COVID-19 related mortality in a real-world cohort of 18,883 patients with pre-malignant and malignant haematological neoplasms: an analysis from the UK's Haematological Malignancy Research Network

Alexandra Smith[1], Clare Frobisher[1], Abraham Varghese[2], Andy Rawstron[3], Simon Crouch[1], Debra Howell[1], Adele Fielding[4], Kirstine Eastick[5], Catherine Cargo[3], Cathy Burton[3], Gordon Cook[2], Nicholas Easom[5], Reuben Tooze[3], Patrick Lillie[5], Eve Roman[1], Russell Patmore[6]

[1] Epidemiology & Cancer Statistics Group, Department of Health Sciences, Centre for Blood Research, University of York, York, YO10 5DD
[2]Department of Haematology, Leeds Cancer Centre, St James's University Hospital, LS9 7LP, UK
[3]Haematological Malignancy Diagnostic Service, St. James's Institute of Oncology, Leeds, LS9 7LP, UK
[4]Hull York Medical School, University of York, Centre for Blood Research, York, YO10 5DD
[5]Department of Infection, Hull University Teaching Hospitals NHS Trust, Hull HU16 5JQ, UK
[6]Queen's Centre for Oncology and Haematology, Castle Hill Hospital, Cottingham, United Kingdom

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Abstract (200 words)

When WHO declared the global COVID-19 pandemic, it was recognised that patients with haematological cancers would be more susceptible to severe disease. Set within a UK population of ~4 million (https://hmrn.org/), all patients diagnosed with haematological neoplasms 2005-2019 who were alive on the 01/01/2020 were followed-up until March 2023. For comparative purposes, a similar age- and sex-matched general population cohort was also constructed. COVID-19 deaths were classified using ICD-10 codes and a multiple cause of death analysis was undertaken using a competing risk approach. Deaths of 486/18,883 haematology patients were attributed to COVID-19, yielding a cumulative incidence of 2.59% (95% Confidence Interval: 2.37-2.82) that was significantly higher than that of the general population (1.65; 95%CI:1.58-1.72). In both cohorts, risks were higher in men, older people, and those with co-morbidities. Within the patient cohort, excess mortality was largely concentrated in those suffering from more indolent conditions.

Patients with the premalignancy MBL, suffered the highest excess mortality in the early phase of the pandemic when, unlike patients with malignancies, they were not advised to shield. Effects of shielding were evident and a clear vaccination benefit was demonstrated, with the exception of CLL and MCL; findings that warrants consideration in relation to other viruses.

Introduction

Caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), COVID-19 was declared a global pandemic by the World Health Organization (WHO) in March 2020.[1] At that time the UK government recognised that some people would be more susceptible to the effects of COVID-19 than others; this included patients with haematological cancers, particularly those undergoing treatment with immunotherapy and/or those who had recently been transplanted. Accordingly, in addition to national lockdown restrictions, specific guidance for those deemed to be clinically extremely vulnerable (CEV) was put in place; this included staying at home for an initial 'shielding' period of at least 12 weeks.[2,3]

Within the first few months of the pandemic it became rapidly apparent that along with older adults and individuals with serious comorbidities, patients with haematological malignancies were indeed at increased risk of severe disease and death than others[4–7] and these findings were confirmed throughout the pandemic.[7–12] Strong associations with age were observed, as seen in the general population; patients over 70 years who contracted SARS-CoV-2 being two to three times more likely than those under 60 years to suffer severe/critical infection.[4,13] Early studies also confirmed acute leukaemia patients were at an increased risk from COVID-19[8,14], and associations have also been reported for lymphoid malignancies especially for chronic lymphocytic leukaemia (CLL)[15–17] and multiple myeloma.[4,8,18,19] These increase risks are thought to be related not only to impaired immune capacity due to immune dysregulation, but also to treatment-related immunosuppressive therapies including B-cell maturation antigen directed therapy, anti-CD20 and anti-CD38 antibodies.[17,18] Furthermore, in addition to monitoring the impact on patients of contracting COVID-19, later studies demonstrated that patients with mature B-cell neoplasms tended to have comparatively low seropositivity rates after COVID-19 vaccination.[20,21]

Covering the full age-spectrum, and comprising over 100 disease subtypes with variable prognoses, therapies and outcomes,[22] the diversity of haematological malignancies makes them one of the most challenging cancer groups to study. Accordingly, population-based data on the full spectrum of haematological malignancies are sparse.[12,23,24] The data included in the present report are from the UK's Haematological Malignancy Research Network (https://hmrn.org/), one of the first specialist registries to be predicated on WHO's ICD-O-3 disease classification and this report focuses on COVID-19 related mortality in haematological neoplasms patients in the three years since the pandemic was declared.

Methods

Initiated in 2004 with the aim of providing robust generalisable data to inform research and clinical practice, HMRN's methods are fully described elsewhere.[25] Briefly, HMRN's catchment population of ~4 million has a sociodemographic profile that is broadly representative of the UK as a whole and clinical practice across the region's 14 hospitals adhere to national guidelines. All patients with haematological cancer or a related disorder within the region are registered on the day they are diagnosed. Diagnoses are centrally made and coded to the latest WHO classification[22] by clinical specialists working at a single integrated haematopathology laboratory, the Haematological Malignancy Diagnostic Service (https://hmds.info/).

HMRN has full ethical approval and Section 251 support under the NHS Act 2006. These permissions allow diagnostic, prognostic and treatment data to be collected from clinical systems, and also allow NHS England to routinely provide nationwide information on deaths, cancer registrations and Hospital Episode Statistics (HES) including admitted patient care (HES-APC). The Charlson Comorbidity Index (CCI) Score[26] was calculated for each patient using ICD-10 codes from HES-APC from 6-years prior to the 1st January, 2020. The income domain of the Index of Multiple Deprivation (IMD)[27](Q1 representing the most affluent fifth of the population) was used as a marker of socio-economic status. Facilitating analyses that require comparisons to be made between people with haematological cancers and unaffected individuals from the general population, each patient diagnosed between

2009 and 2015 (n=18,127) was matched on sex and year of birth to 10 randomly selected controls from the NHS Central Register by NHS England (https://digital.nhs.uk/).[25] All controls resided in the region when their corresponding case was diagnosed, and all are linked by NHS England to the same national databases as the case cohort.

Patients newly diagnosed with a haematological neoplasm 1st January 2005 to 31st December 2019 who were alive on the 1st January 2020 were included in the analysis. Patients were followed-up to the 31st March 2023, and for patients who died information from their death certificate was used to classify cause of death. To ensure that the impact of COVID-19 was not underestimated due to changes in the recording of COVID-19 as a cause of death, coupled with the recognition that many COVID-19 deaths may be influenced by pre-existing co-morbidities, a multiple causes of death (MCoD) analysis[28] was undertaken; wherein any mention on the death certificate of COVID-19, either as an underlying cause of death (UCoD) or contributing causes of death (CCoD), was counted as a COVID-19 related death. Individuals were classified as having a COVID-19 related death using the ICD-10 codes introduced by WHO specifically for this purpose[29]: U07.1 (COVID-19, virus identified); U07.2 (COVID-19, virus not identified); U09.9 (post-COVID-19 condition, unspecified (not used for UCoD)); and U10.9 (multisystem inflammatory syndrome associated with COVID-19, unspecified).

Accounting for deaths from haematological neoplasm (UCoD ICD 10: C81-C96, D45-D47) and other non-COVID-19 causes, a competing risk analysis was used to assess the risk of dying from COVID-19. Survival was examined from the 1st January 2020 to date of death; patients who were still alive were censored at the end of follow-up (31st March, 2023). Analyses were performed using Stata 18 and the risk of death from COVID-19 was calculated using the Stata command 'stcompet', with all other CoDs as competing risks. Statistical significance was assessed by applying a weighted log-rank test defined using the 'stcrprep' command. Associations between baseline socio-demographic and diagnostic factors with COVID-19 mortality were estimated using cause-specific subhazard ratios (sHR) using the Stata command 'stcrreg', based on the method of Fine and Gray[30], adjusting for age, sex, diagnosis, socioeconomic status and co-morbidity. To assess the risk of dying from COVID-19

in people without a haematological neoplasm, the analyses were repeated in the sex- and age- matched general population cohort.

Results

Of the 35,876 patients newly diagnosed with a haematological neoplasm 2005-2019, 18,883 were still alive on the 1st January 2020 (Table 1). Median age of the patients was 71.8 years, there was a slight male predominance (54.3%), a quarter had a co-morbidity score of two or more, and proportionally fewer lived in deprived areas (Table 1). During the 39-month follow-up period (1st January 2020 to 31st March 2023), 21.9% (4,132/18,883) patients died; 32.2% of these deaths (n=1,330) were attributed to haematological neoplasms, and 11.8% (n=486) to COVID-19. Of the 486 COVID-19 deaths, 396 had COVID-19 recorded as the underlying cause and 90 as a contributory cause. The remaining 56% (n=2,316) deaths were attributed to causes other than haematological malignancy or COVID-19.

The cumulative incidence (risk) of death from COVID-19 was 2.59 (95% Confidence Interval (95%CI): 2.37-2.82), with a higher risk in males (2.91, 95%CI: 2.60-3.25) than females (2.20, 95%CI: 1.91-2.53), p=0.0016. Older patients had higher risks than younger patients; cumulative incidence 5.27 (95%CI: 4.65-5.94) in those over 80 years, and 0.13 (95%CI: 0.04-0.36) in those under 50 years (p<0.0001). Although patients living in the most affluent areas (IMD 1) had the lowest incidence (1.94, 95%CI: 1.55-2.39, p=0.013), no trend with increasing deprivation is evident. As might be expected, the presence of co-morbidities was, however, associated with higher COVID-19 mortality; cumulative incidence 4.86 (95%CI: 4.27-5.49) in those with a co-morbidity score of two or more, compared to 1.55 (95%CI: 1.33-1.81) in those with no co-morbidities (p<0.0001). Adjustment for potentially confounding effects of age, sex, deprivation, co-morbidity score and diagnosis did not alter the associations observed, as evident by the reported sub-hazard ratios (sHRs) (Table 1).

With respect to comparisons with the general population, 15% (19,923/132,955) of individuals in the age and sex matched general population cohort died during follow-up (Supplementary Table 1), with 2,190 (11.0%) of these having a COVID-19 MCoD assigned (Figure 1). As expected, the corresponding risk of COVID-19 death was significantly lower (1.65, 95% CI: 1.58-1.72) than in the patient cohort (2.59, 95% CI: 2.37-2.83); but the same

broad trends with sex, age and co-morbidity are evident in both cohorts. Interestingly, however, the increasing risk by deprivation in the general population is less clearly evident in the patient cohort. Similar results were seen when the analyses were repeated for patients diagnosed 2009-2015 and their matched controls (Supplementary Table 2).

Figure 2 shows that patients with haematological neoplasms were at an increased risk of death from the outset of the pandemic. This was apparent during the national shielding period (22nd March, 2020 to 17th September, 2021). When the national vaccination programme opened on 18th January 2021, CEV patients were prioritised, along with those over 70-years. The third lockdown ended around six month later; after which, coinciding with new variants emerging, the risk among patients continued to increase and further diverge from that of the general population. The cumulative incidences for landmark time-periods are reported in Supplementary Table 3.

