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Research Article

Revisiting Cancer Diagnosis in Scotland: Further Insights from the Second Scottish National Cancer Diagnosis Audit

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Objective. To characterise cancer diagnosis in Scottish primary care in 2018/19 and draw comparisons with diagnostic activity in 2014. *Methods*. A national audit of cancer diagnosis undertaken in Scottish general practices. Participating GPs collected diagnostic pathway data on patients diagnosed with cancer in 2018/19 from medical records. These data were supplemented by linkage to the Scottish Cancer Registry and previous audit data from 2014. Analyses explored and compared patient demographics, presentation, diagnostic routes, and intervals. *Results*. Seventy-three practices submitted data on 2,014 cases in 2014 and 90 practices submitted data on 2,318 cases in 2018/2019. Individual demographics and types of cancer were similar. There was a higher proportion of USC (urgent suspected cancer) referrals in 2019 than 2014 (42.9% vs 38.1%, $p = 0.008$) but a similar proportion of emergency presentations (19.2% vs 20.4%). Primary care (median 4 (IQR 0–22) vs 5 (0–23)) and diagnostic intervals (27 (10–59) vs 30 (13–68)) were similar in both periods. Significantly fewer (24.5% vs 28.3, $p = 0.015$) had a diagnostic interval >60 days in 2019 than 2014. Harder to diagnose cancers were more likely to present as emergencies and be subject to prolonged delays in both cohorts. *Conclusions*. The 2014 and 2018/19 cohorts were broadly similar. There is limited evidence that USC use had increased between 2014 and 2018/19. Harder to diagnose cancers are still most likely to present as emergencies and be subject to delays. Overall, it seems there were small improvements in cancer diagnosis prepandemic and a further audit could examine evidence for a postpandemic recovery.

1. Introduction

Over 34,000 people were diagnosed with cancer in Scotland in 2019 and incidence continues to increase [1]. The most common cancers in Scotland are breast, lung, prostate, and colorectal accounting for over half of all cancers [1]. Scotland has typically had poorer survival rates than the European average [2–7], although there have recently been some modest survival improvements [2, 3].

To better understand influences on cancer outcomes in Scotland, there is value in analysing individual patient pathways to cancer diagnosis and the component intervals [8]. These include primary care interval, the time between a patient first presenting in primary care and secondary care referral, and the diagnostic interval, the time between a first presentation in primary care until cancer diagnosis [8]. Prolonged patient pathways vary by cancer type and prolonged intervals have been linked to increased anxiety for patients, later stage at diagnosis, increased costs, and mortality [9–17].

Expediting cancer diagnosis and treatment is a key priority for the Scottish Government [18]. The Scottish Cancer Referral Guidelines for Suspected Cancer, first published in 2002 and in 2019, provide guidance to primary care practitioners on identifying those most likely to have cancer and in need of urgent referral [19, 20]. The Scottish Government published its cancer strategy "Beating Cancer: Ambition and Action" in 2016 [18]. This aims to support

GPs to refer people with suspected cancer early including the introduction of Early Cancer Diagnostic Centres (ECDCs) [18].

Evaluating such strategies is vital to ensure their potential to improve cancer outcomes in Scotland [21]. The National Cancer Diagnosis Audit (NCDA), led by Cancer Research UK, aims to provide greater insight into factors impacting patients' cancer journeys within Scottish primary care. In 2020, Murchie et al. described Scottish primary care cancer diagnostic performance, with data on 2,014 cancer patients within Scotland in the year 2014 [22]. They found most patients within Scotland present first to a GP (71.5%) and approximately a third are referred via the "Urgent Suspicion of Cancer" pathway. Most patients are referred and diagnosed quickly, albeit with variability between cancer sites. Comparison with a similar audit conducted in England in 2014 showed little difference in diagnostic pathways despite diverging health systems [22, 23].

The current paper aims to enhance these insights by adding cases from the second NCDA in Scotland. The current study analyses data from combined Scottish NCDA 2014 and 2018/19 audits.

There were three objectives for the study:

(1) To describe the most recent NCDA dataset to illustrate how cancer was being diagnosed in Scotland between 2018 and 2019

(2) To determine whether important changes to cancer diagnostic pathways may have occurred in Scotland between 2014 and 2018/19

(3) To consider potential of Early Cancer Diagnostic Centres to improve cancer diagnosis in Scotland.

2. Methods

The audit and analysis were approved by the Public Benefit and Privacy Panel (PBPP) of NHS Scotland (project 1819-0169) on 17th June 2019

2.1. Study Variables. Patient demographics (age, sex, socioeconomic, and residential status), cancer type, date of diagnosis, stage, and grade at diagnosis were provided from the Scottish Cancer Registry. Participating GPs provided information on presenting symptoms, consultations, investigations, safety-netting, referrals, avoidable delays, and key pathway dates. The details and sequence of data collection are described.

2.2. Data Collection. Volunteer General Practices were recruited following promotion of the audit by the Royal College of General Practitioners and Cancer Research UK. In addition, e-mail invitations were sent to practice managers at each Scottish General Practice publicising the audit. Practices responding to advert were asked to identify a lead GP with whom all further audit communication was coordinated. Different practices participated in the 2014 audit and 2019 audit.

Subsequently analysts from the Information and Services Division (ISD) of NHS Scotland assigned all incident cancers within participating practices (excluding non-melanoma skin cancer) that had been diagnosed in the practice population between October 2018 and September 2019 using the Scottish Cancer Registry dataset.

Participating practices completed a Caldicott data release form allowing patient information from practice-held electronic primary care records to be shared with ISD and then linked to data from the Scottish Cancer Registry using patients' CHI numbers. The CHI number is a unique 10-character numeric identifier, allocated to each patient. A pre-prepared Excel form was securely sent to the lead GP at each participating practice who coordinated the completion of a proforma for each identified patient. These were then deidentified and returned securely to ISD.

