Accepted: 4 January 2018
DOI: 10.1111/coa.13067

ORIGINAL ARTICLE

WILEY

Socioeconomic deprivation and the burden of head and neck cancer—Regional variations of incidence and mortality in Merseyside and Cheshire, North West, England

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Funding information
Funding was obtained from CHAMPS a Public Health Collaborative aimed at improving health and well-being in the Merseyside and Cheshire region.

Objectives: The aim of this longitudinal study was to examine the distribution of head and neck cancer (HANC) disease burden across the region comparing it to national trends.

Design: We undertook a retrospective study of routine data combining it with indicators of deprivation and lifestyle at small geographical areas within the 9 Local Authorities (LAs) of Merseyside and Cheshire Network (MCCN) for head and neck cancers. Data from the North West of England and England were used as comparator regions.

Setting: This research was undertaken by the Cheshire and Merseyside Public Health Collaborative, UK.

Participants: The Merseyside and Cheshire region serves a population of 2.2 million. Routine data allowed us to identify HANC patients diagnosed with cancers coded ICD C00-C14 and C30-C32 within 3 cohorts 1998-2000, 2008-2010 and 2009-2011 for our analysis.

Main Outcome Measures: Directly age-standardised incidence rates and directly age-standardised mortality rates in the LAs and comparator regions were measured. Lifestyle and deprivation indicators were plotted against them and measured by Pearson's correlation coefficients.

Results: The incidence of head and neck cancer has increased across the region from 1998-2000 to 2008-2010 with a peak incidence for Liverpool males at 35/100 000 population.

Certain Middle Super Output Areas contribute disproportionately to the significant effect of incidence and mortality within LAs. Income deprivation had the strongest correlation with incidence (r = .59) and mortality (r = .53) of head and neck cancer.

Conclusion: Our study emphasises notable geographical variations within the region which need to be addressed through public health measures.

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1 | INTRODUCTION

Head and neck cancer (HANC), which encompasses at least 30 different subsites, is the 6th most common cancer worldwide with an annual disease burden of 550 000 new cases and 300 000 deaths each year.[1-3] Although HANC only constitutes 3% of all cancers in the UK, it is amongst the most debilitating due to the poor survival rates and its impact on appearance, eating, speech and quality of life.[4,5]

The incidence of oral and pharyngeal cancer has continued to increase in the UK, mainly amongst men.[6,7] Previous ecological and case-control studies have shown that lower socioeconomic status is associated with a higher incidence and mortality of HANC. Conway et al[7], in a 26-year longitudinal study, showed that, in Scotland, increasing oral cancer incidence corresponds to widening socioeconomic inequalities. Similarly, Quinn et al[8] demonstrated that people from the most deprived groups have twice the risk of developing laryngeal cancer when compared to the most affluent groups. Regional inequalities in deprivation also mean that there are stark geographical gradients across the United Kingdom for HANCs such as laryngeal cancer.[9]

The extent to which lifestyle risk factors, such as alcohol and smoking, and more novel risk factors, such as human papillomavirus (HPV) and genetic variants, contribute to the burden of disease and interact with socioeconomic factors has yet to be fully understood. Tobacco exposure is hypothesised to be responsible for 33% of HANC cases and alcohol for 4% of cases.[10] The established synergistic effect of both and the social modelling of these risk factors may partly explain the socioeconomic gradient seen in HANC.[11] However, in other cancers (bladder, oesophagus, pancreas and renal) where alcohol and tobacco are causal risk factors the deprivation gap in survival has plateaued and has not widened like it has for certain HANCs.[9]

Routine data sourced from the UK Cancer Information Service (Version 4.5b April 2013) indicated that outcomes for HANC in the Merseyside and Cheshire region are worse than the rest of the country. We undertook a longitudinal registry study to explore the trend of incidence and mortality of HANC (ICD C00-C14 and C30-C32) within the region as a whole, and within defined small geographical areas, linking outcome to deprivation indices.

Keypoints

- The incidence of Head and Neck cancer diagnosed in Merseyside and Cheshire has increased by 40% over a decade.
- The peak incidence for Liverpool males at 35/100,000 is comparable to less economically developed areas in South America and the Indian Subcontinent.
- There is regional variation in incidence and mortality. By using Middle Super Output Areas one can demarcate clusters of high output areas.
- Income deprivation has the strongest correlation for both incidence and mortality.
- Most Head and Neck Cancer is now being diagnosed in those under the age of 65.

