Risk of adverse birth outcomes in populations living near landfill sites

Editorial by McNamee and Dolk

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Abstract

**Objective:** To investigate the risk of adverse birth outcomes associated with residence near landfill sites.

**Design:** Geographical study of risks of adverse birth outcomes in populations living within 2 km of 9565 landfill sites some time between 1982 and 1997 (from a total of 19196 sites) compared with those living further away.

**Setting:** Great Britain.

**Subjects:** Over 8.2 million live births, 43,471 stillbirths, and 124,597 congenital anomalies (including terminations).

**Main outcome measures:** All congenital anomalies combined, some specific anomalies, and prevalence of low and very low birth weight (<2500 g and <1500 g).

**Results:** For all anomalies combined, relative risk of residence near landfill sites (all waste types) was unadjusted, and 1.01 (1.005 to 1.023) adjusted for confounders. Adjusted risks were 1.05 (1.01 to 1.10) for cardiovascular defects, 1.07 (1.04 to 1.10) for hypospadias and epispadias (with no excess of surgical defects), 1.19 (1.05 to 1.34) for surgical correction of gastrochisis and exomphalos, and 1.05 (1.04 to 1.07) for birth weight respectively. There was no excess risk of stillbirth. Findings for special (hazardous) waste were non-special sites. For some specific anomalies, higher risks were found in the period before opening especially hospital admissions for abdominal wall defects.

**Conclusions:** We found small excess risks of congenital anomalies and low and very low birth weight mechanisms are available to explain these findings, and alternative explanations include data artefacts needed to help differentiate between the various possibilities.

What is already known on this topic

Various studies have found excess risks of certain congenital anomalies and low birth weight near landfill sites. Risks up to two to three times higher have been reported.

These studies have been difficult to interpret because of problems of exposure classification, small sample size, confounding, and reporting bias.

What this study adds

Some 80% of the British population lives within 2 km of known landfill sites in Great Britain.

By including all landfill sites in the country, we avoided the problem of selective reporting, and maximised statistical power.
Although we found excess risks of congenital anomalies and low birth weight near landfill sites in Great Britain, they were smaller than in some other studies. Further work is needed to differentiate potential data artefacts and confounding effects from possible causal associations.

**Introduction**

Waste disposal by landfill accounts for over 80% of municipal waste in Britain.\(^1\) Human exposure to toxic chemicals in landfill include volatile organic compounds, pesticides, solvents, and heavy metals\(^2-4\) may occur by dispersion of contaminated leaching or runoff,\(^5\) or by animals and birds, although evidence for any substantial exposures is largely lacking. Congenital anomalies and low birth weight near landfill have been reported,\(^6-9\) including from recent European studies, although some have reported less significant\(^12\) or negative findings.\(^13\) The aim of our present study was to assess birth outcomes associated with residence near landfill using data on all known sites in Great Britain.

**Methods**

**Classification of populations near landfill sites**

Data provided by the national regulatory agencies were merged in a geographical information system to give a database of 19,196 sites. Data on boundaries were unavailable for most sites, so point locations had to be used. For 70% of sites and, for the remainder, the location of the site gateway at the time of reporting. Data from accuracy (often rounded to 1000 metres), and data on area were inadequate to allow estimation of the sites that have changed considerably over time as old areas are closed and new areas develop, while postcode of cases and births) give only an approximation of place of residence, accurate to 10-100 metres in urban areas but >1 km in some rural areas; also, landfill sites are highly clustered, so that individual postcodes may lie close to 30 or more sites. Therefore, distance from nearest landfill site was not regarded as a meaningful proxy for exposure. As a compromise between the need for spatial precision and the limited data, we constructed a 2 km zone around each site (figure), giving resolution similar to or higher than that of dispersion for landfill emissions.\(^14\) Postcodes within the 2 km buffer zone were classified hierarchically still operating took precedence over those closed earlier in the study period, which took precedence over living more than 2 km from all known landfill sites during the study period comprised the reference population.