Information collected using the forms included patient characteristics, presenting symptoms and signs, number and type of consultations prior to referral, primary care-led investigations, and the presence of documented safety-netting (either in the form of "when to represent" or further appointments organised). Information was also collected on whether the individual completing the form considered there had been an avoidable delay "GP perceived avoidable delay" (in three areas of the patient journey—the presentation, between presentation and referral or after referral), using a yes/no tick box. Referral type was also collected including "routine" (nonurgent and nonsuspected cancer referrals), "urgent" (not meeting the cancer referral guidelines but deemed to be needing to be seen urgently by referrer), "urgent suspected cancer" (suspected cancer referral and should receive treatment within 62 days of receipt of referral), emergency (same day admission for investigation), private referral, screening detected, or "others" which included multidisciplinary centre referral. Key dates, including when the patient first presented, when referred from primary care, and when first seen by a specialist in secondary care, were also collected. The form included either tick boxes or drop-down menus with predefined answers, except for dates which had to be entered manually. Cancer type, date of diagnosis, stage, and grade at diagnosis were added by ISD upon receipt using linkage to the Scottish Cancer Registry dataset. Scottish Index of Multiple Deprivation (SIMD) quintile and urban-rural classification were also assigned based on patient residential postcodes at time of diagnosis.

2.3. Data and Statistical Analysis. All analyses were conducted using SPSS version 27.

The distribution of patient characteristics including sex, age group, living arrangements including housebound status, language and communication difficulties, ethnicity, cancer site, SIMD (1 (most deprived)–5 (least deprived)), urban-rural 2-fold classification (a population of less than 3000 people is classified as rural) [20], and presence and type of comorbidities of this cohort was compared with the 2014 cohort as described by Murchie et al. in 2020 [22].

Key variables detailing referral type leading to diagnosis, pathway intervals, and presence or absence of perceived avoidable delay were grouped by sex, age group (0–24, 25–49, 50–64, 65–74, 75–84 and ≥85 years), cancer site, SIMD, urban-rural 2-fold classification, and comorbidity count. The comorbidity count was categorised as 0, 1, 2, and ≥3 based on the number of separate coexisting medical conditions of individuals included from the primary care record. $N < 5$ was used to minimise disclosure risk when illustrating these data in the tables and represents either 0, 1, 2, 3, or 4 patients only in this category.

Two key pathway intervals were analysed in the whole cohort: primary care interval and the diagnostic interval [8]. The primary care interval was calculated from date of first presentation to primary care with symptoms considered relevant to the ultimate cancer diagnosis as judged by the GP completing the proforma to the date of first referral to secondary care. The diagnostic interval was calculated from date of first presentation as above to the date of diagnosis recorded in the Scottish Cancer Registry. Intervals of <0 and >730 days were excluded, as per analysis of previous audits [15, 16]. The median and 25th and 75th centiles are described for the updated 2019 audit, alongside the percentage of patients with a primary care interval or diagnostic interval of >60 or >90 days. The proportion of patients with primary care interval or diagnostic interval of >60 or >90 days were compared between the original 2014 dataset and 2019 dataset with unadjusted and adjusted logistic regression (adjusted for sex, age, cancer site, number of comorbidities, SIMD, and urban/rural classification). To further explore potential sex differences in the pathway primary care and diagnostic intervals were also calculated for males and females separately for the commonest cancers, colon, lung and bronchus, and others, with intervals also calculated separately for the sex specific cancers: female breast, ovarian and gynaecological, and prostate.

In a supplementary analysis, to establish potential benefit from Early Cancer Diagnostic Centres (ECDCs) which were piloted in three Health Boards in Scotland between June 2021 and June 2022, cancer pathway intervals were calculated for patients who, based on their symptoms and signs at diagnosis, would have been eligible for an ECDC referral according to those being applied at three current ECDC sites in Scotland during the pilot [24]. Patients with one or more of the following symptoms were selected: pain, nausea/vomiting, loss of appetite or early satiety, fatigue, jaundice, weight loss, or others as signifying "GP Gut feeling." Patients with one or more of the following clinical findings were also selected: nonspecific anaemia, hypercalcaemia, raised ESR, thrombocytosis, abnormal LFTs, and symptomatic FIT. From this subset, patients with an additional alarm feature or who had been referred as "Urgent-Suspected Cancer" were excluded. The ECDC and non-ECDC samples were described and median (interquartile range) pathway delays (as reported in previous evaluations of ECDC-type initiatives conducted elsewhere) were calculated.

3. Results

3.1. Patient and Practice Characteristics. In 2014, 73 (7.7% of a total of 948) Scottish General Practices submitted data and 90 (9.9% of a total of 911) in 2018/2019 provided 2,014 and 2,318 cancer diagnoses, respectively. Nineteen practices participated in both audits.

There were no notable differences likely to be clinically important between the two audit cohorts in the distribution of individual patient characteristics such as age, sex, cancer type, and comorbidities (Table 1); however, there was a significant difference between cohorts in area-based deprivation (SIMD) and urban-rural classification (SIMD and rurality) likely driven by differences in the GP practices which participated in the 2014 and 2019 audits. There was also a significant difference between cohorts in the distribution of ethnicity and language ability between cohorts although apparently due to a small increase in non-white subjects (16 vs 31) and non-native but fluent English speakers. Patient characteristics of the 2014 audit have previously been described [22]. In the 2019 audit, the median age at diagnosis of included patients was 69 years and 51.1% were women. Stage at diagnosis was available for 71.8% of individuals. Patients were predominately white and native English speakers. Most individuals were not housebound (86.2%) and just over half described cohabiting (55.5%). A quarter of individuals had no comorbidities and just over 20% had three or more comorbidities. The most common comorbidity described was hypertension (34.7%) followed by cardiovascular disease (21%) and then arthritis/musculoskeletal disease (15.9%). With respect to the Scottish Index of Multiple Deprivation (SIMD), 19.9% of individuals were from the most deprived and 22.9% from the least deprived quintiles. Most patients, 78.9%, were urban-dwellers and 21.1% were rural dwellers.

The most common cancer types were lung and bronchus ($n = 371$, 16%), breast ($n = 297$, 12.8%), prostate ($n = 288$, 12.4%), and colon ($n = 235$, 10.1%).

