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Projections of cancer prevalence in the United Kingdom, 2010–2040

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BACKGROUND: There are currently two million cancer survivors in the United Kingdom, and in recent years this number has grown by 3% per annum. The aim of this paper is to provide long-term projections of cancer prevalence in the United Kingdom.

METHODS: National cancer registry data for England were used to estimate cancer prevalence in the United Kingdom in 2009. Using a model of prevalence as a function of incidence, survival and population demographics, projections were made to 2040. Different scenarios of future incidence and survival, and their effects on cancer prevalence, were also considered. Colorectal, lung, prostate, female breast and all cancers combined (excluding non-melanoma skin cancer) were analysed separately.

RESULTS: Assuming that existing trends in incidence and survival continue, the number of cancer survivors in the United Kingdom is projected to increase by approximately one million per decade from 2010 to 2040. Particularly large increases are anticipated in the oldest age groups, and in the number of long-term survivors. By 2040, almost a quarter of people aged at least 65 will be cancer survivors.

CONCLUSION: Increasing cancer survival and the growing/ageing population of the United Kingdom mean that the population of survivors is likely to grow substantially in the coming decades, as are the related demands upon the health service. Plans must, therefore, be laid to ensure that the varied needs of cancer survivors can be met in the future.

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It is estimated that approximately two million people currently alive in the United Kingdom have been previously diagnosed with cancer (Maddams *et al*, 2009). These people are often described as 'cancer survivors', and are enumerated by cancer prevalence statistics. Projections of cancer prevalence can be used to estimate the future burden of cancer and inform the likely resources that will need to be allocated in order to meet the many and varied needs of the population of cancer survivors. They provide valuable intelligence to health service resource planners, as well as those responsible for providing care and support in the community to people affected by cancer and its treatment. Estimates of future cancer incidence and mortality are routinely produced by various bodies at local and national levels (NHS Scotland, 2004; Gatenby *et al*, 2011; Mistry *et al*, 2011; Thames Cancer Registry, 2011), but projections of cancer prevalence are less common and currently there are no widely available national projections for the United Kingdom.

Cancer prevalence increases as new diagnoses are made and decreases as people previously diagnosed die, and is therefore a function of cancer incidence and survival. Population growth and changes in the age structure of a population can also each have a significant impact on cancer prevalence. Different assumptions regarding likely future incidence rates, survival and demographics can, therefore, independently influence projections of cancer prevalence, and it is of interest to explore different future scenarios when projecting cancer prevalence. For example, one may consider a scenario in which existing temporal trends in cancer survival and/or incidence rates continue, or one in which current rates remain constant into the future (Verdecchia *et al*, 2002; Heinavaara and Hakulinen, 2006; Tabata *et al*, 2008).

In this paper, projections of cancer prevalence in the United Kingdom up to the year 2040 are presented for colorectal, lung, prostate and female breast cancer and all cancers combined (excluding non-melanoma skin cancer). In considering different scenarios of future incidence rates and survival, the influence of each is assessed independently from the influence of population demographic changes.

MATERIALS AND METHODS

A model for projecting cancer prevalence

The discrete time model for projecting cancer prevalence described by Fiorentino *et al*, 2011 was used. This model provides a framework for estimating future prevalence without incorporating explicit models of incidence and survival, and as such allows the construction and evaluation of different user specified projections of incidence and survival. Future cancer prevalence is estimated as a proportion of the current prevalent population plus an additional number of new cancer survivors. It is therefore a good model to use when a long time-series of cancer registry data is available such that current cancer prevalence can be estimated directly, and future cancer incidence rates and survival can be reasonably projected from existing trends.

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Future incidence rates were estimated using an age-period Poisson regression model (Clayton and Schifflers, 1987). Future survival, for both the current population of cancer survivors and those anticipated to be diagnosed in the future, was estimated by modelling the yearly probability of dying among cancer survivors; again, a Poisson regression model was used with the number of deaths of cancer survivors as the response variable and age, period and time since diagnosis as the explanatory variables. An interaction term between age and time since diagnosis was included to account for the fact that the risk of dying from a non-cancer cause generally increases with age. A log link function was used for both the incidence and survival regression models, and linear interpolation was used to obtain estimates at the 1-year resolution required by the model for projecting cancer prevalence.

Evaluation exercises were undertaken to explore the forecasting ability of this model for projecting cancer prevalence. By using a test data set and excluding the most recent 10 years of data, it was possible to compare projected and empirical prevalence estimates. These were found to agree to within 5% (Maddams, 2012).

Data

Cancer registry data for England from the National Cancer Data Repository (National Cancer Intelligence Network, 2012) were used. This data set is an amalgamation of data from the eight regional cancer registries in England and provides complete geographical coverage of the country. Details of all registered diagnoses of cancer among residents of England in the period 1971–2008 (inclusive) were available and allowed estimates of 38-year limited duration cancer prevalence at the start of 2009 (i.e., the number of people alive on 1st January 2009 who had been diagnosed with cancer in the period 1971–2008) to be made directly. It is always possible for a small number of cancer registrations never to receive a death notification, leading to so-called 'immortals' in the data set. The impact of these immortals was diminished by imposing a maximum possible attainable age for all registered cancer patients of 99 years. Data were analysed using cohorts of survivors defined by sex and type of cancer: colon, rectum and anus (ICD-10 C18–C21), lung, bronchus and trachea (ICD-10 C33–C34), prostate (ICD-10 C61) and female breast (ICD-10 C50), as well as all other malignant neoplasms combined (ICD-10 C00–C97 excluding non-melanoma skin cancer C44 and those codes mentioned previously).

