challenging. Patients are heterogeneous in general health status and can have comorbidities and age-related conditions such as functional dependence, malnutrition, and cognitive impairment.[2] These factors can hinder cancer diagnosis, impact cancer treatment decision, and complicate long-term management.[3–5]

The term frailty is used to define a vulnerable health state, whereby individuals have diminished resistance to physiological stressors and impaired homeostasis.[6] To optimise cancer treatment for older patients, it is important to identify frailty and underlying geriatric conditions at cancer diagnosis. Geriatric screening and

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Research in context

Evidence before this study

The Geriatric 8 (G8) is a geriatric screening tool validated to identify older patients with cancer who might benefit from a geriatric assessment. To explore existing evidence on the G8 tool, we searched PubMed from database inception to Dec 20, 2022, using the search terms "G8" or "Geriatric 8" or "geriatric screening", and "cancer" or "carcinoma" or "malignancy" or "oncologic" without language restrictions. The diagnostic accuracy of the G8 compared with geriatric assessment is well researched and these studies demonstrate the robustness of this geriatric screening tool. Additionally, the prognostic value of the G8 has been extensively researched and the studies largely confirm that potential frailty based on G8 is associated with a higher risk of mortality. Studies on the association of the G8 with clinical outcomes beyond survival are more scarce and limit outcomes to hospital admissions, post-operative complications, treatment related complications, and toxicity. Furthermore, these outcomes have only been measured during short follow-up times, limiting the translation of findings to the period beyond the first months of treatment and highlighting the need for longer-term patient-centred outcome research.

Added value of this study

To our knowledge, this retrospective analysis is the first study to explore the association between the G8 score and a broad range of health-care utilisation outcomes over a long period of time. We concluded that geriatric screening with G8 at cancer diagnosis can help identify older patients at risk for increased hospital admissions, hospital days, emergency department visits, intensive care days, general practitioner contacts, home care days, and nursing home admissions in the 3 years after diagnosis. Furthermore, the G8 is related to the living situation (ie, at home or in a nursing home) and the level of support provided in these 3 years. This analysis of more than 6000 older patients in daily oncology practice in Belgium was possible through the unique linkage of clinical and population-based data. The use of health-care reimbursement data available on the population-level in Belgium allows a detailed evaluation of the medical care patients received over a long period of time in a real-world setting. The outcomes such as hospital admissions, home care, nursing home admissions, and independent living are also specifically relevant for older patients since they are related to functional independence, which is of high importance during and after cancer treatment.

Implications of all the available evidence

Geriatric screening with G8 at cancer diagnosis can help identify older patients at risk for increased long-term health-care utilisation across primary, hospital, and residential care. Furthermore, an abnormal G8 screening score at cancer diagnosis is associated with a lower likelihood of functional independence after 3 years. These findings further support the use of geriatric screening with G8 in oncology practice for older adults with a new cancer diagnosis. Patient's short-term and long-term risk of increased health-care utilisation and independence is valuable information to consider in the treatment decision process.

geriatric assessment are key elements in achieving this goal and are recommended in the guidelines of various cancer organisations (eg, the International Society of Geriatric Oncology and American Society of Clinical Oncology).[7,8] Geriatric screening with tools such as the Geriatric 8 (G8) is the first step to quickly assess general health status and aids in selecting patients that are in need of geriatric assessment. G8 is based on the Mini-Nutritional Assessment questionnaire and has been shown to have high sensitivity (85%), acceptable specificity (65%), and is one of the more robust geriatric screening tools.[9,10] The high sensitivity is especially important for a good screening tool since it will result in the correct identification of patients who will benefit from a geriatric assessment.

In a busy oncology clinic or setting with scarce resources, geriatric screening with G8 followed by geriatric assessment in the case of an abnormal screening compared with geriatric assessment for all patients, has the potential for more broad implementation.[10,11] However, research on the association of the G8 with clinical outcomes beyond survival is scarce and more evidence is needed for long-term outcomes.[12] Population-based data such as disease registry or administrative health data can help address this gap by providing longitudinal information. Additionally, poorly explored outcomes such as health-care utilisation (ie, hospital admissions, contacts with care providers) can be studied in large cohorts.[13] Linkage of population-based data with primary clinical data provides the added benefit that these long-term outcomes can be correlated with clinical information.

Understanding long-term health-care utilisation and its patterns are especially important for older patients since treatment goals are more likely to focus on quality of life and the desire to maintain functional independence for as long as possible rather than length of life compared with younger patients.[14,15] Increased health-care utilisation can be associated with adverse outcomes (such as treatment complication) or supportive care to maintain quality of life. Insights from this study can contribute to the development of targeted interventions such as dietician or physiotherapist referral to reduce long-term health-care use associated with adverse outcomes.

Using linkage of clinical and population-based data, we aimed to assess long-term health-care utilisation after a new cancer diagnosis in older patients and investigate the association between health-care utilisation and baseline G8 screening results.

Methods

Study design and participants

In this retrospective analysis, we included data for a cohort of patients aged 70 years and older with a new cancer diagnosis in the past 6 months who were included in geriatric screening and assessment studies in Belgium. These consisted of three consecutive multicentre prospective observational cohort studies (n=22 centres) done between Oct 14, 2009 and Feb 27, 2015, to evaluate the implementation of geriatric screening or geriatric assessment (appendix p 2).[16–18] Patients were screened with G8, followed by geriatric assessment in case of an abnormal score (G8 score ≤14) at the time of treatment decision in all three cohort studies. Geriatric screening or geriatric assessment results were communicated to the treating physician. For the current study, the clinical geriatric screening data for the cohort were linked to registry data from the Belgian Cancer Registry and health-care reimbursement data from the InterMutualistic Agency. Databases were linked deterministically based on the patient's unique social security number and researchers only had access to pseudonymised data. The linkage was completed in December, 2020 and has been described in detail elsewhere.[19] Patients were subsequently excluded if InterMutualistic Agency data were missing or if screening with G8 was not performed within 2 months before and up to 6 months after cancer diagnosis. Our sample was restricted to patients who survived at least 3 months after G8 screening and all patients were censored 3 months before death or loss to follow-up to exclude a potential influence of end-of-life care on health-care utilisation.