Subtype-specific COVID-19 mortality data are presented in Figure 3 and Table 2. As illustrated in Figure 3, cumulative incidence was lowest for aggressive conditions; for example, B-lymphoblastic leukaemia (B-ALL), classical Hodgkin lymphoma (CHL), Burkitt lymphoma (BL), large B-cell lymphoma (LBCL) and acute myeloid leukaemia (AML). Conversely, risks were highest among those with diseases that tend to follow chronic remitting-relapsing pathways; for example, mantle cell lymphoma (MCL), myelodysplastic syndromes (MDS), chronic lymphocytic leukaemia (CLL), and myeloma. The contributory role of age is also a factor, since sub-types with the lowest cumulative incidence of death (e.g. B-ALL and CHL) are more likely to be diagnosed at younger ages where the risk of dying from COVID-19 is low, whereas those with the highest cumulative incidence (e.g. MCL, CLL and myeloma) typically occur in those over sixty.

Based on conditions with more than 10 COVID-19 deaths, and using the largest diagnostic group (LBCL) as the baseline comparator, unadjusted and adjusted (sex, age, deprivation and co-morbidity) sHRs are shown in Table 2. Notably, albeit lower than those observed for their malignant counterparts (CLL and myeloma), increased risks of death are also evident for monoclonal B-cell lymphocytosis (MBL) and monoclonal gammopathy of undetermined significance (MGUS); the adjusted sHRs being 1.97 (95%CI: 1.07-3.60) and 1.69 (95%CI: 1.10-

2.60) respectively (MBL patients that progressed to CLL (119/579) and MGUS patients that progressed to myeloma (95/2864) during the 39 months of follow-up were excluded from these analyses).

In contrast to patients with malignant disease, those with MBL and MGUS were not categorised as CEV therefore not advised to shield during the pandemic. The impact of this is evident in Figure 4 which shows the cumulative incidence of COVID-19 death in the general population (black line), the four largest malignant lymphoid subtypes (myeloma, CLL, LBCL, and FL), and the premalignancies MBL and MGUS. MBL patients appeared most at risk at the beginning of the pandemic, but their risk diminished markedly after the vaccination program started. By contrast, although plateauing slightly at the beginning of the vaccination program, the incidence of COVID-19 deaths among patients with CLL continued to rise when shielding and lockdown ended. Likewise, although less marked, post shielding/lockdown increases are also evident for other subtypes, most notably follicular lymphoma (FL). In contrast, the cumulative incidence of COVID-19 deaths in both the general population and LBCL survivors is modest.

The majority of CLL patients did not receive any chemotherapy before the 31st March 2023 (Table 3), with 72.5% (1,672/2,305) managed on Watch & Wait (W&W) and a cumulative COVID-19 incidence of 4.02 (95% CI: 3.15-5.04). The risk among the 633 CLL patients who were treated was marginally higher (6.04, 95% CI: 4.51-7.86), but whether or not therapy was delivered before or during the pandemic (1st January 2020 to 31st March 2023) had little impact. Whilst the findings for myeloma are broadly similar to CLL, patients with FL and LBCL who received treatment during the pandemic had higher risks; 7.15 (95% CI: 4.46-10.66) for FL and 4.23 (95% CI: 2.08-7.55) for LBCL. Unfortunately, it was not possible to evaluate the risk separately for rituximab as the majority of treated FL (87%) patients and LBCL (97%) patients received immunochemotherapy or maintenance therapy.

Discussion

Findings from our large population-based cohort confirm that haematological neoplasm patients were at higher risk of COVID-19 mortality than their age and sex matched general population counterparts. The impact was greatest among patients with chronic disorders like myeloma, CLL, and MDS. Whilst the introduction of the vaccination programme was accompanied by a reduction in COVID-19 deaths across the general population, the same effects were not seen for all haematological malignancy subtypes. Most notably, COVID-19 mortality continued to increase at the same rate in CLL patients. Furthermore, although there was some reduction in patients with myeloma and follicular lymphoma, the slope continued to diverge from that seen in the general population. Moreover, from the start of the pandemic patients with the premalignant conditions MGUS and MBL also exhibited increased COVID-19 mortality. Unlike those with malignant disorders, these individuals were not categorised as clinically vulnerable, and so were not advised to shield. The findings are particularly striking for MBL, where pre-vaccination mortality markedly exceeded that of any other group.

Previous mortality studies have largely been conducted in patients with a confirmed diagnosis of COVID-19, generally among patients hospitalised as a consequence of their COVID-19 diagnosis. Few population-based series[14,23] exist, and as far as we are aware this is the only population-based cohort study that has tracked patients from the start of the pandemic. In light of findings from earlier studies reporting suboptimal immune response in patients with lymphoid neoplasms.[20,21,31–33], many blood cancer patients would have been identified as extremely vulnerable and advised to shield at the start of the pandemic. Most of these would also have been given priority during the vaccination programme commencing January 2021. For some diagnoses, risk continued to increase after the roll-out of the vaccination programme. This was most notably in patients with CLL who have been reported to have impaired vaccination responses[32,34,35], importantly, this difference is unlikely to be solely due to exposure to CLL therapy as a significant proportion of CLL patients had not been treated (72.5%). In contrast, MBL patients, the majority of which are high-count MBLs, appeared to have responded well to COVID-19 vaccination. Furthermore, although challenging to examine in rarer subtypes, patients with mantle cell lymphoma (MCL) appear to exhibit similar trends to those with CLL; the cumulative incidence of COVID-19 death increasing to 5.04% (95%CI: 2.23-9.56) after shielding ended (Supplementary Table

3). Confirming findings from the European MCL Register this supports their call for effective vaccination of MCL patients.[36] Unfortunately, we were unable to examine risk by vaccination status, as this information was not available. However, vaccine uptake was high in England with 90.7% of adults receiving at least one vaccination and 75.8% at least three by March, 2023.[37]

Findings from studies that have examined whether there is an association between active chemotherapy and COVID-19 mortality have been inconsistent.[4,8,38–42] We observed increased risks for LBCL and FL patients on current treatment, and it is likely that despite vaccination, ongoing therapy in patients with FL is contributing to the significant excess COVID-19 mortality. On the other hand, we found that CLL and myeloma patients who received active treatment during the pandemic had similar risks to those who did not. Indeed, comparable to the findings by Mato et al[43], CLL patients who had not been treated experienced a similar incidence of COVID-19 related death to those treated. In contrast, the European Research Initiative on CLL reported that untreated CLL patients with confirmed COVID-19 had a lower risk of death than their treated counterparts.[17,44] In comparing our findings to those of others, it is important to note the design differences between studies. Our cohort comprised patients that had already been diagnosed with a haematological malignancy when the pandemic started, and patients newly diagnosed during the pandemic were not included; accordingly, for conditions that are generally treated intensively immediately after diagnosis, such as acute myeloid leukaemia, the impact of COVID-19 may not have been fully captured.

Major strengths of our study, include its large well-defined population-based catchment area, completeness of case ascertainment, active follow-up via tracking through national systems and integrated single centre diagnostics. Furthermore, the catchment population has a socio-demographic profile that is broadly representative of the UK, the findings reported here can be extrapolated to the UK as a whole. Examining the risk of COVID-19 by ethnicity in our catchment population is however challenging, as in common with many areas in the UK 90% of patients in older age groups self-identify as white. Indeed, of the 486 patients who died of COVID-19, 93.8% were white; 3.3% Asian and 1.4% Black. This contrasts with London, the UK's most ethnically diverse region; indeed, in the study by Shah

et al[45] examining outcomes in haematological malignancy patients admitted with COVID-19 to King's College Hospital London, 60.3% of patients were white, 5.9% Asian and 27.9% Black. Indeed, as these findings are predominantly from a white population, the findings may not be generalisable to other populations around the world.

To minimise potential inaccuracies resulting from deciding whether a person died "from COVID-19" or "with COVID-19", in line with the UK's Office for National Statistics we based our analyses on any mention of COVID-19 on the death certificate. Reassuringly, however, it is worth noting that the proportion of patients that had COVID-19 recorded as the underlying cause were broadly similar in the patient (81.5%) and comparison (84.4%) cohorts. This did not differ substantially by diagnostic subtype (Supplementary Table 4), with the exception of some of the myeloid conditions including chronic myeloproliferative neoplasms (57.1%) and myelodysplastic syndromes (66.7%). A further limitation is that we could not investigate whether any inaccuracies in cause of death recording were exacerbated by differential COVID-19 testing, as information on testing was not available in this study.

The impacts of COVID-19 described here have significant implications for both clinical management and public health policies relating to haematological neoplasms patients. It is clear that, with the exception of CLL, vaccination effectively reduces COVID-19 associated mortality, although this may be mitigated by ongoing therapy in some conditions. The notably high early mortality in patients with MBL strongly suggests that shielding could have reduced deaths, and that these patients would have benefitted from the same advice as those with more advanced disease. This illustrates an unintended negative consequence linked to the necessary but somewhat arbitrary diagnostic criteria that separate malignant and pre-malignant haematological conditions based on estimates of disease burden. It is also clear that vaccination was highly effective for these patients. Current haematological practice does not routinely seek to identify, manage or advise patients with MBL, and to do so would have significant resource implications. However, nuanced approaches based on disease burden could be envisioned. It seems likely that patients with MGUS may also have benefited from similar shielding and vaccination advice, albeit to a lesser extent than those with MBL.

In conclusion, charting the mortality of an unselected cohort of patients with a haematological neoplasm through the COVID-19 pandemic, our findings confirm the virus's deleterious impact, demonstrating that those diagnosed with chronic and premalignant conditions were particularly susceptible. The consequence of national policies such as shielding and the effect of the vaccination programme can clearly be seen; the latter having a clear benefit for all patients with the exception of patients diagnosed with CLL. Although our study is specific to COVID-19 infection, the findings should be considered in relation to other viruses, such as influenza and respiratory syncytial virus that also can cause increased morbidity and mortality in patients with haematological malignancy.

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Data Sharing

Ethical approvals and data restrictions mean that data cannot be shared, but collaborative projects can be undertaken. The corresponding author can be contacted for more information.