**Health and denominator data**

We used national postcoded registers held by the Small Area Health Statistics Unit. These comprised England and Wales, 1983-98, and data on terminations, 1992-8, performed for "grounds E" of the 1967 Abortion Act. Because of concerns about the quality of landfill data for earlier years, and because health data were available only to 1991 before 1982 or opened after 1997 (to allow a one year lag period for the birth outcomes) or for which there were inadequate health data for special (hazardous) waste, 7803 for non-special waste, and 988 handling unknown wastes. The 2 km surrounding these sites included 55% of the national area.
child were born it would suffer from such physical or mental abnormality as to be seriously handicappe Scotland, 1988-94; hospital admissions data for England and Scotland, 1993-8 (Welsh data were cons data, 1983-98.

Cases were coded to ICD-9 (international classification of diseases, ninth revision) from 1983 to 1994, and to ICD-10 there (ICD-9 740-59; ICD-10 Q00-Q99); neural tube defects (ICD-9 740.0-740.2, 741.0-741.9, 742.0; ICD-10 Q00.0-Q00.2, Q05.0-747.9; ICD-10 Q20.0-Q28.9); abdominal wall defects (ICD-9 756.7; ICD-10 Q79.2-Q79.4); hypospadias and epispadias (ICD hypospadias and epispadias (M731, M732); and surgical correction of gastroschisis and exomphalos (T281). Multiple anom anomalies combined).

Surgical corrections (England and Scotland only) were analysed by date of birth, not date of surgical procedure. For hypospadias out before the age of 3 years, and, for gastroschisis and exomphalos, in the first year of life only. Low and very low birth we relevant denominators and years of analysis are shown in table 1.

Table 1. Denominators and years for analyses of birth outcomes near landfill site from any site), and before opening and during operation and after closure for site

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Statistical methods

We calculated risks for the population within 2 km of landfill relative to the reference population by indirisk for all landfill sites. We used model predictions from Poisson regression of data from the reference function included year of birth, administrative region (n=10), sex (for birth weight and stillbirths), and de postcodes to tertiles of the national distribution of the Carstairs’ deprivation index based on 1991 cen tertiles rather than quintiles of the Carstairs index because of the small number of events for the rarer area. We used a descending stepwise selection procedure starting from the fullest model including all depravation, and then the two models were constrained (where necessary) to differ only in terms of depurefication and deprivation-adjusted results only were obtained, and r

Table 2. Models chosen by the stepwise selection procedure in the reference area

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Some degree of overdispersion and a widening of the confidence intervals is to be expected if our model assumptions fail to confounding, or sampling variability of the rates). We therefore calculated Poisson 99% (rather than 95%) confidence interv variability has been captured—we emphasise estimation of relative risks and their stability (or otherwise) to choice of mod

We assessed the sensitivity of our results to model choice by using an alternative model for each birth outcome (table 2). V rural areas only, and for birth weight (where data were sufficient) we examined sensitivity to the use of quintiles (rather than we also examined maternal age (<20 and ≥20 years, available 1986-98 for England and Wales only).

The main analysis identified at outset was for all landfill sites for the combined period during their operation and after closure. Subsidiary analyses examined risks separate ly for special waste sites, and in the period before and after opening for the 5260 landfill sites with available data.

Results

Urban or rural status and Carstairs index were strongly correlated. Within the reference area, 49% of tl was classified as rural (7% for the most deprived tertile), while for all outcomes rates were higher in the with the most affluent areas: the ratio ranged from 1.02 (surgical correction of hypospadias and episp weight). The area within 2 km of the 9565 landfill sites tended to be more deprived than the reference population were in the most deprived tertile of Carstairs score (36% for special waste sites). The area a proportion of births to mothers under 20 years of age (7.7% v 6.1%) and, among women aged 15-44, ii proportion of women of Indian, Pakistani, or Bangladeshi origin (4.8% v 3.2%) and a lower proportion o

Table 3 shows the numbers of cases for each birth outcome and relative risks for the area near landfill for all congenital anomalies combined was 0.92 (99% confidence interval 0.907 to 0.923) unadjusted, and other confounders. After adjustment for deprivation (which reduced excess risks) relative risk was 1.08 (1.01 to 1.15) for abdominal wall defects (and 1.07 (0.98 to 1.18) for hospital admissions). 1.19 (1

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and exomphalos, and 1.05 (1.047 to 1.055) and 1.04 (1.03 to 1.05) for low and very low birth weight cardiovascular defects and 1.07(1.04 to 1.10) and 0.96 (0.90 to 1.02), respectively, for hypospadias an deprivation adjustment had little or no effect).

