

Lung Cancer Incidence and Survival in England

An Analysis by Socioeconomic Deprivation and Urbanization

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Introduction: Most previous studies have investigated either socioeconomic deprivation or urbanization in relationship to lung cancer incidence or survival. We investigated the association between socioeconomic deprivation, urbanization, and lung cancer incidence and survival in England.

Methods: We extracted data on patients diagnosed with lung cancer (ICD-10 C33-C34) between 2003 and 2007 and who were resident in England. We assigned each patient to an urbanization score and to a socioeconomic quintile based on their postcode of residence. We calculated age-specific and age-standardized incidence rates (per 100,000 European standard population) by urbanization, sex, and socioeconomic deprivation group. We used Kaplan-Meier survival analysis to compare the survival of patients from urban and rural areas by socioeconomic deprivation.

Results: A high proportion of urban areas in England were classified as deprived and rural areas were mostly affluent. The incidence of lung cancer was higher in urban areas than in rural areas. In the more affluent areas, the incidence of lung cancer in urban and rural areas was very similar. Survival from lung cancer was slightly higher in affluent areas than in deprived areas. Survival from lung cancer in urban and rural areas was similar across all socioeconomic deprivation quintiles.

Conclusions: The difference in incidence between urban and rural areas can be explained by the differences in the distribution of socioeconomic deprivation quintiles in the two urbanization categories. When socioeconomic deprivation is taken into account, little difference is seen between both the incidence and survival of lung cancer in urban and rural areas.

Key Words: Lung cancer, Urbanization, Socio-economic deprivation, Incidence, Survival.

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Worldwide, lung cancer is the most common cancer and accounts for 1.3 million deaths per year.¹ In the United Kingdom, approximately 39,000 people were diagnosed with

lung cancer in 2007.² Five-year relative survival from lung cancer is approximately 9% for males and 7% for females.³

The incidence of lung cancer varies by socioeconomic deprivation and urbanization. A study conducted in South-East England showed a clearly increased incidence of lung cancer with increasing socioeconomic deprivation scores.⁴ Both in Wales and the United Kingdom overall, higher lung cancer incidence rates are reported for urban than rural areas.^{2,5}

Previous investigations of socioeconomic deprivation and lung cancer survival in the United Kingdom found survival was lower in the most deprived areas compared with those in the least deprived areas.^{6,7} A study conducted in Scotland found that living at increasing distance to the nearest cancer center was associated with poorer survival among patients with lung cancer.⁸

Most previous studies have investigated either socioeconomic deprivation or urbanization in relationship to lung cancer incidence or survival. Herein, we investigate the joint association of socioeconomic deprivation and urbanization with lung cancer incidence and survival in England.

PATIENTS AND METHODS

We extracted data from 161,822 patients who were resident in England and diagnosed with lung cancer (ICD-10 C33-C34) between 2003 and 2007 from the National Cancer Data Repository.⁹ In the survival analysis, follow-up was included up to December 31, 2008. We excluded 116 patients who could not be mapped to an urbanization code. For survival analysis, we further excluded 9276 (5.31%) patients who were identified by death certificate only, 1481 patients who had an incomplete date of diagnosis, and 10 patients with date-sequence inconsistencies leading to apparently negative survival. Thus, 150,939 patients were included in the survival analysis.

Lower super output areas (LSOAs) are geographic areas of a consistent size that cover a population of approximately 1500 persons. Based on the income domain of the Indices of Multiple Deprivation 2007,¹⁰ LSOAs were grouped into five socioeconomic deprivation quintiles, each containing 20% of LSOAs in England. Patients with lung cancer were assigned to a socioeconomic deprivation quintile based on their postcode of residence that is mapped to the LSOAs. For the purpose of this analysis, the LSOAs were assigned to be either urban or rural according to the Office for National Statistics's definition that was introduced in 2004.¹¹

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We calculated age-standardized incidence rates (ASR, per 100,000 European standard population) by socioeconomic deprivation quintile and urbanization category for males and females. We used Kaplan-Meier analysis to compare the survival between patients living in urban and rural areas by socioeconomic deprivation quintile. We used a log-rank test (at 5% significance level) to test the null hypothesis that survival in the two categories is identical.