3.2. Referral Type. Table 2 outlines the referral route for patients in the 2019 audit. The urgent suspicion of cancer (USC) pathway was used in 42.9% of patients with 19.2% referred as an emergency (including patients admitted to hospital by a GP or self-presenting to Accident and Emergency). There were large variations between cancer types. In individuals diagnosed with melanoma, "other gynaecological," ovarian, oesophageal, breast, and prostate cancer over 50% of referrals were via the USC route (60.7%, 60%, 60%, 59.7%, 53.2%, and 53.8%, respectively), whereas in individuals diagnosed with leukaemia, pancreatic cancer, and multiple myeloma less than 25% were referred as USC (17.4%, 23.5%, and 16.7%, respectively). Emergency referral was most common in individuals with brain, pancreatic, multiple myeloma, and leukaemia cancers (67.6%, 51%, 50%, and 47.8%, respectively).

Table 1: Patient characteristics and comparison of 2014 and 2019 cohorts.

	2014 *N* (%)	2019 *N* (%)	Total *N* (%)	Sig[1]
Total	2014 (100)	2318 (100)	4332 (100)	
Sex				
Male	998 (49.6)	1133 (48.9)	2131 (49.2)	0.196
Female	1016 (50.4)	1185 (51.1)	2201 (50.8)	
Age categories (years)				
0–24	17 (0.8)	26 (1.1)	43 (1)	
25–49	184 (9.1)	210 (9.1)	394 (9.1)	
50–64	522 (25.9)	606 (26.1)	1128 (26)	0.097
65–74	564 (28)	715 (30.8)	1279 (29.5)	
75–84	520 (25.8)	570 (24.6)	1090 (25.2)	
≥85	207 (10.3)	191 (8.2)	398 (9.2)	
Cancer types				
Colon	183 (9.1)	235 (10.1)	418 (9.6)	
Lung and bronchus	358 (17.8)	371 (16)	729 (16.8)	
Breast	270 (13.4)	297 (12.8)	567 (13.1)	0.255
Prostate	222 (11)	288 (12.4)	510 (11.8)	
Others	981 (48.7)	1127 (48.6)	2108 (48.7)	
Stage at diagnosis				
1	270 (13.4)	439 (18.9)	709 (16.4)	
2	262 (13)	352 (15.2)	614 (14.2)	
3	250 (12.4)	343 (14.8)	593 (13.7)	0.08
4	423 (21)	531 (22.9)	954 (22)	
Unknown	809 (40.2)	653 (28.2)	1462 (33.7)	
Ethnicity				
White	1928 (95.7)	2234 (96.4)	4162 (96.1)	
Mixed, Black, Asian, and others	16 (0.8)	31 (1.4)	47 (1)	0.007
Unknown	70 (3.5)	53 (2.3)	123 (2.8)	
Language ability				
Native English speaker	1910 (94.8)	2238 (96.5)	4148 (95.8)	<0.001
Communication difficulties				
None	1575 (78.2)	1978 (85.3)	3553 (82)	
≥1	288 (14.3)	256 (11)	544 (12.6)	<0.001
Not known	151 (7.5)	84 (3.6)	235 (5.4)	
Comorbidities				
None	497 (24.8)	595 (25.9)	1092 (25.4)	
1	553 (27.6)	690 (30.1)	1243 (28.9)	
2	507 (25.3)	510 (22.2)	1017 (23.7)	0.067
≥3	444 (22.2)	498 (21.7)	942 (21.9)	
Not known	13	25	38	
Patient SIMD at diagnosis				
1	464 (23)	457 (19.9)	921 (21.3)	
2	374 (18.6)	447 (19.4)	821 (19)	
3	340 (16.9)	443 (19.3)	783 (18.1)	<0.001
4	452 (22.4)	428 (18.6)	880 (20.4)	
5	384 (19.1)	526 (22.9)	910 (21.1)	
Not known	0	17	17	
2-fold urban rural classification				
Urban	1538 (76.4)	1810 (78.9)	3348 (77.7)	
Rural	476 (23.6)	485 (21.1)	961 (22.3)	0.049
Not known	0	23	23	

[1]Chi-squared test.

Individuals aged 0–24 and 85 years and over had a lower percentage of USC referrals (26.9% and 29.3%) and higher percentage of emergency referrals (42.3% and 36.1%, respectively). Individuals with no comorbidities had a higher percentage of urgent suspicion of cancer referrals compared with individuals with three or more comorbidities (47.7% and 35.3%, respectively) with the inverse seen for emergency referral (15.1% and 24.9%, respectively). Table 3 compares

Table 2: Type of referral for 2019 only.

