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Epidemiology of basal and cutaneous squamous cell carcinoma in the United Kingdom 2013-2015: a cohort study

Running header: Epidemiology of BCC and cSCC in UK 2013-2015

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What's already known about this topic?

Keratinocyte cancers (KCs) are the most common cancer affecting Caucasian populations.

The incidence of Basal Cell Carcinoma (BCC) and cutaneous Squamous Cell Carcinoma (cSCC) is increasing worldwide including the UK, most commonly in elderly male Caucasian patients. These cancers are traditionally substantially under-reported and frequently excluded from national cancer statistics.

What does this study add?

Using improved data collection methods in England and validated, tumour reporting techniques, we report the most accurate BCC and cSCC incidence data for the UK ever published.

Identifying the 1st BCC and cSCC per patient per annum, the incidence of BCC and cSCC in the UK (excluding Wales) was 285 and 77 per 100,000 person-years respectively between 2013 and 2015, with more than 210,000 KCs in the UK in 2015.

Abstract

Background

Basal cell carcinoma (BCC) and cutaneous squamous cell carcinoma (cSCC), together known as keratinocyte cancers (KCs), are the commonest cancer in Caucasian populations. Recent improvements to registry data collection in England has allowed more accurate analysis of the epidemiology of BCC and cSCC and for the first time we are able to provide an accurate (representative) tumour burden for KC in the UK.

Objective

To estimate the incidence of BCC and cSCC in the UK.

Methods

A cohort of patients with KCs between 2013 and 2015 were identified using linkage to diagnostic codes derived from pathology reports collected into the national cancer registry. Data from England's cancer registry were combined with data from Scotland, Northern Ireland and Wales. European Age Standardised incidence rates (EASRs) of the first BCC and cSCC per patient per annum (PPPA) were calculated.

Results

In the UK, the EASR of the first BCC and cSCC PPPA 2013-2015 were 285 and 77 per 100,000 person-years respectively (211,120 KCs total in 2015). The mean annual percentage increase was 5% between 2013-2015 for both BCC and cSCC. By counting the first tumour per patient per year, we

include an additional 51% KCs compared to the previous reporting technique which counts only the first BCC and cSCC in a patient's lifetime, yet it represents a probable underestimation of 5-11% of the true tumour count.

Conclusions

Based on an improved methodology, a more representative incidence of KC is presented, which is essential to healthcare planning and will lead to improved understanding of the epidemiology of KC.

Introduction:

Keratinocyte cancers (KCs), the collective term for basal cell carcinomas (BCCs) and cutaneous squamous cell carcinomas (cSCCs), are the most common cancers in the UK and the most common cancer in white ethnic populations worldwide. However, epidemiological data in the UK have historically been of relatively poor quality. [1-5] Due to high volume and multiplicity of KCs, they have frequently been excluded from national cancer registries and statistics. Previous studies have reported that incidence rates of KC are increasing worldwide and evidence from local audits suggest that the rate of increase in the UK may be higher than in European counterparts [6-13]. Increasing tumour incidence is presumed to be a result of an ageing population, increased ultraviolet (UV) radiation exposure with easier access to travel abroad and a higher proportion of fairer skin types in the UK compared to other countries, [6, 14] but little is known about the epidemiology of KC in the UK.

The healthcare workload burden and cost of KC is substantial within dermatology departments in the UK, where these cancers are often seen urgently, within two weeks of referral. In 2008, skin cancer management costs were estimated to be between £106–£112 million and approximately £889 - £1226 per KC in England.[15] A decade later, these estimates are likely to be substantially higher, with advances in treatment approaches and increase in patient volume. Furthermore, despite a relatively low mortality, morbidity through cosmetic disfigurement and functional morbidity is considerable given that KCs are frequently multiple and most commonly located on the face.

Despite the high volume and associated costs of KC, limited research progress has been reported. This discrepancy was highlighted by a UK Translational Research Network in Dermatology (UKTREND) e-DELPHI exercise which assessed the research needs of clinicians in the UK and identified research into KC as a priority area.[16]

In 1999, the United Kingdom and Ireland Association of Cancer Registries (UKIACR) ruled that due to complexities in registering multiple pathology reports accurately, only the first BCC or cSCC per patient is reported, despite all pathology reports now being routinely collected since 2013 in England, Scotland and Northern Ireland.[17] This rule is also used in many cancer registries worldwide.[6] The impact of this registration approach was that previous figures were clearly significant underestimations of national incidence in UK. Metachronous and synchronous BCCs and cSCCs are common[18]. After a diagnosis of BCC, the 3 year risk of a subsequent BCC is estimated to

be 44%, with 10% developing a further BCC within 6 months [10, 19-21]. Likewise, after an initial cSCC, the 5 year risk of a further cSCC is estimated to be 37% [21]. Previous studies have shown that when counting all BCCs as opposed to the 1st registered BCC, an additional 30-50% of tumours are counted [10, 22, 23, 24]. Changes in cancer registration processes in England, including the introduction of national automated registration have enabled the development of a more comprehensive BCC and cSCC dataset for the first time.

The objective of this study was to validate improved data collection methods and report the incidence and survival for BCC and cSCC from the cancer registry data at a national level for the first time.

Materials and methods:

Study design, setting and participants:

Data were provided by the National Cancer Registration and Analysis Service (NCRAS), England. It is mandatory for all NHS pathology laboratories, and recommended to all private pathology laboratories in England, to provide all cancer pathology to NCRAS and NCRAS data quality teams ensure pathology laboratories are compliant. These pathology reports are combined with information from the Patient Administration System (PAS) and Cancer Outcomes and Services Dataset (COSD) to form a cancer registration record. Since 2013 in England this process became nationalised and mostly automated; a majority of tumours are registered based upon the pathology report laboratory codes and text information provided. The minority which do not meet the automated processor's selection criteria are manually registered.

BCC and cSCC were identified using the ICD-10 (International Classification of Diseases) site codes and ICD-02 morphology and behaviour codes (supplementary table). The date of receipt of the pathology sample was used as the date of diagnosis, to identify the first BCC and cSCC per patient per annum (PPPA).

Data were also provided by Information Services Division Scotland, the Northern Ireland cancer registry and the Welsh Cancer Intelligence & Surveillance Unit (WCISU). Welsh data collection is acknowledged by the registry to be incomplete (personal communication with WCISU), awaiting changes to be enforced from 2016 data onwards. Welsh data were therefore excluded from the analyses, except for overall tumour count.

Validation

To confirm the accuracy of the data and the use of the first PPPA technique, a randomised selection of 500 BCC patients and 500 cSCC patients in 2013 in England were reviewed by a single dermatologist [ZV]. Tumours diagnosed in the previous calendar year, recurrences of previous tumours and incorrectly coded tumours were excluded e.g. Bowens disease. Additional tumours collected but not counted with the first PPPA technique (i.e. more than one tumour per annum) were analysed to provide an estimate of how the first PPPA compares to manually registering all tumours per patient and also to assess the validity of the registration process in England. Furthermore, in Scotland, because all cSCCs are registered except in specific cases such as patients

with genetic predisposition to multiple cSCCs, Scottish data was also used to assess the first PPPA technique vs registering all tumours manually.