RESULTS

In England, 81.5% (26,455) LSOAs were urban and 18.6% (6027) were rural. Table 1 presents the distribution of

TABLE 1. Distribution of Urban and Rural Lower Super Output Areas by Socioeconomic Deprivation Quintile in England

| Socioeconomic Deprivation Quintile | Urban% | Rural% |
|------------------------------------|--------|--------|
| Affluent (1) | 18.1 | 28.5 |
| 2 | 16.7 | 34.7 |
| 3 | 19.0 | 24.2 |
| 4 | 22.2 | 10.4 |
| Deprived (5) | 24.1 | 2.2 |
| Total | 100.0 | 100.0 |

urban and rural areas by socioeconomic deprivation group. A high proportion (24%) of urban areas was deprived, and most of the rural areas were affluent. Figure 1 shows the geographical distribution of socioeconomic deprivation group in England with darker areas indicating higher levels of deprivation. Figure 2 shows the geographical distribution of urbanization in England with darker areas representing higher levels of urbanization.

Incidence

Table 2 presents the incidence rates of lung cancer with corresponding confidence intervals (CIs) by socioeconomic deprivation group for males and females. Incidence of lung cancer was higher in males than in females in all deprivation groups. The incidence of lung cancer in males was higher in deprived areas (ASR = 98.5, 95% CI: 97.3–99.8) than in affluent areas (ASR = 39.2, 95% CI: 38.5–39.9). The incidence rates of lung cancer in females was also higher in deprived areas (ASR = 58.5, 95% CI: 57.6–59.4) than in affluent areas (ASR = 22.5, 95% CI: 22.0–23.0).

Table 3 presents lung cancer incidence and 95% CI by urbanization for males and females. In males, the incidence was higher in urban (ASR = 64.5, 95% CI: 64.0–65.0) than in rural areas (ASR = 48.2, 95% CI: 47.4–48.9). Similarly,