The study protocol and linkage process were approved by the Belgian Information Security Committee and ethics committees of all 22 hospitals included in the three geriatric screening and assessment studies. Considering the retrospective design, the need for informed consent was waived.

Data sources

We derived clinical data (2009–2015) from the geriatric screening and assessment studies that provided baseline patient characteristics (age, sex), clinical variables (Charlson Comorbidity Index,[20] Eastern Cooperative Oncology Group Performance Status [ECOG-PS], poly-pharmacy[21]), sociodemographic variables (educational level and marital status), and G8 results.[16–18]

Cancer registry data (collected between 2009 and 2015) were obtained from Belgian Cancer Registry, a national population-based registry recording all new invasive tumours (with the exception of basal cell carcinomas) of Belgian residents with complete coverage since 2004. For this study, Belgian Cancer Registry provided date of diagnosis, tumour type (International Classification of Diseases, tenth revision) and stage (tumor–node–metastasis classification, sixth and seventh editions), and survival status. Reasons for exclusion were non-Belgian residency or tumour not registered (not defined as an invasive tumour or outpatient with only clinical diagnosis—eg, ovarian cancer in situ).

Health-care reimbursement data were obtained from the InterMutualistic Agency, which manages population-based administrative databases containing all health-care reimbursements of Belgian residents from mandatory health insurance. Feasibility of linkage has been described previously.[19] Reasons for exclusion were frontier workers (ie, working and living in different countries) or European Commission employees exempted from mandatory health insurance. For the current study, the InterMutualistic Agency provided all billed medical acts (predominantly fee-for-service system) for the 3-year period after G8 screening. InterMutualistic Agency data were used to determine outcomes on the basis of charged nomenclature codes.

See Online for appendix

For more on the **Belgian Cancer Registry** see https://kankerregister.org

For more on the **InterMutualistic Agency** see http://www.aim-ima.be

Exposure and outcome variables

The G8 consists of seven items from the Mini-Nutritional Assessment and one age-related item. The score ranges from 0–17: a score of 14 or less is considered an abnormal score.[9] The G8 was analysed dichotomously as it is validated in older patients using the cutoff score of 14. The continuous scale was not considered in this analysis because dichotomous scoring is more easily translatable to clinical practice.

Outcomes of interest were: number of inpatient hospital admissions, number of inpatient hospital days, number of emergency department visits, number of days in intensive care, number of days with general practitioner (GP) contact, number of contacts with a specialist (multiple contacts on 1 day was possible), number of days with home care during the follow-up period, and time to first nursing home admission, obtained from the InterMutualistic Agency data. More information on outcomes and corresponding Belgian nomenclature codes for reimbursement are in the appendix (pp 3–4).

Outcomes were analysed from the day after the date of G8 until 3 years after or until censoring at 3 months before death or loss to follow-up. Patients were censored to exclude the potential influence of end-of-life care.

Statistical analysis

Baseline characteristics are summarised by frequencies and percentages and were compared between patients with normal and abnormal G8 scores. Baseline was defined as the date of performance of the G8 screening. Outcomes were assessed up to 3 years after date of screening. Patients who died were censored 3 months before death and patients who were lost to follow-up were censored 3 months before loss to follow-up date (since their date of death was unknown).

For potentially recurrent outcomes (ie, hospital admissions, hospital days, emergency department visits, intensive care days, GP contacts, specialist contacts, and

home care days), event rates were calculated using the number of events divided by person-time at risk. Exact 95% CIs for the event rates were estimated based on the χ^2 distribution.[22] We calculated event rates per 3 months person-time (stratified by G8 score) and per person-year over the full 3-year period (whole cohort and stratified by G8 score). Simple Poisson regression was used to assess statistical significance at each timepoint, and to estimate rate ratios (RRs) indicating the association between G8 score and number of events in the 3-year period. Additionally, multiple Poisson regression models were constructed to adjust for case-mix differences (full model was fitted [no selection]). Covariates were selected on the basis of findings from the literature[23,24] and clinical experience. Adjustment was made for age (70–74, 75–79, 80–84, and ≥85 years), sex (female, male), tumour type (37 tumour types and one other category; appendix pp 5–6), stage (I, II, III, IV, not applicable [NA], missing), cohort identification (study 1, study 2, study 3), Charlson Comorbidity Index (score 0, no comorbidity; score 1–2, mild comorbidity; score 3–4, moderate comorbidity; score ≥5, severe comorbidity), educational level (higher education, upper secondary education, lower secondary education, primary education, illiterate, other, missing), and marital status (partnered, not partnered, other, missing).

Nursing home admission was considered as a non-recurrent outcome and was analysed as time to first admission within 3 years. Cumulative incidence was calculated as a time-to-event analysis, using the Kaplan-Meier method to estimate the probability of nursing home admission stratified by G8 score. The log-rank test was used to evaluate differences by G8 score.

To illustrate transitions between living situation (home, home with home care, and nursing home) from baseline to 3 years after, we constructed Sankey diagrams (alluvial flow diagrams) with the software Visual Paradigm.[25]

p<0·05 was considered to indicate a statistical significant difference. Missing baseline information was assigned to a separate category, no imputation techniques were used. All analyses were performed in SAS (version 9.4).