Variables

Patient demographics such as age (taken as a continuous variable taken from day of diagnosis), sex and self reported ethnicity were analysed from NCRAS which derives information from PAS and COSD. Deprivation quintiles were calculated using the patient's Lower Super Output Area at diagnosis linked to the Index of Multiple Deprivation 2015.[25]

Statistical analysis

The NCRAS data were extracted using an Oracle SQL developer© Version 4.1.5.21 (Oracle, California, USA). Microsoft© excel version 2010 (Microsoft, California, USA) and Stata© version 14 (Stata Corporation, College Station, TX, USA) were used for statistical analyses. Randomisation as listed above was performed using random number generator from Excel© 2010.

European Age-adjusted incidence rates (EASR) are weighted based upon European standard populations 2013 in 5 year age bands. The EASR of cSCC and BCC 1st PPPA were calculated across gender and nations (England, Scotland and Northern Ireland). Welsh data were excluded from EASR and age specific rates due to lack of completeness. The estimated annual percentage changed (EAPC) was calculated as the mean change in EASR per year.

Statistics for absolute number of deaths attributed to non-melanoma skin cancer was as reported by the Office of National Statistics.[26]

The Pohar-Perme estimator was used to calculate age-standardised net survival with the 'stns' command in Stata 14. This analysis was age-standardised using weights from the International Cancer Survival Standard (ICSS)[27] i.e. survival was standardised based upon expected survival of age and sex specific groups. Life tables were obtained from the Cancer Survival Group at the London School of Hygiene and Tropical Medicine. Vital status of patients was determined until 31st December 2016. [28]

Results:

Validation

Overall, an additional 51% KC tumours were identified using first PPPA technique compared to identifying only the first incident tumour of all time. Analysing the first BCC PPPA in England 2013-2015 (n=410,716) compared to 1st registered (n=268565) resulted in 53% further BCC tumours recorded over 3 years. Likewise, when counting first PPPA cSCC (n=104529) compared to 1st registered (n=76977) an additional 36% cSCC tumours were recorded.

To assess the 1st PPPA technique and use of an automated processor in England, a randomly selected cohort of 500 BCC and 500 cSCC patients from the English cancer registry in 2013 were selected and the number of tumours per patient was counted. Counting the first tumour PPPA resulted in 10.6% fewer BCC tumours and 6.8% fewer cSCC tumours, figure 1.

In Scotland, all cSCC tumours are registered manually except cases of genetic predisposition, therefore we compared the registered cSCC tumour count to the 1st PPPA technique in Scotland. This found an underestimation 5.3% of all cSCCs by using the 1st PPPA, figure 1.
Analysing the automated processing technique in England, only 0.8% (8/1000) tumours were incorrectly coded e.g. Bowens disease coded as an invasive cSCC.

UK Incidence of KC
The absolute 1st PPPA BCC count increased in the three year period from 145,817 to 166,448 in 2015, figure 2. The EASR of 1st PPPA BCC in the UK from 2013-2015 was 352/100,000 Person Years (PY) in males and 219/100,000 PY in females. More than 85% of BCCs in the UK occurred in England and the EASR was highest in England compared to other UK nations, figure 2. For the UK, the Estimated Annual Percentage Change (EAPC) was 5% for BCC, but much lower in Northern Ireland (0.3%).

The absolute cSCC count of 1st PPPA increased from 38,664 in 2013 to 44,672 in 2015 in the UK, figure 2. The EASR of 1st PPPA cSCC from 2013-2015 was 111 in men and 42/100,000 PY in women with highest rates seen in Northern Ireland, figure 2. The EAPC of cSCC was around 6% in the three year period.

Geographic incidence differences in UK:
The incidence rates of 1st PPPA KC differ across the UK and are highest in southern and coastal regions, figure 3. The highest BCC rates were observed in Southwest England (EASR 362/100,000 PY) and the lowest EASR was in Dumfries and Galloway (39/100,000 PY). For cSCC, the highest rates were observed in Southwest England and the lowest in Shetland (EASR 107 and 345 /100,000 PY, respectively). Several regions such as London and have notably lower EASR as expected.

Demographics of KC patients in England
1st all-time BCC and cSCC patients were more commonly males, with a male: female ratio 1.2:1 for BCC and 1.7:1 for cSCC, table 1. The median age at time of incident tumour was approximately 71 years (interquartile range (IQR) =62-80) for BCC and 79 years (IQR 71-85) for cSCC. The age specific rates for both BCC and cSCC clearly increase with age and are much higher and steeper among men than women, figure 4. For both BCC and cSCC, fewer than 1% of individuals self-reported as non-white, with a substantial proportion of missing data (up to 34%). The distribution of the deprivation quintiles is comparable for both tumour types between men and women.

Body site of KCs in England
The majority of KCs are located in the head and neck region, especially on the face (between 27% and 40.9%; table 1). Compared to cSCCs, BCCs tend to be more common on the trunk and are less frequent on the upper extremities. In men, 15.8% of cSCCs were located on the ear whereas the ear was affected in only 1.3% of women. A quarter of cSCCs in women were located on the lower extremities, which is five-fold more than in men. In approximately 15% of BCCs and 5% of cSCCs, body site was not reported, table 1.

KC specific mortality in England:
The absolute number of deaths with an underlying cause of 'non melanoma skin cancers' (which includes other skin cancers such as Merkel cell carcinomas) in England were 489 in 2013, 626 in 2014 and 624 in 2015.

Three year net survival was 101.9% (95% CI 101.8-102.0) for BCC and 96.2% (CI 95.9-96.6) for cSCC overall. For men, three year net survival was 101.9% (95% CI 101.8-102.1) for BCC and 95.7% (95% CI 95.3-96.2) for cSCC. For women, three year net survival was 101.9% (95% CI 101.7-102.0) for BCC and 97.1% (96% CI 96.6-97.6) for cSCC.

Discussion:

We report the largest and most complete dataset for national incidence of KC ever published, with over 210,000 tumours reported in 2015 in the UK. With significant increases in tumour count between 2013 and 2015, KCs represent an overwhelming burden on the workload of healthcare resources. KCs occur mainly in older people, and because of steadily aging populations, the pressure on the health service is likely to further increase. Of note, skin cancers are four times more common than any other cancer in the UK in 2015.[26] This study provides much needed information, as highlighted in recent epidemiological reviews of KC [3, 7-9, 29].

Due to the frequent multiplicity of KCs, the UKIACR method of only counting one tumour per patient has resulted in substantial underestimation of national tumour counts. We validate a technique to assess 1st PPPA BCC and cSCC that identified 51% additional tumours compared to the standard first registered BCC and cSCC UKIACR method. While less accurate than manually registering all KCs, this method allows improved incidence reports with minimal additional workload and is easily achievable with access to pathology or cancer registry data. Our validation study would imply that when counting all tumours i.e multiple tumours per patient per year, true tumour count is likely to be 5-10% higher than those provided by the 1st PPPA technique.

Strengths and Limitations:

The combined UK registries form the largest population based KC registry in the world; an essential tool for assessing the epidemiology of these tumours and the main strength of our study. However, inherent to large national pathology based cancer registries there are several potential sources of under-reporting such as use of topical and destructive treatments without histological confirmation, miscoding or the impact of long waiting lists. Also, there are regional differences in KC registration within the UK which may have affected comparisons between regions. For example, all cSCCs are manually registered in Scotland therefore rates will be comparatively higher than 1st PPPA counts, despite this; rates remain lower than England and Northern Ireland. Due to the introduction of new automated report processing technology in 2013, the data collection prior to 2013 may be less complete. Therefore the increase in first registered tumours in subsequent years may be an overestimation, but this does not apply to 1st PPPA reporting. Since the KC registry is based on routinely collected data and linked to other national data sources, the granularity of the data is not always sufficient e.g. missing data in self-reported ethnicity, tumour localisation and lack of UV radiation exposure data.
Primary cSCC affecting perianal sites have a different pathogenesis, with human papillomavirus infection thought to be an important cause rather than UV radiation [30]. However, ICD-10 coding of perianal tumours classifies these to be coded as 'truncal' tumours and therefore this precludes accurate identification of these tumours.

