QUEEN'S UNIVERSITY BELFAST

Cancer Incidence Projections in Northern Ireland to 2040

Northern Ireland Cancer Registry Group (2020). Cancer Incidence Projections in Northern Ireland to 2040. *Cancer Epidemiology Biomarkers & Prevention*, *29*(7), 1398-1405. https://doi.org/10.1158/1055-9965.EPI-20-0098

Published in:
Cancer Epidemiology Biomarkers & Prevention

Document Version:
Peer reviewed version

Queen's University Belfast - Research Portal:
Link to publication record in Queen's University Belfast Research Portal

Publisher rights
Copyright © 2020 by the American Association for Cancer Research.
This work is made available online in accordance with the publisher's policies. Please refer to any applicable terms of use of the publisher.

General rights
Copyright for the publications made accessible via the Queen's University Belfast Research Portal is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The Research Portal is Queen's institutional repository that provides access to Queen's research output. Every effort has been made to ensure that content in the Research Portal does not infringe any person's rights, or applicable UK laws. If you discover content in the Research Portal that you believe breaches copyright or violates any law, please contact openaccess@qub.ac.uk.

Open Access
This research has been made openly available by Queen's academics and its Open Research team. We would love to hear how access to this research benefits you. – Share your feedback with us: http://go.qub.ac.uk/oa-feedback

Download date:25. Mar. 2025

Cancer incidence projections in Northern Ireland to 2040

David W. Donnelly[1], Lesley A. Anderson[1,2]; Anna Gavin[1]; for the Northern Ireland Cancer Registry Group[1]

1. Northern Ireland Cancer Registry, Queen's University Belfast, Belfast, Northern Ireland.
2. Centre for Public Health, Queen's University Belfast, Belfast, Northern Ireland.

Running title: Cancer incidence projections in Northern Ireland

Key words: Cancer, incidence, trends, projections, registry

Disclosure of potential conflicts of interest: The authors declare no potential conflicts of interest.

Funding: The Northern Ireland Cancer Registry is funded by the Public Health Agency. The funders had no role in the study design, data collection, analysis and interpretation of results, or writing of the manuscript.

Correspondence to: David Donnelly, Northern Ireland Cancer Registry, Queen's University Belfast, Mulhouse Building, Grosvenor Road, Belfast BT12 6DP, Northern Ireland, UK. E-mail: david.donnelly@qub.ac.uk

Word Count: Abstract: 243 words, Manuscript: 3,117 words, Table/Figures: 5

Abstract

Background: Data on historical trends and estimates of future cancer incidence are essential if cancer services are to be adequately resourced in future years.

Methods: Age-standardised incidence rates for all cancers combined and 19 common cancers diagnosed during 1993-2017 were determined by sex, year of diagnosis and age. Data were fitted using an age-period-cohort model, which was used to predict rates in future years up to 2040. These were combined with population projections to provide estimates of the future case number.

Results: Compared to the annual average in 2013-2017, for all cancers (excluding non-melanoma skin) age-standardised incidence rates are expected by 2040 to fall 9% among males and rise 12% among females, while the number of cases diagnosed is projected to increase by 45% for males and 58% for females. Case volume is projected to rise for all cancer types except for cervical and stomach cancer, with the annual number of cases diagnosed projected to more than double among males for melanoma, liver, and kidney cancers, and among females for liver, pancreatic and lung cancers.

Conclusion: Increased numbers of cancer cases is projected, due primarily to projected increases in the number of people aged 60 years and over.

Impact: Projected increases will significantly impact the health services which diagnose and treat cancer. However, while population growth is primarily responsible, reduction of exposure to cancer risk factors, especially tobacco use,

obesity, alcohol consumption and UV radiation, could attenuate the predicted increase in cancer cases.

Introduction

Careful monitoring of trends in cancer incidence by national cancer registries is essential if high quality cancer diagnosis and treatment services are to be adequately maintained and resourced. However, cancer is not a disease with a single set of characteristics. There are many different types, each of which occur at different rates depending upon demographic (age, sex, socio-economic background, area of residence) [1], lifestyle [2] and genetic factors [3]. While historic trends provide evidence of changes in these risk factors and the effect of interventions such as screening or vaccination, projections provide a general guide to expected patient volumes, which is helpful in planning future health services and identifying resource requirements.

Previous analysis of cancer incidence trends in Northern Ireland (NI) [1] indicates that the age-standardised incidence rate (ASIR) of all cancers (excluding non-melanoma skin cancer (NMSC)) is declining among men, but increasing among women. However, the strong relationship between cancer and age [1] means that the number of cases projected in future years will be largely dependent on changes in the size and age distribution of the population. Since 1993 the population of NI has increased by 12% from 1.64 million to 1.87 million in 2017 [4]. Future population projections suggest a further increase of 7% to 2.00 million by 2040 [5]. However, 282,100 people were aged 60 years and over in 1993, compared to 402,800 people in 2017 [4], an increase of 43%, with the population in this age group projected to increase by a further 49% between 2017 and 2040, reaching 600,800 people [5]. This large growth in the population aged 60 years and over makes it imperative that some indication of its impact on cancer incidence in future years is made available.

We thus examine historical trends in cancer incidence using data from the population based cancer registry in NI which began in 1993, and project these trends forward to the year 2040 using well established age-period-cohort (APC) models [6-9]. The resulting projected incidence for all cancers combined and the nineteen most common cancers will assist in planning cancer services in the future and highlight the types of cancer that may benefit from further preventative measures.

Material and methods

Data on all cancer cases (ex. NMSC) diagnosed in NI between 1993 and 2017 were extracted from the NI Cancer Registry (NICR), while historical population data was provided by the NI Statistics and Research Agency [4] and population projections by the Office of National Statistics [5]. NICR has ethical approval from the Office of Research Ethics Northern Ireland for collection of the data used in this study.