	Routine	Urgent	Urgent suspected cancer	Private health clinic referral	Emergency referral	Screening detected	Others	Not known	Total
	N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Total	191 (8.2)	209 (9)	995 (42.9)	33 (1.4)	444 (19.2)	150 (6.5)	152 (6.6)	144 (6.2)	2318
Sex									
Male	120 (10.6)	101 (8.9)	490 (43.2)	21 (1.9)	214 (18.9)	37 (3.3)	85 (7.5)	65 (5.7)	1133
Female	71 (6.0)	108 (9.1)	505 (42.6)	12 (1)	230 (19.4)	113 (9.5)	67 (5.7)	79 (6.7)	1185
Age categories (years)									
0–24	<5	<5	7 (26.9)	<5	11 (42.3)	0 (0)	<5	<5	26
25–49	20 (9.5)	16 (7.6)	104 (49.5)	11 (5.2)	34 (16.2)	8 (3.8)	9 (4.3)	8 (3.8)	210
50–64	42 (6.9)	59 (9.7)	274 (45.2)	9 (1.5)	83 (13.7)	72 (11.9)	30 (5)	37 (6.1)	606
65–74	72 (10.1)	62 (8.7)	313 (43.8)	7 (1)	112 (15.7)	58 (8.1)	47 (6.6)	44 (6.2)	715
75–84	45 (7.9)	49 (8.6)	241 (42.3)	<5	135 (23.7)	12 (2.1)	43 (7.5)	41 (7.2)	570
≥85	10 (5.2)	21 (11)	56 (29.3)	<5	69 (36.1)	0 (0)	22 (11.5)	12 (6.3)	191
Cancer site categories									
Bladder	5 (8.5)	6 (10.2)	26 (44.1)	<5	13 (22)	0 (0)	<5	<5	59
Brain	6 (16.2)	<5	<5	<5	25 (67.6)	0 (0)	0 (0)	<5	37
Breast	13 (4.4)	20 (6.7)	158 (53.2)	8 (2.7)	16 (5.4)	67 (22.6)	<5	12 (4)	297
Colon	12 (5.1)	29 (12.3)	79 (33.6)	0 (0)	49 (20.9)	48 (20.4)	<5	15 (6.4)	235
Gynae–others	6 (6.0)	14 (14)	60 (60)	0 (0)	7 (7)	8 (8)	<5	<5	100
Leukaemia	<5	<5	8 (17.4)	0 (0)	22 (47.8)	0 (0)	6 (13)	5 (10.9)	46
Liver and bile tract	5 (9.1)	<5	14 (25.5)	0 (0)	21 (38.2)	<5	10 (18.2)	<5	55
Lung and bronchus	14 (3.8)	29 (7.8)	132 (35.6)	0 (0)	113 (30.5)	<5	47 (12.7)	35 (9.4)	371
Lymphoma	9 (8.9)	10 (9.9)	41 (40.6)	6 (5.9)	22 (21.8)	0 (0)	8 (7.9)	5 (5)	101
Melanoma	19 (16.2)	11 (9.4)	71 (60.7)	<5	0 (0)	<5	12 (10.3)	<5	117
Multiple myeloma	<5	<5	5 (16.7)	0 (0)	15 (50)	<5	<5	<5	30
Oesophageal	<5	8 (12.9)	37 (59.7)	0 (0)	10 (16.1)	<5	<5	<5	62
Oral/ oropharyngeal	<5	8 (11.1)	37 (51.4)	<5	<5	0 (0)	<5	18 (25)	72
Others	11 (9.8)	12 (10.7)	43 (38.4)	5 (4.5)	24 (21.4)	<5	9 (8)	7 (6.3)	112
Ovarian	<5	<5	27 (60)	0 (0)	11 (24.4)	0 (0)	<5	<5	45
Pancreas	<5	<5	12 (23.5)	<5	26 (51)	<5	<5	<5	51
Prostate	55 (19.1)	26 (9)	155 (53.8)	5 (1.7)	19 (6.6)	<5	18 (6.3)	7 (2.4)	288
Rectal	9 (9.8)	9 (9.8)	41 (44.6)	<5	<5	16 (17.4)	<5	7 (7.6)	92
Renal	9 (12.7)	8 (11.3)	22 (31)	<5	19 (26.8)	<5	9 (12.7)	<5	71
Stomach and small intestine	<5	5 (7.4)	26 (38.2)	<5	24 (35.3)	0 (0)	<5	5 (7.4)	68
Unknown primary	0 (0.0)	<5	0 (0)	0 (0)	<5	0 (0)	<5	<5	9
Patient SIMD[1]									
1	30 (6.6)	40 (8.8)	176 (38.5)	<5	102 (22.3)	31 (6.8)	39 (8.5)	38 (8.3)	457
2	34 (7.6)	38 (8.5)	190 (42.5)	<5	92 (20.6)	31 (6.9)	30 (6.7)	30 (6.7)	447
3	47 (10.6)	49 (11.1)	190 (42.9)	6 (1.4)	83 (18.7)	23 (5.2)	16 (3.6)	29 (6.5)	443
4	33 (7.7)	43 (10)	191 (44.6)	8 (1.9)	68 (15.9)	31 (7.2)	32 (7.5)	22 (5.1)	428
5	47 (8.9)	38 (7.2)	242 (46)	15 (2.9)	96 (18.3)	32 (6.1)	33 (6.3)	23 (4.4)	526
2-fold urban rural classification[2]									
Urban	148 (8.2)	166 (9.2)	759 (41.9)	20 (1.1)	359 (19.8)	122 (6.7)	117 (6.5)	119 (6.6)	1810
Rural	42 (8.7)	42 (8.7)	228 (47)	12 (2.5)	81 (16.7)	26 (5.4)	33 (6.8)	21 (4.3)	485

Table 2: Continued.

	Routine	Urgent	Urgent suspected cancer	Private health clinic referral	Emergency referral	Screening detected	Others	Not known	Total
	N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Comorbidities[3]									
None	46 (7.7)	51 (8.6)	284 (47.7)	17 (2.9)	90 (15.1)	54 (9.1)	18 (3)	35 (5.9)	595
1	59 (8.6)	59 (8.6)	317 (45.9)	8 (1.2)	115 (16.7)	51 (7.4)	42 (6.1)	39 (5.7)	690
2	43 (8.4)	48 (9.4)	208 (40.8)	<5	112 (22)	30 (5.9)	40 (7.8)	25 (4.9)	510
≥3	42 (8.4)	51 (10.2)	176 (35.3)	<5	124 (24.9)	15 (3)	51 (10.2)	36 (7.2)	498

[1]Not including 17 with unknown SIMD; [2]not including 23 with unknown rurality; [3]not including 25 with unknown comorbidity.

Table 3: Type of referral and percentages compared between time periods.

	Valid *N*	Routine	Urgent	Urgent suspected cancer (USC)	Private health clinic referral	Emergency referral	Screening detected	Others	Not known
		%	%	%	%	%	%	%	%
2014	1974	**10.5**	9.4	**38.1**	1.1	20.4	6.0	**8.5**	6.0
2019	2318	**8.2**	9.0	**42.9**	1.4	19.2	6.5	**6.6**	6.2
Change		**−2.3**	0.4	**4.8**	0.3	−1.2	0.5	**−1.9**	0.2

Chi-squared test 0.008.

referral routes between the 2014 and 2018/19 audits demonstrating an increase of 4.8% in USC referrals and a 1.2% reduction in emergency presentations and 2.3% reduction in routine referrals between the two time periods.