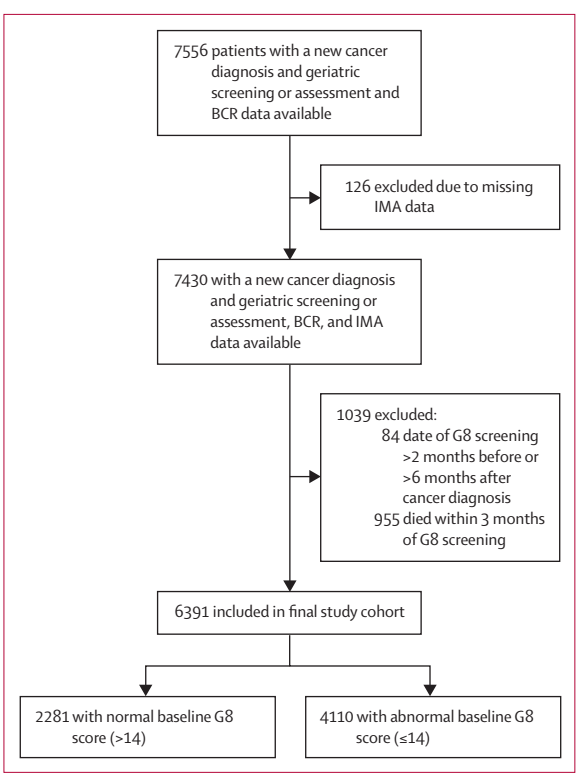

Figure 1: **Patient selection**
BCR=Belgian Cancer Registry. IMA=InterMutualistic Agency. G8=Geriatric 8.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

Between Oct 19, 2009, and Feb 27, 2015, 7556 older patients were diagnosed with cancer (only new diagnoses, no progression or relapse),[21] of whom 6391 met the inclusion criteria for the current study and were included in the final cohort for data analysis (figure 1). The median age of patients was 77 years (IQR 74–82) and 3823 (59·8%) of 6391 patients were female. The most common cancer diagnoses were breast cancer (1881 [29·4%] of 6391 patients), colon cancer (990 [15·5%]), and lung cancer (577 [9·0%]) and 1072 (16·8%) had stage IV disease (table 1).

Each patient underwent geriatric screening with G8 (performed a median of 20 days [IQR 8–36] after cancer diagnosis) and 4110 (64·3%) of 6391 patients had an abnormal G8 score. The distribution of most baseline variables was different between the two G8 score groups (normal *vs* abnormal; table 1). Patients with an abnormal G8 score were older, had different tumour types (more colon and lung cancers among patients with an abnormal score *vs* more breast and prostate cancers among patients with a normal score), had more advanced cancers, and had more comorbidities.

At 3 years after G8 screening, 2694 (42·2%) of 6391 patients were censored (n=2602 died; n=4 were lost to follow-up; n=88 had died or were lost-to-follow-up in the 3 months after the 3-year follow-up period). In the group with a normal baseline G8 score, 478 (21·0%) of 2281 patients were censored and in the group with an abnormal baseline G8 score, 2128 (51·8%) of 4110 patients were censored. Median follow-up time was 3·0 years (IQR 1·1–3·0). In the 3 years after screening, 4634 (72·5%) of 6391 patients had at least one new hospital admission with an event rate of 0·91 admissions (95% CI 0·90–0·93) and 11·86 hospital days per person-year (95% CI 11·81–11·92; table 2). 2967 (46·4%) of 6391 patients had at least one emergency department visit with an event rate of 0·43 visits (0·42–0·44) per person-year and