Historical and estimated future national population data were supplied by the Office for National Statistics (ONS). The 'principal' (i.e., the most likely) 2008-based projections of the size of the population of England and the United Kingdom, by age, sex and year up to 2040, were used (Office for National Statistics, 2012b). These forecast that the population of the United Kingdom will grow by almost 20% from 62 million in 2009 to 74 million in 2040. Additionally the population is forecast to become older, with the median age anticipated to increase from 37 to 41 years (males) and from 40 to 43 years (females), and the proportion of the population at least 65 years of age expected to increase from 16% in 2009 to 24% in 2040.

Analysis

Using these data, and the regression models described previously, projections of 38-year cancer prevalence in England up to the year 2040 (according to attained age, time since diagnosis, cancer type and sex) were made. These were then adjusted to account for survivors diagnosed >38 years previously (i.e., to give estimates of complete prevalence), using 'completeness indices' (Capocaccia and De Angelis, 1997) calculated previously as part of the work contained in Maddams *et al* (2009). These are displayed in Table 1. It was assumed that these indices (calculated based on prevalence data for 2005) applied for all years in the period 2009–2040; this was considered to be reasonable given that the required adjustments were small, although (as noted in Maddams *et al* (2009)) completeness indices for male lung cancer may have been underestimated.

Table 1 Thirty-eight year completeness indices for cancer prevalence in England, 2005, by broad age group, sex and cancer type

	Age group		
Sex/Cancer type	**0–44**	**45–64**	**⩾65**
Males			
Colon, rectum and anus	1.0000	0.9980	0.9795
Lung, bronchus and trachea	1.0000	0.9955	0.8032
Prostate	1.0000	1.0000	0.9978
All other malignant neoplasms	0.9958	0.9672	0.9422
Females			
Colon, rectum and anus	0.9997	0.9946	0.9576
Lung, bronchus and trachea	1.0000	0.9976	0.9371
Breast	1.0000	0.9983	0.9214
All other malignant neoplasms	0.9970	0.9673	0.8757

Estimates for England were generalised to the United Kingdom by assuming that the number of cancer survivors per 100 000 population was the same in the United Kingdom as in England in each broad age group (0–44, 45–64 and ⩾65 years) and time since diagnosis band (0–1, 1–5 and ⩾5 years). Although age-standardised incidence and mortality rates are lower in England than in the other United Kingdom countries (Cancer Research UK, 2011a, b), this was considered to be a reasonable assumption given that, currently, the population of England accounts for $\sim$84% of the UK population (Office for National Statistics, 2012a).

Projection scenarios

Projections of cancer prevalence are dependent on the assumptions surrounding future incidence and survival that are made. The regression procedures described above can provide estimates under the assumption that existing trends in each will continue. However, for long-term projections (up to the year 2040) this assumption may not be realistic. For example, recent decades have seen advances in medicine that have, together with other factors, led to generally increasing survival for most types of cancer. It is perhaps optimistic to expect such increases to continue in the same way for the next 30 years. Other factors, such as the introduction of a breast cancer screening programme in the United Kingdom or the PSA test for prostate cancer, have caused rapid increases in recorded cancer incidence rates and changes to case-mix which cannot realistically be expected to continue to 2040 as they are clearly the result of specific interventions. By the same token, it is not possible to anticipate the effect of any new public health initiative or screening programme that might be introduced in the future.

For these reasons, a range of estimates of future cancer prevalence were made, based on different assumptions regarding future incidence rates and survival. Two different assumptions were used: (a) the 'dynamic' assumption that specified existing trends would continue in the period 2009–2040; and (b) the 'static' assumption that specified age and sex-specific incidence rates and survival would remain constant from the most recent year for which data were available (2008) all the way to 2040. The model for projecting cancer prevalence was then run multiple times by applying each assumption to each of the inputs (i.e., incidence rates and survival) in turn, thereby defining a set of scenarios for which future cancer prevalence was estimated – see Table 2. Implausibly high projections of prostate cancer incidence were obtained using the log linear regression model described

Table 2 Scenarios for which cancer prevalence was projected

Input data	Scenario number			
	1[a]	2	3[a]	4
Incidence rates	Dynamic	Static	Dynamic	Static
Survival	Dynamic	Static	Static	Dynamic
Population demographics	Dynamic	Dynamic	Dynamic	Dynamic

[a]Incidence rates for prostate cancer were assumed to be static under scenarios 1 and 3, due to the unreliability of the projected prostate cancer incidence rates. Scenarios 3 and 4 are therefore the same as scenarios 2 and 1, respectively, for prostate cancer, and as such are omitted from Figure 5.