Interpretation:

The distribution of recorded anatomical sites for primary KCs differed between men and women, which is in line with other studies [4, 20]. This may relate to varying UV radiation exposure as a result of male pattern baldness and cultural preferences, i.e. shorter hair for men and women wearing dresses/skirts. This may explain why men are more likely to develop KCs on the ear and scalp, and for women the lower limb is preferentially affected. However, the commonest site in both sexes for KC was the face.

The regional variations identified in KC incidence may reflect reducing incidence with higher latitude/lower UV exposure. In addition, in urban areas ethnicity may be more diverse, and behaviour may differ in terms of outdoor work and activities, figure 3. It is unclear why Northern Ireland has a higher cSCC incidence compared to other nations, this could relate to a higher number of outdoor occupations, recent public health campaigns, variation in clinical practice or data collection.[31, 32] Compared to elsewhere in the world, incidence rates of KC in the UK are lower than those published in Australia, but higher than elsewhere in Europe and USA with varying rates presumably due to skin type/genetic predisposition and UV radiation exposure. [6, 10, 18, 24]

Similar to previous studies, we show that BCC and cSCC are both significantly associated with lower deprivation quintiles[33]. This is likely to be the result of the expense of foreign travel and increased leisure time being more affordable in these quintiles, equating to higher UV exposure in the generations affected as well as increased awareness of skin cancer and access to healthcare.

According to national statistics, 86% of the population in England and Wales are of 'white' ethnicity, however of those with known ethnicity, 99.3% of primary cSCC patients are of white ethnicity, which may be mainly due to these skin types having reduced protection from UV radiation.[34]

Although the net survival of over 95% for both types of KC the overall prognosis of KC is very good, only a minority of cSCC patients develops advanced disease. Despite low mortality rates, KCs represent an overwhelming tumour burden in the population.[35] We confirm an interesting observation that patients who develop their first BCC have a 3 year net survival of over 100%.[36] This can be in part the result of the association of BCC with lower deprivation quintiles, fitness for biopsy excluding older more frail patients from our cohort and general adherence to healthier outdoors lifestyles. Figure 4 shows that at the age of 85 a peak in incidence rate occurs, suggesting that patients where the risk outweighs benefit for BCC treatment are excluded, i.e. frailer, older patients with more comorbidities.

Conclusion

A new technique taking advantage of the modernisation of national cancer registration and data collection in the UK has resulted in significantly improved reporting of KC incidence. We have validated this registration and data collection approach here and now demonstrate more accurately the huge and steadily increasing trend in KC incidence in the UK. This scale of the disease burden posed by KC inevitably has implications for healthcare resources. The more accurate incidence data reported here and now available prospectively through improved KC registration will undoubtedly

facilitate improved service planning and provision in the future. In addition, it will lead to improved understanding of the natural history and prognosis of KC. Finally, it provides further evidence for the importance of future skin cancer prevention initiatives as part of strategies to reduce the morbidity and future healthcare resource implications of KC.

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References:

1. Trakatelli, M., et al., *Epidemiology of nonmelanoma skin cancer (NMSC) in Europe: accurate and comparable data are needed for effective public health monitoring and interventions.* Br J Dermatol, 2007. **156 Suppl 3**: p. 1-7.
2. Diepgen, T.L. and V. Mahler, *The epidemiology of skin cancer.* Br J Dermatol, 2002. **146 Suppl 61**: p. 1-6.
3. Lansbury, L., et al., *Interventions for non-metastatic squamous cell carcinoma of the skin.* Cochrane Database of Systematic Reviews, 2010(4).
4. Hollestein, L.M., E. de Vries, and T. Nijsten, *Trends of cutaneous squamous cell carcinoma in the Netherlands: Increased incidence rates, but stable relative survival and mortality 1989-2008.* European Journal of Cancer, 2012. **48**(13): p. 2046-2053.
5. Holterhues, C., et al., *Incidence and trends of cutaneous malignancies in the Netherlands, 1989-2005.* J Invest Dermatol, 2010. **130**(7): p. 1807-12.
6. Lomas, A., J. Leonardi-Bee, and F. Bath-Hextall, *A systematic review of worldwide incidence of nonmelanoma skin cancer.* Br J Dermatol, 2012. **166**(5): p. 1069-80.
7. Nijsten, T. and I.M. Leigh, *Keratinocyte skin cancers in the spotlight.* Br J Dermatol, 2017. **177**(2): p. 334-335.
8. Verkouteren, J.A.C., et al., *Epidemiology of basal cell carcinoma: scholarly review.* Br J Dermatol, 2017. **177**(2): p. 359-372.
9. Green, A.C. and C.M. Olsen, *Cutaneous squamous cell carcinoma: an epidemiological review.* Br J Dermatol, 2017. **177**(2): p. 373-381.
10. de Vries, E., et al., *Population-based estimates of the occurrence of multiple vs first primary basal cell carcinomas in 4 European regions.* Arch Dermatol, 2012. **148**(3): p. 347-54.
11. Reinau, D., et al., *Epidemiology of basal cell carcinoma in the United Kingdom: incidence, lifestyle factors, and comorbidities.* Br J Cancer, 2014. **111**(1): p. 203-6.
12. Carsin, A.E., L. Sharp, and H. Comber, *Geographical, urban/rural and socioeconomic variations in nonmelanoma skin cancer incidence: a population-based study in Ireland.* Br J Dermatol, 2011. **164**(4): p. 822-9.
13. Goon, P.K., et al., *Predicted cases of UK skin SCC and BCC in 2020 and 2025: Horizon planning for NHS Dermatology and Dermatopathology.* Br J Dermatol, 2016.
14. Levell, N.J., et al., *Basal cell carcinoma epidemiology in the UK: the elephant in the room.* Clin Exp Dermatol, 2013. **38**(4): p. 367-9.