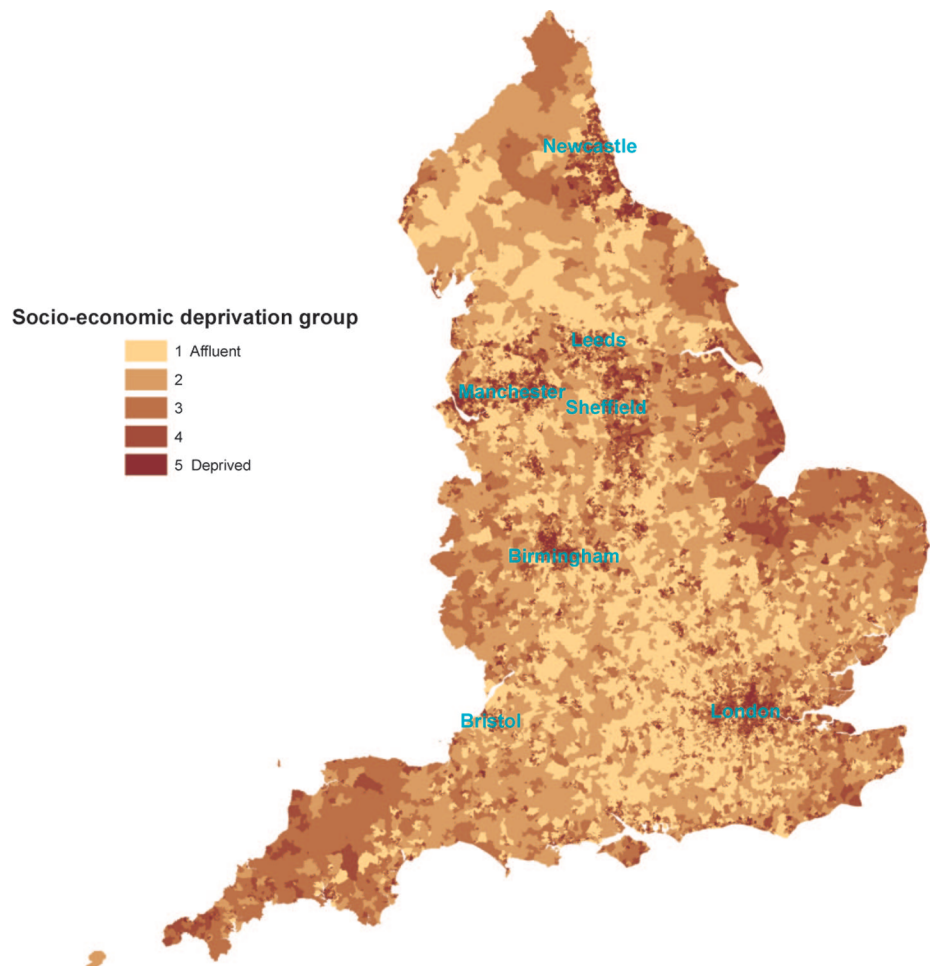


FIGURE 1. Map of England highlighting affluent and deprived areas based on the income domain of the Indices of Deprivation.

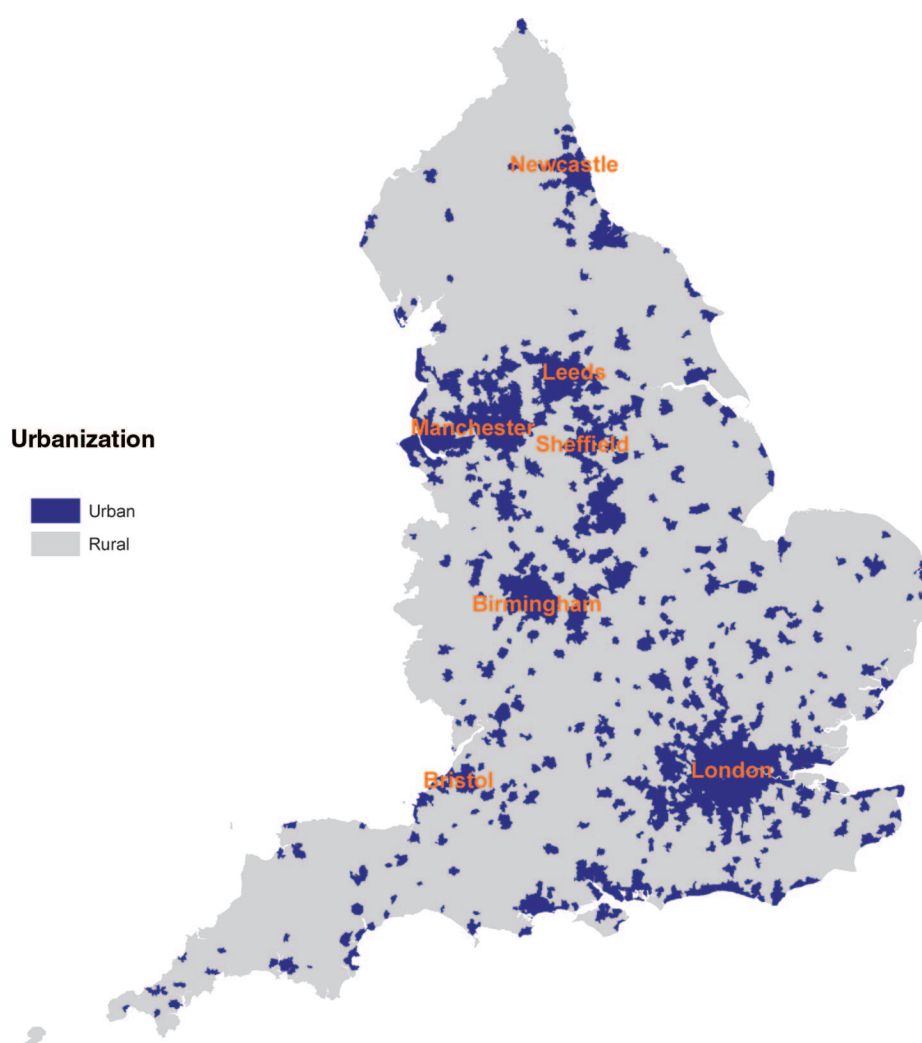


FIGURE 2. Map of England highlighting urban and rural areas.