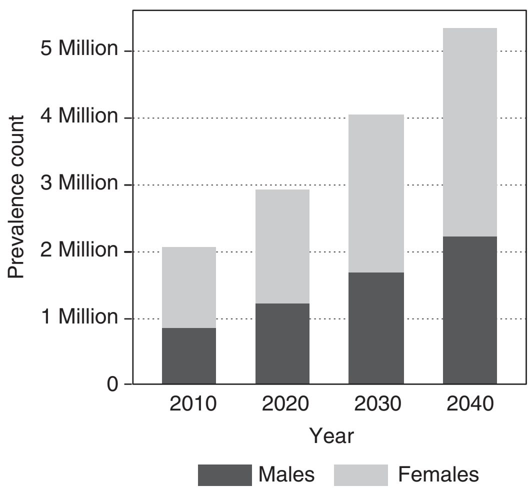

Figure 1 Total number of survivors of all malignant neoplasms combined (excluding non-melanoma skin cancer) in the United Kingdom, 2010–2040, under projection scenario 1 (dynamic incidence rates for all cancer types except prostate, dynamic survival and dynamic population demographics).

previously (due to the particularly sharp increases seen in recent years as a result of the introduction of PSA testing as a screening tool (Evans and Møller, 2003)), and therefore the dynamic assumption was not used for prostate cancer incidence.

In all scenarios, population demographics were assumed to be dynamic based on the ONS projections. These do, however, incorporate assumptions about general population mortality rates (including those for cancer survivors), which are separate from, and potentially inconsistent with, the static/dynamic assumptions used here.

RESULTS

Under projection scenario 1 (in which incidence rates and survival are both assumed to be dynamic), the total number of survivors of all malignant neoplasms combined in the United Kingdom is estimated to grow by approximately one million every decade – from 2.1 million in 2010 to 2.9, 4.0 and 5.3 million in 2020, 2030 and 2040, respectively (Figure 1). Not only will there be more cancer survivors under this scenario, but they will account for a larger proportion of the population – from 2.8% of the male population in 2010 to 6.2% in 2040, and from 3.9% to 8.5% of the female population (Table 3). However, the growth rate of cancer prevalence is projected to slow down over the 30-year period; the average annual percentage change in the number of survivors is projected to decrease from 3.7% in the 2010s to 2.7% in the 2040s for males, and from 3.3% to 2.9% for females (see Table 4).

Table 3 Complete prevalence in the United Kingdom, 2010–2040, by cancer type and sex, under projection scenario 1 (dynamic incidence rates for all cancer types except prostate, dynamic survival and dynamic population demographics). Number of survivors (proportion of the population per 100 000)

Sex/ Cancer type	Year			
	2010	2020	2030	2040
Males				
Colorectal	127 000 (415)	188 000 (572)	274 000 (783)	377 000 (1048)
Lung	39 000 (127)	40 000 (121)	41 000 (118)	42 000 (116)
Prostate	255 000 (835)	416 000 (1264)	620 000 (1771)	831 000 (2306)
Other	429 000 (1401)	579 000 (1759)	762 000 (2178)	966 000 (2684)
All	850 00 (2777)	1 223 000 (3717)	1 697 000 (4850)	2 216 000 (6153)
Females				
Colorectal	116 000 (368)	152 000 (451)	200 000 (561)	255 000 (697)
Lung	26 000 (81)	40 000 (120)	64 000 (179)	95 000 (261)
Breast	570 000 (1803)	840 000 (2500)	1 212 000 (3406)	1 683 000 (4598)
Other	517 000 (1635)	672 000 (1999)	866 000 (2434)	1 092 000 (2983)
All	1 229 000 (3887)	1 705 000 (5071)	2 342 000 (6579)	3 125 000 (8538)

Table 4 Average annual percentage change in the number of cancer survivors (average annual percentage change in the proportion of the population who are cancer survivors) in the United Kingdom, 2010–2040, by cancer type and sex, under projection scenario 1 (dynamic incidence rates for all cancer types except prostate, dynamic survival and dynamic population demographics)

Sex/Cancer type	Period		
	2010–2020	2020–2030	2030–2040
Males			
Colorectal	4.0 (3.3)	3.8 (3.2)	3.2 (3.0)
Lung	0.3 (− 0.5)	0.3 (− 0.3)	0.1 (− 0.2)
Prostate	5.0 (4.2)	4.1 (3.4)	3.0 (2.7)
Other	3.0 (2.3)	2.8 (2.2)	2.4 (2.1)
All	3.7 (3.0)	3.3 (2.7)	2.7 (2.4)
Females			
Colorectal	2.7 (2.0)	2.8 (2.2)	2.5 (2.2)
Lung	4.7 (4.0)	4.6 (4.0)	4.1 (3.8)
Breast	4.0 (3.3)	3.7 (3.1)	3.3 (3.0)
Other	2.7 (2.0)	2.6 (2.0)	2.3 (2.1)
All	3.3 (2.7)	3.2 (2.6)	2.9 (2.6)

The number of survivors of each individual cancer type, and the proportion of the population that they comprise, are also projected to increase substantially under projection scenario 1, with one exception: male lung cancer prevalence is projected to exhibit only modest increases in terms of numbers (0.3%, 0.3% and 0.1% per year in each decade between 2010 and 2040), and to decrease slightly in terms of the proportion of the population (− 0.5%, − 0.3% and − 0.2% per year in each decade; see Table 4). This is in contrast to the prevalence of female lung cancer which is projected to increase by 4.7%, 4.6% and 4.1% (count) and by 4.0%, 4.0% and 3.8% (proportion of the population) in each decade. These are the largest projected proportional increases of any cancer apart from prostate cancer in the 2010s. Despite this, however, the number of female lung-cancer survivors will remain relatively modest under this scenario, accounting for just 3.1% of all female cancer survivors, and 0.3% of the whole female population, by 2040 (Table 3 and Figure 2). It is prostate cancer prevalence which is projected to increase at the fastest rate among males under projection scenario 1 (Table 4), despite this scenario assuming static prostate cancer incidence rates from 2009 onwards. By 2040 the total number of prostate cancer survivors