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Table 1 Characteristics of patients diagnosed 2005 to 2019 who were alive on the 1st January 2020, followed up to 31st March 2023; distributed by cause of death, cumulative incidence, and subhazard ratio for COVID-19 related deaths

	Patients n (%)						Cause of Death - COVID-19		
			Cause of Death						
	Total	Died after 1st Jan, 2020	Haematological Neoplasm[1]	Other Causes	COVID-19[2] Multiple Causes (MCoD)		Cumulative Incidence (95% CI)	Unadjusted subhazard ratios (95% CI) [3]	Adjusted subhazard ratios (95% CI)[4]
Total	**18883 (100)**	**4132 (21.9)**	**1330 (32.2)**	**2316 (56.0)**	**486 (11.8)**		**2.59 (2.37-2.82)**	**-**	**-**
Sex									
Male	10255 (54.3)	2345 (56.8)	785 (59.0)	1263 (54.5)	297 (61.1)		2.91 (2.60-3.25)	1.00 (baseline)	1.00 (baseline)
Female	8628(45.7)	1787 (43.2)	545 (41.0)	1053 (45.5)	189 (38.9)		2.20 (1.91-2.53)	0.75 (0.63-0.90)	0.75 (0.62-0.90)
Age on the 1st January, 2020 (years)									
Median (IQR)	71.8 (60.8-79.9)	80.6 (73.2-86.4)	77.4 (70.4-83.9)	82.2 (75.1-87.5)	80.0 (72.7-85.8)				
<50	2376 (12.6)	63 (1.5)	35 (2.6)	25 (1.1)	3 (0.6)		0.13 (0.04-0.36)	-	-
50-59	2109 (11.2)	143 (3.5)	70 (5.3)	50 (2.2)	23 (4.7)		1.10 (0.72-1.62)	0.69 (0.43 - 1.11)	0.75 (0.46 - 1.21)
60-69	3905 (20.7)	473 (11.4)	204 (15.3)	207 (8.9)	62 (12.8)		1.60 (1.24-2.03)	1.00 (baseline)	1.00 (baseline)
70-79	5829 (30.9)	1292 (31.3)	463 (34.8)	676 (29.2)	153 (31.5)		2.63 (2.24-3.07)	1.66 (1.24 - 2.23)	1.61 (1.19 - 2.16)
≥80	4664 (24.7)	2161 (52.3)	558 (42.0)	1358 (58.6)	245 (50.4)		5.27 (4.65-5.94)	3.37 (2.55 - 4.45)	3.01 (2.26 – 4.00)
Index of Multiple Deprivation (Income Domain)									
1 – Affluent	4197 (22.2)	920 (22.6)	304 (22.9)	535 (23.1)	81 (16.7)		1.94 (1.55-2.39)	1.00 (baseline)	1.00 (baseline)
2	4210 (22.3)	923 (22.6)	312 (23.5)	490 (21.2)	121 (24.9)		2.89 (2.41-3.43)	1.49 (1.13-1.98)	1.55 (1.17-2.04)
3	3557 (18.8)	785 (19.3)	264 (19.8)	439 (19.0)	82 (16.9)		2.32 (1.86-2.85)	1.20 (0.88-1.63)	1.23 (0.90-1.67)
4	3133 (16.6)	683 (16.8)	219 (16.5)	369 (15.9)	95 (19.5)		3.05 (2.49-3.70)	1.58 (1.18-2.13)	1.64 (1.22-2.21)
5 – Deprived	3519 (18.6)	766 (18.8)	221 (16.6)	446 (19.3)	99 (20.4)		2.83 (2.32-3.42)	1.46 (1.09-1.97)	1.71 (1.27-2.30)
Not Known	267 (1.4)	55 (1.3)	10 (0.8)	37 (1.6)	8 (1.6)		-	-	-
Co-morbidity Score excl. malignancy									
0	10138 (53.7)	1290 (31.2)	477 (35.9)	656 (28.3)	157 (32.3)		1.55 (1.33-1.81)	1.00 (baseline)	1.00 (baseline)
1	3906 (20.7)	885 (21.4)	313 (23.5)	472 (20.4)	100 (20.6)		2.57 (2.10-3.10)	1.66 (1.29-2.14)	1.38 (1.07-1.78)
≥2	4721 (25.0)	1943 (47.0)	538 (40.5)	1176 (50.8)	229 (47.1)		4.86 (4.27-5.49)	3.19 (2.60-3.90)	2.14 (1.73-2.66)
Not Known	118 (0.6)	14 (0.3)	2 (0.2)	12 (0.5)	-				

[1] ICD 10 codes: C81-C96, D45-47. [2] Multiple Causes (MCoD): U07.1, U07.2, U09.9, U10.9. [3] Subhazard ratios estimated for categories >10 MCoD COVID-19 deaths, [4]adjusted for sex, age, Index of Multiple Deprivation (income domain), diagnosis group & co-morbidity score

Table 2 Patients diagnosed with a haematological malignancy 2005-19 who were alive on the 1st January 2020, followed up to 31st of March 2023; distributed by subtype, cause of death, cumulative incidence of death, and subhazard ratio for COVID-19 related deaths (multiple causes – MCoD): Haematological Malignancy Research Network

	Patients n (%)							Cause of Death - COVID-19[3]		
Diagnosis [1]	Total	Median age 1st Jan, 2020 (years)	Died after 1st Jan, 2020	Cause of Death				Cumulative Incidence (95% CI)	Unadjusted subhazard ratios (95% CI)[5]	Adjusted subhazard ratios (95% CI) [6]
				Haematological Neoplasm[3]	Other Causes	COVID-19[4]				
All diagnoses	**18883**	71.9	**4132 (21.9)**	**1330 (32.2)**	**2316 (56.0)**	**486 (11.8)**		**-**	**-**	**-**
Myeloid										
Chronic myeloid leukaemia	429	61.4	56 (13.1)	13 (23.2)	39 (69.6)	4 (7.1)		0.93 (0.32-2.25)	-	-
Myelofibrosis	135	74.5	62 (45.9)	30 (48.4)	24 (38.7)	8 (12.9)		5.93 (2.77-10.78)	-	-
Chronic MPNs	2181	72.6	439 (20.1)	92 (21.0)	312 (71.1)	35 (8.0)		1.61 (1.14-2.21)	1.21 (0.74-1.99)	1.17 (0.71-1.92)
CMML	108	75.0	67 (62.0)	38 (56.7)	25 (37.3)	4 (6.0)		3.70 (1.21-8.53)	-	-
Myelodysplastic syndromes	358	77.0	195 (54.5)	100 (51.3)	77 (39.5)	18 (9.2)		5.05 (3.11-7.67)	3.87 (2.14-7.01)	2.75 (1.52-5.00)
Acute myeloid leukaemia	356	61.0	92 (25.8)	70 (76.1)	16 (17.4)	6 (6.5)		1.69 (0.70-3.47)	-	-
APL	89	52.9	3 (3.4)	1 (33.3)	2 (66.7)	-		-	-	-
Lymphoid										
B-lymphoblastic leukaemia	358	14.8	22 (6.1)	17 (77.3)	4 (18.2)	1 (4.5)		0.28 (0.03-1.48)	-	-
T-lymphoblastic leukaemia	88	23.5	3 (3.4)	2 (66.7)	-	1 (33.3)		1.15 (0.10-5.58)	-	-
MBL[2]	579	75.6	123 (21.2)	-	104 (84.6)	19 (15.4)		3.30 (2.06-4.99)	2.51 (1.40-4.50)	1.97 (1.07-3.60)
Chronic lymphocytic leukaemia	2344	73.6	544 (23.2)	134 (24.6)	295 (54.2)	115 (21.1)		4.92 (4.09-5.85)	3.74 (2.48-5.66)	3.22 (2.14-4.87)
Hairy cell leukaemia	143	71.0	15 (10.5)	8 (53.3)	7 (46.7)	-		-	-	-
LPD, NOS	573	77.1	179 (31.2)	41 (22.9)	113 (63.1)	25 (14.0)		4.39 (2.92-6.29)	3.35 (1.95-5.74)	2.46 (1.42-4.24)
Marginal zone lymphoma	1161	74.0	262 (22.6)	77 (29.4)	159 (60.7)	26 (9.9)		2.24 (1.50-3.22)	1.70 (0.99-2.90)	1.45 (0.85-2.47)
MGUS[2]	2864	75.7	620 (21.6)	8 (1.3)	529 (85.3)	83 (13.4)		2.91 (2.34-3.58)	2.21 (1.44-3.39)	1.69 (1.10-2.60)
Plasmacytoma	94	69.6	15 (16.0)	9 (60.0)	4 (26.7)	2 (13.3)		2.15 (0.41-6.82)	-	-
Myeloma	1452	72.6	533 (36.7)	336 (63.0)	150 (28.1)	47 (8.8)		3.25 (2.43-4.26)	2.47 (1.54-3.94)	2.11 (1.32-3.38)
Follicular lymphoma	1272	69.5	198 (15.6)	63 (31.8)	103 (52.0)	32 (16.2)		2.54 (1.78-3.52)	1.91 (1.15-3.16)	2.01 (1.20-3.35)
Mantle cell lymphoma	177	72.3	57 (32.2)	25 (43.9)	20 (35.1)	12 (21.1)		6.82 (3.72-11.18)	5.23 (2.67-10.26)	4.56 (2.30-9.04)
Large B-cell lymphomas	2111	71.1	383 (18.1)	132 (34.5)	223 (58.2)	28 (7.3)		1.33 (0.91-1.90)	*1.00 (baseline)*	*1.00 (baseline)*
Burkitt lymphoma	113	35.5	11 (9.7)	5 (45.5)	5 (45.5)	1 (9.1)		0.88 (0.08-4.38)	-	-
Peripheral T-cell lymphomas	126	62.9	29 (23.0)	21 (72.4)	7 (24.1)	1 (3.4)		0.79 (0.07-3.96)	-	-
Cutaneous T-cell lymphomas	79	67.7	16 (20.3)	5 (31.2)	8 (50.0)	3 (18.8)		3.80 (1.01-9.73)	-	-
LGL leukaemia	120	73.0	25 (20.8)	7 (28.0)	16 (64.0)	2 (8.0)		1.67 (0.33-5.36)	-	-
Classical Hodgkin lymphoma	1032	44.0	69 (6.7)	24 (34.8)	40 (58.0)	5 (7.2)		0.49 (0.19-1.09)	-	-
NLPHL	155	51.2	12 (7.7)	2 (16.7)	8 (66.7)	2 (16.7)		1.29 (0.26-4.21)	-	-

[1]Diagnostic subgroups >75 subjects at study entry. 95%CI: Confidence Intervals. APL: Acute promyelocytic leukaemia, MPNs: myeloproliferative neoplasms, Chronic myelomonocytic leukaemia, MGUS: monoclonal gammopathy of undetermined significance, MBL: monoclonal B-cell lymphocytosis, LPD NOS: Lymphoproliferative Disorders, Not Otherwise Specified, LGL leukaemia: T-cell large granular lymphocytic leukaemia, NLPHL: nodular lymphocyte predominant Hodgkin lymphoma. [2] Excluding disease progression to CLL (MBL, n=119) or myeloma (MGUS, n=95). [3]ICD 10 codes: C81-C96, D45-47. [4]Multiple Causes (MCoD): U07.1, U07.2, U09.9, U10.9. [5]Subhazard ratios estimated > 10 COVID-19 deaths, [6]adjusted for sex, age, Index of Multiple Deprivation (income domain) & co-morbidity score.