15. Vallejo-Torres, L., et al., *Measuring current and future cost of skin cancer in England.* J Public Health (Oxf), 2014. **36**(1): p. 140-8.
16. Healy, E., et al., *Identification of translational dermatology research priorities in the U.K.: results of an electronic Delphi exercise.* Br J Dermatol, 2015. **173**(5): p. 1191-1198.
17. UKIACR, *CODING AND CLASSIFICATION GROUP (CCG) - THE PRACTISE ON CODING AND CLASSIFICATION POLICY AND PRACTICE AGREED BY THE CCG.* Date Agreed: 02/03/1999 Accessed 19/6/2018 https://www.mylearningspace.me.uk/moodle/pluginfile.php/8354/mod_resource/content/2/The-Practise.pdf.
18. Bielsa, I., et al., *Population-based incidence of basal cell carcinoma in a Spanish Mediterranean area.* British Journal of Dermatology, 2009. **161**(6): p. 1341-1346.
19. Marcil, I. and R.S. Stern, *Risk of developing a subsequent nonmelanoma skin cancer in patients with a history of nonmelanoma skin cancer: a critical review of the literature and meta-analysis.* Arch Dermatol, 2000. **136**(12): p. 1524-30.
20. Flohil, S.C., et al., *Incidence, prevalence and future trends of primary basal cell carcinoma in the Netherlands.* Acta Derm Venereol, 2011. **91**(1): p. 24-30.
21. Flohil, S.C., et al., *Risk of subsequent cutaneous malignancy in patients with prior keratinocyte carcinoma: a systematic review and meta-analysis.* Eur J Cancer, 2013. **49**(10): p. 2365-75.
22. Lucke, T.W., D.J. Hole, and R.M. Mackie, *An audit of the completeness of non-melanoma skin cancer registration in Greater Glasgow.* Br J Dermatol, 1997. **137**(5): p. 761-3.
23. Poirier, V., *The Role of the South West Public Health Observatory as the Lead Cancer Registry for Skin Cancer (presentation).* British Association Dermatologist's Non-Melanoma Skin Cancer Conference, 2013.
24. Pandeya, N., C.M. Olsen, and D.C. Whiteman, *The incidence and multiplicity rates of keratinocyte cancers in Australia.* Med J Aust, 2017. **207**(8): p. 339-343.
25. Ministry of Housing, communities and local government. *Index of Multiple Deprivation*. 2015; Available from: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015.
26. Office of National Statistics. *Cancer registration statistics, England: 2015*. 2017 23/05/2017; Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/datasets/cancerregistrationstatisticscancerregistrationstatisticsengland.
27. Corazziari, I., M. Quinn, and R. Capocaccia, *Standard cancer patient population for age standardising survival ratios.* Eur J Cancer, 2004. **40**(15): p. 2307-16.
28. London School of Hygiene and Tropical Medicine. *Life tables*. Available from: http://csg.lshtm.ac.uk/tools-analysis/uk-life-tables/.
29. Leigh, I.M., *Progress in skin cancer: the U.K. experience.* Br J Dermatol, 2014. **171**(3): p. 443-445.
30. Dawson, H. and S. Serra, *Tumours and inflammatory lesions of the anal canal and perianal skin revisited: an update and practical approach.* J Clin Pathol, 2015. **68**(12): p. 971-981.
31. Public Health Agency *Skin cancer prevention*. Available from: http://www.publichealth.hscni.net/directorate-public-health/health-and-social-wellbeing-improvement/skin-cancer-prevention.
32. Public Health Agency Care in the sun: Outdoor Work, Sports and Leisure; Available from: https://careinthesun.org/sun-protection/outdoor-work-sports-and-leisure/.
33. Doherty, V.R., et al., *Trends in skin cancer incidence by socioeconomic position in Scotland, 1978–2004.* Br J Cancer, 2010. **102**(11): p. 1661-1664.
34. Office of National Statistics. *Ethnicity and National Identity in England and Wales: 2011*. 2012; Available from:

https://www.ons.gov.uk/peoplepopulationandcommunity/culturalidentity/ethnicity/articles/ethnicityandnationalidentityinenglandandwales/2012-12-11.
35. Venables, Z.C., et al., *Nationwide Incidence of Metastatic Cutaneous Squamous Cell Carcinoma in England.* JAMA Dermatol, 2018.
36. Eisemann, N., et al., *Survival with nonmelanoma skin cancer in Germany.* Br J Dermatol, 2016. **174**(4): p. 778-85.

Legends:

Figure 1. Analysis of 1st tumour per patient per annum technique for counting keratinocyte cancers from registry data

Figure 2a-d. National tumour count and incidence rate of basal cell carcinoma (BCC) and cutaneous squamous cell carcinoma (cSCC) using the 1st tumour per patient per annum technique except for cSCC data for Scotland where all cSCC are registered, Welsh data are excluded from incidence rates due to incomplete data collection. 2a. National BCC tumour count 2013-2015. 2b. National age standardised incidence rate of BCC 2013-2015. 2c. National cSCC tumour count 2013-2015. 2d. National age standardised incidence rate of cSCC 2013-2015.

Figure 3a. Regional basal cell carcinoma age standardised incidence rates in UK 2013-2015 using the 1st tumour per patient per annum technique. Welsh data are excluded due to incomplete data collection. 3b. Regional cutaneous squamous cell carcinoma (cSCC) age standardised incidence rates in UK 2013-2015 using the 1st tumour per patient per annum technique except in Scotland where all cSCC are registered. Welsh data are excluded due to incomplete data collection.

Figure 4a-b Age specific rates of basal cell carcinoma (BCC) and cutaneous squamous cell carcinoma (cSCC) in males and females 2013-2015, England. Using data for 1st tumour all time. 4a. Age specific rates of BCC. 4b. Age specific rates of cSCC.

Supplementary Table. Classification of basal cell carcinoma and cutaneous squamous cell carcinoma

Table 1 Patient demographics of 1st registered basal cell carcinoma and cutaneous squamous cell carcinoma in England 2013-2015

Patient demographics of 1st registered tumour	1st BCC n=268565				1st cSCC n=76977			
	Male n=144680		Female n=123885		Male n=48254		Female n= 28723	
Age Median (IQR) years	72 (63-79)		71 (60-80)		78 (71-84)		80 (71-87)	
Age								
0-29	464	0.3%	641	0.5%	30	0.1%	26	0.1%
30-39	2229	1.5%	3066	2.5%	123	0.3%	98	0.3%
40-49	7685	5.3%	9680	7.8%	655	1.4%	489	1.7%
50-59	16660	11.5%	16148	13.0%	2117	4.4%	1491	5.2%
60-69	35487	24.5%	27893	22.5%	7352	15.2%	3930	13.7%
70-79	46551	32.2%	33990	27.4%	16158	33.5%	7735	26.9%
80-89	30631	21.3%	25913	20.9%	17822	36.9%	10385	36.2%
90+	4973	3.4%	6554	5.3%	3997	8.3%	4569	15.9%
Ethnicity								
white	97418	67.3%	80690	65.1%	43283	89.7%	25226	87.8%
mixed	63	0.0%	69	0.1%	29	0.1%	22	0.1%
Indian/ other asian background	108	0.1%	114	0.1%	73	0.2%	50	0.2%
Afrocaribbean/other black background	57	0.0%	61	0.0%	42	0.1%	38	0.1%
Chinese	22	0.0%	23	0.0%	7	0.0%	8	0.0%
Other ethnic group	402	0.3%	371	0.3%	169	0.4%	96	0.3%
Unknown	46610	32.2%	42557	34.4%	4651	9.6%	3283	11.4%
Deprivation Quintiles								
1 (least deprived)	40366	27.9%	32572	26.3%	12792	26.5%	7096	24.7%
2	37363	25.8%	31004	25.0%	12451	25.8%	7064	24.6%
3	30101	20.8%	26108	21.1%	10200	21.1%	6295	21.9%
4	21915	15.1%	20045	16.2%	7642	15.8%	4825	16.8%
5 (most deprived)	14935	10.3%	14156	11.4%	5169	10.7%	3443	12.0%
Site of 1st registered BCC or cSCC								
Lip (cutaneous)	1491	1.0%	3219	2.6%	815	1.7%	679	2.4%
Eyelid incl. canthus	6353	4.4%	8019	6.5%	584	1.2%	483	1.7%
Ear	9439	6.5%	1568	1.3%	7601	15.8%	363	1.3%
Face	55213	38.2%	50691	40.9%	13126	27.2%	9308	32.4%
Scalp/Neck	11315	7.8%	8265	6.7%	11566	24.0%	1669	5.8%
Trunk incl. perianal	22630	15.6%	14484	11.7%	3080	6.4%	2201	7.7%
Upper limb incl. shoulder	9870	6.8%	7479	6.0%	6947	14.4%	5416	18.9%
Lower limb incl. hip	5637	3.9%	10951	8.8%	2367	4.9%	7205	25.1%
Skin NOS	22732	15.7%	19209	15.5%	2168	4.5%	1399	4.9%

CI = confidence interval IQR=Interquartile range NOS = Not Otherwise Specified

Table 1. Patient demographics of 1st all-time registered basal cell carcinoma and cutaneous squamous cell carcinoma, England 2013-2015.