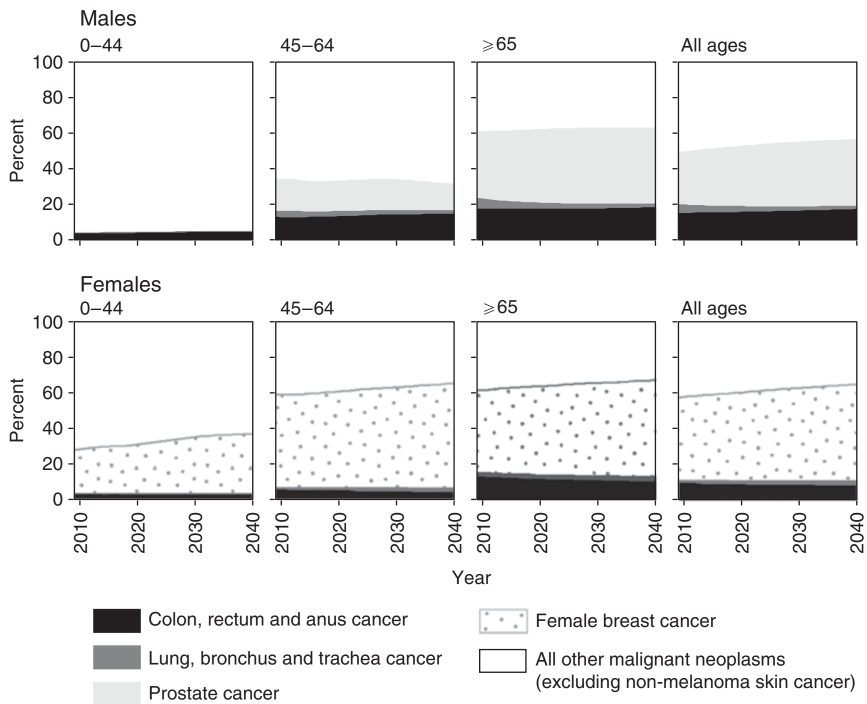

Figure 2 Distribution between cancer types of cancer survivors in the United Kingdom, 2009–2040, by attained age and sex, under projection scenario 1 (dynamic incidence rates for all cancer types except prostate, dynamic survival and dynamic population demographics). Proportion of total number of survivors accounted for by each cancer type.

is projected to have more than trebled to around 830 000, accounting for ∼2.3% of the male population overall (Table 3) and considerably more than this in the older age groups (figures not shown).

In the age groups under 65, the proportion of the population who are cancer survivors (all malignant neoplasms combined) is projected to increase modestly between 2010 and 2040 under projection scenario 1. However, more dramatic increases are projected for the oldest age group; the proportion of the population aged at least 65 years who are cancer survivors will almost double to 23.3% (males) and 24.9% (females) by 2040 under projection scenario 1 (Table 5). Currently, a large majority of cancer survivors are aged 65 years and over; in 2009, the proportion was 66.7% among male cancer survivors and 59.4% among females. Under projection scenario 1 this will rise to 82.3% and 73.1% in 2040, for males and females, respectively (Figure 3). By far the largest contributing cancer types in this age group are prostate and female breast (Figure 2).

Figure 4 shows the projected changes in the distribution of cancer survivors between different time since diagnosis bands under projection scenario 1. A large majority of all cancer survivors are currently at least 5 years beyond diagnosis, and this proportion is projected to increase from 55.2% in 2009 to 65.5% in 2040 for males and from 66.0% to 70.9% for females. Accordingly, the proportion of all survivors who are <5 years beyond diagnosis is projected to decrease. Nonetheless, the actual number of survivors who are <5 years beyond diagnosis is projected to more than double from 2010 to 2040, from around 800 000 to around 1.7 million (Table 6).

Projection scenario 1 (in which incidence rates and survival were assumed to be dynamic) generally resulted in the highest projected cancer prevalence, and scenario 2 (i.e., static incidence rates and survival) in the lowest. For all malignant neoplasms and ages combined, the number of cancer survivors in 2040 was projected to be 5.3 million under scenario 1 and 3.5 million under scenario 2 (Table 5). By comparison, scenarios 3 and 4 gave projections of 4.1 million and 4.5 million, respectively.

All projection scenarios for the majority of combinations of cancer type and sex resulted in increasing cancer prevalence (Figure 5). The notable exception was, however, male lung cancer prevalence, which exhibited quite different patterns from that of the other cancer types studied. The number of male lung-cancer survivors is projected to remain roughly constant under projection scenario 1 (dynamic incidence rates and survival), to increase if incidence rates are assumed to be static (scenarios 2 and 4) and to decrease if incidence rates are assumed to be dynamic but survival static (scenario 3).