Table 3 Patients diagnosed diagnosed 2005 to 2019 and alive on the 1st January, 2020, followed up to 31st March 2023 by cause of death, cumulative incidence for COVID-19 related death by treatment status: Haematological Malignancy Research Network

		Total	Died after 1st Jan, 2020	COVID-19 Multiple Causes (MCoD) [1]	COVID-19 Cumulative incidence (95% CI)
Chronic lymphocytic leukaemia[3]		**2305 (100)**	**544 (100)**	**115 (100)**	**4.54 (3.74-5.45)**
Watch & Wait only		1672 (72.5)	333 (61.2)	67 (58.3)	4.02 (3.15-5.04)
Chemotherapy		633 (27.5)	211 (38.8)	39 (33.9)	6.04 (4.51-7.86)
On treatment Jan 2020-March 2023:		633 (100)	211 (100)	39 (100)	
	No	296 (46.8)	74 (48.7)	17 (43.6)	5.74 (3.48-8.80)
	Yes	337 (53.2)	100 (51.3)	22 (56.4)	6.54 (4.23-9.52)
Myeloma		**1452 (100)**	**533 (100)**	**47 (100)**	**3.25 (2.43-4.26)**
Watch & Wait only		440 (30.3)	121 (22.7)	10 (21.3)	2.27 (1.17-4.00)
Chemotherapy/Radiotherapy		1012 (69.7)	412 (77.3)	37 (78.7)	3.68 (2.64-4.98)
On treatment Jan 2020-March 2023:		1012 (100)	412 (100)	37 (100)	
	No	561 (55.4)	189 (45.9)	21 (56.8)	3.77 (2.41-5.58)
	Yes	451 (44.6)	223 (54.1)	16 (43.2)	3.58 (2.13-5.60)
Follicular lymphoma		1272 (100)	198 (100)	32 (100)	2.54 (1.78-3.52)
Watch & Wait only		271 (21.3)	43 (21.7)	6 (18.8)	2.25 (0.93-4.59)
Chemotherapy/Radiotherapy		1001 (78.7)	155 (78.3)	26 (81.2)	2.62 (1.76-3.76)
On treatment Jan 2020-March 2023:		1001 (100)	155 (100)	26 (100)	
	No	732 (73.1)	92 (59.4)	7 (26.9)	0.97 (0.43-1.91)
	Yes	269 (26.9)	63 (40.6)	19 (73.1)	7.15 (4.46-10.66)
Large B-cell lymphomas		2111 (100)	383 (100)	28 (100)	1.33 (0.91-1.90)
Chemotherapy		2063 (97.7)	370 (96.6)	28 (100)	1.36 (0.93-1.94)
On treatment Jan 2020-March 2023:					
	No	1849 (89.6)	293 (79.2)	19 (67.9)	1.03 (0.64-1.58)
	Yes	214 (10.4)	77 (20.8)	9 (32.1)	4.23 (2.08-7.55)

[1]Multiple Causes (MCoD): U07.1, U07.2, U09.9, U10.9. [2]95%CI: Confidence Intervals[3] Treatment status not known for 39 patients

Figure 1 Cumulative incidence (risk) of death from COVID-19 by baseline characteristics for patients with haematological malignancies (✚) and the age-sex matched general population comparison group (✚)

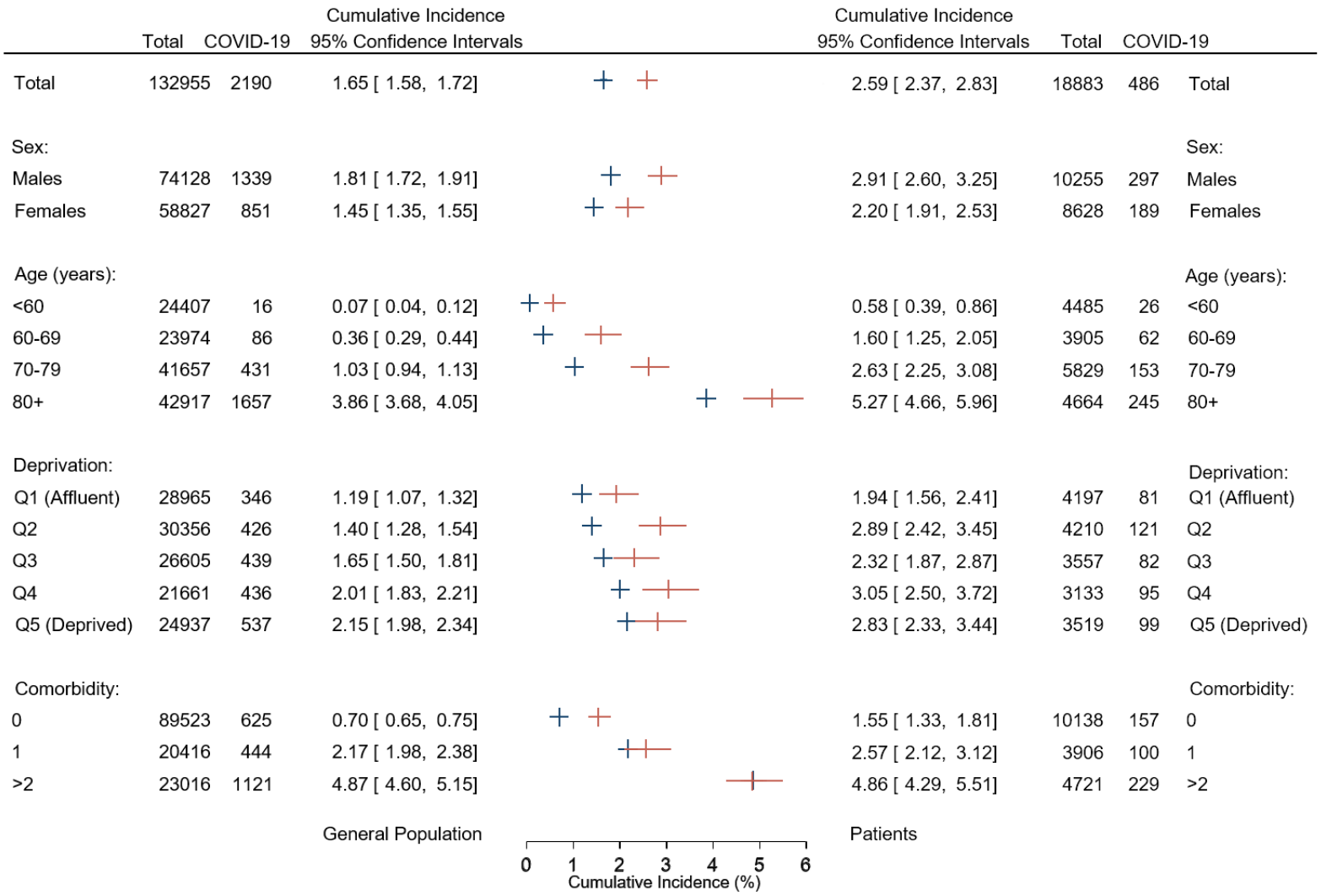


Figure 2 Cumulative Incidence of COVID-19 related deaths of patients and the age-sex matched general population comparison group

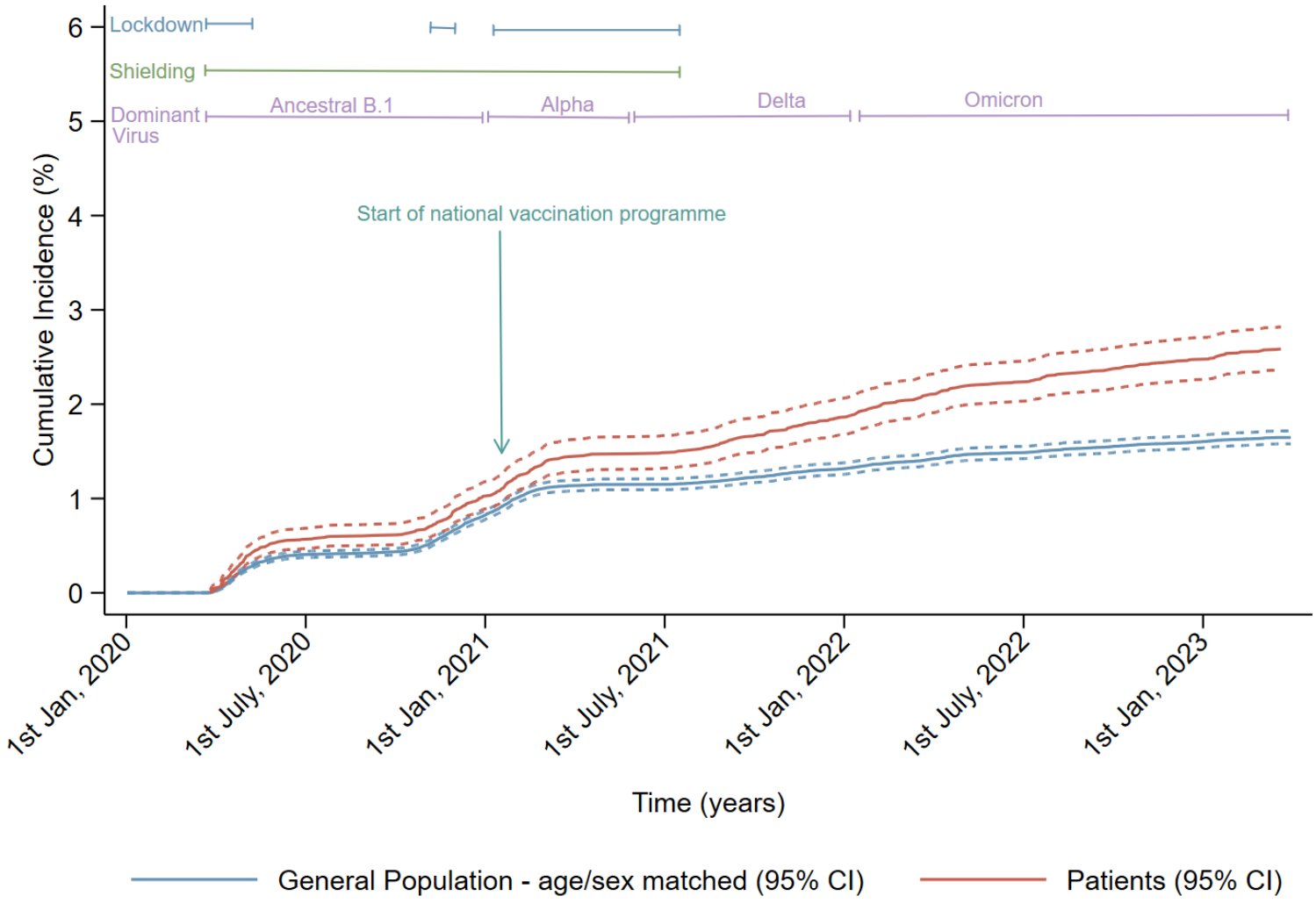


Figure 3 Cumulative Incidence of COVID-19 related deaths distributed by diagnostic group

Figure 4 Cumulative Incidence of COVID-19 related deaths distributed by diagnostic group