TABLE 2. Age-Standardized Incidence Rate per 100,000 European Standard Population (ASR) of Lung Cancer in Males and Females by Socioeconomic Deprivation, England, 2003–2007

| Socioeconomic Deprivation Quintile | Males | | | Females | | |
|------------------------------------|-------|-------------------------|-------|---------|-------------------------|-------|
| | ASR | 95% Confidence Interval | | ASR | 95% Confidence Interval | |
| | | Lower | Upper | | Lower | Upper |
| Affluent (1) | 39.2 | 38.5 | 39.9 | 22.5 | 22.0 | 23.0 |
| 2 | 47.4 | 46.7 | 48.1 | 27.2 | 26.7 | 27.7 |
| 3 | 56.9 | 56.0 | 57.7 | 33.0 | 32.4 | 33.6 |
| 4 | 73.8 | 72.8 | 74.8 | 42.1 | 41.3 | 42.8 |
| Deprived (5) | 98.5 | 97.3 | 99.8 | 58.5 | 57.6 | 59.4 |

among females, the incidence of lung cancer was higher in urban areas (ASR = 37.3, 95% CI: 37.4–38.1) than in rural areas (ASR = 27.2, 95% CI: 26.7–27.7).

Figures 3 shows the variation in lung cancer incidence among males and females jointly by socioeconomic depriva-

TABLE 3. Age-Standardized Incidence Rate per 100,000 European Standard Population (ASR) of Lung Cancer in Males and Females by Urbanization, England, 2003–2007

| Urbanization | Males | | | Females | | |
|--------------|-------|-------------------------|-------|---------|-------------------------|-------|
| | ASR | 95% Confidence Interval | | ASR | 95% Confidence Interval | |
| | | Lower | Upper | | Lower | Upper |
| Urban | 64.5 | 64.0 | 65.0 | 37.3 | 37.4 | 38.1 |
| Rural | 48.2 | 47.4 | 48.9 | 27.2 | 26.7 | 27.7 |

tion and urbanization. The incidence of lung cancer in males and females in urban and rural area was similar for each socioeconomic deprivation quintile, although the incidence in urban areas was slightly higher in deprivation quintiles 2, 3, and 4. The incidence of lung cancer increased with deprivation in both urban and rural areas.

Survival

Table 4 presents the 1-year lung cancer survival in males and females jointly by urbanization and socioeconomic

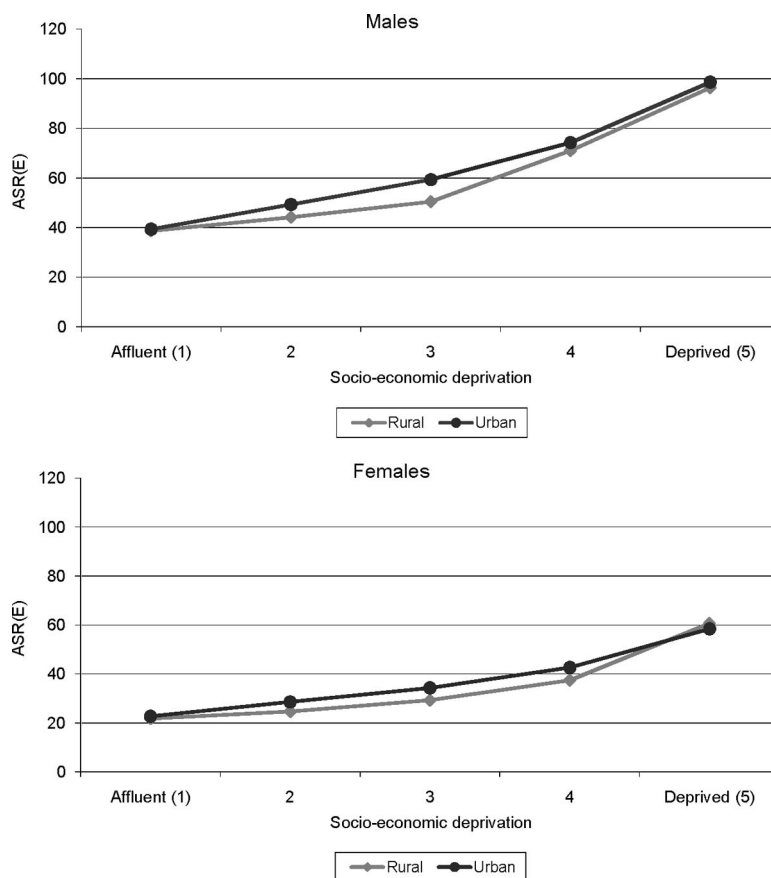


FIGURE 3. Age-standardized incidence rate (ASR) in lung cancer incidence among males and females, respectively, by joint socioeconomic deprivation and urbanization, England, 2003–2007.