In most cases, each projection scenario resulted in substantially different prevalence projections. Perhaps the most notable exception was for female colorectal cancer for which there was little difference between the projections made under scenarios 2 and 3, and similarly between those made under scenarios 1 and 4 (Figure 5). This is due to the fact that incidence rates of female colorectal cancer have been quite static in recent years, thus there is little difference between the static and dynamic assumption in this case.

DISCUSSION

The results presented in this paper provide a detailed set of projections of cancer prevalence in the United Kingdom for the next 3 decades, up to 2040. Given the inherent uncertainty involved in such long-term forecasting, four different scenarios of future cancer incidence rates, cancer survival and population demographics – the three factors which directly influence cancer prevalence – were considered separately (Table 2). The results for scenario 1 were given special consideration. This was the scenario under which empirical trends in cancer incidence rates and survival were extrapolated, without attenuation, from 2009 up to 2040. (Prostate cancer incidence rates were kept static, as the extrapolation results were considered to be extremely unrealistic in this instance). It should be kept in mind that this scenario is based on the simplistic, and in places optimistic, assumption that

Table 5 Complete prevalence of all malignant neoplasms (excluding non-melanoma skin cancer) in the United Kingdom, 2010–2040, by attained age, sex and projection scenario (Number of survivors (proportion of the population per 100 000))

		Year			
Sex/Age	**Scenario**	**2010**	**2020**	**2030**	**2040**
Males					
0–44	1	70 000 (381)	74 000 (391)	83 000 (424)	85 000 (431)
	2	71 000 (385)	77 000 (409)	86 000 (436)	85 000 (432)
	3	70 000 (384)	76 000 (405)	86 000 (438)	87 000 (442)
	4	70 000 (382)	75 000 (395)	83 000 (423)	83 000 (421)
45–64	1	208 000 (2669)	250 000 (3037)	283 000 (3459)	307 000 (3632)
	2	209 000 (2690)	250 000 (3037)	267 000 (3265)	268 000 (3175)
	3	210 000 (2700)	257 000 (3116)	280 000 (3421)	291 000 (3447)
	4	207 000 (2659)	244 000 (2956)	270 000 (3290)	281 000 (3329)
⩾65	1	573 000 (12 656)	899 000 (15 558)	1 330 000 (18 698)	1 824 000 (23 301)
	2	571 000 (12 616)	806 000 (13 948)	1 008 000 (14 167)	1 154 000 (14 743)
	3	572 000 (12 647)	822 000 (14 220)	1 051 000 (14 771)	1 235 000 (15 780)
	4	571 000 (12 626)	881 000 (15 252)	1 275 000 (17 928)	1 706 000 (21 790)
All	1	850 000 (2777)	1 223 000 (3717)	1 697 000 (4850)	2 216 000 (6153)
	2	851 000 (2779)	1 133 000 (3444)	1 361 000 (3890)	1 507 000 (4186)
	3	853 000 (2785)	1 155 000 (3510)	1 417 000 (4051)	1 614 000 (4481)
	4	848 000 (2771)	1 199 000 (3645)	1 628 000 (4653)	2 070 000 (5748)
Females					
0–44	1	93 000 (525)	103 000 (567)	124 000 (655)	130 000 (690)
	2	93 000 (523)	97 000 (533)	108 000 (572)	105 000 (556)
	3	94 000 (528)	104 000 (573)	123 000 (653)	128 000 (679)
	4	93 000 (521)	96 000 (526)	108 000 (570)	106 000 (560)
45–64	1	399 000 (4952)	506 000 (5914)	608 000 (7299)	709 000 (8419)
	2	399 000 (4955)	462 000 (5393)	477 000 (5729)	473 000 (5613)
	3	402 000 (4987)	512 000 (5979)	593 000 (7113)	665 000 (7889)
	4	397 000 (4920)	456 000 (5330)	488 000 (5860)	502 000 (5958)
⩾65	1	736 000 (12 801)	1 095 000 (15 909)	1 610 000 (19 261)	2 285 000 (24 852)
	2	732 000 (12 739)	984 000 (14 298)	1 213 000 (14 514)	1 376 000 (14 970)
	3	733 000 (12 750)	1 021 000 (14 824)	1 361 000 (16 283)	1 714 000 (18 643)
	4	735 000 (12 791)	1 056 000 (15 339)	1 436 000 (17 173)	1 840 000 (20 014)
All	1	1 229 000 (3887)	1 705 000 (5071)	2 342 000 (6579)	3 125 000 (8538)
	2	1 225 000 (3875)	1 543 000 (4590)	1 799 000 (5053)	1 954 000 (5340)
	3	1 229 000 (3887)	1 636 000 (4868)	2 077 000 (5836)	2 507 000 (6850)
	4	1 225 000 (3874)	1 608 000 (4784)	2 031 000 (5707)	2 448 000 (6689)