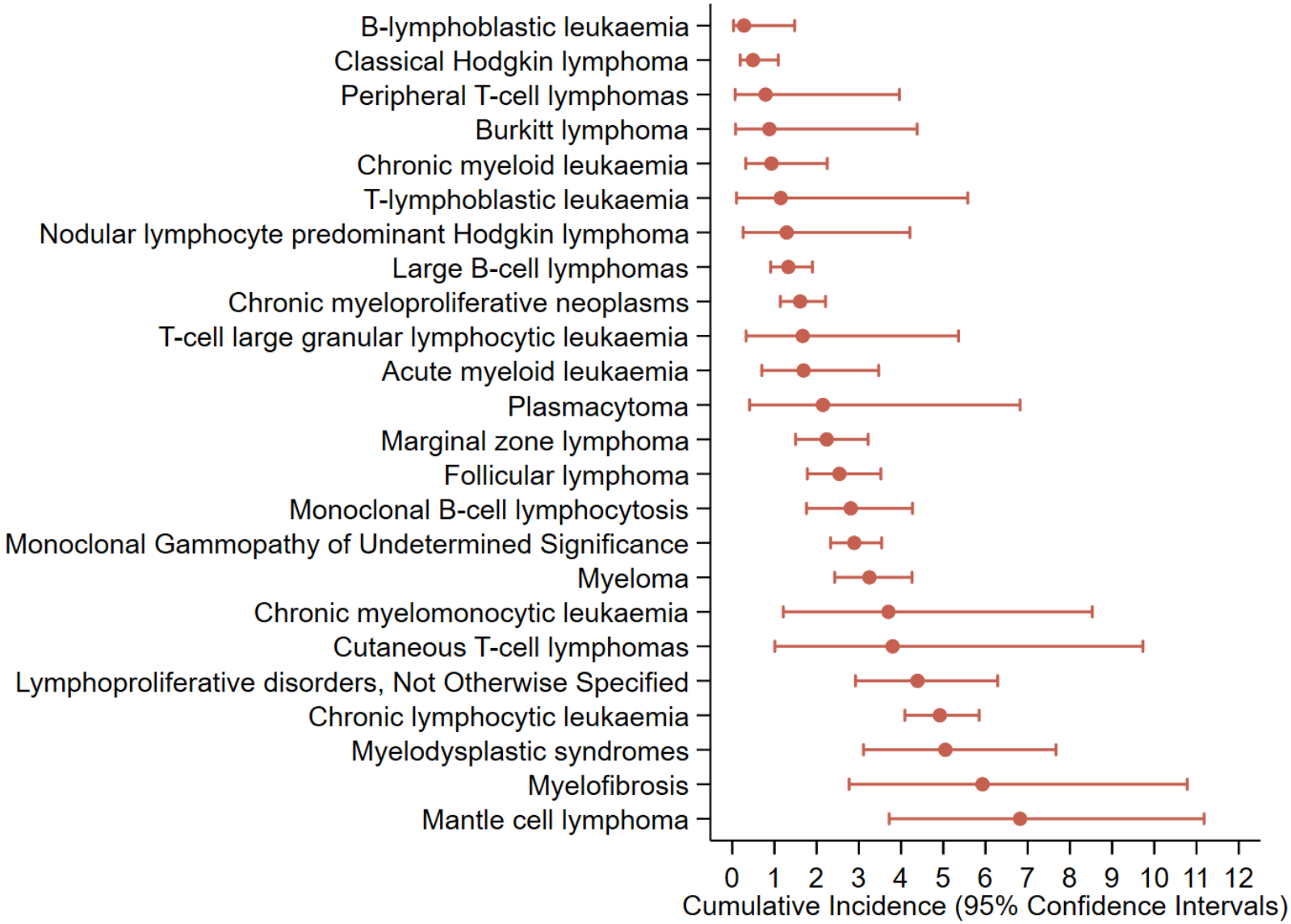
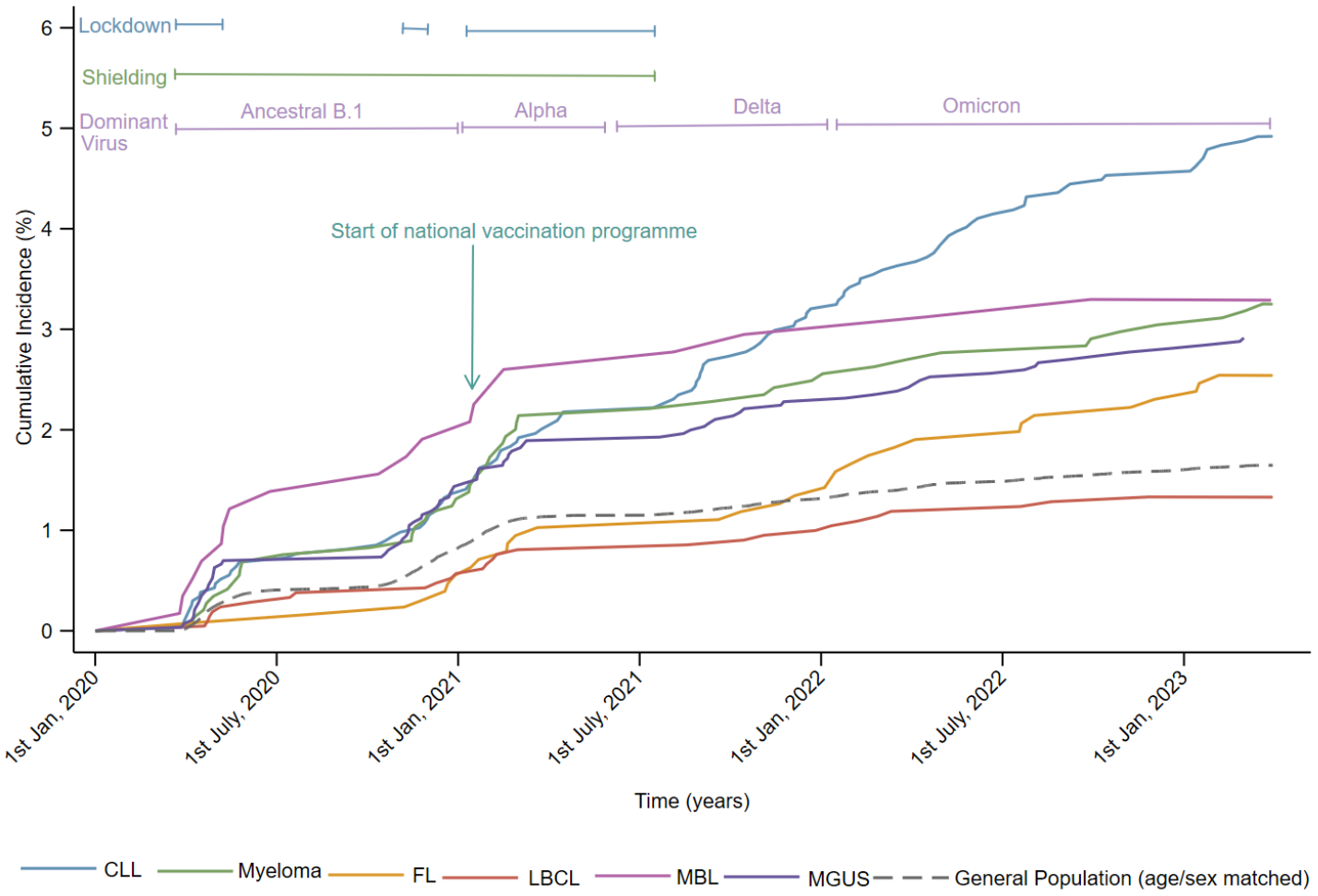


Figure 4 Cumulative Incidence of COVID-19 related deaths for patients and the general population comparison group



Supplementary Table 1: Characteristics of the general population comparison group alive on the 1st January, 2020, followed up to 31st March 2023 by cause of death, cumulative incidence and COVID-19 related death

	Patients n (%)	General population comparison group n (%)				
				Cause of Death		
		Total	Died after 1st Jan, 2020	Other Causes	COVID-19[1] Multiple Causes (MCoD)	Cumulative Incidence COVID-19 (95% CI)
Total	**18883 (100)**	**132955 (100)**	**19923 (15.0)**	**17733 (89.0)**	**2190 (11.0)**	**1.65 (1.58-1.72)**
Sex						
Male	10255 (54.3)	74128 (55.8)	11326 (56.8)	9987 (56.3)	1339 (61.1)	1.81 (1.71-1.90)
Female	8628(45.7)	58827 (44.3)	8597 (43.2)	7746 (43.7)	851 (38.9)	1.45 (1.35-1.55)
Age at the start of the pandemic (years)						
Median (IQR)	71.8 (60.8-79.9)	74.2 (64.4-82.4)	85.0 (79.4 - 89.5)	85.0 (79.3 - 89.5)	85.5 (80.4 - 90.0)	
<50	2376 (12.6)	12686 (9.5)	43 (0.2)	41 (0.2)	2 (0.1)	0.02 (0.00-0.06)
50-59	2109 (11.2)	11721 (8.8)	175 (0.9)	161 (0.9)	14 (0.6)	0.12 (0.07-0.20)
60-69	3905 (20.7)	23974 (18.0)	937 (4.7)	851 (4.8)	86 (3.9)	0.36 (0.29-0.44)
70-79	5829 (30.9)	41657 (31.3)	4302 (21.6)	3871 (21.8)	431 (19.7)	1.03 (0.94-1.14)
≥80	4664 (24.7)	42917 (32.2)	14466 (72.6)	12809 (72.2)	1657 (75.7)	3.86 (3.68-4.05)
IMD (Income Domain)						
1 – Affluent	4197 (22.2)	28965 (21.8)	3702 (18.6)	3356 (18.9)	346 (15.8)	1.19 (1.07-1.32)
2	4210 (22.3)	30356 (22.8)	4351 (21.8)	3925 (22.1)	426 (19.5)	1.40 (1.28-1.54)
3	3557 (18.8)	26605 (20.0)	4137 (20.8)	3698 (20.9)	439 (20.0)	1.65 (1.50-1.81)
4	3133 (16.6)	21661 (16.3)	3559 (17.9)	3123 (17.6)	436 (19.9)	2.01 (1.83-2.21)
5 – Deprived	3519 (18.6)	24937 (18.8)	4133 (20.7)	3596 (20.3)	537 (24.5)	2.15 (1.98-2.34)
Not Known	267 (1.4)	431 (0.3)	41 (0.2)	35 (0.2)	6 (0.3)	1.19 (1.07-1.32)
Co-morbidity Score excl. malignancy						
0	10138 (53.7)	89523 (67.3)	6779 (34.0)	6154 (34.7)	625 (28.5)	0.70 (0.65-0.75)
1	3906 (20.7)	20416 (15.4)	4082 (20.5)	3638 (20.5)	444 (20.3)	2.17 (1.98-2.38)
≥2	4721 (25.0)	23016 (17.3)	9062 (45.5)	7941 (44.8)	1121 (51.2)	4.87 (4.60-5.15)
Not Known	118 (0.6)	-	-	-	-	-

	Patients n (%)	General population comparison group n (%)					
		Total	Died after 1st Jan, 2020	Cause of Death			
				Other Causes	COVID-19[1] Multiple Causes (MCoD)	Cumulative Incidence COVID-19 (95% CI)	
Co-morbidity Score incl. malignancy							
0	6069 (32.1)	86100 (64.8)	6054 (30.4)	5488 (30.9)	566 (25.8)	0.66 (0.61-0.71)	
1	1631 (8.6)	18378 (13.8)	3459 (17.4)	3064 (17.3)	395 (18.0)	2.15 (1.95-2.37)	
≥2	11065 (58.6)	28477 (21.4)	10410 (52.3)	9181 (51.8)	1229 (56.1)	4.32 (4.08-4.56)	
Not Known	118 (0.6)	-	-	-	-		
Diagnoses[2]							
Myeloid							
Chronic myeloid leukaemia	429	2288 (1.7)	198 (1.0)	172 (1.0)	26 (1.2)	1.14 (0.76-1.64)	
Myelofibrosis	135	1065 (0.8)	186 (0.9)	158 (0.9)	28 (1.3)	2.63 (1.79-3.72)	
Chronic MPNs	2181	11279 (8.5)	1705 (8.6)	1512 (8.5)	193 (8.8)	1.71 (1.48-1.96)	
CMML	108	1527 (1.1)	352 (1.8)	318 (1.8)	34 (1.6)	2.23 (1.57-3.06)	
Myelodysplastic syndromes	358	6252 (4.7)	1296 (6.5)	1139 (6.4)	157 (7.2)	2.51 (2.14-2.92)	
Acute myeloid leukaemia	356	7800 (5.9)	1233 (6.2)	1108 (6.2)	125 (5.7)	1.60 (1.34-1.90)	
APL	89	602 (0.5)	25 (0.1)	22 (0.1)	3 (0.1)	0.50 (0.14-1.38)	
Lymphoid							
B-lymphoblastic leukaemia	358	2336 (1.8)	42 (0.2)	36 (0.2)	6 (0.3)	0.26 (0.11-0.54)	
T-lymphoblastic leukaemia	88	540 (0.4)	10 (0.1)	9 (0.1)	1 (0.0)	0.19 (0.02-1.00)	
MBL[3]	579	4742 (3.6)	797 (4.0)	714 (4.0)	83 (3.8)	1.75 (1.41-2.15)	
Chronic lymphocytic leukaemia	2344	13809 (10.4)	2221 (11.1)	1971 (11.1)	250 (11.4)	1.81 (1.60-2.04)	
Hairy cell leukaemia	143	674 (0.5)	72 (0.4)	66 (0.4)	6 (0.3)	0.89 (0.37-1.85)	
LPD, NOS	573	3340 (2.5)	729 (3.7)	646 (3.6)	83 (3.8)	2.49 (2.00-3.05)	
Marginal zone lymphoma	1161	7819 (5.9)	1281 (6.4)	1130 (6.4)	151 (6.9)	1.93 (1.64-2.25)	
MGUS[3]	2864	16311 (12.3)	2876 (14.4)	2568 (14.5)	308 (14.1)	1.89 (1.69-2.11)	
Plasmacytoma	94	1002 (0.8)	137 (0.7)	124 (0.7)	13 (0.6)	1.30 (0.73-2.16)	
Myeloma	1452	13318 (10.0)	2357 (11.8)	2101 (11.8)	256 (11.7)	1.92 (1.70-2.17)	
Follicular lymphoma	1272	7260 (5.5)	762 (3.8)	692 (3.9)	70 (3.2)	0.96 (0.76-1.21)	
Mantle cell lymphoma	177	1617 (1.2)	284 (1.4)	253 (1.4)	31 (1.4)	1.92 (1.33-2.68)	
Large B-cell lymphomas	2111	16926 (12.7)	2401 (12.1)	2151 (12.1)	250 (11.4)	1.48 (1.30-1.67)	
Burkitt lymphoma	113	794 (0.6)	48 (0.2)	44 (0.2)	4 (0.2)	0.50 (0.17-1.23)	
Peripheral T-cell lymphomas	126	1695 (1.3)	213 (1.1)	187 (1.1)	26 (1.2)	1.53 (1.03-2.21)	
Cutaneous T-cell lymphomas	79	432 (0.3)	41 (0.2)	37 (0.2)	4 (0.2)	0.93 (0.31-2.23)	