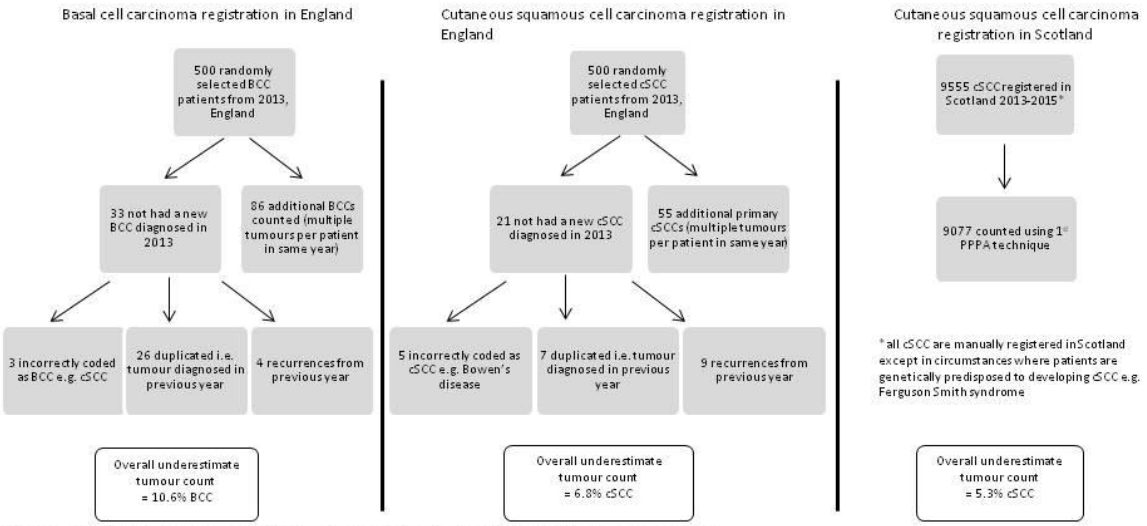
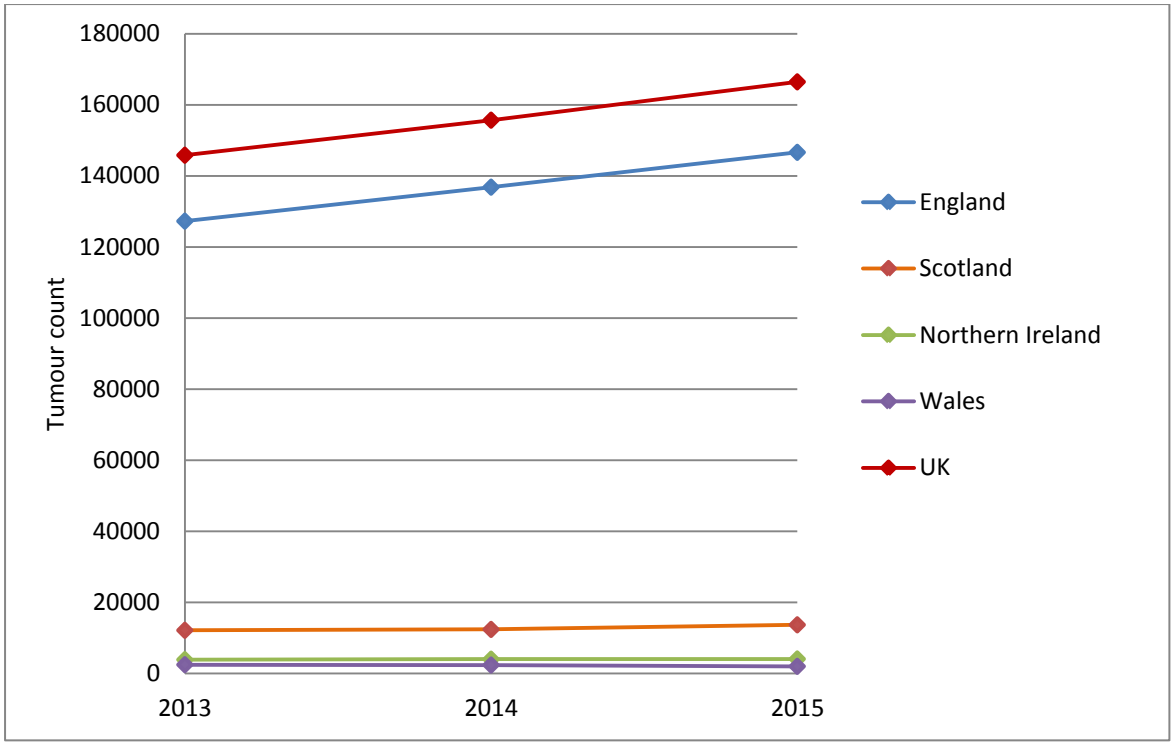
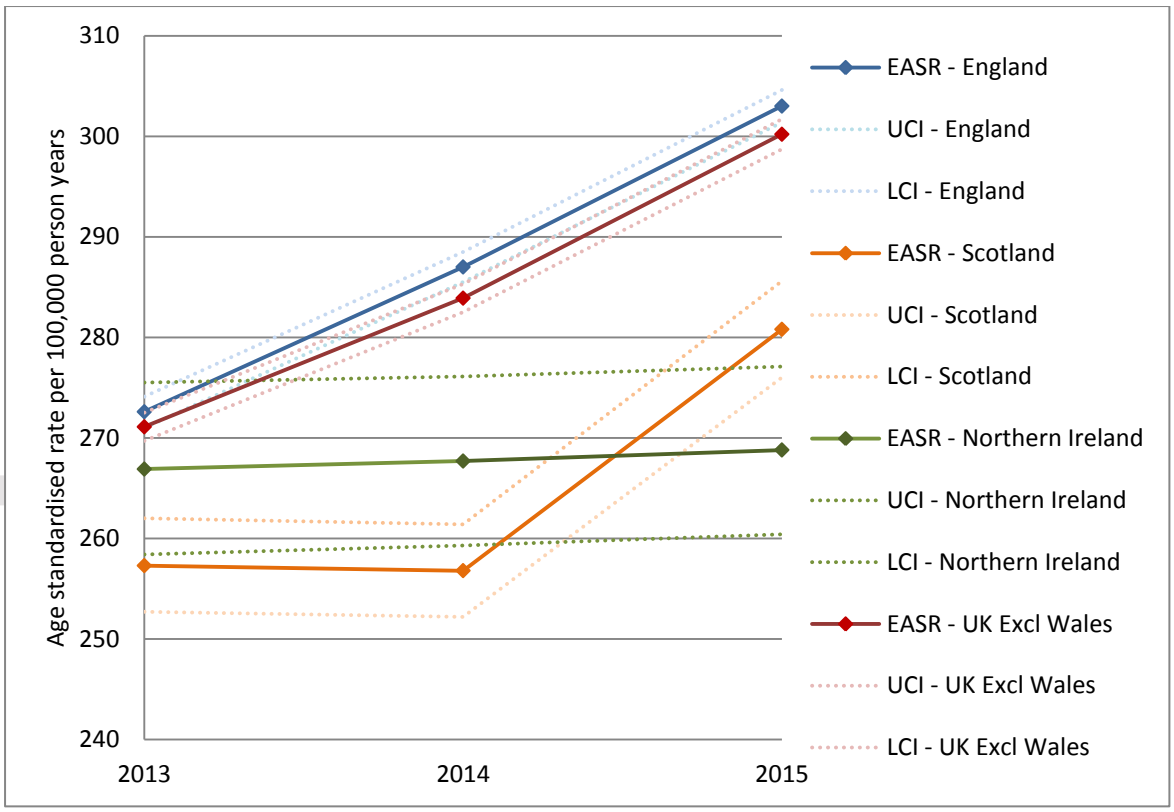