TABLE 4. One-Year Lung Cancer Survival in Males and Females by Urbanization and Socioeconomic Deprivation, England, 2003–2007

| Socioeconomic Deprivation Quintile | Urbanization | | | | | | Log Rank Test | |
|------------------------------------|--------------|-------------------------|-------|----------|-------------------------|-------|---------------|------|
| | Urban | | | Rural | | | | |
| | Survival | 95% Confidence Interval | | Survival | 95% Confidence Interval | | | |
| | | Lower | Upper | | Lower | Upper | | |
| Males | | | | | | | | |
| 1 (Affluent) | 0.27 | 0.26 | 0.28 | 0.29 | 0.28 | 0.31 | 6.24 | 0.01 |
| 2 | 0.26 | 0.25 | 0.27 | 0.26 | 0.25 | 0.28 | 0.31 | 0.58 |
| 3 | 0.25 | 0.25 | 0.26 | 0.25 | 0.24 | 0.26 | 0.37 | 0.54 |
| 4 | 0.26 | 0.25 | 0.26 | 0.25 | 0.23 | 0.27 | 1.42 | 0.23 |
| 5 (Deprived) | 0.26 | 0.25 | 0.26 | 0.25 | 0.21 | 0.28 | 0.18 | 0.67 |
| Females | | | | | | | | |
| 1 (Affluent) | 0.31 | 0.30 | 0.32 | 0.32 | 0.30 | 0.34 | 0.10 | 0.75 |
| 2 | 0.29 | 0.28 | 0.30 | 0.29 | 0.28 | 0.31 | 0.17 | 0.68 |
| 3 | 0.29 | 0.28 | 0.30 | 0.28 | 0.26 | 0.30 | 2.03 | 0.15 |
| 4 | 0.28 | 0.27 | 0.29 | 0.26 | 0.24 | 0.28 | 4.43 | 0.04 |
| 5 (Deprived) | 0.28 | 0.27 | 0.29 | 0.27 | 0.23 | 0.31 | 0.23 | 0.63 |

deprivation. Survival of lung cancer was higher in females than in males in all urbanization and socioeconomic deprivation groups. In all four sex and urbanization strata, survival was higher in the affluent group than in the deprived group.

Patients from a deprived area had a lower survival than those from an affluent area ($p < 0.001$). Survival did not vary systematically with urbanization, but in males in the most affluent quintile, survival in rural areas (survival = 0.29, 95%

CI: 0.28–0.31) was higher than in urban areas (survival = 0.27, 95% CI: 0.26–0.28). In females, in quintile 4, survival was higher in urban areas (survival = 0.28, 95% CI: 0.27–0.29) than in rural areas (survival = 0.26, 95% CI: 0.24–0.28). In both males and females, survival varied less across the urban than the rural socioeconomic deprivation quintiles.

DISCUSSION

Incidence

Lung cancer incidence has been reported to be increasing with increasing levels of socioeconomic deprivation⁴ and to be higher in urban than in rural areas.^{5,12} Our finding that a large proportion of the population in the urban areas was deprived and most rural areas were affluent was similar to a report from Wales that covered the same time period (2003–2007),⁵ and this underscores the importance of jointly considering these measures when drawing inferences from the variation in incidence and mortality or survival estimates between urban and rural areas.

The Welsh study reported higher incidence rates in urban than in rural areas, but the differences between rural and urban rates disappeared when the levels of deprivation were taken into account and an increasing trend for the incidence rate according to higher levels of deprivation was observed.⁵ Similarly, we found a higher incidence of lung cancer in urban areas, however, when we analyzed the incidence rate stratified by socioeconomic deprivation, the difference between lung cancer incidence in urban and rural areas within each socioeconomic deprivation quintile is small, and no difference in incidence was observed between rural and urban areas in the most affluent and the most deprived groups.