	Patients n (%)	General population comparison group n (%)					
		Total	Died after 1st Jan, 2020	Cause of Death			
				Other Causes	COVID-19[1] Multiple Causes (MCoD)	Cumulative Incidence COVID-19 (95% CI)	
LGL leukaemia	120	770 (0.6)	103 (0.5)	92 (0.5)	11 (0.5)	1.43 (0.76-2.47)	
Classical Hodgkin lymphoma	1032	6066 (4.6)	305 (1.5)	268 (1.5)	37 (1.7)	0.61 (0.44-0.83)	
NLPHL	155	900 (0.7)	35 (0.2)	28 (0.2)	7 (0.3)	0.78 (0.35-1.54)	

[1]Multiple Causes (MCoD): U07.1, U07.2, U09.9, U10.9. [2]Diagnostic subgroups >75 subjects at study entry. APL: Acute promyelocytic leukaemia, MPNs: myeloproliferative neoplasms, Chronic myelomonocytic leukaemia, MGUS: monoclonal gammopathy of undetermined significance, MBL: monoclonal B-cell lymphocytosis, LPD NOS: Lymphoproliferative Disorders, Not Otherwise Specified, LGL leukaemia: T-cell large granular lymphocytic leukaemia, NLPHL: nodular lymphocyte predominant Hodgkin lymphoma. [3]Excluding disease progression to CLL for MBL cases (n=119) or myeloma for MGUS cases (n=95)

Supplementary Table 2 Characteristics of patients diagnosed with a haematological malignancy 2009-15 and their matched general population comparison group alive on the 1st January 2020, followed up to 31st of March 2023 by cause of death, cumulative incidence and COVID-19 related death

		General population comparison group n (%)				Patients diagnosed 2009-15 n (%)				Cumulative Incidence COVID-19 (95% CI)	
		Total	**Died after 1st Jan, 2020**	**COVID-19[1] Multiple Causes (MCoD)**		**Total**	**Died after 1st Jan, 2020**	**COVID-19[1] Multiple Causes (MCoD)**		**Comparison group**	**Patients**
Total		**68482 (100)**	**6732 (9.8)**	**729 (10.8)**		**8081 (100)**	**1750 (21.7)**	**208 (11.9)**		**1.06 (0.99-1.14)**	**2.58 (2.25-2.94)**
Sex											
Male		36582 (53.4)	3682 (54.7)	404 (55.4)		4330 (53.6)	966 (55.2)	125 (60.1)		1.10 (1.00-1.22)	2.90 (2.43-3.43)
Female		31900 (46.6)	3050 (45.3)	325 (44.6)		3751 (46.4)	784 (44.8)	83 (39.9)		1.02 (0.91-1.13)	2.20 (1.91-2.53)
Age at the start of the pandemic (years)											
Median (IQR)		70.1 (58.8-77.8)	81.5 (75.4 - 86.4)	82.6 (77.0 - 87.5)		72.1 (61.0-80.4)	81.7 (74.6 - 87.0)	80.4 (73.7 - 85.6)			
<50		9921 (14.5)	37 (0.5)	1 (0.1)		1004 (12.4)	14 (0.8)	-		-	-
50-59		8578 (12.5)	128 (1.9)	10 (1.4)		878 (10.9)	46 (2.6)	5 (2.4)		0.12 (0.06-0.21)	0.57 (0.22-1.28)
60-69		15481 (22.6)	557 (8.3)	53 (7.3)		1649 (20.4)	172 (9.8)	26 (12.5)		0.34 (0.26-0.45)	1.58 (1.06-2.28)
70-79		21460 (31.3)	2174 (32.3)	216 (29.6)		2460 (30.4)	531 (30.3)	70 (33.7)		1.01 (0.88-1.15)	2.85 (2.25-3.56)
≥80		13042 (19.0)	3836 (57.0)	449 (61.6)		2090 (25.9)	987 (56.4)	107 (51.4)		3.44 (3.14-3.77)	5.12 (4.23-6.13)
IMD (Income Domain)											
1 – Affluent		14880 (21.7)	1229 (18.3)	116 (15.9)		1838 (22.7)	392 (22.4)	35 (16.8)		0.78 (0.65-0.93)	1.91 (1.36-2.62)
2		15400 (22.5)	1401 (20.8)	145 (19.9)		1813 (22.4)	397 (22.7)	52 (25.0)		0.94 (0.80-1.10)	2.87 (2.17-3.72)
3		13530 (19.8)	1347 (20.0)	141 (19.3)		1510 (18.7)	316 (18.1)	32 (15.4)		1.04 (0.88-1.22)	2.12 (1.48-2.95)
4		11148 (16.3)	1231 (18.3)	135 (18.5)		1300 (16.1)	291 (16.6)	43 (20.7)		1.21 (1.02-1.43)	3.32 (2.44-4.40)
5 – Deprived		13271 (19.4)	1505 (22.4)	189 (26.0)		1495 (18.5)	326 (18.6)	42 (20.2)		1.42 (1.23-1.64)	2.82 (2.06-3.75)
Not Known		253 (0.4)	19 (0.3)	3 (0.4)		125 (1.5)	28 (1.6)	4 (1.9)		-	-
Co-morbidity Score excl. malignancy											
0		49756 (72.7)	2438 (36.2)	217 (29.8)		4355 (53.9)	517 (29.5)	59 (28.4)		0.44 (0.38-0.50)	1.36 (1.05-1.74)
1		9477 (13.8)	1348 (20.0)	145 (19.9)		1655 (20.5)	361 (20.6)	46 (22.1)		1.53 (1.30-1.79)	2.79 (2.07-3.66)
≥2		9249 (13.5)	2946 (43.8)	367 (50.3)		2044 (25.3)	870 (49.7)	103 (49.5)		3.97 (3.58-4.38)	5.04 (4.15-6.05)
Not Known		-	-	-		27 (0.3)	2 (0.1)	-		-	-

	General population comparison group n (%)			Patients diagnosed 2009-15 n (%)			Cumulative Incidence COVID-19 (95% CI)	
	Total	Died after 1st Jan, 2020	COVID-19[1] Multiple Causes (MCoD)	Total	Died after 1st Jan, 2020	COVID-19[1] Multiple Causes (MCoD)	Comparison group	Patients
Co-morbidity Score inc. malignancy								
0	48110 (70.3)	2159 (32.1)	197 (27.0)	2660 (32.9)	276 (15.8)	33 (15.9)	0.41 (0.36-0.47)	1.24 (0.87-1.72)
1	8630 (12.6)	1132 (16.8)	127 (17.4)	662 (8.2)	136 (7.8)	21 (10.1)	1.47 (1.23-1.74)	3.18 (2.03-4.73)
≥2	11742 (17.1)	3441 (51.1)	405 (55.6)	4732 (58.6)	1336 (76.3)	154 (74.0)	3.45 (3.13-3.79)	3.26 (2.78-3.79)
Not Known	-	-	-	27 (0.3)	2 (0.1)	-	-	-
Diagnosis								
Myeloid								
Chronic myeloid leukaemia	1705 (2.5)	91 (1.4)	10 (1.4)	187 (2.3)	20 (1.2)	3 (1.5)	0.59 (0.30-1.05)	1.60 (0.44-4.29)
Myelofibrosis	442 (0.7)	50 (0.7)	11 (1.5)	53 (0.7)	31 (1.8)	2 (1.0)	2.49 (1.32-4.27)	3.77 (0.70-11.48)
Chronic MPNs	7484 (11.0)	788 (11.8)	92 (12.7)	893 (11.1)	199 (11.5)	15 (7.3)	1.23 (1.00-1.50)	1.68 (0.99-2.70)
CMML	173 (0.3)	30 (0.5)	6 (0.8)	21 (0.3)	13 (0.8)	1 (0.5)	3.47 (1.43-6.99)	4.76 (0.33-19.70)
Myelodysplastic syndromes	901 (1.3)	111 (1.7)	17 (2.4)	116 (1.4)	52 (3.0)	8 (3.9)	1.89 (1.14-2.94)	6.90 (3.23-12.46)
Acute myeloid leukaemia	1203 (1.8)	41 (0.6)	5 (0.7)	128 (1.6)	16 (0.9)	2 (1.0)	0.42 (0.16-0.93)	1.56 (0.31-5.04)
APL	365 (0.5)	9 (0.1)	1 (0.1)	38 (0.5)	3 (0.2)	-	0.27 (0.03-1.45)	-
Lymphoid								
B-lymphoblastic leukaemia	1527 (2.2)	4 (0.1)	1 (0.1)	154 (1.9)	3 (0.2)	-	0.07 (0.01-0.37)	-
T-lymphoblastic leukaemia	316 (0.5)	-	-	32 (0.4)	-	-	-	-
MBL[2]	1880 (2.8)	242 (3.6)	32 (4.4)	242 (3.0)	56 (3.2)	7 (3.4)	1.70 (1.19-2.37)	2.91 (1.29-5.62)
Chronic lymphocytic leukaemia	9148 (13.5)	1088 (16.3)	120 (16.6)	1106 (13.8)	260 (15.1)	52 (25.2)	1.31 (1.09-1.56)	4.70 (3.57-6.06)
Hairy cell leukaemia	539 (0.8)	41 (0.6)	3 (0.4)	62 (0.8)	4 (0.2)	-	0.56 (0.16-1.53)	-
LPD, NOS	1612 (2.4)	263 (4.0)	24 (3.3)	205 (2.6)	64 (3.7)	13 (6.3)	1.49 (0.98-2.17)	6.37 (3.57-10.29)
Marginal zone lymphoma	4467 (6.6)	516 (7.8)	52 (7.2)	540 (6.7)	141 (8.2)	14 (6.8)	1.16 (0.88-1.51)	2.60 (1.49-4.20)
MGUS[2]	9845 (14.5)	1365 (20.5)	128 (17.7)	1254 (15.7)	315 (18.2)	42 (20.4)	1.30 (1.09-1.54)	3.35 (2.46-4.46)
Plasmacytoma	296 (0.4)	18 (0.3)	1 (0.1)	34 (0.4)	6 (0.3)	1 (0.5)	0.34 (0.03-1.77)	2.94 (0.22-13.01)
Myeloma	4688 (6.9)	510 (7.7)	57 (7.9)	547 (6.8)	205 (11.9)	13 (6.3)	1.22 (0.93-1.56)	2.38 (1.34-3.93)
Follicular lymphoma	4897 (7.2)	360 (5.4)	36 (5.0)	552 (6.9)	85 (4.9)	6 (2.9)	0.74 (0.53-1.01)	1.09 (0.46-2.27)
Mantle cell lymphoma	504 (0.7)	56 (0.8)	2 (0.3)	60 (0.7)	19 (1.1)	4 (1.9)	0.40 (0.08-1.35)	6.67 (2.15-14.82)
Large B-cell lymphomas	8414 (12.4)	778 (11.7)	83 (11.5)	971 (12.1)	165 (9.6)	14 (6.8)	0.99 (0.79-1.22)	1.45 (0.83-2.36)
Burkitt lymphoma	444 (0.7)	9 (0.1)	1 (0.1)	46 (0.6)	4 (0.2)	1 (0.5)	0.23 (0.02-1.20)	2.17 (0.17-9.95)