2 | METHOD

2.1 | Ethical considerations

All aggregate data were anonymised.

2.2 | Study design and setting

We undertook an analytical study of routine data sourced from the UK Cancer Information Service Version 4.5b April 2013 combined with indicators of deprivation and lifestyle at small geographical areas within the 9 LAs of Merseyside and Cheshire (Liverpool, Halton, Sefton, Knowsley, Warrington, St Helens, Wirral, Cheshire West and Chester and Cheshire East).

2.3 | Participants

The Merseyside and Cheshire region serves a population of 2.2 million.[12] For the purpose of this study, HANC patients diagnosed with cancers coded ICD C00-C14 and C30-C32 within the 3 cohorts 1998-2000, 2008-2010 and 2009-2011 were included in our analyses. Data from the North West of England, Greater Manchester and England as a whole are used as comparators.

The Merseyside and Cheshire Area was separated into Lower Super Output Areas (LSOAs) and Middle Supper Output Areas (MSOAs). LSOAs are areas of contiguous postcodes derived from the Office for National Statistics that contain on average 1500 people. Similarly, MSOAs are geographical areas with a mean average of 7200 people.[13] Data at the LSOA were required to calculate the deprivation measures, whereas the MSOA geographical data were used to define incidence during 2008-10 and mortality during 2009-2011.

2.4 | Primary outcomes and covariates

The primary clinical outcomes were directly age-standardised incidence rates for HANC between 1998-2000 and 2008-2010 and directly age-standardised mortality rates for the period 2009-2011 in the LAs and comparator regions. These were calculated by UK Cancer Information Service using the European Standard Population 1976 with 95% confidence intervals (Table 1). Five-year age intervals up to 85 years of age and 85+ thereafter were used to obtain the age-adjusted rates.

The primary deprivation measures were based on deprivation by area of residence. The English Indices of Deprivation (2010) includes income deprivation (those households reliant on means-tested benefits), which was calculated from LSOA to MSOA level data. This and other lifestyle and deprivation covariates were plotted against MSOAs incidence and mortality rates (Table 2). These covariates included households in poverty 2007/2008 at MSOA level (below 60% of the national median income); prevalence of smoking and

TABLE 1 Directly age-standardised incidence (2008-2010) and mortality (2009-2011) rates (DSR) per 100 000 population of head and neck cancers (ICD10 C00-C14 + C30-C32) for males and/or females with 95% confidence intervals

Head & neck (ICD10:C00-C14+ C30-32)	Direct age-standardised incidence rate (95% confidence intervals)			Direct age-standardised mortality rates (95% confidence intervals)		
	Total	Male	Female	Total	Male	Female
Comparator areas						
England	13.19 (13.02, 13.36)	18.94 (18.65, 19.24)	7.45 (7.27, 7.63)	3.86 (3.77, 3.95)	5.70 (5.55, 5.86)	2.02 (1.93, 2.11)
North West	15.76 (15.25, 16.28)*	22.74 (21.87, 23.63)*	8.78 (8.26, 9.32)*	4.55 (4.29, 4.83)*	6.82 (6.36, 7.31)*	2.29 (2.04, 2.56)
Greater Manchester	16.98 (16.09, 17.90)*	24.52 (23.01, 26.10)*	9.44 (8.53, 10.41)*	4.64 (4.20, 5.11)*	7.07 (6.29, 7.93)*	2.41 (1.99, 2.89)
Merseyside & Cheshire	16.24 (15.37, 17.13)*	23.41 (21.93, 24.96)*	9.07 (8.19, 10.00)*	4.72 (4.28, 5.19)*	7.45 (6.65, 8.33)*	2.36 (1.95, 2.83)
Local authorities						
Liverpool	23.49 (20.90, 26.27)*	34.60 (30.15, 39.49)*	12.37 (9.89, 15.33)*	7.60 (6.18, 9.23)*	11.63 (9.19, 14.53)*	3.57 (2.32, 5.29)*
Sefton	18.74 (16.11, 21.73)*	29.02 (24.36, 34.50)*	8.46 (6.19, 11.45)	5.15 (3.91, 6.81)	7.62 (5.44, 10.59)	2.69 (1.54, 4.73)
Knowsley	18.45 (14.70, 22.84)*	25.79 (19.50, 33.37)*	11.11 (7.40, 16.05)	5.63 (3.61, 8.27)	8.77 (5.33, 13.64)	2.49 (0.85, 5.54)
Halton	17.34 (13.51, 21.95)*	22.40 (16.19, 30.38)	12.29 (7.85, 18.17)*	5.74 (3.59, 8.62)	8.48 (4.85, 13.97)	2.99 (1.23, 6.43)
Wirral	16.88 (14.51, 19.60)*	24.18 (20.16, 28.88)*	9.57 (7.17, 12.58)	4.93 (3.70, 6.50)	7.68 (5.47, 10.63)	2.19 (1.21, 3.83)
St. Helens	15.57 (12.61, 19.06)	24.55 (19.23, 30.94)	6.59 (4.03, 10.22)	4.67 (3.11, 6.72)	7.07 (4.39, 10.81)	2.26 (0.94, 4.86)
Warrington	12.28 (9.73, 15.28)	18.23 (13.88, 23.60)	6.34 (3.93, 9.64)	4.29 (2.86, 6.16)	7.15 (4.50, 10.72)	1.43 (0.44, 3.64)
Cheshire West and Chester	12.06 (10.11, 14.31)	16.94 (13.69, 20.74)	7.19 (5.16, 9.82)	3.80 (2.77, 5.12)	5.57 (3.80, 7.90)	2.02 (1.09, 3.65)
Cheshire East	12.01 (10.25, 14.03)	15.49 (12.69, 18.76)	8.53 (6.50, 11.08)	3.15 (2.34, 4.22)	4.55 (3.14, 6.45)	1.75 (1.00, 3.11)