3.3. Primary Care and Diagnostic Intervals and Avoidable Delays. Table 4 details primary care intervals for the 2019 audit, and details on the 2014 cohort were previously published [22]. The median primary care interval was 4 days (IQR 0–22 days), with 10.9% of individuals having a primary care interval >60 days and 7.5% of individuals with a primary care interval >90 days. The primary care interval was shortest in individuals with breast cancer (0, IQR 0-1) and those diagnosed with melanoma (0, IQR 0–2) and longest in individuals with an unknown primary (55, IQR 14–76) or multiple myeloma (27, IQR 3–49). There were no significant differences between male and female patients for non-sex specific cancers which are further described in supplementary Table 2. For colon cancer, the median primary care interval for men was 8 days (IQR 1–22 days) and for women, it was 6 days (IQR 1–21 days), $p = 0.885$. For lung and bronchus cancer, the median primary care interval for men was 7 days (IQR 0–30.5 days) and for women, it was 11 days (IQR 0–26 days), $p = 0.575$. For all other non-sex specific cancers combined the median primary care interval for men was 4 days (IQR 0–27 days) and for women, it was 3 days (IQR 0–28.5 days), $p = 0.753$.

There did not appear to be any clinically important differences in primary care interval based on SIMD status (3 days in least deprived vs 4 days in most deprived), although individuals living in an urban setting had a shorter median primary care interval of 3 days (IQR 0–20) compared with 7 days (IQR 0–29) in individuals living within a rural setting.

Table 5 details diagnostic intervals for the 2018/19 audit. The median diagnostic interval was 27 days (IQR 10–59), with 24.5% of individuals having a diagnostic interval >60 days and 16.2% of individuals with a diagnostic interval >90 days. The diagnostic interval was shortest for individuals with leukaemia (7, IQR 2.5–33), pancreatic cancer (12.5, IQR 1.5–35), and brain cancer (16.5, IQR 0–43) and longest in prostate (44.5, IQR 23–105) and rectal cancer (40.5, IQR 19–122). There were no clinically important differences in diagnostic intervals between men and women within non-sex specific cancers (supplementary Table 1).

In 39.4% of cases, GPs perceived there had been an avoidable delay. This ranged from 57.4% of individuals with rectal cancer to 21.1% of individuals with leukaemia (supplementary Table 2). GP perceived avoidable delay appeared lower in the most deprived areas (31.8%) and higher in rural settings (48.3%).

3.4. Comparison between 2014 and 2019 Audits. Tables 1, 3, and 6 compare data between the 2014 and the 2019 audit. Table 1 shows that the individual demographics and types of cancer were similar in both audits. There was a change in the pattern of referrals from 2014 to 2019 ($p = 0.008$) with an increase in "urgent suspected cancer" and corresponding decrease in "routine," "emergency," and "others" referrals (Table 3). The median primary care interval was 5 days (IQR 0–23 days) in 2014 and 4 days (IQR 0–22 days) in 2019. There was no significant difference in the proportion of individuals

Table 4: Primary care interval (PCI) descriptive statistics with percentages of patients with PCI of >60 and >90 days for 2019 (excluding screening detected patients[1]).

	Total	Missing	Primary care interval	PCI >60 days	PCI >90 days
	N	*N*	Median days (25th–75th centile)	%	%
Total	2125	602	4 (0–22)	10.9	7.5
Sex					
Male	1092	331	7 (0–28)	11.3	7.4
Female	1033	271	2 (0–17)	10.5	7.6
Age categories (years)					
0–24	26	7	6 (0–15)	0	0
25–49	197	39	1 (0–16)	12	7
50–64	519	119	3 (0–19.5)	10.3	7.3
65–74	642	172	6 (0–27)	11.7	8.3
75–84	551	189	3 (0–21)	9.4	6.4
≥85	190	76	7 (0–33)	14.9	10.5
Cancer site categories					
Bladder	59	16	6 (0–21)	16.3	9.3
Brain	37	16	4 (1–25)	$n < 5$	$n < 5$
Breast	211	24	0 (0-1)	5.3	4.3
Colon	170	47	7 (1–21)	14.6	11.4
Gynae–others	88	11	1 (0–4)	$n < 5$	$n < 5$
Leukaemia	45	20	3 (1–22)	12	12
Liver and bile tract	54	23	7 (0–32)	12.9	9.7
Lung and bronchus	371	144	8 (0–29)	9.3	5.3
Lymphoma	101	26	9 (0–42)	14.7	10.7
Melanoma	117	21	0 (0–2)	7.3	6.3
Multiple myeloma	30	16	27 (3–49)	$n < 5$	$n < 5$
Oesophageal	62	10	3 (0–27.5)	11.5	$n < 5$
Oral/oropharyngeal	72	29	4 (0–57)	23.3	14
Others	108	33	7 (0–33)	9.3	5.3
Ovarian	45	11	6 (0–29)	11.8	$n < 5$
Pancreas	50	13	2 (0–22)	$n < 5$	$n < 5$
Prostate	288	74	11 (3–28)	12.6	8.9
Rectal	69	12	3 (0–26)	19.3	12.3
Renal	71	24	3 (0–24)	8.5	$n < 5$
Stomach and small intestine	68	26	8.5 (1–29)	14.3	11.9
Unknown primary	9	6	55 (14–76)	$n < 5$	0
Comorbidity category					
None	526	105	3 (0–20)	10.2	7.8
1	625	168	4 (0–22)	11.6	6.8
2	470	139	3 (0–21)	10	6.6
≥3	481	179	6 (0–29)	11.9	8.9
Patient SIMD at diagnosis					
1	417	144	3 (0–23)	8.8	4
2	404	116	4 (0–20)	9	5.9
3	415	116	3 (0–28)	14	9.7
4	392	106	3.5 (0–21)	11.2	8.7
5	482	114	4 (0–24)	11.4	8.7
2-fold urban rural classification					
Urban	1655	483	3 (0–20)	10.2	6.7
Rural	449	110	7 (0–29)	13.9	10.3

[1]The 2019 survey included an initial question: "Was the patient's cancer known to be detected by NHS cancer screening services relevant to this diagnosis?" any patient where the GP had responded yes to this question were excluded from further analysis and accounts for the difference in valid *N* between the analysis on referrals compared with PCI/DI.

who had a primary care interval >60 days ($p = 0.719$) and >90 days, respectively, ($p = 0.845$). Similarly, the median diagnostic interval was 30 days (IQR 13–68 days) in 2014 and 27 days (IQR 10–59) in 2019. There was a small but significant decrease in the proportion of individuals who had a diagnostic interval >60 days, 28.3% in 2014 and 24.5% in 2019 ($p = 0.015$), but no difference in the proportion >90 days ($p = 0.216$).