	Full cohort (n=6391)	Cohort categorised by G8 score	
		Normal G8 score (n=2281)	Abnormal G8 score (n=4110)
Age, years			
70–74	2031 (31·8%)	1050 (46%)	981 (23·9%)
75–79	1958 (30·6%)	828 (36·3%)	1130 (27·5%)
80–84	1484 (23·2%)	333 (14·6%)	1151 (28·0%)
≥85	918 (14·4%)	70 (3·1%)	848 (20·6%)
Median (IQR)	77 (74–78)	75 (72–78)	79 (75–84)
Mean (SD)	78·1 (5·6)	75·7 (4·2)	79·4 (5·8)
Range	70–100	70–94	70–100
Sex			
Female	3823 (59·8%)	1369 (60·0%)	2454 (59·7%)
Male	2568 (40·2%)	912 (40·0%)	1656 (40·3%)
Tumour type			
Breast	1881 (29·4%)	907 (39·8%)	974 (23·7%)
Colon	990 (15·5%)	267 (11·7%)	723 (17·6%)
Lung	577 (9·0%)	151 (6·6%)	426 (10·4%)
Rectum	427 (6·7%)	150 (6·6%)	277 (6·7%)
Prostate	367 (5·7%)	238 (10·4%)	129 (3·1%)
Non-Hodgkin lymphoma	248 (3·9%)	68 (3·0%)	180 (4·4%)
Corpus uteri	176 (2·8%)	72 (3·2%)	104 (2·5%)
Bladder	172 (2·7%)	47 (2·1%)	125 (3·0%)
Head and neck	164 (2·6%)	47 (2·1%)	117 (2·8%)
Oesophagus	163 (2·6%)	28 (1·2%)	135 (3·3%)
Pancreas	160 (2·5%)	24 (1·1%)	136 (3·3%)
Ovary	156 (2·4%)	41 (1·8%)	115 (2·8%)
Multiple myeloma	94 (1·5%)	22 (1·0%)	72 (1·8%)
Stomach	94 (1·5%)	21 (0·9%)	73 (1·8%)
Kidney	79 (1·2%)	26 (1·1%)	53 (1·3%)
Other*	643 (10·1%)	172 (7·5%)	471 (11·5%)
Combined stage†			
I	1247 (19·5%)	625 (27·4%)	622 (15·1%)
II	1672 (26·2%)	676 (29·6%)	996 (24·2%)
III	1331 (20·8%)	454 (19·9%)	877 (21·3%)
IV	1072 (16·8%)	242 (10·6%)	830 (20·2%)
Missing	404 (6·3%)	170 (7·5%)	290 (7·1%)
NA‡	665 (10·4%)	114 (5·0%)	495 (12·0%)
G8 screening score (0–17)			
Normal (>14)	2281 (35·7%)	NA	NA
Abnormal (≤14)	4110 (64·3%)	NA	NA
Cohort identification§			
Study 1	1025 (16·0%)	354 (34·5%)	671 (65·5%)
Study 2	778 (12·2%)	317 (40·7%)	461 (59·3%)
Study 3	4588 (71·8%)	1610 (35·1%)	2978 (64·9%)
Charlson Comorbidity Index (0–37)			
No comorbidity (score 0)	2158 (33·8%)	988 (43·3%)	1170 (28·5%)
Mild comorbidity (score 1–2)	2659 (41·6%)	907 (39·8%)	1752 (42·6%)
Moderate comorbidity (score 3–4)	1075 (16·8%)	278 (12·2%)	797 (19·4%)
Severe comorbidity (score ≥5)	467 (7·3%)	99 (4·3%)	368 (9·0%)
Missing	32 (0·5%)	9 (0·4%)	23 (0·6%)
Number of current medications			
0–4	3175 (49·7%)	1529 (67·0%)	1646 (40·0%)
≥5	3081 (48·2%)	696 (30·5%)	2385 (58·0%)
Missing	135 (2·1%)	56 (2·5%)	79 (1·9%)
ECOG-PS score			
0	2585 (40·4%)	1600 (70·1%)	985 (24·0%)
1	2076 (32·5%)	574 (25·2%)	1502 (36·5%)
2	850 (13·3%)	75 (3·3%)	775 (18·9%)
3	660 (10·3%)	30 (1·3%)	630 (15·3%)
4	204 (3·2%)	0	204 (5·0%)
Missing	16 (0·3%)	2 (0·1%)	14 (0·3%)
Education level			
Higher	1131 (17·7%)	441 (19·3%)	690 (16·8%)
Upper secondary	1734 (27·1%)	607 (26·6%)	1127 (27·4%)
Lower secondary	2373 (37·1%)	744 (32·6%)	1629 (39·6%)
Primary	654 (10·2%)	144 (6·3%)	510 (12·4%)
Illiterate	42 (0·7%)	3 (0·1%)	39 (0·9%)
Other	53 (0·8%)	11 (0·5%)	42 (1·0%)
Missing	404 (6·3%)	331 (14·5%)	73 (1·8%)
Marital status			
Partnered	3327 (52·1%)	1282 (56·2%)	2045 (49·8%)
Not partnered	2716 (42·5%)	685 (30·0%)	2031 (49·4%)
Other	30 (0·5%)	8 (0·4%)	22 (0·5%)
Missing	318 (5·0%)	306 (13·4%)	12 (0·3%)
Living situation			
Home¶	5014 (78·5%)	2038 (89·4%)	2976 (72·4%)
Home with home care	1190 (18·6%)	233 (10·2%)	957 (23·3%)
Nursing home	187 (2·9%)	10 (0·4%)	177 (4·3%)

Data are n (%), unless otherwise specified. Ethnicity data of patients were not collected. Data were obtained from geriatric screening and assessment studies (age, sex, Charlson Comorbidity index, polypharmacy, ECOG-PS, educational level [self-reported], marital status [self-reported]); Belgian Cancer Registry (tumor type, combined stage); InterMutualistic Agency (living situation). G8=Geriatric 8. NA=not applicable. ECOG-PS=Eastern Cooperative Oncology Group Performance Status. *Frequencies of ≤60 in the full cohort were categorised as other (an exhaustive list of tumour types is included appendix [p 5]). †Combined stage: the pathological stage takes priority over the clinical, except for cases with clinical stage IV, missing pathological stage, or pathological stage defined after neo-adjuvant treatment. ‡TNM staging is not applicable for certain tumour sites (eg, tumours of the central nervous system) or morphology codes (eg, angiosarcoma). §Patients were selected from three consecutive multicentric prospective observational cohort studies (October, 2009 to February, 2015), cohort identification specifies which study (appendix [p 2]). ¶If not home with home care or in nursing home at baseline.

Table 1: **Patient characteristics for the full cohort and cohort stratified by G8 score**

995 (15·6%) patients spent at least 1 day in intensive care with an event rate of 0·36 intensive care days (95% CI 0·35–0·37) per person-year. 5985 (95·2%) of

	Full cohort (n=6391)	Cohort categorised by G8 score		
		Normal G8 score (n=2281)	Abnormal G8 score (n=4110)	p value*
Hospital admissions	0·91 (0·90–0·93)	0·72 (0·70–0·74)	1·06 (1·04–1·08)	<0·0001
Hospital days	11·86 (11·81–11·92)	7·04 (6·97–7·10)	15·47 (15·38–15·56)	<0·0001
Emergency department visits	0·43 (0·42–0·44)	0·30 (0·29–0·32)	0·53 (0·51–0·55)	<0·0001
Intensive care days	0·36 (0·35–0·37)	0·25 (0·24–0·26)	0·44 (0·43–0·46)	<0·0001
GP contacts†	10·96 (10·91–11·02)	8·95 (8·88–9·03)	12·47 (12·40–12·55)	<0·0001
Specialist contacts	9·93 (9·87–9·98)	10·35 (10·27–10·43)	9·61 (9·54–9·68)	<0·0001
Home care days	54·20 (54·08–54·32)	31·45 (31·31–31·60)	71·18 (71·00–71·37)	<0·0001

Data are event rate per person-year (95% CI). A normal G8 score was higher than 14 and an abnormal score was 14 or less. G8=Geriatric 8. GP=general practitioner. *Calculated with Poisson regression. †101 patients registered in community health centres were excluded since the number of GP contacts could not be distinguished.