*An asterisk indicates a result that is significantly higher than the England rate ($P < .05$).

obesity (BMI $\geq$ 30) estimated from the Health Survey for England 2006-2008; harmful drinking estimates (people at increasing and high risk of alcohol-related harm: men who regularly drink >3 Units/d and women who regularly drink >2 Units/d) derived from the Alcohol Segmentation postcode tool.

2.5 | Statistical analysis

Comparisons were made of the direct age-standardised incidence and mortality rates between the comparator regions and the LAs. Using England as a benchmark, 95% confidence intervals derived from UK Cancer Information Service allowed us to compare the confidence intervals of the estimates with non-overlapping confidence intervals being considered as statistically significant difference.[14]

Lifestyle and deprivation measures were plotted against direct age-standardised incidence and mortality rates to obtain correlation relationships as measured by Pearson's correlation coefficients.

3 | RESULTS

3.1 | Clinical outcome measures

3.1.1 | Incidence

The direct age-standardised incidence rate for HANC (2008-2010) in Merseyside and Cheshire (16.24 per 100 000 population) was significantly higher than for England (13.2 per 100 000) (Table 1).

Comparisons within the Merseyside and Cheshire region revealed that 5 LAs (Liverpool, Sefton, Knowsley, Halton and Wirral) had statistically significantly higher HANC incidence rates (2008-2010) than England. Liverpool had the highest incidence rate, 23.5 cases per 100 000, whereas Cheshire East had the lowest incidence rate of 12.0 per 100 000.

Gender-specific age-standardised incidence rates showed that the incidence of HANC is statistically significantly higher in men than women for all LAs and comparator regions (2008-2010) except in Halton. Halton was 1 of 2 LAs, together with Liverpool, where females had statistically significantly higher HANC incidence rates than England.

Comparisons of the LAs to England revealed that 4 LAs in Merseyside and Cheshire (Liverpool, Sefton, Knowsley and Wirral) had statistically significantly higher male-specific HANC incidence rates than England (18.9 per 100 000 population). Liverpool had the highest HANC peak incidence rate for males at 34.6 cases per 100 000 population.