Table 5: Diagnostic interval descriptive statistics with percentages of patients with DI of >60 and >90 days for 2019 (excluding screen detected).

	Total	Missing	Diagnostic interval	DI > 60 days	DI > 90 days
	N	*N*	Median days (25th–75th centile)	%	%
Total	2125	414	27 (10–59)	24.5	16.2
Sex					
Male	1092	238	30 (11–70)	28.2	19.2
Female	1033	176	23 (9–48)	20.9	13.2
Age categories (years)					
0–24	26	4	22 (7–49)	$n < 5$	$n < 5$
25–49	197	21	25.5 (10–51.5)	20.5	11.9
50–64	519	79	25 (12–56)	23.2	13.2
65–74	642	124	29 (11–70)	27.8	20.5
75–84	551	133	23 (7–53)	22.2	13.6
≥85	190	53	27 (7–88)	30.7	24.8
Cancer site categories					
Bladder	59	7	27.5 (8.5–68)	25	19.2
Brain	37	7	16.5 (0–43)	20	13.3
Breast	211	19	20 (11.5–35)	7.8	4.2
Colon	170	27	32 (12–76)	31.5	21.7
Gynae–other	88	8	24.5 (12.5–52)	18.8	10
Leukaemia	45	9	7 (2.5–33)	19.4	13.9
Liver and bile tract	54	22	17.5 (1.5–34)	12.5	9.4
Lung and bronchus	371	93	17 (3–44)	18.7	11.5
Lymphoma	101	19	33 (15–76)	28	19.5
Melanoma	117	10	21 (13–49)	21.5	9.3
Multiple myeloma	30	7	37 (20–77)	34.8	17.4
Oesophageal	62	7	28 (12–71)	27.3	12.7
Oral/oropharyngeal	72	24	35.5 (15.5–97.5)	37.5	27.1
Others	108	23	30 (10–67)	30.6	17.6
Ovarian	45	8	21 (8–47)	21.6	8.1
Pancreas	50	6	12.5 (1.5–35)	13.6	9.1
Prostate	288	70	44.5 (23–105)	36.7	27.5
Rectal	69	13	40.5 (19–122)	35.7	30.4
Renal	71	21	36.5 (9–94)	42	28
Stomach and small intestine	68	11	20 (3–56)	24.6	21.1
Unknown primary	9	3	34 (14–55)	16.7	16.7
Comorbidity category					
No comorbidities	526	71	28 (13–53)	22.2	13.6
1 comorbidity	625	100	23 (10–58)	24	16
2 comorbidities	470	100	22.5 (7–51)	21.6	14.9
≥3 comorbidities	481	133	31.5 (10.5–78)	31.3	21
Patient SIMD at diagnosis					
1	417	103	22 (8–55)	23.2	11.1
2	404	74	25 (8–56)	22.7	16.1
3	415	75	29.5 (11.5–63.5)	26.2	19.4
4	392	74	27 (10–61)	25.2	14.5
5	482	86	28 (12–62.5)	25.8	19.2
2-fold urban rural classification					
Urban	1655	333	25 (10–56)	23.8	15.7
Rural	449	78	33 (12–70)	28	18.6

3.5. Potential for ECDC Benefit. Based on symptoms and signs recorded at presentation, 776 (17.9%) cases out of 4,331 in the combined dataset may have been eligible for ECDC referral (supplementary Table 3). Of these cases, 186 (24.0%) were patients subsequently diagnosed with lung cancer, with colon cancer being the next most common diagnosis in 69 (8.9%) of cases. In this subset of patients, median primary care interval was 7 days (IQR 0–29) compared to 4 days (0–21) ($p = 0.001$) for those patients that may not have been eligible for ECDC referral. Conversely, subsequent intervals were all significantly shorter in the ECDC sample compared to those who may not have been eligible for ECDC referral (supplementary Table 4).

Table 6: Primary care intervals and diagnostic intervals where the interval was greater than 60 and 90 days, respectively, for both time periods (excluding screen detected).