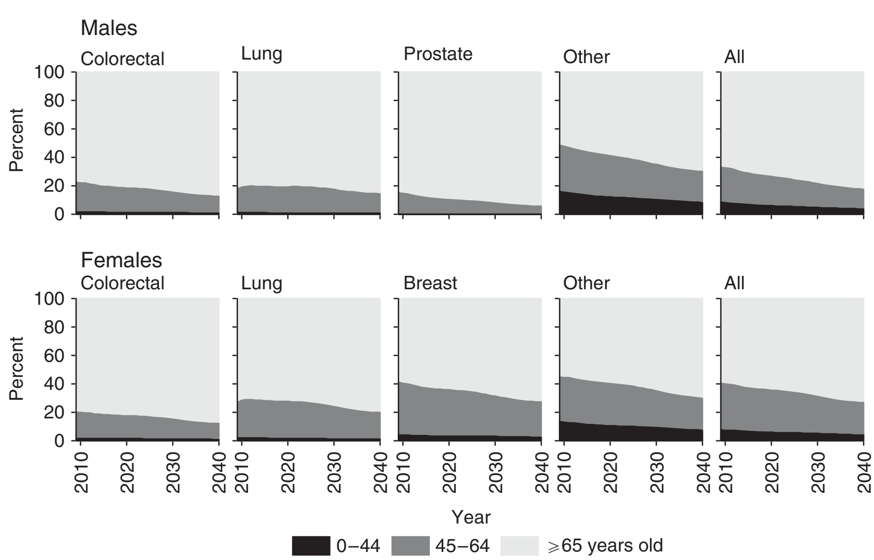

Figure 3 Age distribution of cancer survivors in the United Kingdom, 2009–2040, by cancer type and sex, under projection scenario 1 (dynamic incidence rates for all cancer types except prostate, dynamic survival and dynamic population demographics). Proportion of total number of survivors in each attained age group.

Epidemiology

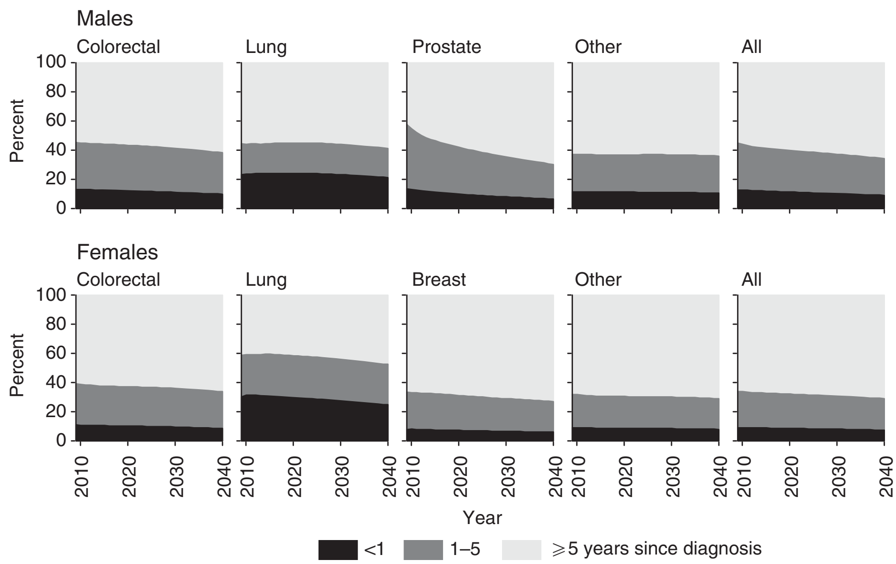

Figure 4 Time since diagnosis distribution of cancer survivors in the United Kingdom, 2009–2040, by cancer type and sex, under projection scenario 1 (dynamic incidence rates for all cancer types except prostate, dynamic survival and dynamic population demographics). Proportion of total number of survivors in each time since diagnosis band.

Table 6 Prevalence of all malignant neoplasms (excluding non-melanoma skin cancer) in the United Kingdom, 2010–2040, by the time since diagnosis, sex and projection scenario (Number of survivors (proportion of the population per 100 000))

		Year			
Sex/Years since diagnosis	**Scenario**	**2010**	**2020**	**2030**	**2040**
Males					
<1	1	109 000 (355)	140 000 (425)	176 000 (503)	205 000 (568)
	2	109 000 (356)	130 000 (396)	152 000 (434)	163 000 (453)
	3	111 000 (362)	135 000 (409)	160 000 (459)	178 000 (495)
	4	107 000 (349)	135 000 (411)	166 000 (476)	187 000 (519)
1–5	1	265 000 (867)	349 000 (1059)	457 000 (1307)	559 000 (1553)
	2	267 000 (874)	319 000 (971)	367 000 (1049)	396 000 (1101)
	3	267 000 (874)	331 000 (1005)	391 000 (1117)	436 000 (1211)
	4	265 000 (867)	336 000 (1021)	427 000 (1222)	505 000 (1402)
⩾5	1	476 000 (1555)	734 000 (2232)	1 064 000 (3040)	1 452 000 (4033)
	2	474 000 (1550)	684 000 (2078)	842 000 (2408)	948 000 (2633)
	3	474 000 (1550)	689 000 (2095)	866 000 (2475)	999 000 (2775)
	4	476 000 (1555)	728 000 (2213)	1 034 000 (2955)	1 378 000 (3827)
Females					
<1	1	113 000 (358)	147 000 (437)	190 000 (535)	235 000 (643)
	2	111 000 (351)	124 000 (370)	139 000 (391)	147 000 (402)
	3	115 000 (364)	143 000 (426)	178 000 (499)	212 000 (578)
	4	109 000 (345)	128 000 (381)	150 000 (421)	165 000 (451)
1–5	1	302 000 (954)	401 000 (1192)	530 000 (1490)	675 000 (1846)
	2	303 000 (958)	344 000 (1024)	378 000 (1063)	400 000 (1094)
	3	303 000 (958)	389 000 (1157)	478 000 (1342)	568 000 (1551)
	4	302 000 (954)	355 000 (1055)	421 000 (1184)	481 000 (1313)
⩾5	1	814 000 (2575)	1 157 000 (3442)	1 621 000 (4555)	2 214 000 (6050)
	2	811 000 (2565)	1 074 000 (3196)	1 281 000 (3599)	1 407 000 (3844)
	3	811 000 (2565)	1 105 000 (3286)	1 422 000 (3994)	1 728 000 (4721)
	4	814 000 (2575)	1 125 000 (3348)	1 460 000 (4102)	1 802 000 (4925)