During 1998-2000, there were 998 new cases of HANC coded as ICD C00-C14 and C30-C32, diagnosed in Merseyside and Cheshire. A decade later (2008-2010), there were 1397 new cases recorded. This equates to 133 more HANC cases a year being diagnosed in Merseyside and Cheshire and an increase of 40% over the decade. The age demographic of the incident cohort had also altered. In 1998-2000, the modal patient age was 70-79 years in the region. In 2008-2010, this decreased to 60-69 years. In 1998-2000, 49% of cases were diagnosed in those under 65 years. In 2008-2010, this proportion increased to 53% meaning most HANC in

TABLE 2 Correlation of Merseyside and Cheshire MSOA directly age-standardised incidence (2008-2010) and mortality (2009-2011) rates per 100 000 population for head and neck cancers (ICD10 C00-C14 + C30-C32) with indicators of deprivation and lifestyle

Indicator	Incidence (*r*)	Mortality (*r*)	Correlation
Income deprivation Percentage living in income deprived households reliant on means-tested benefit (Source: Income domain score from the Indices of Deprivation, 2010)	.59	.53	moderate positive
Households in poverty Percentage of Households Below 60% of the Median Income (after housing costs). (Source: ONS Households in Poverty: Model Based Estimates at MSOA Level, 2007/2008)	.53	.45	moderate positive
Smoking Percentage of the adult population who are current smokers (2006-08). (Source: APHO—Estimates of Adults' Health and Lifestyles)	.51	.49	moderate positive
Harmful drinking Percentage of the population at high/increasing risk of alcohol-related harm (Source: Alcohol Learning Centre Segmentation Tool 2013)	.55	.49	moderate positive
Obesity Percentage of the adult population with obesity (2006-08) (Source: APHO—Estimates of Adults' Health and Lifestyles)	.28	.29	weak positive

Merseyside and Cheshire are diagnosed in those under the age of 65 (Figure 1).

3.1.2 | Mortality

Direct age-standardised mortality rates for HANC (2009-2011) in Merseyside and Cheshire (4.7 per 100 000 population) were statistically significantly higher than for England (3.9 per 100 000). They were also similar to the North West (4.6 per 100 000 population) and Greater Manchester (4.6 per 100 000 population) comparator areas (Table 1).

Comparisons of the 9 LAs (2009-2011) revealed that 7 LAs (Liverpool, Halton, Knowsley, Sefton, Wirral, St. Helens and Warrington) had higher HANC mortality rates than England (3.86 per 100 000 population). However, only Liverpool LA had a statistically significantly higher mortality rate of 7.6 per 100 000 population than England. Cheshire East had the lowest age-standardised mortality rate with 3.15 deaths per 100 000 population. No single LA in the region had a significantly lower mortality rate than England.

Gender-specific age-standardised mortality rates (Table 1) showed that the mortality of HANC is statistically significantly higher in men than women for in Merseyside and Cheshire and comparator regions (2009-2011) except in Halton, Knowsley and St. Helens. Merseyside and Cheshire had a significantly higher male HANC mortality rate (7.45 per 100 000 population) than England (5.7 per 100 000 population), but for females, there was no significant difference.

Comparisons of the gender-specific mortality rates to England revealed that only Liverpool had a statistically significantly higher male (11.63 per 100 000 population) and female (3.57 per 100 000 population) mortality rates than England (2009-2011). Only the male HANC mortality rate for Liverpool (11.63 per 100 000 population) was statistically significantly higher than all the other LAs and comparator regions.

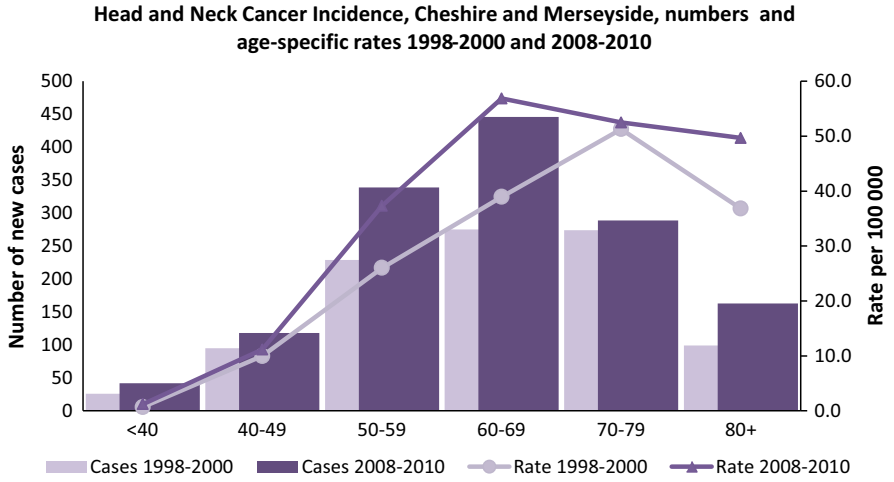


FIGURE 1 Age specific incidence rates of head and neck cancer in the Merseyside and Cheshire area between 1998-2000 and 2008-2010 (ICD10 C00-C14 + C30-C32)

3.2 | Deprivation measures

In Merseyside and Cheshirea, third of the population live in areas considered to be amongst the 20% most deprived in England.