	% PCI >60 days		% PCI >90 days		PCI valid *N*		% DI >60 days		% DI >90 days		DI valid *N*	
	2014	2019	2014	2019	2014	2019	2014	2019	2014	2019	2014	2019
Total	11.3	10.9	7.7	7.5	1314	1523	28.3	24.5	17.8	16.2	1572	1711
Sex												
Male	12.5	11.3	8.2	7.4	656	761	31.5	28.2	19.3	19.2	791	854
Female	10.2	10.5	7.1	7.6	658	762	25.1	20.9	16.3	13.2	781	857
Age categories (years)												
0–24	$n < 5$	$n < 5$	$n < 5$	$n < 5$	7	19	$n < 5$	$n < 5$	$n < 5$	$n < 5$	11	22
25–49	8.9	12.0	5.6	7.0	124	158	23.7	20.5	12.5	11.9	152	176
50–64	12.7	10.3	9.3	7.3	332	400	30.8	23.2	20.8	13.2	390	440
65–74	12.0	11.7	8.5	8.3	376	470	32.4	27.8	20.2	20.5	445	518
75–84	11.2	9.4	6.3	6.4	348	362	25.5	22.2	16.2	13.6	408	418
≥85	8.7	14.9	6.3	10.5	127	114	22.3	30.7	13.3	24.8	166	137
Cancer site categories												
Colon	12.2	14.6	9.2	11.4	98	123	32.1	31.5	22.1	21.7	131	143
Lung and bronchus	17.2	9.3	9.0	5.3	221	227	28.3	18.7	18.9	11.5	286	278
Breast	$n < 5$	5.3	1.2	4.3	173	187	5.9	7.8	2.7	4.2	188	192
Prostate	13.8	12.6	11.9	8.9	160	214	48.0	36.7	28.6	27.5	175	218
Comorbidity category												
None	10.2	10.2	7.6	7.8	315	421	28.5	22.2	17.1	13.6	369	455
1	10.0	11.6	6.8	6.8	370	457	25.0	24.0	16.6	16.0	440	525
2	9.8	10.0	5.3	6.6	337	331	27.0	21.6	15.1	14.9	404	370
≥3	16.4	11.9	11.9	8.9	286	302	34.2	31.3	23.6	21.0	351	348
Patient SIMD at diagnosis												
1	10.1	8.8	8.0	4.0	286	273	26.0	23.2	17.2	11.1	354	314
2	10.0	9.0	6.3	5.9	240	288	28.7	22.7	16.9	16.1	296	330
3	10.2	14.0	7.6	9.7	225	299	26.2	26.2	17.9	19.4	263	340
4	13.4	11.2	7.3	8.7	314	286	31.6	25.2	19.3	14.5	358	318
5	12.4	11.4	9.2	8.7	249	368	28.6	25.8	17.6	19.2	301	396
2-fold urban rural classification												
Urban	10.7	10.2	7.1	6.7	987	1172	27.4	23.8	17.0	15.7	1191	1322
Rural	13.1	13.9	9.5	10.3	327	339	31.2	28.0	20.2	18.6	381	371

4. Discussion

4.1. Summary of Key Findings. In this study, we describe the updated National Cancer Diagnosis Audit and compare the findings with the previous audit carried out in 2014. The proportion of patients being referred via a USC referral was significantly higher in 2019 audit with a similar proportion of patients being diagnosed following an emergency presentation. There do not appear to have been any notable and clinically significant changes in primary care and diagnostic intervals between the two audit periods. However, we documented a significant reduction in the proportion of patients with diagnostic interval >60 days in the latest audit cohort. There remains clear variation between cancer site in the use of "urgent suspected cancer referral" pathway, the length of the primary care interval/diagnostic interval, and the presence of avoidable delays. There was no difference in the primary care and diagnostic interval in nongender specific cancers. In 2019, overall, the median primary care interval was 4 days, and the diagnostic interval was 27 days. A subset of patients who may have been eligible for ECDC referral were identified amongst whom lung, colon, and liver and bile tract cancers were the commonest diagnoses. Overall, their median primary care interval was 7 days and diagnostic interval 24 days.

4.2. Context with Other Literature. Almost half (42.9%) of the patients were referred through the "Urgent-Suspected Cancer" (USC) pathway, a 4.8% increase from 38.1% in 2014. There is some evidence that mortality is lower amongst patients from general practices which make more USC referrals, particularly for the four main cancer (breast, lung, colorectal, and prostate) types [25–28]. This effect is thought to result from earlier stage at diagnosis and supports increasing use of USC referrals and lowering of referral thresholds [29]. In this context our results are encouraging since they suggest that GPs began to use the USC route more frequently between the two audit periods which could be contributing to a greater proportion of cancers being diagnosed at an earlier stage in Scotland. This point will, however, require to be confirmed using the much larger dataset provided by the Scottish Cancer Registry. The Scottish Cancer Referral guidelines were updated in early

2019 with some thresholds being reduced [19]. Due to the overlap between the guideline update and the audit, it is difficult to be certain that the update directly impacted USC referrals, but it may represent an encouraging trend. Conversely, random case-mix of easier and harder to diagnose cancer occurring between practices and time periods could account for some of the differences seen [30]. Of note, the percentage of individuals referred via USC in Scotland continues to be below that described in the English NCDA, a point worthy of further exploration [23].

Our findings are consistent with previous research that cancers with "nonspecific" presenting symptoms are less likely to be referred via the USC route including leukaemia, pancreatic cancer, and multiple myeloma [31]. Whereas, cancers which present with more identifiable alarm symptoms, such as an abnormal mole or breast lump, are more likely to be referred urgently.

An "inverse *n*" pattern of USC referrals with age was observed, whereby the oldest and youngest individuals were less likely to have an USC referral which may reflect variation in cancer types but might also suggest a lower index of suspicion for patients at the extremes of age [31]. In addition, the Scottish Cancer Referral Guidelines have age thresholds within their referral criteria for some cancer types which may impact on the number of USC referrals in different age groups. Individuals with higher number of comorbidities appeared to be less likely to have an USC referral. This may reflect symptoms being attributed to comorbid conditions, such as the overlapping nature of COPD symptoms and lung cancer. Nearly one fifth of new cancer diagnoses were via emergency presentation, consistent with earlier research, and were most common for individuals with brain cancer, pancreatic cancer, multiple myeloma, and leukaemia [23, 32]. There was no change in the percentage of emergency presentations between the time periods investigated. Emergency presentation has been linked with increased mortality and worse patient experience [33, 34]. However, avoiding such presentations is challenging and they may in fact reflect appropriate patient care in many cases [32].

There was an encouraging significant reduction in the proportion of individuals with a diagnostic interval >60 days in the 2019 cohort and a nonsignificant reduction in individuals with a diagnostic interval >90 days. This is a welcome finding as it is recognised that prolonged diagnostic intervals can worsen cancer outcomes [17, 35]. This may reflect a small increase in USC referrals, but equally could relate to enabling GPs to refer directly for imaging such as CT chest, abdomen, and pelvis. However, the relationship between diagnostic interval and cancer outcomes is complex [35]. Shorter diagnostic intervals may result from expedited diagnosis caused by disease severity/emergency presentation and may have worse outcomes. As seen in this dataset, leukaemia, pancreatic, and brain cancer all had short diagnostic intervals but high rates of emergency referrals. Therefore, it is important to interpret diagnostic intervals in the context of a complex and dynamic process from patient presentation to ultimate cancer diagnosis and outcome. In addition, the importance of the diagnostic interval can vary by cancer type with a delay in a rapidly progressive cancer leading to worse outcomes than a more indolent cancer type.