Figure 1. Analysis of 1st tumour per patient per annum technique for counting keratinocyte cancers from registry data

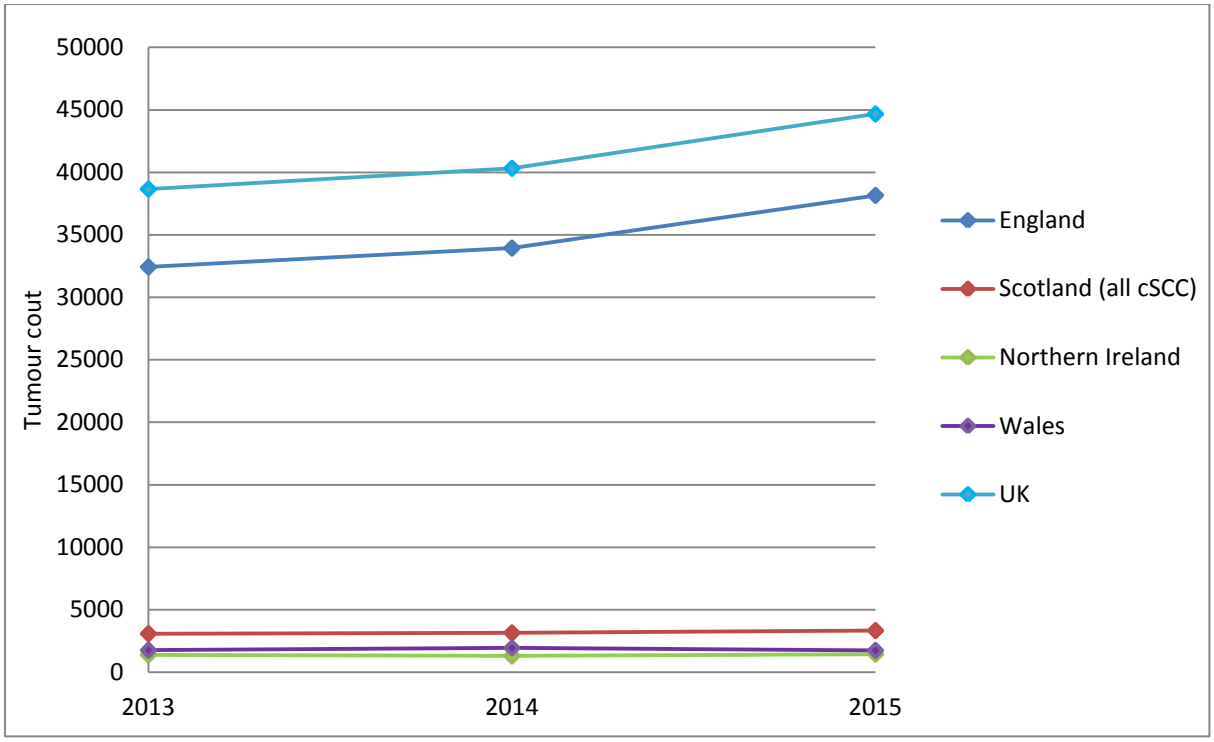


2a. National BCC tumour count, 2013-2015.