Income deprivation (2010) in the Merseyside and Cheshire area demonstrated the strongest correlation (r = .59) with direct age-standardised HANC incidence rates in the region (2008-2010). Beyond this, percentage of households in poverty (r = .53), prevalence of adult smokers (r = .51), populations at high and increasing risk of alcohol-related harm (r = .55) all demonstrated moderately positive correlations with HANC incidence rates (2008-2010) (Table 2). Similarly, the strongest correlation with age-standardised mortality rates was income deprivation (r = .53) and again, percentage of households in poverty (r = .45), adult smokers (r = .49), populations at high and increasing risk of alcohol-related harm (r = .49) all demonstrated moderately positive correlations (Table 2).

3.3 | Middle super output area maps

Following division of the Merseyside and Cheshire region into smaller MSOAs of age-standardised HANC incidence rates (2008-2010) and mortality rates (2009-2011) (Figure 2a, b), one can objectively see clusters of concurrent HANC incidence and mortality. Epicentres of high incidence (42.6-56.8 per 100 000 population) encompass Bootle and Liverpool amongst other less focussed regions notably Runcorn, St Helens, Crewe and Birkenhead. Intuitively, mortality rates are also high (19.5-25.9 per 100 000) in the Liverpool, Bootle and Birkenhead region (Figure 2b).

4 | DISCUSSION

4.1 | Key findings

Our cross-sectional study shows that for HANC, both the incidence (2008-2010) and mortality (2009-2011) rates in the Merseyside and Cheshire region are higher than for England. However, this statistically significant difference is not uniformly spread across the region. The Liverpool LA was consistently and statistically significantly higher than for the rest of England for both incidence (2008-2010) and mortality (2009-2011), male and female. The peak incidence rate was for Liverpool males whose incidence of HANC at 35 per 100 000 population is higher than less economically developed provinces in South America, the Indian subcontinent and South Africa.[2,15] The incidence of HANC has also increased by 40% in the region between 1998-2000 and 2008-2010, predominantly affecting those under the age of 65.

When comparing gender-specific age-standardised incidence and mortality rates across the LAs, it is worth noting that male rates for incidence are on average 1.8-3.6 times higher than their female counterparts, and for mortality, the range is larger between 2.6 and 5 times.

Income deprivation has the strongest correlation for both incidence (r = .59) and mortality (r = .53) for HANC in the region more so than harmful alcohol consumption and smoking.

4.2 | Comparisons with other studies

The incidence rates at all sites for HANC are rising and they are not exclusively associated with alcohol consumption and smoking.[16] Patients from poorer backgrounds have a higher incidence rate, delayed initial presentation time and higher mortality rates than their affluent counterparts.[17] This is despite there being no association between more deprived persons receiving less aggressive curative treatment. However, perhaps due to the increased stage at initial presentation, Rylands et al[18] 2016 noted that Cheshire and Merseyside patients receiving palliative care treatment tended to live in the most deprived areas.