existing trends in cancer incidence rates and survival will continue unabated for the next 30 years. Nonetheless, this scenario is the most empirically based of those presented.

Of course, it is impossible to anticipate with any precision the future events and interventions that may effect changes in cancer prevalence – for example, new screening programmes, public health initiatives or cancer treatments. In certain instances, alternative scenarios to projection scenario 1 may be considered more likely based on other intelligence – for example, explicit estimates of the future effects of new and/or existing screening tools and programmes (Mistry *et al*, 2011). A limitation of the present paper is the simplicity of the age-period model used to

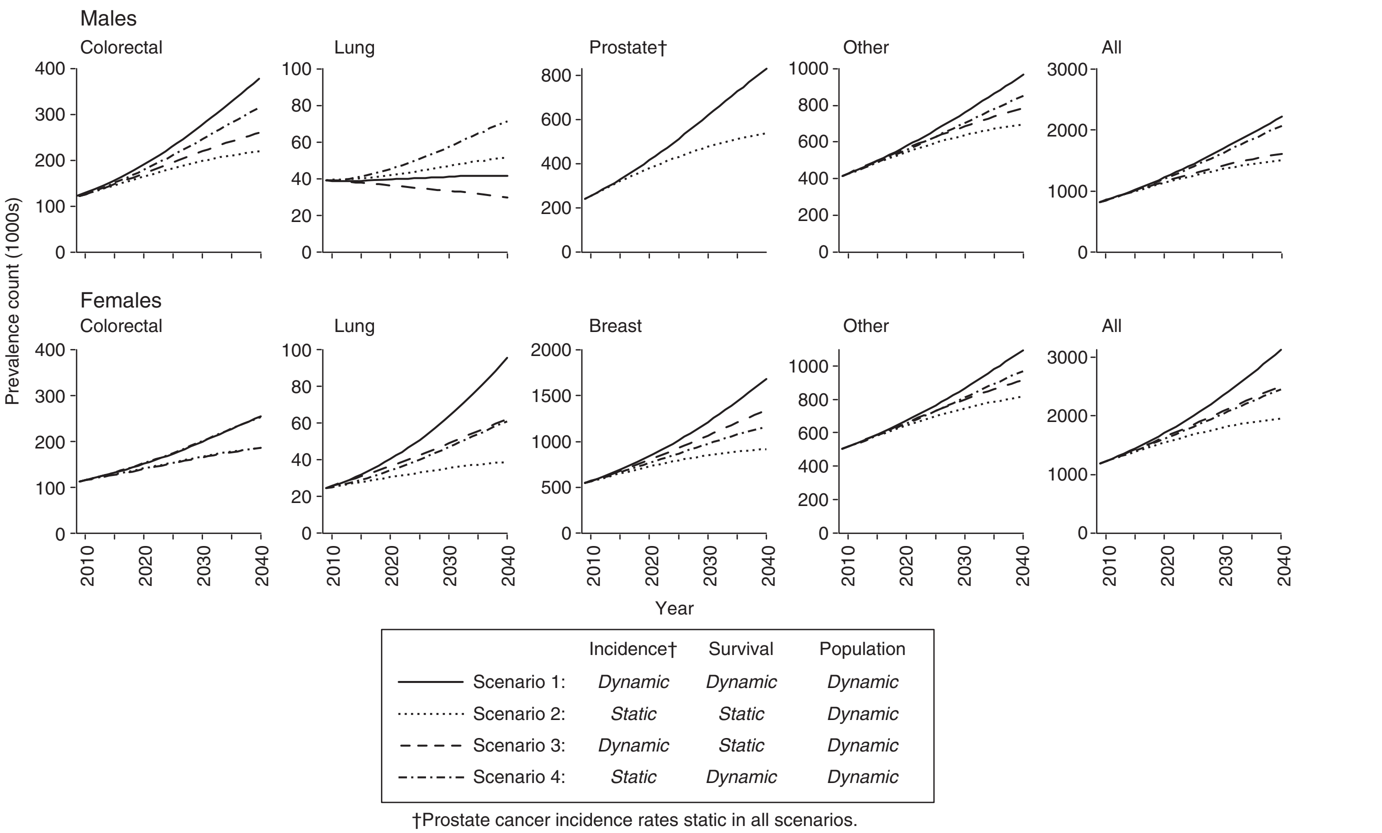

Figure 5 Complete prevalence of cancer in the United Kingdom, 2009–2040, by cancer type, sex and projection scenario.

project cancer incidence rates. However, this model was chosen to illustrate what *might* happen if current trends continue unabated, and for comparison with scenarios in which no change in incidence rates was assumed.