Cancer data were coded using the International Classification of Diseases (ICD10) [10], with codes C00-C97 (excluding C44) used to identify relevant cases, and specific cancer types classified using the codes specified in table 1. Age at diagnosis was grouped into five-year age bands (0-4 years up to 90+ years), which along with year of diagnosis, was used to derive a five-year birth cohort.

Five-year age group was further categorised into six broader age groups specific to each cancer site, with the boundaries for these age groups chosen so that each age group had an approximately equal number of cases. ASIRs for each cancer site, sex and the broader age groups were generated for each calendar year using the 2013 European standard population. The annual percentage change in rates, with 95% confidence intervals (CI), for each cancer type, sex and age group (including all ages) were determined using the JoinPoint regression program [11] which provided details of any changes in the trend direction during 1993-2017.

For each cancer site, sex and broader age group, age-specific incidence rates (I_{ay}) for each five-year age group (a) and year of diagnosis (y) were modelled using an APC model of the form:

$$I_{ay} = (f_a(a) + f_y(y) + f_c(c))^5$$

where $f_a(a)$ is the contribution made by five-year age group a, $f_y(y)$ is the contribution made by single year of diagnosis y and $f_c(c)$ is the contribution made by five-year birth cohort c. This generalised linear model, which utilises a power 5 link function, was found by Moller et al [6] to provide better predictions than many common alternatives, including the frequently used Poisson model. In this model both f_a and f_c are linear functions, however if f_y were also linear, one of the three independent variables would be eliminated as a result of collinearity. As previously applied by Smittenaar *et al* [8], we have thus used natural cubic splines to represent f_y. In this approach the linear contribution to the trend made by the year and cohort variables are collated into a single term, known as the drift, leaving the non-linear part of the trend resulting from these components free to coexist in the regression model. The added benefit of the use of natural cubic splines is that these fit any changes in the direction of the trend much better than a simple linear approach. To ensure the best possible fit with regards change in trend direction three evenly spaced knots between 1993 and 2017 were used as the default when representing year using cubic splines, however, the number and placement of knots was modified for specific cancer types and/or age groups to reflect the results of the Joinpoint trend analysis. For example, if Joinpoint analysis indicated a turning point between 1993 and 2017 then an additional knot was added, with the location of this turning point included as one of the knots.

In order to estimate future cancer incidence we assumed that the most recent trend will continue for the foreseeable future. However, as in previous studies [6-8], the future drift component is dampened using a geometric progression that reduces the

drift by half over a twenty-year period as current trends are unlikely to continue indefinitely. The degree of dampening chosen was based upon application of similar models to data from 1993-2012 in order to predict incidence in 2017 and is comparable to that used by Moller *et al* [6].

The APC model provides estimates of the age-specific incidence rates in future years for each cancer site, sex and five-year age group. These projected rates are then multiplied by the population projections for that age group to give an estimate of the number of cases in future years. They are then summed to give an estimate for all ages, and are also used in combination with the European standard population to give a projection for the ASIR. An estimate of the accuracy of the prediction is provided using 95% confidence intervals, which are provided in the supplementary material.

Analysis was conducted using Stata version 15 and used the rc_spline program to derive the cubic splines [12].

Results

During the entire 1993-2017 period under investigation there were 190,538 cancers (ex. NMSC) diagnosed, with 50.3% of these among women. More recently, in 2013-2017 there were 4,691 male and 4,710 female cases diagnosed each year. The most common cancer types were prostate (24.2%), lung (14.5%) and colorectal (13.9%) among men and breast (29.7%), lung (13.0%) and colorectal (11.3%) among women (Table 1). The average age at diagnosis for all cancers (ex. NMSC) was 67 years (Male: 68, Female: 66), but ranged from 37 years for testicular cancer to 74 years for bladder cancer.

Trends 1993-2017

Between 1993-1997 and 2013-2017 the average number of cases of cancer (ex NMSC) increased by 50.0% from 6,267 cases per year to 9,401 cases per year (Male increase: 52.2%, Female increase: 47.8%). The majority of this increase is a result of the ageing of the population as the corresponding ASIRs have only increased by 11.2% (Male increase: 2.2%, Female increase: 15.5%) between 1993-1997 and 2013-2017.

However, the rate of change of ASIRs over time has not been constant. Among males ASIRs decreased between 1993 and 1999 by 1.6% per year (95% CI: 0.5-2.6%), increased between 1999 and 2009 by 1.3% per year (95% CI: 0.8-1.8%) and decreased again between 2009 and 2017 by 0.7% per year (95% CI: 0.2-1.3%). Among women there was no significant change in ASIRs between 1993 and 2001, while between 2001 and 2017 ASIRs increased by 1.0% per year (95% CI: 0.2-1.3%) (Table 2).

Different cancer types also demonstrated considerably different trends over time. At the end of 2017 significant increases in male ASIRs were apparent for melanoma and head and neck, oesophageal, pancreatic and kidney cancers, while there were significant decreases for colon, prostate, stomach and bladder cancers. Among women there were significant ASIR increases for melanoma, leukaemia, and breast, lung, head and neck, liver and kidney cancers, while significant decreases occurred for rectal, stomach, cervical, ovarian and bladder cancers (Table 2).

Projections up to 2040

Compared to rates in 2013-2017, ASIRs of cancer (ex. NMSC) are projected to decline among men with a 7% decrease by 2025 and a 9% decrease by 2040. Among women ASIRs are projected to continue to increase, with a 7% rise by 2025 and a 12% rise by 2040 predicted (Figure 1a).