Despite some encouraging trends in referral rates and diagnostic intervals demonstrated in the updated 2019 cohort in over a third of cases GPs described the patient experiencing an avoidable delay within the patient journey.

In considering the pathway intervals for those patients included in the cohort who had nonspecific signs and symptoms at presentation and would likely qualify for ECDC referral, some limited comparisons could be made with results from similar initiatives in other countries [36–40]. The most meaningful comparison perhaps is with the secondary care interval reported in the English ACE MDC evaluation which was longer than that observed in the current cohort [8, 40]. This raises the possibility that ECDC may not significantly expedite the diagnosis of cancers which present in Scotland with nonspecific symptoms. It will be important, therefore, that the evaluation of the ECDC pilot in Scotland closely considers patient perspectives and the benefits of promptly ruling out cancer.

4.3. Strengths and Limitations. A strength of this audit is it provides a unique insight into data collected from primary care itself on the diagnostic processes by GPs. The audit links staging and cancer diagnosis data with information directly collected from primary care records by clinical experts in the form of GPs and then data were subsequently handled by highly skilled data professionals and robust cleaning undertaken. However, it must be recognised that each practice completed its own patient data collection on details such as first presentation to primary care with symptoms suggestive of cancer and the presence of avoidable delays. Thus, there was the potential for data collection bias whereby variation exists between GPs interpretation of the questions and completion of the data collection form. The cases were allocated to GPs centrally. The overall return rate of completed audit records by GP practices was 77%. There was a notable drop of completed audit records during the COVID-19 pandemic which may be due to pressures within the practices during this time. Nevertheless, it is possible that GPs completed audits on patients which were likely to reflect more favourably on the practice, thus influencing the length of primary care and diagnostic intervals and the presence of avoidable delays.

When comparing the two audit cycles, it must also be recognised that different practices participated in both audits and so any comparison must be interpreted with caution. Furthermore, the data were provided by volunteer practices and GPs. This raises the possibility that participating practices and GPs differed from those who did not participate and may have introduced biases into the data. The identity of participating practices and GPs was not made available to researchers meaning we could not explore these differences in detail, but it is an important point that should be borne in mind whilst considering the results. It could be, for example, that participating practices were those who had GPs with a particular interest in cancer care, were encouraged to participate due to recent difficult cases, had

recently undergone restructuring, or were training practices. Overall, there is the possibility that participating practices differed in important respects with those that did not participate, but the need to assure practice anonymity prevents us from exploring this point in detail. Whilst there was no difference in the age, cancer type, number of comorbidities, and stage at diagnosis between the two audit cohorts, there were significant differences in the SIMD and urban/rural mix and we have published a separate paper exploring the observed influence of socioeconomic status and place of residence on diagnostic pathways in the combined audits [41]. We have thus focussed on any substantive differences between the two cohorts in their referral type, primary care, and diagnostic interval. There is, therefore, the possibility that case-mix could influence these comparisons. A further point to note is that the 2nd NCDA was completed prior to the 2020–22 global COVID-19 pandemic which will have altered the cancer diagnostic landscape in Scotland, and probably for the worse [42]. It seems sensible to suggest that methods followed in these two audit cycles, if repeated in future, could provide a useful reflection on the cancer diagnostic performance within the Scottish NHS which could inform policy-makers on the extent to which the service has recovered.

5. Conclusions

Patients comprising the 2014 and 2019 cohorts were broadly similar with respect to type of cancer and individual demographics. The proportion of USC referrals increased from 38.1% to 42.9% between the two time periods and slightly fewer patients experienced prolonged delays. Together, this suggests improvement in NHS Scotland's prepandemic cancer performance likely resulting from increased adherence to urgent suspected guidelines by GPs. We believe that these gains can be consolidated by disseminating the reported results to GP colleagues via training and messaging from Scottish Government and other relevant professional organizations. Our data suggest that prolonged delays and emergency presentation are still more likely for cancers such as multiple myeloma that are often considered harder to diagnose due to nonspecific symptoms at presentation and have previously been documented to be more likely to have multiple consultations prior to referral [43]. This reinforces the importance of ongoing and extended efforts to introduce ECDCs in other areas of Scotland. It is important too that ECDCs are widely publicized to the public, so that they can be usefully discussed with GPs during relevant consultations. We would recommend that further regular audits using similar methods should form part of NHS Scotland's post-COVID recovery plans. Repeated audit cycles will also enable a large and valuable dataset to accrue. This may enable further research in to whether characteristics of the primary care practice (such as list size or geographical coverage) influences cancer diagnoses in Scotland.

Data Availability

In compliance with all regulatory and legal requirements, data were stored, accessed, and analysed with the National Safe Haven maintained by NHS National Services Scotland. Outputs were subject to disclosure checks with members of the Electronic Data Research and Innovation (eDRIS) team of the Information and Statistics Division, Scotland, prior to release to the research team for inclusion in this manuscript. Any future access to this dataset would require application to the Scottish Government.

Ethical Approval

The 2nd NCDA in Scotland received full approval from the Public Benefit and Privacy Panel for Health of the Scottish NHS (project 1819-0169) on 17th June 2019.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

Supplementary Table 1: the primary care and diagnostic interval comparisons for sex within the main cancer types in the 2019 data. Supplementary Table 2: the percentages of GPs who perceived there to have an avoidable delay in the patients' journey. Supplementary Table 3: the cancer sites of prospective ECDC sample versus not ECDC eligible sample. Supplementary Table 4: pathway intervals of potential ECDC sample versus not ECDC eligible sample. (*Supplementary Materials*)

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