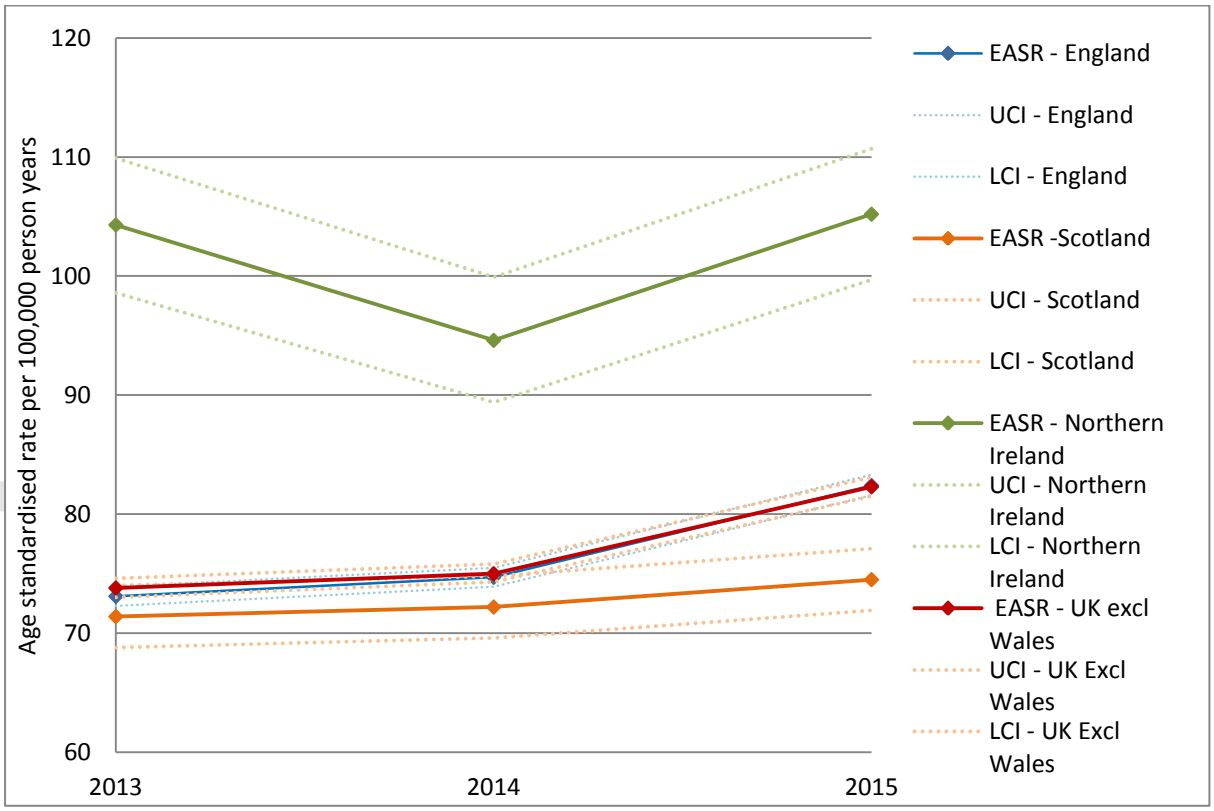


UCI = Upper Confidence Interval 95% LCI = Lower Confidence Interval 95%

2b. National age standardised incidence rate of BCC, 2013-2015



2c. National cSCC tumour count, 2013-2015



UCI = Upper Confidence Interval 95% LCI = Lower Confidence Interval 95%

2d. National age standardised incidence rate of cSCC 2013-2015

Figure 2a-d. National tumour count and incidence rate of basal cell carcinoma (BCC) and cutaneous squamous cell carcinoma (cSCC) using the 1st tumour per patient per annum technique except for cSCC data for Scotland where all cSCC are registered, Welsh data is excluded from incidence rates due to incomplete data collection. 2a. National BCC tumour count 2013-2015. 2b. National age standardised incidence rate of BCC 2013-2015. 2c. National cSCC tumour count 2013-2015. 2d. National age standardised incidence rate of cSCC 2013-2015.

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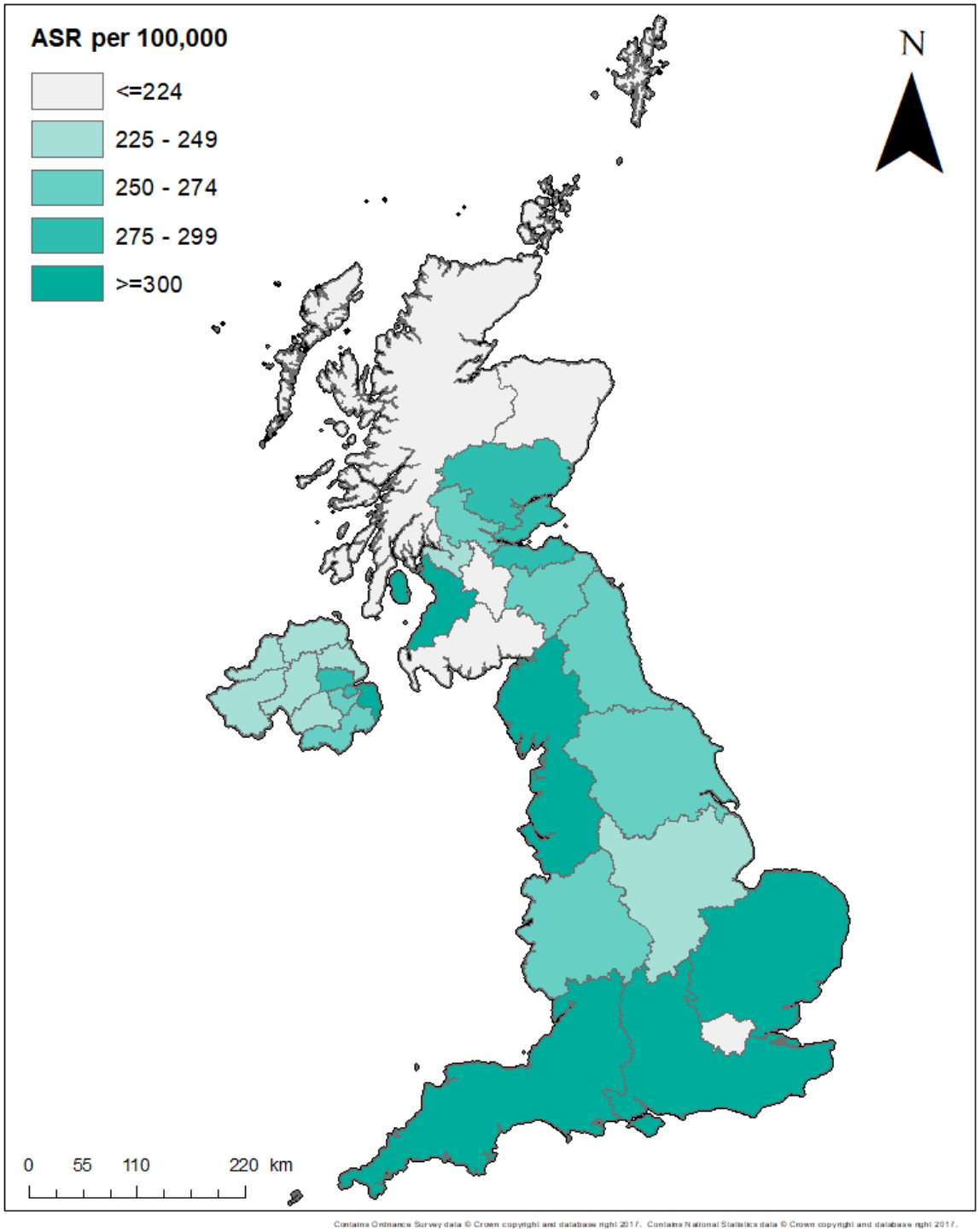