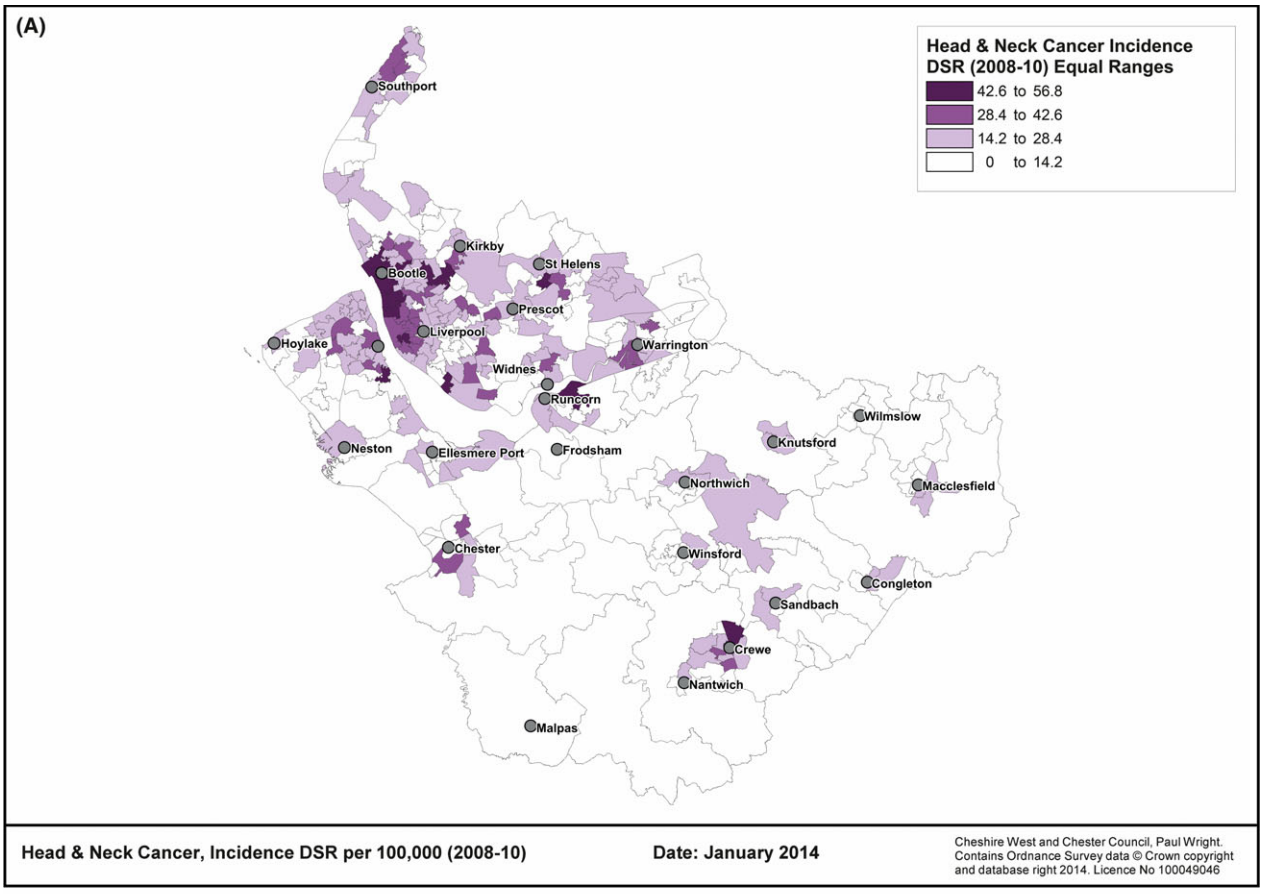
The disease burden of HANC is not equally distributed by anatomical site with projections estimating that a 239% increase in oropharyngeal cancer cases will occur by 2025 in England with large increases in those less than 50 years of age.[19] But, like laryngeal cancer, this disease burden will not be equally shared, with Northern England traditionally exhibiting higher incidence and mortality rates for oropharyngeal and laryngeal cancer.[20]

4.3 | Clinical applicability

The magnitude of variation across the Merseyside and Cheshire region is stark with a decreasing gradient from the more urbanised and deprived parts of Liverpool to the more rural Cheshire East.

Liverpool was the most deprived LA in England in 2010.[21] Together with Sefton, Knowsley, Halton and Wirral, it had statistically significantly higher HANC incidence rates than England as a whole between 2008 and 2010. In all these areas, life expectancy is lower than the national average and hospital stays due to alcohol-related harm are higher than the national average.[22] With the exception of the Sefton LA, adult smoking is also higher than the national average in these LAs. The percentage of residents who live in the most deprived areas of these 5 LAs ranges from just over 20% in Sefton LA to over 60% in Liverpool LA. Sefton compares favourably to the other 4 LAs but, on closer inspection of the MSOA map (Figure 2a), one can see that for the Sefton LA, incidence of HANC is focussed in 2 areas, Bootle and Southport. Hence, these areas may be contributing disproportionately to the significant effect seen for the incidence of HANC. This highlights one of the benefits of geographically mapping data using MSOA information. Furthermore, MSOAs with high incidence rates do not always translate to a highest mortality and vice versa. For example, 1 area of Winsford has a relatively high mortality rate (19.5-25.9 per 100 000) compared to its relatively lower, incidence rate (14.2-28.4 per 100 000).