		General population comparison group n (%)				Patients diagnosed 2009-15 n (%)				Cumulative Incidence COVID-19 (95% CI)	
		Total	Died after 1st Jan, 2020	COVID-19[1] Multiple Causes (MCoD)		Total	Died after 1st Jan, 2020	COVID-19[1] Multiple Causes (MCoD)		Comparison group	Patients
Peripheral T-cell lymphomas		492 (0.7)	33 (0.5)	6 (0.8)		54 (0.7)	8 (0.5)	1 (0.5)		1.22 (0.51-2.52)	1.85 (0.15-8.62)
Cutaneous T-cell lymphomas		259 (0.4)	19 (0.3)	4 (0.6)		31 (0.4)	6 (0.3)	2 (1.0)		1.54 (0.52-3.68)	6.45 (1.15-18.62)
LGL leukaemia		532 (0.8)	61 (0.9)	9 (1.2)		65 (0.8)	17 (1.0)	1 (0.5)		1.69 (0.84-3.08)	1.54 (0.13-7.28)
Classical Hodgkin lymphoma		4408 (6.5)	117 (1.8)	15 (2.1)		460 (5.7)	23 (1.3)	2 (1.0)		0.34 (0.20-0.55)	0.44 (0.09-1.48)
NLPHL		753 (1.1)	26 (0.4)	5 (0.7)		78 (1.0)	1 (0.1)	-		0.66 (0.26-1.48)	-

[1] Multiple Causes (MCoD): U07.1, U07.2, U09.9, U10.9. APL: Acute promyelocytic leukaemia, MPNs: myeloproliferative neoplasms, Chronic myelomonocytic leukaemia, MGUS: monoclonal gammopathy of undetermined significance, MBL: monoclonal B-cell lymphocytosis, LPD NOS: Lymphoproliferative Disorders, Not Otherwise Specified, LGL leukaemia: T-cell large granular lymphocytic leukaemia, NLPHL: nodular lymphocyte predominant Hodgkin lymphoma. [2] Excluding disease progression to CLL for MBL or myeloma for MGUS.

Supplementary Table 3: Cumulative incidence and COVID-19 related death by landmark timeperiods of the COVID-19 pandemic by diagnosis

	Landmark Time Periods							
	Start of the pandemic to the start of the national vaccination programme 1st Jan, 2020 to 18th Jan, 2021				12 months after the national vaccination programme started 18th Jan, 2021 to 18th Jan, 2022			
Diagnosis[1]	**Total**	**Died n (% of total)**	**COVID-19[2] Multiple Causes (MCoD) n (% of deaths)**	**Cumulative Incidence COVID-19 (95% CI)**	**Alive on the 18th Jan, 2021[3]**	**Died n (% of total)**	**COVID-19[2] Multiple Causes (MCoD) n (% of deaths)**	**Cumulative Incidence COVID-19 (95% CI)**
General Population	**132955**	**6975 (5.2)**	**1222 (17.5)**	**0.92 (0.87-0.97)**	**125980**	**5870 (4.7)**	**562 (9.6)**	**0.45 (0.41-0.48)**
All diagnoses	**18883**	**1575 (8.3)**	**209 (13.3)**	**1.11 (0.97-1.27)**	**17249**	**1247 (7.2)**	**154 (12.3)**	**0.90 (0.77-1.05)**
Myeloid								
Chronic myeloid leukaemia	429	31 (7.2)	2 (6.5)	0.47 (0.10-1.58)	398	11 (2.8)	2 (18.2)	0.50 (0.10-1.70)
Myelofibrosis	135	27 (20.0)	3 (11.1)	2.22 (0.61-5.86)	108	22 (20.4)	4 (18.2)	3.70 (1.21-8.53)
Chronic MPNs	2181	144 (6.6)	12 (8.3)	0.55 (0.30-0.94)	2035	151 (7.4)	15 (9.9)	0.74 (0.43-1.19)
CMML	108	29 (26.9)	2 (6.9)	1.85 (0.36-5.92)	79	20 (25.3)	-	-
Myelodysplastic syndromes	358	87 (24.3)	9 (10.3)	2.52 (1.25-4.56)	269	53 (19.7)	4 (7.5)	1.49 (0.50-3.54)
Acute myeloid leukaemia	356	59 (16.6)	5 (8.5)	1.40 (0.53-3.09)	297	19 (6.4)	1 (5.3)	0.34 (0.03-1.76)
APL	89	2 (2.2)	-	-	87	-	-	-
Lymphoid								
B-lymphoblastic leukaemia	358	9 (2.5)	1 (11.1)	0.28 (0.03-1.48)	349	7 (2.0)	-	-
T-lymphoblastic leukaemia	88	3 (3.4)	1 (33.3)	1.15 (0.10-5.58)	84	-	-	-
MBL[4]	579	49 (8.5)	13 (26.5)	2.25 (1.26-3.72)	528	40 (7.6)	4 (10.0)	0.76 (0.26-1.84)
Chronic lymphocytic leukaemia	2344	162 (6.9)	36 (22.2)	1.54 (1.10-2.10)	2180	185 (8.5)	41 (22.2)	1.88 (1.37-2.52)
Hairy cell leukaemia	143	6 (4.2)	-	-	137	4 (2.9)	-	-
LPD, NOS	573	66 (11.5)	11 (16.7)	1.93 (1.03-3.32)	504	53 (10.5)	7 (13.2)	1.39 (0.62-2.73)
Marginal zone lymphoma	1161	86 (7.4)	16 (18.6)	1.38 (0.82-2.18)	1074	70 (6.5)	6 (8.6)	0.65 (0.29-1.30)
MGUS[4]	2864	235 (8.2)	42 (17.9)	1.47 (1.08-1.96)	2613	179 (6.9)	23 (12.8)	0.88 (0.58-1.30)
Plasmacytoma	94	3 (3.2)	-	-	91	6 (6.6)	-	1 (16.7)
Myeloma	1452	218 (15.0)	22 (10.1)	1.52 (0.98-2.25)	1228	174 (14.2)	15 (8.6)	1.22 (0.72-1.97)
Follicular lymphoma	1272	58 (4.6)	8 (13.8)	0.63 (0.30-1.20)	1207	51 (4.2)	12 (23.5)	1.00 (0.55-1.70)
Mantle cell lymphoma	177	33 (18.6)	4 (12.1)	2.27 (0.75-5.34)	143	9 (6.3)	4 (44.4)	2.80 (0.92-6.52)
Large B-cell lymphomas	2111	153 (7.2)	12 (7.8)	0.57 (0.31-0.97)	1952	122 (6.2)	10 (8.2)	0.51 (0.27-0.92)
Burkitt lymphoma	113	3 (2.7)	1 (33.3)	0.88 (0.08-4.38)	110	4 (3.6)	-	-
Peripheral T-cell lymphomas	126	21 (16.7)	1 (4.8)	0.79 (0.07-3.96)	105	3 (2.9)	-	-
Cutaneous T-cell lymphomas	79	7 (8.9)	1 (14.3)	1.27 (0.11-6.09)	72	7 (9.7)	1 (14.3)	1.39 (0.12-6.63)
LGL leukaemia	120	9 (7.5)	-	-	111	6 (5.4)	1 (16.7)	
Classical Hodgkin lymphoma	1032	29 (2.8)	4 (13.8)	0.39 (0.13-0.95)	997	19 (1.9)	1 (5.3)	0.10 (0.01-0.55)
NLPHL	155	3 (1.9)	1 (33.3)	0.65 (0.06-3.26)	151	4 (2.6)	1 (25.0)	0.66 (0.06-3.34)