By 2040, compared to the 2013-2017 average, male ASIRs are projected to decrease by more than 20% for stomach and bladder cancers and increase by more than 20% for melanoma, oesophageal, liver and kidney cancers. Also compared to the 2013-2017 average, female ASIRs are projected to decrease by more than 20% by 2040 for stomach and cervical cancers and increase by more than 20% for melanoma, head & neck, uterine, liver, kidney, pancreatic, lung and breast cancer (Figure 2).

Compared to the annual number of cases diagnosed in 2013-2017, the number of all cancer (ex NMSC) cases is expected to rise by 16% for men and by 24% for women

to 5,463 and 5,840 cases respectively by 2025. By 2040 the number of cases per year is projected to be 6,788 male and 7,450 female cases, a 45% rise among men and a 58% rise among women (Figure 1b, Table 3).

By 2040 the number of cancers diagnosed each year among men is projected to increase for all cancer types except stomach cancer, while among women increases are expected for all cancer types except cervical and stomach cancer. In particular, the number of cases diagnosed each year is expected to more than double among males for melanoma, liver and kidney cancers, and among females for liver, pancreatic and lung cancers (Table 3).

More detailed information for each cancer site is available in the supplementary material.

Discussion

In the twenty-five years that cancer incidence data has been recorded in NI, there has been an increase of 50.0% in the annual number of cases registered. This is primarily a result of increases in the population aged 60 years and over, where cancer risk is highest [1]. However, additional factors are relevant as increases in ASIRs are also present for many cancer types. In order to aid future service delivery along with the development of strategies to deal with this increasing case volume, we have presented data on cancer incidence trends in NI collated from a registry which has a high level of completeness and consistency in classification and collection methodology [13], and used these trends to derive estimates of cancer incidence up to the year 2040 using well established methodology [6-9]. We found that the next twenty-five years are likely to see a similar increase of 51.0% in cancer cases, with incidence of all types of cancer, except cervical and stomach cancer, projected to increase. Liver cancer, kidney cancer, pancreatic cancer and melanoma are all projected to double in case volume. Increases among women are expected to be greater than those for men, as incidence rates of the most common cancers (prostate, colorectal, lung) are expected to decline among men, while breast and lung cancer incidence rates are expected to increase among women.

In NI 38% of cancers (ex NMSC) are attributable to fourteen specific risk factors associated with patient life style [2]. Changes in these risk factors, including tobacco use, alcohol consumption, obesity, poor diet, lack of physical exercise, exposure to ultraviolet or ionising radiation and infections such as human papillomavirus, have the potential to alter cancer incidence rates. However, detailed trend data on life style factors within the NI population is sparse, making it difficult to assess the

impact on future cancer incidence of historical, recent or future changes in life style factors.

Among the life style factors associated with cancer risk, changes in prevalence of tobacco use could potentially have the greatest impact on cancer incidence trends, as tobacco use is suggested to cause 15% of all cancer cases and at least 72% of lung cancers in the UK [2]. Among adults aged 16 years and over 20% of men and 18% of women were current smokers during 2017/18, a decline on smoking prevalence in 2010/11 when 25% of men and 23% of women smoked [14]. The projected increase of 46% by 2040 in lung cancer incidence rates among females may therefore be overly pessimistic if the reported decline in smoking among women begins to impact lung cancer incidence rates in the next few decades.

A similar consideration must be given to cancer types that have a strong relationship to particular life style risk factors, including melanoma and UV exposure [15], liver cancer and alcohol [16], and for obesity, physical activity and diet related cancers, such as uterine, oesophageal, colorectal, breast, pancreatic, and liver cancers [17-19]. Changes to any of these lifestyle factors could have a considerable impact on the incidence of these cancers.

In recent years (2013-2017) colorectal cancer incidence rates have declined, with this decline projected to continue for the next 5-10 years before starting to increase again. A possible contributory factor to this is the introduction of the colorectal screening program in 2010 for people aged 60 to 74 years old. This program uses the Faecal Occult Blood Test (FOBT) [20] which reduces colorectal cancer incidence

by identification and later treatment of precancerous lesions [21]. However, the decrease in colorectal cancer incidence rates among females has been smaller than that among men, making it difficult to fully attribute the downward trend to colorectal cancer screening. Complicating matters further is the future introduction of the Faecal Immunochemical Test (FIT) in NI as the primary screening test for 60-74 year olds [22]. This test has also been shown to reduce incidence of colorectal cancer [23] and may lead to increased uptake as a result of the test being simpler and more socially acceptable [24]. The presented projections of colorectal cancer should thus be treated with caution as the impact of this planned intervention is unclear. However, colorectal cancer incidence rates were increasing prior to this intervention, thus we would expect rates to begin to increase again once colorectal cancer screening is more established, and the full reduction in colorectal cancer incidence as a result of this intervention has occurred.

Nearly all cases of cervical cancer are related to infection by human papilloma virus (HPV) [25], thus girls aged 12 to 13 years old have been offered a vaccination against HPV genotypes 16 and 18 since 2008 [26]. Modelling studies from Australia suggest that cervical cancer incidence rates will decline considerably as the cohort of vaccinated girls reaches the age when cervical cancer risk begins to increase [27]. Cervical cancer incidence trends in NI are projected to decline in a similar manner, although it is too early for the recent downward trend in cervical cancer in NI to be explained by introduction of the HPV vaccination programme. The projected decrease in NI along the lines of the Australian study may thus be coincidental.

Prostate cancer incidence trends are highly correlated with the use of Prostate Specific Antigen (PSA) testing in a population [27]. In NI incidence rates of prostate cancer increased rapidly from 1998 to 2008, which coincided with the introduction of PSA testing in the mid-1990s. Since 2008 rates have declined slightly, with future projections based upon this assumption. Future change in PSA or other testing levels has the potential to produce prostate cancer levels that deviate considerably from presented future estimates.