The incidence of HANC in the Merseyside and Cheshire region has increased over the last decade by 40%; this is in keeping with the U.K. trend.[23] When examining HANC incidence trends by age, our study showed that although the incidence of HANC has increased across all age groups (Figure 1), the majority of HANC cases now occur in patients younger than 65 years of age. This trend is broadly seen elsewhere in the UK where increases in the younger age groups have been more rapid and more widely distributed.[23] This increase is


(A)
Head & Neck Cancer Incidence
DSR (2008-10) Equal Ranges
42.6 to 56.8
28.4 to 42.6
14.2 to 28.4
0 to 14.2
Southport
Kirkby
Bootle
St Helens
Prescot
Liverpool
Hoylake
Warrington
Widnes
Runcorn
Wilmslow
Knutsford
Neston
Ellesmere Port
Frodsham
Northwich
Macclesfield
Chester
Winsford
Congleton
Sandbach
Crewe
Nantwich
Malpas
Head & Neck Cancer, Incidence DSR per 100,000 (2008-10)
Date: January 2014
Cheshire West and Chester Council, Paul Wright.
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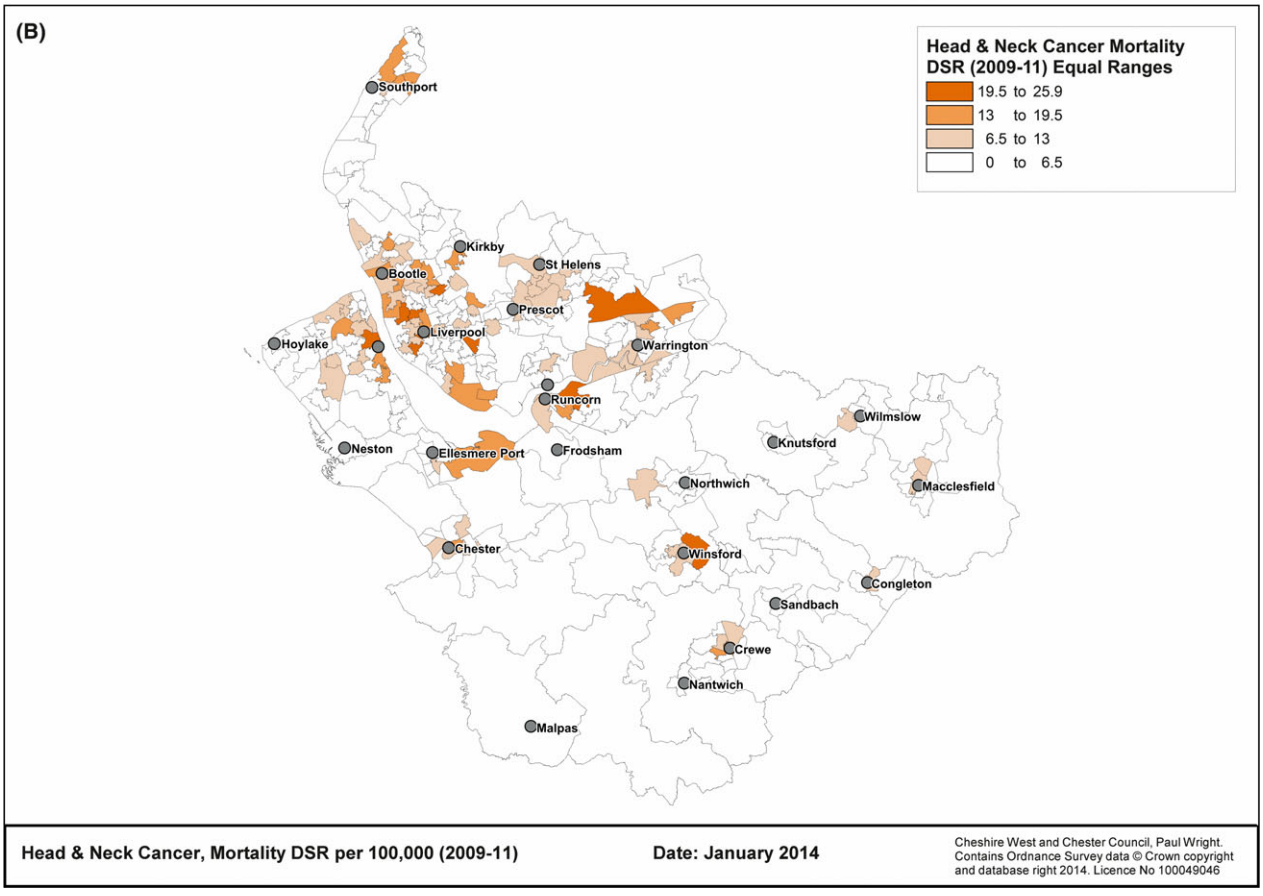
(B)
Head & Neck Cancer Mortality
DSR (2009-11) Equal Ranges
19.5 to 25.9
13 to 19.5
6.5 to 13
0 to 6.5
Southport
Kirkby
Bootle
St Helens
Prescot
Liverpool
Hoylake
Warrington
Runcorn
Wilmslow
Knutsford
Neston
Ellesmere Port
Frodsham
Northwich
Macclesfield
Chester
Winsford
Congleton
Sandbach
Crewe
Nantwich
Malpas
Head & Neck Cancer, Mortality DSR per 100,000 (2009-11)
Date: January 2014
Cheshire West and Chester Council, Paul Wright.
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FIGURE 2 (a) A map of Merseyside and Cheshire Middle Super Output Areas (MSOA) directly age standardised incidence rates for head and neck cancers (ICD10 C00-C14+ C30-C32) per 100 000, 2008-2010. (b) A map of Merseyside and Cheshire Middle Super Output Areas (MSOA) directly age standardised mortality rates for head and neck cancers (ICD10 C00-C14 + C30-C32) per 100 000, 2009-2011