Table 2: **3-year follow-up of health-care utilisation in older patients after new cancer diagnosis**

6290 patients had at least one contact with a GP with an event rate of 10·96 contacts (95% CI 10·91–11·02) and 6035 (94·4%) of 6391 patients had at least one contact with a specialist with an event rate of 9·93 contacts (95% CI 9·87–9·98) per person-year. During the 3-year follow-up period, overall 4265 (66·7%) of 6391 patients received home care with an event rate of 54·20 days (95% CI 54·08–54·32) per person-year.

The frequency of events for hospital admissions, emergency department visits, GP contacts, and specialist contacts outcomes was highest in the first 3 months after G8 screening (figure 2). After 3 months, the frequency of these events decreased strongly with the exception of GP contacts and home care days, which remained relatively high throughout the 3-year period. The number of hospital admissions and hospital days, emergency department visits, intensive care days, GP contacts, and home care days per 3 months during the 3-year follow-up period was significantly higher among patients with abnormal G8 scores at baseline than those with normal G8 scores at baseline (figure 2). For days spent in intensive care, the number of days per 3 months was only significantly higher for patients with an abnormal G8 score than those with a normal score in the first 2·5 years after G8 screening (figure 2D). For contacts with a specialist, patients with an abnormal G8 score had had significantly fewer contacts per 3 months in the 3-year follow-up period than did patients with a normal G8 score (figure 2F).

On the basis of univariable regression, an abnormal G8 score was associated with a higher risk of increased hospital admissions (RR 1·47 [95% CI 1·41–1·52]), hospital days (2·20 [2·17–2·22]), emergency department visits (1·76 [1·66–1·86]), intensive care days (1·77 [1·67–1·89]), GP contacts (1·39 [1·38–1·41]), and home care days (2·26 [2·25–2·27]) in the 3-year period (table 3). For contacts with a specialist, there was an inverse association (0·93 [0·92–0·94]). After adjustment for case-mix variables, the association between an abnormal G8 score and all outcomes was maintained, although estimated adjusted RRs (aRRs) decreased. Patients with an abnormal baseline G8 score had significantly more hospital admissions (aRR 1·20 [95% CI 1·15–1·25]), hospital days (1·66 [1·64–1·68]), emergency department visits (1·42 [1·34–1·52]), intensive care days (1·49 [1·39–1·60]), general practitioner contacts (1·19 [1·17–1·20]), and home care days (1·59 [1·58–1·60]). The aRR increased for number of contacts with a specialist (0·97 [0·95–0·98]; table 3).

Of the 6204 patients not living in a nursing home at baseline, 547 (8·8%) had a nursing home admission in the 3 years following G8 screening. The nursing home admission occurred after a mean duration of 11·8 months (SD 11·1) after G8 screening and the cumulative risk of being admitted to a nursing home in the 3-year follow-up period was 10·9%. When stratified by G8 score, risk of being admitted to a nursing home was higher among patients with an abnormal G8 score than a normal score (16·7% *vs* 3·1% at 3 years, logrank p<0·0001; figure 3).

At baseline, more patients with an abnormal G8 score were receiving home care or lived in a nursing home than patients with a normal G8 score (figure 4). At 3 years, 1451 (62·3%) of 2281 patients in the normal G8 score group continued to live independently at home and 503 (22·0%) had died, were lost to follow-up, or censored (figure 4; appendix p 7). At 3 years, among the 4110 patients with an abnormal G8 score at baseline, 2191 (53·3%) had died, were lost to follow-up, or censored and 1057 (25·7%) continued to live independently at home. More patients with an abnormal baseline G8 score received home care or lived in a nursing home after 3 years than did patients with a normal G8 score (10·6% *vs* 17·4%; appendix p 7). Of the patients who were alive after 3 years, 180 (10·1%) 1778 in the normal G8 score group and 467 (24·3%) of 1919 patients in the abnormal G8 score group had moved to a more supported living situation (home to home with home care, home to nursing home, or home with home care to nursing home).

Discussion

In this retrospective analysis, we assessed long-term health-care utilisation after cancer diagnosis in older patients with survival of at least 3 months after cancer diagnosis and the association of G8 score with long-term healthcare utilisation. In the first 3 months after diagnosis, the health-care utilisation peaked (typically related to active cancer treatment) and then decreased in the time thereafter. Only GP contacts and home care remained high throughout the whole 3-year period, highlighting primary care as a key element of the health-care system for older patients. Health-care utilisation in terms of hospital admissions, hospital days, emergency department visits, intensive care days, GP contacts, home care days, and nursing home admissions following