In the United Kingdom, cancer incidence rates are generally increasing; of the cancers studied here, it was only incidence rates of male lung cancer that exhibited a decreasing trend in the period 1971–2008. Cancer survival is also generally increasing. The reasons for these observed trends vary according to the cancer type in question. For example, recorded prostate cancer incidence rates have increased rapidly since the introduction of the PSA test and, as many cancers are now being diagnosed earlier, recorded survival has also increased (Cancer Research UK, 2010; Evans and Møller, 2003); recorded female breast cancer incidence rates have increased because of greater public awareness of the early symptoms and the introduction of a national screening programme in England (NHS Cancer Screening Programmes, 2012); and male lung cancer incidence rates have declined due, mainly, to a reduction in the prevalence of smoking among men in England since the 1970s (Davy, 2006). General increases in cancer survival have been brought about by advances in cancer treatment, as well as a greater focus on earlier diagnosis. Increasing cancer incidence and survival act to increase cancer prevalence, as the former means that more cancers are being diagnosed and the latter that people are living longer with cancer. Furthermore, the population of the United Kingdom is growing in size and is also ageing (Office for National Statistics, 2012c). Combined, these demographic changes also lead to increasing cancer prevalence as there are more people to be diagnosed with cancer and a greater proportion of these are in the older age groups for which cancer incidence rates are highest.

Projection scenario 1 resulted in the highest estimates of cancer prevalence for almost all cancer types, sexes and age groups. The main exception to this was male lung cancer, incidence rates of which have been decreasing in recent years. By considering the other three scenarios, the extents to which changes in cancer incidence rates, survival or population demographics are likely to affect cancer prevalence, if existing trends continue, can be quantified separately.

For example, almost identical projections of the number of female survivors of all malignant neoplasms combined were made under projection scenarios 3 (dynamic incidence rates and static survival) and 4 (static incidence rates and dynamic survival). This implies that, overall, the projected increase in female cancer prevalence due to increasing incidence rates is roughly the same as that due to increasing survival. By considering the projections of cancer prevalence under scenario 2 it can be seen that, even if incidence rates and survival were to remain constant from 2009 onwards, the number of male and female survivors would still increase. This is partly due to the growing and ageing population. However, the prevalence *proportions* in each age group will also increase under scenario 2, implying that static incidence rates and survival by themselves would act to increase cancer prevalence.

The age structure of the population of cancer survivors will, under projection scenario 1, become increasingly dominated by the oldest age groups: in 2040, 77% of all cancer survivors will be aged at least 65 years under this scenario. Perhaps even more notably, it is projected that in 2040 almost one quarter of all people in the United Kingdom aged at least 65 years will be cancer survivors – the equivalent figure for 2008 was one eighth (Maddams *et al*, 2009). This result, in particular, highlights the potential for significant increases in the burden of cancer on health service and community care resources if current trends in cancer incidence and survival continue. It is vitally important, therefore, that careful plans are laid so that resources exist to meet the needs of cancer survivors in the future, particularly given the likely large increases in the number of survivors over the current retirement age and the impact of cancer on a person's fitness to work.

The precise needs of cancer survivors in the United Kingdom, and how best to meet them, is the subject of ongoing research (Richards *et al*, 2011) but still more needs to be done. The results presented in this paper, and elsewhere, provide some further insight. Time since diagnosis has been shown to be a key indicator of the quantity of cancer-related acute health care utilised by the population of cancer survivors in the United Kingdom (Maddams *et al*, 2011a, b). The first year following diagnosis and the last year of life contain the highest levels of acute cancer-related health service utilisation, but there is also a significant amount of usage in the period 1–5 years after diagnosis. Under projection scenario 1, the number of survivors in each of the time since diagnosis bands <1, 1–5 and $\geqslant 5$ years will increase, but the number who are long-term survivors will increase at the fastest rate – by 2040, 69% of all survivors will be at least 5 years beyond diagnosis under this scenario, compared with 62% in 2009. This will have an impact on the quantity and nature of health and social care required by cancer survivors, with a greater focus on rehabilitation and the long-term, post-treatment effects of cancer.

It is hoped that the projections of cancer prevalence contained in this paper will be of use to health service commissioners and resource planners. The results highlight the potential for significantly elevated demands on health service resources in the future – the number of cancer survivors requiring initial and ongoing treatment during the first 5 years after diagnosis is likely to increase substantially as the population of the United Kingdom grows and ages, and as cancer incidence rates and survival continue to increase in general. It is clear, therefore, that adequate planning to ensure that the best possible use is made of available health service resources for cancer survivors is essential. Furthermore, as the population of cancer survivors becomes older, cancer will increasingly need to be considered as one of multiple co-morbidities, and efficient integration of different clinical specialities will be important. Health policies aimed at primary prevention, especially multi-factorial prevention including improving diet and reducing smoking and alcohol intake, should be reinforced as these represent the best strategy for arresting the present increasing trends in cancer incidence. The coming decades are likely to bring difficult financial circumstances, which will test the ability of statutory and voluntary organisations to meet the diverse needs of those diagnosed with cancer, but the work contained in this paper, and elsewhere, provides intelligence that may help us meet these challenges.

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