in the light of a falling prevalence of smoking in the UK.[24] However, alcohol, nutrition, occupation and HPV16 status are also associated with HANC. The latter is particularly important as there has been a rapid rise in HPV-positive oropharyngeal cancer in some parts of the Western World, which tends to occur in a younger population approximately 10 years younger than HPV-negative patients, across a greater socioeconomic range.[25]

Despite 7 of the 9 LAs having higher mortality rates than the English average, only Liverpool had a statistically significantly higher mortality rate than England. However, the cumulative effect is that the Merseyside and Cheshire region has a significantly higher mortality rate than England.

Previously, Conway et al[26] demonstrated that income deprivation is associated with a more than twofold increased risk of HANC. Our study found income deprivation to have the strongest correlation for both incidence (r = .59) and mortality (r = .53) for HANC in the region, more than smoking and harmful drinking which followed closely behind. Although alcohol and smoking are estimated to synergistically contribute to 75% of HANC cases, with smoking as the predominant risk factor, there may be unexplained risks through which lower socioeconomic deprivation exerts its influence.[27]

4.4 | Limitations of the study

This descriptive study is limited in that we cannot prove causation nor determine the effect size of the deprivation measures analysed. We could not comment on occupational exposures, HPV status, stage or histology at presentation, and educational status and access to healthcare facilities which may confound any correlation. We also acknowledge that confidence intervals in some cases may overlap and represent a significant difference between groups. Further, we assume linearity for the Pearson's correlation coefficient when comparing indicators of deprivation against HANC incidence and mortality.

5 | CONCLUSION

In conclusion, our study shows that there are geographical variations within the Merseyside and Cheshire region for HANC (ICD C00-C14 and C30-C32) incidence and mortality. Specifically, Liverpool LA has incidence rates comparable to less economically developed countries. The MSOA map has identified concentrated areas of HANC incidence and mortality within LA. There is a changing demographic of HANC within the region as it is predominantly affecting a younger cohort of patients than before. Of the deprivation measures, the strongest correlation is associated with income deprivation. We intend that our findings will inform and direct public health interventions towards primary prevention in the region.

CONFLICT OF INTEREST

Nothing to declare.

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How to cite this article: Taib BG, Oakley J, Dailey Y, et al. Socioeconomic deprivation and the burden of head and neck cancer—Regional variations of incidence and mortality in Merseyside and Cheshire, North West, England. *Clin Otolaryngol*. 2018;00:1–8. https://doi.org/10.1111/coa.13067