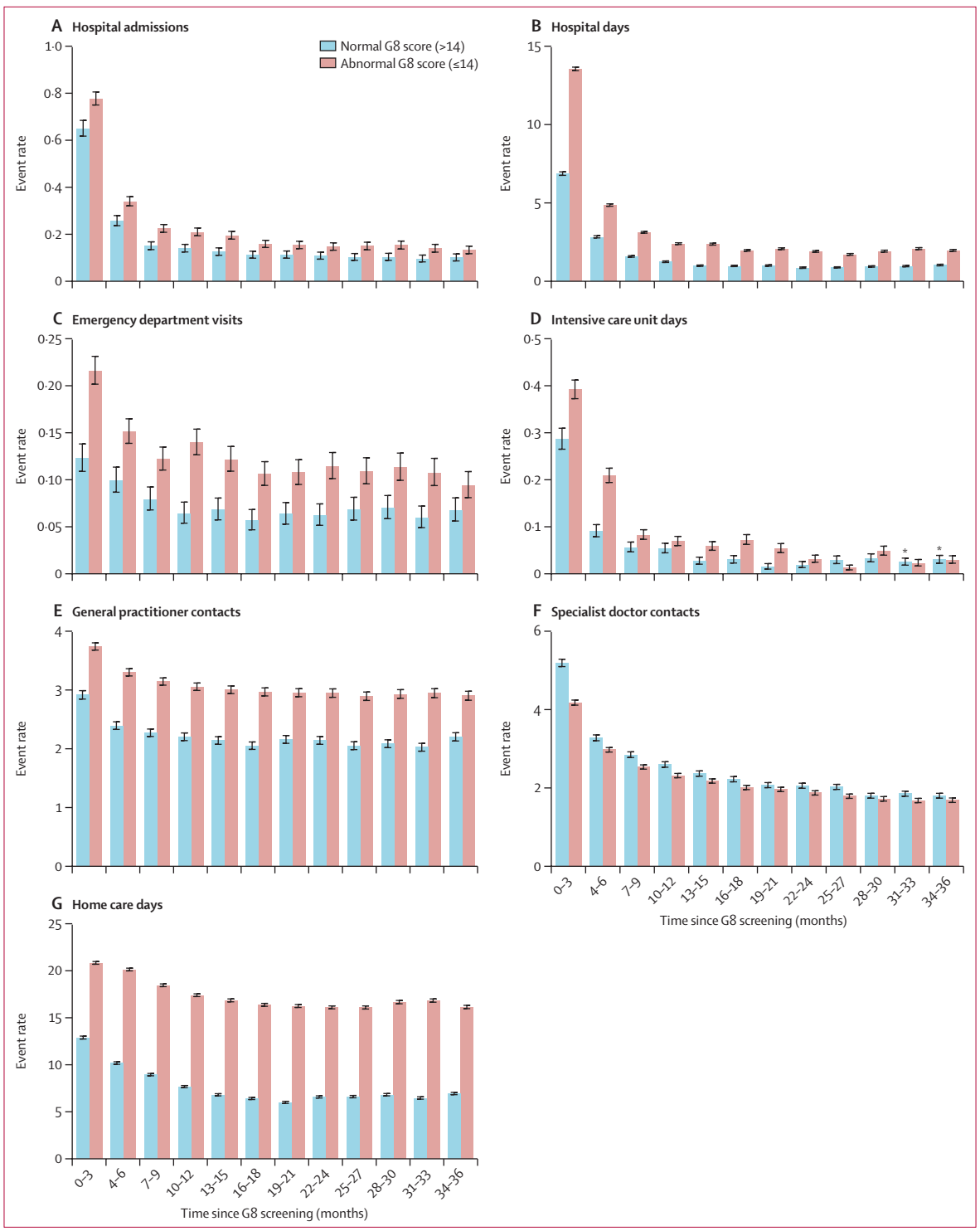

Figure 2: **Health-care utilisation in older patients after new cancer diagnosis**
Event rates are presented per 3 person-months, stratified by baseline G8 screening score. G8=Geriatric 8. *All results statistically significant (p<0·05), unless indicated.

cancer diagnosis was significantly higher among patients with potential frailty based on G8 than patients with a normal G8 score, and this difference persisted over time and after adjustment for confounding variables. Patients with an abnormal G8 score had fewer contacts with a specialist than patients with a normal score.

	Hospital admissions		Hospital days		Emergency department visits		Intensive care days		GP contacts*		Specialist contacts		Home care days	
	RR (95% CI)	p value	RR (95% CI)	p value	RR (95% CI)	p value	RR (95% CI)	p value	RR (95% CI)	p value	RR (95% CI)	p value	RR (95% CI)	p value
Unadjusted														
Normal G8 score	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
Abnormal G8 score	1·47 (1·41–1·52)	<0·0001	2·20 (2·17–2·22)	<0·0001	1·76 (1·66–1·86)	<0·0001	1·77 (1·67–1·89)	<0·0001	1·39 (1·38–1·41)	<0·0001	0·93 (0·92–0·94)	<0·0001	2·26 (2·25–2·27)	<0·0001
Adjusted†														
Normal G8 score	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
Abnormal G8 score	1·20 (1·15–1·25)	<0·0001	1·66 (1·64–1·68)	<0·0001	1·42 (1·34–1·52)	<0·0001	1·49 (1·39–1·60)	<0·0001	1·19 (1·17–1·20)	<0·0001	0·97 (0·95–0·98)	<0·0001	1·59 (1·58–1·60)	<0·0001

G8=Geriatric 8. GP=general practitioner. RR=rate ratio. *101 patients registered in community health centre were excluded since the number of GP contacts could not be distinguished. †Adjusted for age, sex, tumour type, tumour stage, cohort identifier, Charlson Comorbidity Index, educational level, and marital status.

Table 3: **The association of baseline G8 score and health-care utilisation outcomes in older patients in the 3 years after new cancer diagnosis**

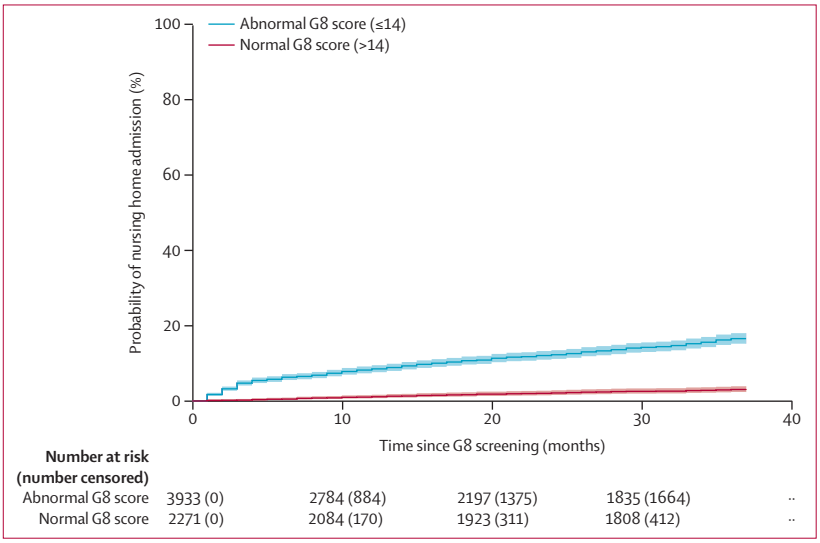

Figure 3: **Probability of nursing home admission after new cancer diagnosis in older patients with cancer, stratified by baseline G8 screening score**
G8=Geriatric 8.