Compared to cancer incidence projections in the UK up to 2035, trends in NI are broadly similar, however some differences are apparent for particular cancer types. Rates of prostate and ovarian cancer in NI are projected to decline, while in the UK an increase is forecast. Conversely rates of male oesophageal and female lung and uterine cancer are forecast to increase in NI, but are expected to remain steady or decline slightly in the UK. The projected increases in melanoma, liver cancer and breast cancer in NI are larger than the equivalent increases in the UK [8]. The exact reason for any differences are unclear, but are likely to be complex and partially related to lifestyle issues. For example, prevalence of smoking varies by UK nation, and while smoking prevalence is declining across the UK, the rate of change also varies between countries [28].

The current projections, while based upon good quality data and well established methodology, have limitations. Being based upon a smaller population than many other countries, annual cancer incidence rates can vary considerably, thus providing a degree of uncertainty in any trend analysis, projections based upon them and the baseline against which any percentage change is measured. These projections are

also susceptable to changes in population estimates, coding of cancer type and choice of prediction methodology, as a range of viable alternatives to the approach used here exist [6,30-34]. In addition, public health initiatives targeted at cancer prevention and public awareness can cause fluctuations in the trend [35,36], in particular, environmental and policy initiatives (e.g. smoking-free areas, screening, and vaccinations) can have a considerable impact of reducing the cancer burden. The projections presented, particularly the longer term figures, should thus be used only as a guide as to the current direction that cancer trends are taking, and should be revised periodically to take account of changes in the above mentioned factors. Comparisons with previous cancer incidence projections [37] indicates considerable agreement for some cancers (e.g. breast and melanoma), but considerable revisions for others (e.g. colorectal and cervical). These later changes are demonstrative of the impact that public health interventions can have on cancer incidence rates (e.g. screening and vaccinations respectively), but can also indicate that an associated risk factor has, in the past, become more prevalent in the population.

Conclusion

Over the next two decades cancer incidence in NI is expected to increase by 51%, with incidence doubling for many cancers. This will have a significant impact on the resources needed to diagnose and treat cancer. Cancer burden could, however, be reduced if further progress is made in improving the general health of the population through reduction of exposure to cancer risk factors especially tobacco, excessive alcohol consumption, exposure to UV radiation and HPV.

Acknowledgements: NICR uses data provided by patients and collected by the health service as part of their care and support.

The Northern Ireland Cancer Registry Group consists of: Bernadette Anderson, Ronan Campbell, Paula Darragh, Sarah Davidson, Laura Dwyer, Deirdre Fitzpatrick, Donna Floyd, Colin Fox, Paul Frew, Tewodros Getachew, Jackie Kelly, Sinead Lardner, Ashley Levickas, Marsha Magee, Clare Marks, Brid Morris-Canter, Jacqui Napier, Eamon O'Callaghan, Jamie Roebuck, Gerard Savage.

Ethical approval: NICR has ethical approval from the Office of Research Ethics Northern Ireland.

Authorship contributions:

Conception and design: D.W. Donnelly, L. Anderson, A. Gavin

Development of methodology: D.W. Donnelly

Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): D.W. Donnelly, NI Cancer Registry Group

Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): D.W. Donnelly

Writing, review, and/or revision of the manuscript: D.W. Donnelly, L. Anderson, A. Gavin

Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): D.W. Donnelly, NI Cancer Registry Group

Study supervision: L. Anderson, A. Gavin

References

1. Northern Ireland Cancer Registry. 2017 Cancer incidence, survival, mortality and prevalence data. Available at http://www.qub.ac.uk/research-centres/nicr/CancerInformation/official-statistics/. Accessed 18 Oct 2019
2. Brown KF, Rumgay H, Dunlop C, et al. The fraction of cancer attributable to modifiable risk factors in England, Wales, Scotland, Northern Ireland, and the United Kingdom in 2015. Br J Cancer 2018; 118:1130-1141. doi:10.1038/s41416-018-0029-6
3. Engmann NJ, Golmakani MK, Miglioretti DL, Sprague BL, Kerlikowske K, Breast Cancer Surveillance Consortium. Population-attributable risk proportion of clinical risk factors for breast cancer. JAMA Oncol 2017; 3:1228-1236. doi:10.1001/jamaoncol.2016.6326
4. Northern Ireland Statistics and Research Agency. Mid-year Population Estimates. Available at https://www.nisra.gov.uk/statistics/population/mid-year-population-estimates. Accessed 18 Oct 2019
5. Office for National Statistics. National Population Projections. Available at https://www.nisra.gov.uk/statistics/population/national-population-projections. Accessed 18 Oct 2019
6. Moller B, Fekjaer H, Hakulinen T, Sigvaldason H, Storm HH, Talback M, Haldorsen T. Prediction of cancer incidence in the Nordic countries: empirical comparison of different approaches. Stat Med 2003; 22:2751–2766
7. Sasieni P. Age-period-cohort models in Stata. Stata J 2012; 12: 45-60
8. Smittenaar CR, Petersen KA, Stewart K, Moitt N. Cancer incidence and mortality projections in the UK until 2035. Br J Cancer 2016; 115:1147-1155. doi:10.1038/bjc.2016.304
9. National Cancer Registry Ireland. Cancer incidence projections for Ireland: 2020-2045. Available at https://www.ncri.ie/publications/cancer-trends-and-projections. Accessed 18 Oct 2019
10. World Health Organisation. ICD10 International Classification of Diseases 10th revision. Geneva: WHO; 1997
11. Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. Stat Med 2000;19:335-351
12. Dupont WD, Plummer WD. RC_SPLINE: Stata module to generate restricted cubic splines. Available at https://ideas.repec.org/c/boc/bocode/s447301.html. Accessed 24 Oct 2019
13. Kearney TM, Donnelly C, Kelly JM, O'Callaghan EP, Fox CR, Gavin AT. Validation of completeness and accuracy of the Northern Ireland Cancer Registry. Cancer Epidemiol 2015; 39: 401-404. doi:10.1016/j.canep.2015.02.005
14. Corrigan D, Scarlett M. Health Survey (NI): First Results 2017/18. Available at https://www.health-ni.gov.uk/sites/default/files/publications/health/hsni-first-results-17-18.pdf. Accessed 22 Oct 2019
15. International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Vol. 100d: Radiation. Lyon: IARC Press, 2012
16. International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Vol. 96: Alcohol Consumption and Ethyl Carbonate. Lyon: IARC Press, 2010
17. International Agency for Research on Cancer. IARC Handbooks of Cancer Prevention Vol. 6: Weight Control and Physical Activity. Lyon: IARC Press, 2002
18. International Agency for Research on Cancer. IARC Handbooks of Cancer Prevention Vol. 8: Fruit and Vegetables. Lyon: IARC Press, 2003
19. World Cancer Research Fund/American Institute for Cancer Research. Food, nutrition, physical activity and the prevention of cancer: A global perspective. Washington DC: AICR, 2007
20. Public Health Agency. Overview of the NI Bowel Cancer Screening Programme. Available at http://www.cancerscreening.hscni.net/Overview_Bowel_Programme.htm. Accessed 22 Oct 2019
21. Mandel JS, Church TR, Bond JH, et al. The effect of fecal occult-blood screening on the incidence of colorectal cancer. N Engl J Med 2000; 343:1603-1607
22. Department of Health. The Department of Health is today making two significant health protection announcements. Available at https://www.health-ni.gov.uk/news/department-health-today-making-two-significant-health-protection-announcements. Accessed 22 Oct 2019
23. Buskermolen M, Cenin DR, Helsingen LM. Colorectal cancer screening with faecal immunochemical testing, sigmoidoscopy or colonoscopy: a microsimulation modelling study. BMJ 2019; 367:l5383. doi:10.1136/bmj.l5383
24. Chambers JA, Callander AS, Grangeret R, O'Carroll RE. Attitudes towards the Faecal Occult Blood Test (FOBT) versus the Faecal Immunochemical Test (FIT) for colorectal cancer screening:

perceived ease of completion and disgust. BMC Cancer 2016; 16:1-7. doi:10.1186/s12885-016-2133-4
25. International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Vol. 90: Human Papillomaviruses. Lyon: IARC Press, 2007
26. Public Health Agency. Vaccination Coverage. Available at http://www.publichealthagency.org/directorate-public-health/health-protection/vaccination-coverage. Accessed 22 Oct 2019
27. Hall MT, Simms KT, Lew JB, et al. The projected timeframe until cervical cancer elimination in Australia: a modelling study. Lancet Public Health 2019; 4:e19-e27. doi:10.1016/S2468-2667(18)30183-X
28. Carsin AE, Drummond FJ, Black A, et al. Impact of PSA testing and prostatic biopsy on cancer incidence and mortality: A comparative study between Republic of Ireland and Northern Ireland. Cancer Causes Control 2010; 21:1523-1531. doi:10.1007/s10552-010-9581-y
29. Office for National Statistics. Adult smoking habits in the UK: 2018. Available at https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandlifeexpectancies/bulletins/adultsmokinghabitsingreatbritain/2018. Accessed 12 Nov 2019
30. Best A, Haozaus EA, de Gonzalez AB, et al. Premature mortality projections in the USA through 2030: a modelling study. Lancet Public Health 2018; 3: e374-e384. doi:10.1016/ S2468-2667(18)30114-2
31. Riebler A, Held L. Projecting the future burden of cancer: Bayesian age-period-cohort analysis with integrated nested Laplace approximations. Biomedical journal 2017; 59: 531-549. doi: 10.1002/bimj.201500263.
32. Poirier AE, Ruan Y, Walter SD, et al. The future burden of cancer in Canada: Long-term cancer incidence projections 2013-2042. Cancer Epidemiology 2019; 59: 199-207. doi: 10.1016/j.canep.2019.02.011
33. Rosenberg PS, Check DP, Anderson WF. A web tool for age-period-cohort analysis of cancer incidence and mortality rates. Cancer Epidemiol Biomarkers Prev 2014; 23:2296-2302. doi:10.1158/1055-9965.EPI-14-0300
34. Quante AS, Ming C, Rottmann, et al. Projections of cancer incidence and cancer-related deaths in Germany by 2020 and 2030. Cancer Medicine 2016; 5:2649-2656. doi:10.1002/cam4.767
35. Ironmonger L, Ohuma E, Ormiston-Smith N, Gildea C, Thomson CS, Peake MD. An evaluation of the impact of large-scale interventions to raise public awareness of a lung cancer symptom. Br J Cancer 2015; 112L 207-216. doi:10.1038/bjc.2014.596
36. Cancer Research UK. Be clear on cancer evaluation update. Available at https://www.cancerresearchuk.org/sites/default/files/evaluation_results_2014.pdf. Accessed 12 Nov 2019
37. Northern Ireland Cancer Registry. Cancer incidence trends 1993-2013, with projections to 2035. Available at http://www.qub.ac.uk/nicr. Accessed 22 Oct 2019