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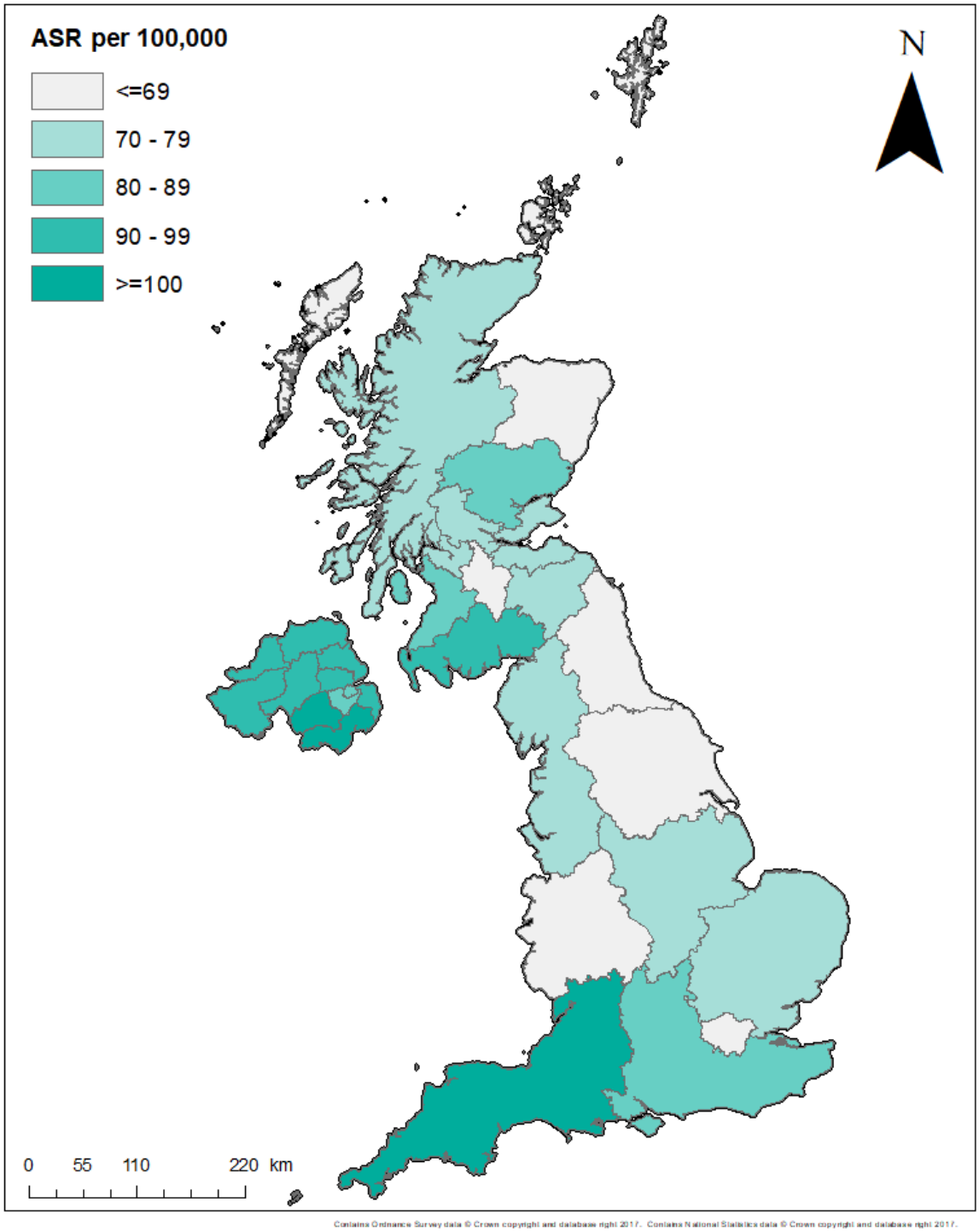
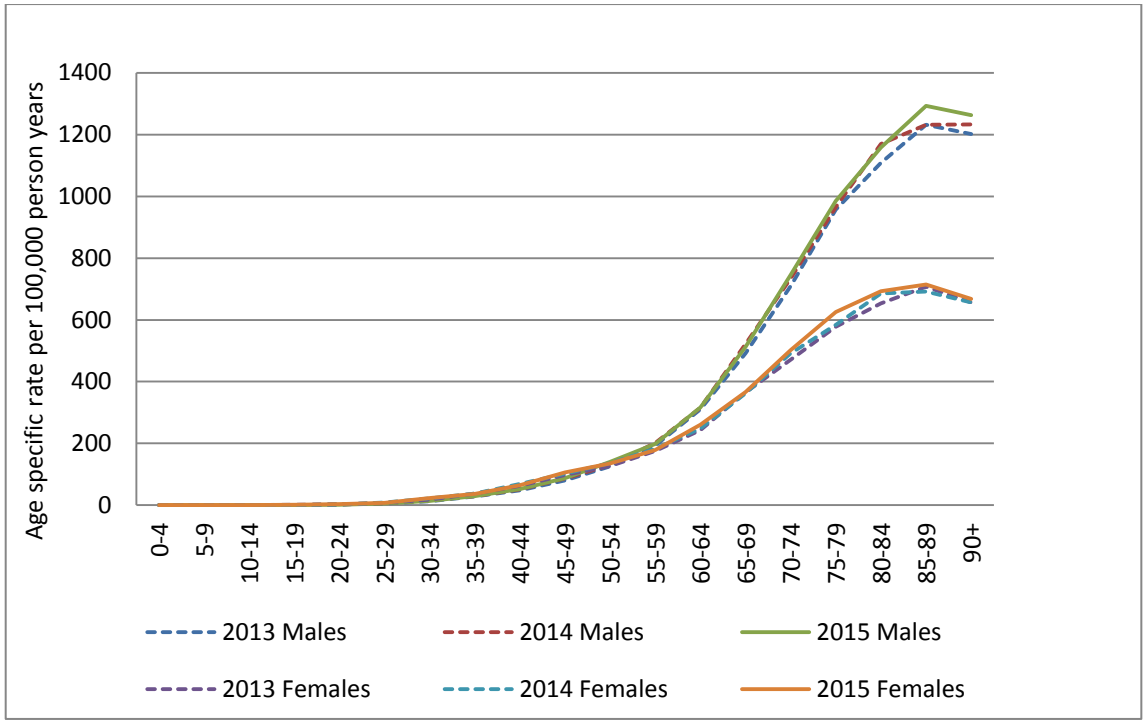
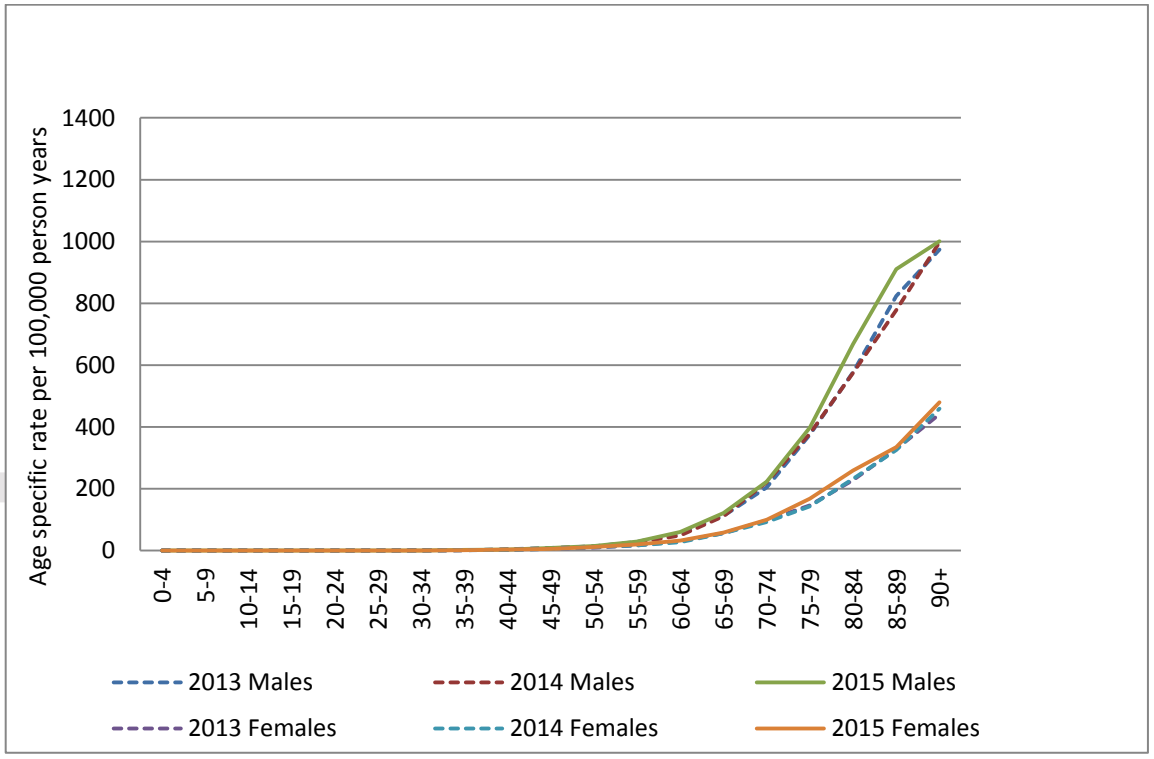
Protecting and improving the nation's health





4a. Age specific rates of BCC



4b. Age specific rates of cSCC

Figure 4a-b Age specific rates of basal cell carcinoma (BCC) and cutaneous squamous cell carcinoma (cSCC) in males and females 2013-2015, England. Using data for 1st tumour all time. 4a. Age specific rates of BCC. 4b. Age specific rates of cSCC