Little research has been done on the long-term health-care utilisation among older patients with cancer and the existing research has mostly focused on specific tumour types and settings (eg, post-operatively, post-chemotherapy) with shorter follow-up. Usually only one or two outcomes regarding health-care utilisation are addressed and not the totality of outcomes across primary, specialty, hospital, and residential care. Direct comparison is thus difficult but generally the number of hospital admissions, hospital days, emergency department visits, GP contacts, and home care days were higher in our cohort than reported elsewhere (eg, 0·91 hospital admissions per person-year *vs* 0·77;[26] 11·9 hospital days per person-year *vs* 2·6;[27] 10·96 GP contacts per year *vs* 3·25[28]).[26–30] This difference could be due to the vulnerability of the included cohort, as reflected by the high proportion of patients with an abnormal G8 score at cancer diagnosis (64%). Existing literature suggests a decrease in health-care use over time with the exception of GP contacts, which is consistent with our results.[27,28,30] This supports evidence of a first acute treatment phase after cancer diagnosis with high overall health-care utilisation and a survivorship phase with focus on primary care.[31]

Our study further focused on the association between the G8 score and long-term health-care utilisation. Patients with an abnormal G8 score had higher health-care utilisation than those with normal scores with the exception of specialist contacts. These patients thus have higher care needs because of their poorer general health status but are perhaps less frequently referred to specialist as a result. Frailty could also physically restrict patients from visiting a specialist and the higher number of GP contacts could indicate that patients with frailty are more often managed by their GP. Research on the association of the G8 with health-care utilisation are scarce and the few studies available only assessed hospital admissions and are restricted by short-term follow-up of 1–12 months. The majority of these studies found that patients with an abnormal G8 score had a higher risk for unplanned hospital admission.[32–36] The diagnostic performance (compared with geriatric assessment, the gold standard to identify frailty) and prognostic value of G8 for overall survival are more frequently investigated and distinguished the G8 as a robust screening tool to identify older patients with a poorer prognosis who need a geriatric assessment.[10,12,21,37] This shows that the current study is, to our knowledge, the first to evaluate the association of the G8 with long-term health-care utilisation in a broad sense, including the patient's trajectory in primary, specialty, hospital, and residential care.

In the full cohort, 66·7% received home care and 8·8% had a new nursing home admission in the 3-year follow-up. Additionally, a discrepancy based on baseline G8 score was observed. In the group with an abnormal G8 score, more patients received home care or lived in a

nursing home after 3 years compared with patients with a normal G8 score (10·6% *vs* 17·4%; appendix p 7). Comparing care transitions at 1-year and 3-year timepoints (appendix p 8), transitions seemed to be mostly already determined in the first year after diagnosis, which emphasises the importance of the first year after diagnosis with regard to patient's independence. Some studies have assessed the use of home and residential care and conclude their use is higher in the older population with cancer than the general older population.[26,38–40] Two of the studies also investigated care transitions in older patients with cancer but focused on home care or residential care alone.[39,40] The findings of these studies also underlined the importance of the first year after cancer diagnosis as a pivotal point in the care trajectory after cancer diagnosis.

All these findings add to the literature supporting the use of G8 in oncology practice. It is not only a useful geriatric screening tool[9] but also a means to identify older patients with a short-term and long-term risk of increased health-care utilisation. This is valuable information to consider in the treatment decision process when selecting therapies with potential toxicity or risk of functional decline. Additionally, the G8 screening tool aids the selection of patients who are at high risk of increased health-care utilisation. Ultimately, geriatric interventions have to be implemented that can optimise outcomes by decreasing adverse health-care utilisation in this population. Randomised controlled trials have shown that geriatric assessment-driven interventions can decrease hospital admissions, emergency department visits, and intensive care unit admissions that are associated with a high burden for older patients.[41,42] The outcomes such as hospital admissions, home care, nursing home admissions, and independent living are also specifically relevant for older patients since they are associated with functional independence, which is of great value during and after cancer treatment. However, G8 is not an optimum screening tool. G8 has a high sensitivity but moderate specificity, resulting in fit patients being wrongly classified as potentially frail with the G8. The sensitivity and specificity might vary by tumour type and modified versions of the G8 have been developed (after completion of the geriatric screening and assessment studies) to optimise its diagnostic performance.[37,43,44] Additionally, many other screening tools exist (eg, Vulnerable Elders Survey-13).[37] Geriatric assessment for all older patients starting cancer treatment remains the gold standard, however, in settings with resource constraints or paucity of geriatrics-trained health-care providers, geriatric screening with G8 is a valid first step in the comprehensive geriatric assessment process.

A major strength of this study is the large cohort of more than 6000 patients, which was representative of nearly all solid and haematological malignancies observed in daily oncology practice in Belgium, thus results should be widely applicable. Furthermore, a variety of outcomes across the spectrum of hospital, primary, specialty, and residential care were studied, providing detailed information on health-care utilisation overall. Additionally, these outcomes were studied over a 3-year period, highlighting long-term care needs, which is usually not feasible in prospective studies. We only performed association statistics and therefore we cannot evaluate the predictive utility of the G8 for long-term health-care utilisation. Furthermore, the analysis was restricted to patients who survived at least 3 months after G8 screening, which is a limitation. The reimbursement data used to measure the outcomes are also not collected for research purposes. This implies that the quality control is less stringent than clinical studies. Furthermore, the financial incentive in the billing of health-care services can disfigure data. These issues are however inherent to this type of data and do not outweigh the benefits. Characteristics of the Belgian health-care system, that is generally easily accessible, also influence the results and can restrict the generalisability to other settings. Additionally, some factors such as treatment or disease relapse that could influence the occurrence of outcomes were not