Table 1: Total and average number of cases per year

Cancer type	ICD10 code	Males		Females	
		Total number of cases 1993-2017	Average number of cases per year 2013-2017	Total number of cases 1993-2017	Average number of cases per year 2013-2017
Colon cancer	C18	8,923	424	8,527	395
Rectal cancer	C19-C20	5,155	228	3,371	138
Breast cancer	C50	195	11	27,515	1,398
Lung cancer	C33-C34	14,996	680	10,580	610
Prostate cancer	C61	20,558	1,133	-	-
Head & neck cancer	C00-C14, C30-C32	4,556	232	1,939	96
Oesophageal cancer	C15	2,840	151	1,542	67
Stomach cancer	C16	3,613	137	2,280	80
Liver cancer	C22	1,260	85	746	48
Pancreatic cancer	C25	2,388	130	2,377	124
Melanoma	C43	2,723	174	3,693	203
Cervical cancer	C53	-	-	2,200	83
Uterine cancer	C54-C55	-	-	4,591	249
Ovarian cancer	C56-C57.4	-	-	4,658	208
Kidney cancer	C64	3,027	199	1,998	116
Bladder cancer	C67	3,710	155	1,506	64
Brain & CNS cancer	C70-C72, C75.1-C75.3	1,879	85	1,358	64
NH lymphoma	C82-C86	3,616	184	3,391	151
Leukaemia	C91-C95	2,775	134	2,051	95
All cancers ex. NMSC	C00-C43, C45-C97	94,732	4,691	95,806	4,710

CNS: Central Nervous System, NMSC: Non-Melanoma Skin Cancer, NH: Non-Hodgkin

Table 2: Annual percentage change in age-standardised incidence rates by sex and cancer type

Cancer type	Males		Females	
	Period of diagnosis	Annual percentage change (95% CI)	Period of diagnosis	Annual percentage change (95% CI)
Colon cancer	1993-2000	-2.5 (-4.7,-0.4)*	1993-2017	-0.1 (-0.5,0.4)
	2000-2012	1.7 (0.7,2.7)*		
	2012-2017	-5.1 (-7.9,-2.2)*		
Rectal cancer	1993-2017	-0.3 (-0.8,0.2)	1993-2017	-0.8 (-1.3,-0.3)*
Breast cancer	-	-	1993-2017	1.3 (1.1,1.5)*
Lung cancer	1993-1999	-2.6 (-4.8,-0.2)*	1993-2006	0.7 (-0.4,1.8)
	1999-2017	-0.4 (-0.8,0.0)	2006-2017	3.6 (2.4,4.7)*
Prostate cancer	1993-1998	-0.5 (-5.4,4.6)	-	-
	1998-2008	4.5 (2.8,6.2)*	-	-
	2008-2017	-1.4 (-2.7,-0.1)*	-	-
Head & neck cancer	1993-2001	-3.3 (-5.8,-0.7)*	1993-2017	0.9 (0.3,1.6)*
	2001-2017	1.1 (0.3,2.0)*		
Oesophageal cancer	1993-2017	0.6 (0.1,1.2)*	1993-2017	-0.6 (-1.3,0.1)
Stomach cancer	1993-2017	-2.6 (-3.1,-2.1)*	1993-2017	-2.4 (-3.0,-1.8)*
Liver cancer	1993-1999	-6.8 (-14.9,2.1)	1993-2003	-4.6 (-10.4,1.6)
	1999-2012	7.6 (4.9,10.3)*	2003-2017	5.4 (2.0,8.9)*
	2012-2017	-1.3 (-7.7,5.5)		
Pancreatic cancer	1993-2017	1.0 (0.1,1.9)*	1993-1998	-3.8 (-10.3,3.2)
			1998-2012	3.1 (1.5,4.8)*
			2012-2017	-2.3 (-7.7,3.4)
Melanoma	1993-2017	3.8 (3.0,4.6)*	1993-2017	2.3 (1.9,2.8)*
Cervical cancer	-	-	1993-2004	-2.6 (-4.8,-0.4)*
	-	-	2004-2008	9.4 (-6.6,28.2)
	-	-	2008-2017	-5.4 (-8.1,-2.7)*
Uterine cancer	-	-	1993-2009	3.7 (2.8,4.6)*
	-	-	2009-2017	0.1 (-1.7,2.1)
Ovarian cancer	-	-	1993-1998	5.2 (0.3,10.4)*
	-	-	1998-2017	-0.7 (-1.2,-0.1)*
Kidney cancer	1993-2017	3.4 (2.9,4.0)*	1993-2017	2.8 (2.0,3.6)*
Bladder cancer	1993-2017	-1.7 (-2.2,-1.1)*	1993-2017	-1.1 (-2.1,-0.2)*
Brain & CNS cancer	1993-2017	0.5 (-0.3,1.2)	1993-2017	0.0 (-1.0,1.1)
Non-Hodgkin Lymphoma	1993-2007	-0.5 (-1.6,0.5)	1993-2017	0.1 (-0.4,0.7)
	2007-2011	6.6 (-3.3,17.7)		
	2011-2017	-1.6 (-4.5,1.5)		
Leukaemia	1993-2017	0.3 (-0.4,0.9)	1993-2017	0.8 (0.1,1.5)*
All cancers ex. NMSC	1993-1999	-1.6 (-2.6,-0.5)*	1993-2001	0.2 (-0.5,0.8)
	1999-2009	1.3 (0.8,1.8)*	2001-2017	1.0 (0.8,1.2)*
	2009-2017	-0.7 (-1.3,-0.2)*		

*CNS: Central Nervous System, NMSC: Non-Melanoma Skin Cancer, CI: Confidence interval, *p<0.05, - not applicable*