The difference in the incidence of lung cancer in urban and rural areas and between socioeconomic groups can most likely be explained by the difference in smoking patterns,¹² where a high prevalence of smokers is found in urban areas¹³ and in socioeconomically deprived groups.¹⁴ Some studies^{15,16} have suggested that air pollution plays a role in the development of lung cancer. Nevertheless, the difference in lung cancer incidence between rural and urban areas in our study is small and not consistent across the five socioeconomic deprivation quintiles, which argues against air pollution being a significant contributor to lung cancer incidence.

In 1997, the United Kingdom developed an air quality strategy to reduce the levels of health-threatening pollutants, and a ban on smoking in public spaces was introduced by the government in July 2007 to help prevent the development of lung cancer and other smoking-related diseases.

Survival

Lung cancer survival has been reported to be poorer in rural areas and in more deprived socioeconomic groups.^{5,8,17} The study from Wales⁵ reported higher mortality rates in urban areas, but as with the incidence rate, this difference disappeared in favor of an increasing trend with increasing socioeconomic deprivation. In a similar fashion, 1-year survival seemed to decrease with increasing levels of deprivation in our study, and although survival seemed to be better

among the rural groups for males, this trend was reversed with increasing levels of deprivation among females. A study carried out in Scotland⁸ reported a worse survival with increasing levels of deprivation and increasing settlement size. When the analysis was adjusted for deprivation, survival was shown to be better in areas with smaller settlement size and worse with increasing distance to a cancer center. This suggests that the effect on survival may be less likely to be attributable to socioeconomic deprivation. Nevertheless, it should be taken into account that Scotland is largely made up of rural areas, and levels of deprivation are more difficult to assess in rural areas where affluence and poverty can coexist in close proximity.

Exploring the reasons behind the survival differences, subsequent analyses of the Scottish data revealed that patients with lung cancer who lived more remotely had poorer survival due to more advanced disease at diagnosis¹⁸ but little evidence that deprivation and rurality were associated with treatment modalities and no increase in treatment delay.¹⁹

The difference in survival in urban and rural areas may be explained by the increasing distance to a cancer center. Nevertheless, because of a lack of information on distance to the nearest center, we were unable to investigate this further, and this may limit generalizability to other countries.

A study assessing excess deaths in England and Wales according to socioeconomic deprivation, latitude, and urbanization found that behavioral factors, and smoking in particular accounted for most of the excess mortality in general, and lung cancer specifically in more deprived areas, but noted that the effect may be more strongly related to morbidity than mortality.²⁰ Nevertheless, as smoking is the main contributing factor to lung cancer risk and also gives rise to increased levels of comorbidity, this may restrict treatment options and, therefore, give rise to impaired survival. It is known that smoking prevalence is higher in urban areas and increases with socioeconomic deprivation^{21,22}; however, because of our absence of individual information on smoking, we were unable to investigate any further.

In general, lung cancer survival improved during the 1990s. Nevertheless, survival in England and Wales is still lower than Scotland, Northern Ireland, and the Republic of Ireland,²³ although these differences are still smaller than the differences observed globally²⁴ or within Europe.²⁵

Poorer survival in the most deprived areas could be due to late diagnosis and lower access to NHS treatment among the patients from more deprived areas than those from the most affluent areas.¹⁹ Poor survival in deprived areas may, therefore, involve more complex factors such as stage at diagnosis and treatment. Further analyses incorporating disease stage at diagnosis may improve our understanding of the impact it has on survival outcomes. Age, stage, histology, treatment, and smoking status all affect survival and may confound the observed differences in survival between rural and urban place of residence by socioeconomic status. Because of a lack of information on staging, treatment, and smoking status, we were unable to assess the impact these factors may have. Nevertheless, in a subset of patients for

whom this information was available, the confounding effect of age, sex, and histology was found to be absent.

CONCLUSION

The difference in lung cancer incidence between urban and rural areas can largely be explained by the differences in the distribution of socioeconomic deprivation. When socioeconomic deprivation is taken into account, little difference is seen in the incidence of lung cancer and the survival of patients with lung cancer living in urban and rural areas.

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