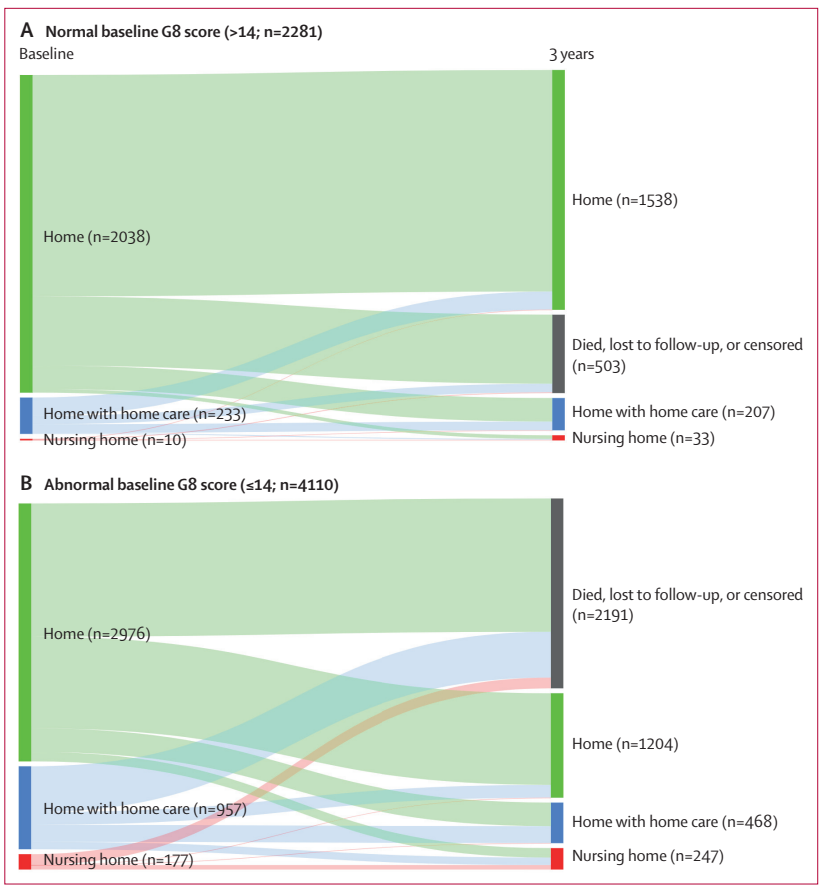

Figure 4: **Sankey diagram of transitions in living situation of older patients with cancer after new cancer diagnosis, by baseline G8 screening score**
G8=Geriatric 8.

considered. However, we did adjust for other important confounding factors such as comorbidities and marital status.

Future studies with a prospective design will be needed to confirm these findings and to identify the cause of increased health-care utilisation in patients with an abnormal G8 scores. Furthermore, comparative analyses between G8 and other geriatric screening tools, such as ECOG-PS, for predicting long-term outcomes would be valuable. Additionally, the impact of geriatric interventions on long-term health-care utilisation should be studied.

In conclusion, this study captured different aspects of the care pathway of older patients after cancer diagnosis through the unique linkage of clinical and population-based data. In older patients, health-care utilization peaked in the first 3 months after diagnosis, after which primary care remained the main pillar of care. Furthermore, we demonstrated that an abnormal baseline G8 score is strongly associated with increased long-term health-care utilisation in terms of hospital admissions, hospital days, emergency department visits, intensive care days, GP contacts, home care days, and nursing home admissions in the older population with cancer. This information could be valuable in the cancer treatment decisions process and to enable discussion around expectations regarding short-term and long-term health-care support with older patients.

Contributors

LD, CK, FV, and HW conceived and initiated the study, and supervised its conduct and data analysis. VD and KVans accessed and verified the data and performed data analysis. VD, KVans, LD, GS, CK, FV, and HW performed data interpretation, manuscript preparation, and editing. All authors had access to the data included in the manuscript, contributed to data collection, reviewed the manuscript, approved the final version of the manuscript for publication, and had final responsibility for the decision to submit for publication.

Declaration of interests

LD reports a research grant (via their institution) from Boehringer Ingelheim; consulting fees from Roche; lecture fees from Roche, Bristol Myers Squibb, MSD, Servier, and Sanofi; travel expenses from Roche, AstraZeneca, and MSD; and advisory board fees from MSD, Bristol Myers Squibb, and AstraZeneca. PRD reports a research grant (via their institution) from Pfizer; consulting fees from Bristol Myers Squibb, Merck/Pfizer, and Ipsen; lecture fees from Bayer; travel expenses from Janssen; and owns stock in Alkermes and Biocartis Group NV. GJ reports research grants (via their institution) from Novartis, Roche, and Pfizer; and reports consulting fees, lecture fees, travel expenses, or advisory board fees from Novartis, Amgen, Roche, Pfizer, Bristol Myers Squibb, Eli Lilly, AstraZeneca, Daiichi Sankyo, AbbVie, Seagen, Medimmune, and Merck. DB reports consulting fees from Incyte and travel expenses from the European Hematology Association, I-Well, Abbvie, and Janssen. JF received advisory board fees or lecture fees (via their institution) from Pfizer, GlaxoSmithKline, Merck, and Janssen. HW received research grants (via their institution) from Roche, Novartis, and Gilead; and received consulting fees, lecture fees, or travel expenses from AbbVie, Daiichi, Gilead, Eli Lilly, Pfizer, AstraZeneca, EISAI, Immutep Pty, MSD, AstraZeneca Ireland, and Relay Therapeutics. All other authors declare no competing interests.

Data sharing

The linked data used in the current study are not publicly available because of data protection and security reasons. The study protocol, programming code, and summarised data are available from the corresponding author upon reasonable request.

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