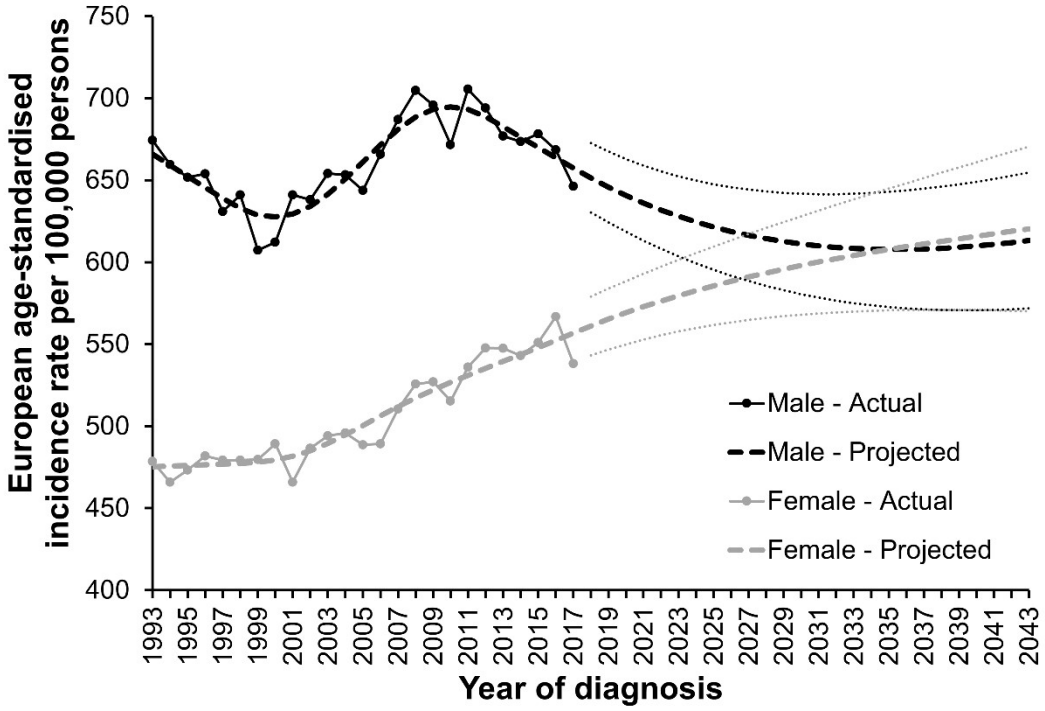
Table 3: Projected annual number of cases for all cancers (ex. NMSC) by gender and cancer type

Cancer type	Males					Females				
	2013-2017 cases per year	2025		2040		2013-2017 cases per year	2025		2040	
		Projected number of cases	Prediction interval	Projected number of cases	Prediction interval		Projected number of cases	Prediction interval	Projected number of cases	Prediction interval
All (ex. NMSC)	4,691	5,463	5,214 - 5,711	6,788	6,400 - 7,177	4,710	5,840	5,605 - 6,074	7,450	6,995 - 7,905
Colon	424	478	412 - 544	649	564 - 734	395	478	426 - 531	639	563 - 715
Rectal	228	244	201 - 287	326	272 - 380	138	151	124 - 179	193	161 - 226
Breast	-	-	-	-	-	1,398	1,769	1,649 - 1889	2,201	1,986 - 2,417
Lung	680	815	725 - 905	1,003	870 - 1,136	610	956	856 - 1,055	1,344	1,102 - 1,587
Prostate	1,133	1,272	1,154 - 1,390	1,537	1,360 - 1,714	-	-	-	-	-
Head & Neck	232	291	242 - 341	358	281 - 434	96	140	111 - 169	191	142 - 240
Oesophageal	151	213	173 - 254	292	222 - 362	67	81	61 - 102	100	75 - 125
Stomach	137	123	91 - 156	115	83 - 146	80	75	55 - 95	68	47 - 88
Liver	85	164	127 - 200	237	161 - 314	48	85	58 - 112	134	53 - 215
Pancreatic	130	181	143 - 219	251	194 - 308	124	177	143 - 210	262	206 - 319
Melanoma	174	266	213 - 318	433	320 - 546	203	273	233 - 313	370	306 - 434
Cervical	-	-	-	-	-	83	46	30 - 63	23	12 - 34
Uterine	-	-	-	-	-	249	335	291 - 378	459	392 - 526
Ovarian	-	-	-	-	-	208	201	167 - 234	235	196 - 274
Kidney	199	309	262 - 356	417	331 - 503	116	167	137 - 196	213	167 - 259
Bladder	155	163	125 - 200	205	163 - 247	64	78	57 - 99	119	89 - 149
Brain & CNS	85	93	70 - 117	104	76 - 132	64	77	57 - 97	97	72 - 122
NH Lymphoma	184	233	189 - 277	287	222 - 352	151	167	137 - 197	217	179 - 256
Leukaemia	134	167	132 - 202	207	163 - 251	95	115	91 - 139	142	113 - 170