	Shielding period 22nd March, 2020 to 17th September, 2021				End of shielding/lockdown to end of follow-up 17th September, 2021 to 31st March, 2023			
Diagnosis[1]	**Total alive on the 22nd March, 2020[3]**	**Died n (% of total)**	**COVID-19[3] Multiple Causes (MCoD) n (% of deaths)**	**Cumulative Incidence COVID-19 (95% CI)**	**Total alive on the 17th Sept 2021[3]**	**Died n (% of total)**	**COVID-19[3] Multiple Causes (MCoD) n (% of deaths)**	**Cumulative Incidence COVID-19 (95% CI)**
Controls	**131585**	**9322 (7.1)**	**1611 (17.3)**	**1.22 (1.17-1.28)**	**122263**	**9231 (7.6)**	**579 (6.3)**	**0.47 (0.44-0.51)**
All diagnoses	**18510**	**2026 (10.9)**	**310 (15.3)**	**1.68 (1.50-1.87)**	**16378**	**1747 (10.7)**	**176 (10.1)**	**1.08 (0.93-1.24)**
Myeloid								
Chronic myeloid leukaemia	423	32 (7.6)	4 (12.5)	0.94 (0.32-2.27)	381	18 (4.7)	-	-
Myelofibrosis	128	36 (28.1)	5 (13.9)	3.91 (1.46-8.31)	92	19 (20.7)	3 (15.8)	3.26 (0.88-8.43)
Chronic MPNs	2147	207 (9.6)	21 (10.1)	0.98 (0.63-1.47)	1929	198 (10.3)	14 (7.1)	0.73 (0.42-1.19)
CMML	100	36 (36.0)	2 (5.6)	2.00 (0.39-6.36)	64	23 (35.9)	2 (8.7)	3.12 (0.59-9.65)
Myelodysplastic syndromes	332	97 (29.2)	12 (12.4)	3.60 (1.96-6.00)	234	73 (31.2)	6 (8.2)	2.56 (1.06-5.22)
Acute myeloid leukaemia	342	60 (17.5)	6 (10.0)	1.75 (0.73-3.60)	280	18 (6.4)	-	-
APL	88	1 (1.1)	-	-	87	1 (1.1)	-	-
Lymphoid								
B-lymphoblastic leukaemia	355	12 (3.4)	1 (8.3)	0.28 (0.03-1.49)	342	7 (2.0)	-	-
T-lymphoblastic leukaemia	88	3 (3.4)	1 (33.3)	1.15 (0.10-5.58)	84	-	-	-
MBL[4]	569	69 (12.1)	16 (23.2)	2.81 (1.68-4.42)	497	46 (9.3)	3 (6.5)	0.60 (0.17-1.66)
Chronic lymphocytic leukaemia	2314	241 (10.4)	63 (26.1)	2.73 (2.12-3.45)	2067	273 (13.2)	52 (19.0)	2.52 (1.91-3.26)
Hairy cell leukaemia	143	10 (7.0)	-	-	133	5 (3.8)	-	-
LPD, NOS	556	88 (15.8)	16 (18.2)	2.88 (1.72-4.52)	467	76 (16.3)	9 (11.8)	1.93 (0.96-3.50)
Marginal zone lymphoma	1145	115 (10.0)	20 (17.4)	1.75 (1.10-2.64)	1028	132 (12.8)	6 (4.5)	0.58 (0.25-1.22)
MGUS[4]	2812	301 (10.7)	60 (19.9)	2.14 (1.65-2.73)	2491	270 (10.8)	23 (8.5)	0.92 (0.60-1.36)
Plasmacytoma	93	8 (8.6)	1 (12.5)	1.08 (0.09-5.24)	83	6 (7.2)	1 (16.7)	1.20 (0.10-5.82)
Myeloma	1397	280 (20.0)	33 (11.8)	2.37 (1.66-3.27)	1108	198 (17.9)	14 (7.1)	1.26 (0.73-2.07)
Follicular lymphoma	1259	76 (6.0)	13 (17.1)	1.04 (0.58-1.73)	1172	110 (9.4)	19 (17.3)	1.63 (1.02-2.49)
Mantle cell lymphoma	164	25 (15.2)	5 (20.0)	3.05 (1.15-6.55)	139	20 (14.4)	7 (35.0)	5.04 (2.23-9.56)
Large B-cell lymphomas	2073	194 (9.4)	18 (9.3)	0.87 (0.54-1.35)	1870	154 (8.2)	10 (6.5)	0.53 (0.28-0.96)
Burkitt lymphoma	112	5 (4.5)	1 (20.0)	0.89 (0.08-4.41)	106	5 (4.7)	-	-
Peripheral T-cell lymphomas	121	17 (14.0)	1 (5.9)	0.83 (0.07-4.11)	104	7 (6.7)	-	-
Cutaneous T-cell lymphomas	78	11 (14.1)	2 (18.2)	2.56 (0.49-8.03)	67	4 (6.0)	1 (25.0)	1.49 (0.13-7.08)
LGL leukaemia	117	9 (7.7)	-	-	108	13 (12.0)	2 (15.4)	1.85 (0.36-5.92)
Classical Hodgkin lymphoma	1025	36 (3.5)	5 (13.9)	0.49 (0.19-1.09)	977	26 (2.7)	-	-
NLPHL	155	6 (3.9)	2 (33.3)	1.29 (0.26-4.21)	147	6 (4.1)	-	-

[1]Diagnostic subgroups >75 subjects at study entry. APL: Acute promyelocytic leukaemia, MPNs: myeloproliferative neoplasms, Chronic myelomonocytic leukaemia, MGUS: monoclonal gammopathy of undetermined significance, MBL: monoclonal B-cell lymphocytosis, LPD NOS: Lymphoproliferative Disorders, Not Otherwise Specified, LGL leukaemia: T-cell large granular lymphocytic leukaemia, NLPHL: nodular lymphocyte predominant Hodgkin lymphoma. [2]Multiple Causes (MCoD): U07.1, U07.2, U09.9, U10.9. [3]Total number of patients avaiable at the start of the time-period maydiffer due to censoring. [4]Excluding disease progression to CLL (MBL, n=119) or myeloma (MGUS, n=95).

Supplementary Table 4: Patients diagnosed with a haematological malignancy 2009-15 and their matched general population comparison group alive on the 1st January 2020, followed up to 31st of March 2023 by COVID-19 related death by primary and contributing cause

	Patients n (%)						General population comparison group n (%)				
		Cause of Death		COVID-19[1] Cause of Death					COVID-19[1] Cause of Death		
	Died	Haemato-logical Neoplasm[2]	Other Causes	Multiple Causes	Primary (Underlying)	Contributing	Died	Other Causes	Multiple Causes	Primary (Underlying)	Contributing
Total	**4132 (100)**	**1330 (32.2)**	**2316 (56.0)**	**486 (11.8)**	**396 (81.5)**	**90 (18.5)**	**19923 (100)**	**17733 (89.0)**	**2190 (11.0)**	**1848 (84.4)**	**342 (15.6)**
Diagnosis[3]											
Myeloid											
Chronic myeloid leukaemia	56 (13.1)	13 (23.2)	39 (69.6)	4 (7.1)	4 (100)	-	198 (1.0)	172 (1.0)	26 (1.2)	22 (84.6)	4 (15.4)
Myelofibrosis	62 (45.9)	30 (48.4)	24 (38.7)	8 (12.9)	7 (87.5)	1 (12.5)	186 (0.9)	158 (0.9)	28 (1.3)	26 (92.9)	2 (7.1)
Chronic MPNs	439 (20.1)	92 (21.0)	312 (71.1)	35 (8.0)	20 (57.1)	15 (42.9)	1705 (8.6)	1512 (8.5)	193 (8.8)	152 (78.8)	41 (21.2)
CMML	67 (62.0)	38 (56.7)	25 (37.3)	4 (6.0)	1 (25.0)	3 (75.0)	352 (1.8)	318 (1.8)	34 (1.6)	31 (91.2)	3 (8.8)
Myelodysplastic syndromes	195 (54.5)	100 (51.3)	77 (39.5)	18 (9.2)	12 (66.7)	6 (33.3)	1296 (6.5)	1139 (6.4)	157 (7.2)	131 (83.4)	26 (16.6)
Acute myeloid leukaemia	92 (25.8)	70 (76.1)	16 (17.4)	6 (6.5)	4 (66.7)	2 (33.3)	1233 (6.2)	1108 (6.2)	125 (5.7)	109 (87.2)	16 (12.8)
APL	3 (3.4)	1 (33.3)	2 (66.7)	-	-	-	25 (0.1)	22 (0.1)	3 (0.1)	-	3 (100)
Lymphoid											
B-lymphoblastic leukaemia	22 (6.1)	17 (77.3)	4 (18.2)	1 (4.5)	-	1 (100)	42 (0.2)	36 (0.2)	6 (0.3)	3 (50.0)	3 (50.0)
T-lymphoblastic leukaemia	3 (3.4)	2 (66.7)	-	1 (33.3)	1 (100)	-	10 (0.1)	9 (0.1)	1 (0.0)	1 (100)	-
MBL[2]	123 (21.2)	-	104 (84.6)	19 (15.4)	18 (94.7)	1 (5.3)	797 (4.0)	714 (4.0)	83 (3.8)	66 (81.5)	15 (18.5)
Chronic lymphocytic leukaemia	544 (23.2)	134 (24.6)	295 (54.2)	115 (21.1)	99 (86.1)	16 (13.9)	2221 (11.1)	1971 (11.1)	250 (11.4)	213 (85.2)	37 (14.8)
Hairy cell leukaemia	15 (10.5)	8 (53.3)	7 (46.7)	-	-	-	72 (0.4)	66 (0.4)	6 (0.3)	-	6 (100)
LPD, NOS	179 (31.2)	41 (22.9)	113 (63.1)	25 (14.0)	21 (84.0)	4 (16.0)	729 (3.7)	646 (3.6)	83 (3.8)	71 (85.5)	12 (14.5)
Marginal zone lymphoma	262 (22.6)	77 (29.4)	159 (60.7)	26 (9.9)	24 (92.3)	2 (7.7)	1281 (6.4)	1130 (6.4)	151 (6.9)	133 (88.1)	18 (11.9)
MGUS[2]	620 (21.6)	8 (1.3)	529 (85.3)	83 (13.4)	71 (85.5)	12 (14.5)	2876 (14.4)	2568 (14.5)	308 (14.1)	258 (84.9)	46 (15.1)
Plasmacytoma	15 (16.0)	9 (60.0)	4 (26.7)	2 (13.3)	1 (50.0)	1 (50.0)	137 (0.7)	124 (0.7)	13 (0.6)	12 (92.3)	1 (7.7)
Myeloma	533 (36.7)	336 (63.0)	150 (28.1)	47 (8.8)	37 (78.7)	10 (21.3)	2357 (11.8)	2101 (11.8)	256 (11.7)	213 (83.2)	43 (16.8)
Follicular lymphoma	198 (15.6)	63 (31.8)	103 (52.0)	32 (16.2)	28 (87.5)	4 (12.5)	762 (3.8)	692 (3.9)	70 (3.2)	59 (84.3)	11 (15.7)
Mantle cell lymphoma	57 (32.2)	25 (43.9)	20 (35.1)	12 (21.1)	9 (75.0)	3 (25.0)	284 (1.4)	253 (1.4)	31 (1.4)	26 (83.9)	5 (16.1)
Large B-cell lymphomas	383 (18.1)	132 (34.5)	223 (58.2)	28 (7.3)	22 (78.6)	6 (21.4)	2401 (12.1)	2151 (12.1)	250 (11.4)	211 (84.4)	39 (15.6)
Burkitt lymphoma	11 (9.7)	5 (45.5)	5 (45.5)	1 (9.1)	1 (100)	-	48 (0.2)	44 (0.2)	4 (0.2)	3 (75.0)	1 (25.0)
Peripheral T-cell lymphomas	29 (23.0)	21 (72.4)	7 (24.1)	1 (3.4)	1 (100)	-	213 (1.1)	187 (1.1)	26 (1.2)	22 (84.6)	4 (15.4)
Cutaneous T-cell lymphomas	16 (20.3)	5 (31.2)	8 (50.0)	3 (18.8)	2 (66.7)	1 (33.3)	41 (0.2)	37 (0.2)	4 (0.2)	3 (75.0)	1 (25.0)
LGL leukaemia	25 (20.8)	7 (28.0)	16 (64.0)	2 (8.0)	1 (50.0)	1 (50.0)	103 (0.5)	92 (0.5)	11 (0.5)	10 (90.9)	1 (9.1)
Classical Hodgkin lymphoma	69 (6.7)	24 (34.8)	40 (58.0)	5 (7.2)	5 (100)	-	305 (1.5)	268 (1.5)	37 (1.7)	32 (86.5)	5 (13.5)
NLPHL	12 (7.7)	2 (16.7)	8 (66.7)	2 (100)	2 (100)	-	35 (0.2)	28 (0.2)	7 (0.3)	6 (85.7)	1 (14.3)

[1]Multiple Causes (MCoD): U07.1, U07.2, U09.9, U10.9 [2]ICD 10 codes: C81-C96, D45-47. [3]Diagnostic subgroups more than 75 diagnoses. APL: Acute promyelocytic leukaemia, MPNs: myeloproliferative neoplasms, Chronic myelomonocytic leukaemia, MGUS: monoclonal gammopathy of undetermined significance, MBL: monoclonal B-cell lymphocytosis, LPD NOS: Lymphoproliferative Disorders, Not Otherwise Specified, LGL leukaemia: T-cell large granular lymphocytic leukaemia, NLPHL: nodular lymphocyte predominant Hodgkin lymphoma, [3] Excluding disease progression to CLL (MBL, n=119) or myeloma (MGUS, n=95).