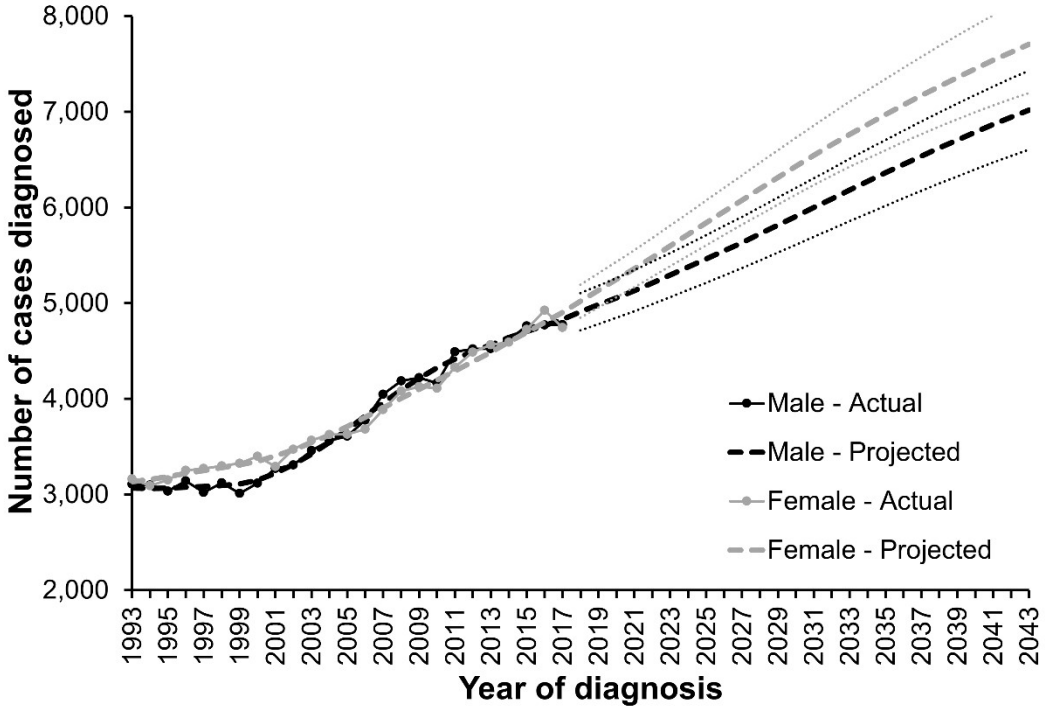
CNS: Central Nervous System, NMSC: Non-Melanoma Skin Cancer, NH: Non-Hodgkin, - not applicable

Figure 1: Projected age-standardised incidence rates and numbers of cases for all cancers (ex. NMSC) by gender

(a) Age-standardised incidence rates

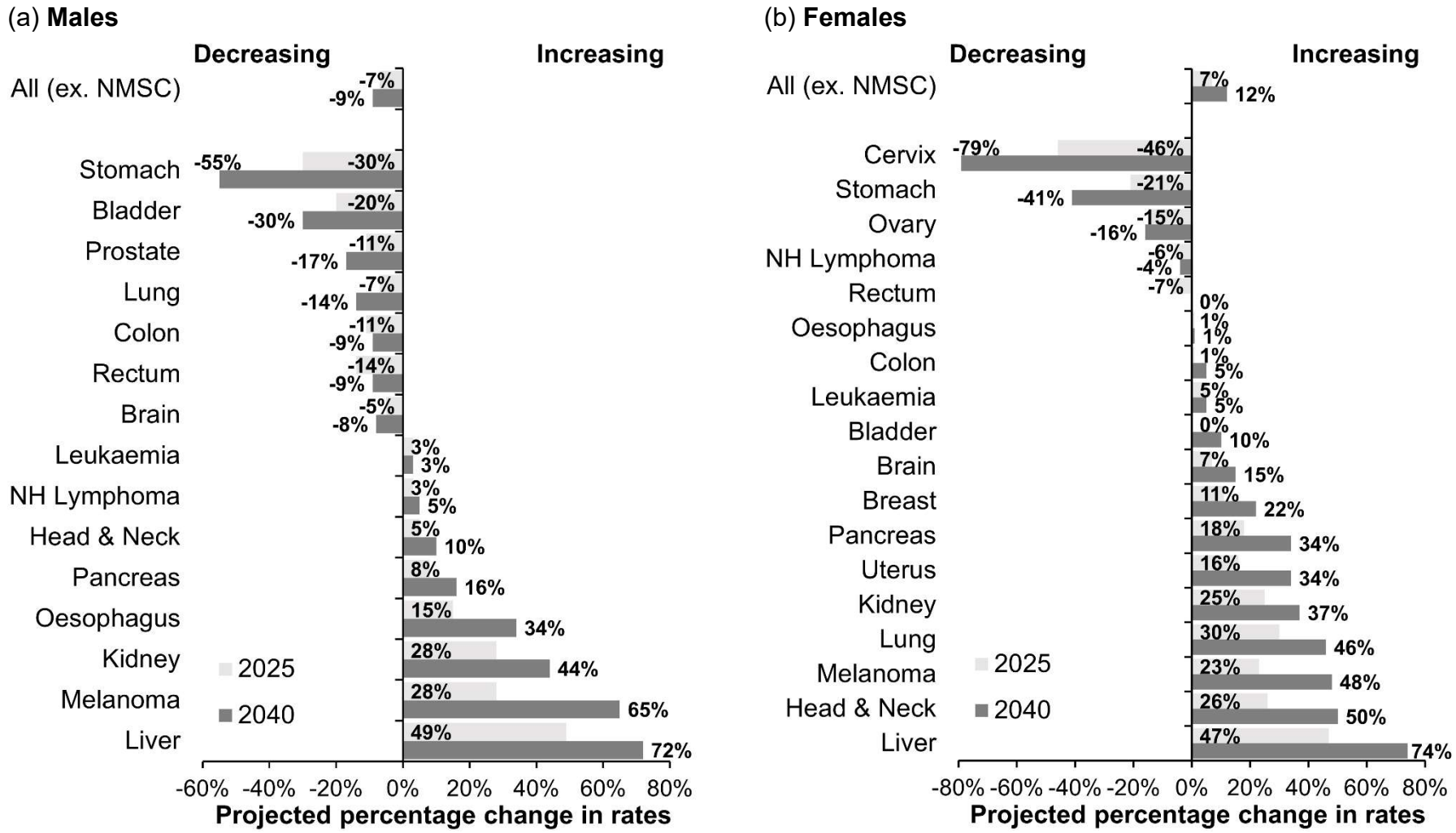


(b) Number of cases diagnosed



Note: Dotted lines represent prediction intervals.

Figure 2: Projected change in age-standardised incidence rates by gender and cancer type compared to 2013-2017 average



NMSC: Non-Melanoma Skin Cancer, NH: Non-Hodgkin

Supplementary Data

Supplement.pc