Table 3. Risks of congenital anomalies, stillbirths, and low and very low birth weight site (all waste types) during operation or after closure compared with those in the

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Table 4 summarises findings (adjusted for deprivation) for the special and non-special waste sites, and

For special waste sites, risks above one were found for all but two outcomes, ranging up to 1.11 (1.03 hypospadias and epispadias. For the specific anomalies, except neural tube and cardiovascular defect a landfill site compared with after opening, especially for hospital admissions for abdominal wall defect after opening.

Table 4. Estimated relative risks (99% confidence intervals) of birth outcomes for adjusted for deprivation and other variables* according to waste type and to oper the study period

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Sensitivity analysis showed that the risk estimates were robust to the different models used. Urban c deprivation included, though modelling of data for rural areas only (where numbers of cases were muc estimates for neural tube defects and hypospadias and epispadias—relative risks (for all waste types, 1.01 (0.94 to 1.09) respectively. Inclusion of maternal age as a confounder had only a small effect on r

**Discussion**

This is by far the largest study of associations between residence near landfill and adverse birth outcomes risk of neural tube defects, abdominal wall defects, surgical correction of gastroschisis and exomphalos. Findings for cardiovascular defects and hypospadias and epispadias were inconsistent, and there was including all landfill sites in Great Britain and using routine data sources, we avoided the possibility of t and maximised statistical power, but problems with data quality and confounding could have led to spurious associations.

**Exposure classification and data quality issues**

In the absence of information on site or geological factors affecting emissions from landfill, we examined potential hazard. The UK practice of co-disposal of special and non-special wastes (in contrast, for ex special waste sites handle small volumes of hazardous wastes. They are subject to stricter management hazardous wastes may have been disposed of, unreported, in non-special sites. Thus exposure risks f from other sites. Exposures to environmental contamination from sources other than landfill may also the mineral or other excavations, often on old industrial or contaminated land or close to current industrial activities.

A key issue was the possibility of misclassification from use of a 2 km zone to define proximity to landfill sites. However, in view of the low spatial resolution of the landfill data (hundreds of metres) and complex nature of landfill sites, using finer subdivisions of the 2 km zone or distance as a continuous measure would have bias yield meaningful results. Misclassification of potential exposure to landfill may also have occurred if mothers moved home c

While the data for births and stillbirths are well recorded, the national congenital anomaly system in England and Wales is incomplete (reporting in Scotland), and there were marked fluctuations in rates of anomalies over the study period, partly because of co-change in calendar year to deal with fluctuating rates, but ascertainment artefacts could have bias with respect to landfill locations. Though we had no reason to suspect that this had occurred, such inconsistencies could explain hand, we included data on terminations to improve ascertainment, especially for neural tube defects, and included data on independent source of data for those specific anomalies.

**Confounding**

We addressed confounding in two ways. Firstly, analysis included potential confounders, with and with confounding may persist if the adjustment did not account completely for relevant individual characteristics.

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during pregnancy.\textsuperscript{26} As in the Eurohazcon study,\textsuperscript{10} maternal age (for risk of abdominal wall defects\textsuperscript{27}) in the United States,\textsuperscript{28} location of waste sites near ethnic minority communities was not a key feature, birth weight,\textsuperscript{29,30} and (more weakly) of certain congenital anomalies (especially neural tube defects\textsuperscript{31}), South Asian origin,\textsuperscript{32} but the higher proportions of women of Indian, Pakistani, or Bangladeshi origin living near landfill area would explain only around 1\% excess in our study.

Secondly, we examined rates both before and after the opening of landfill sites that opened during the study period. Becau subject to confounding by sociodemographic factors than comparisons between different areas—although confounding by outcomes studied here\textsuperscript{17} is possible. Consequently, we did not compare the risks before and after opening directly but estimated each with respect to the period before opening (and which were higher than in the period during operation or after closure). This implies that factors other than landfill might be responsible. The Nant-y-Gwyddon study also noted an excess risk of all congenital anomalies combined\textsuperscript{11} before the site was opened.\textsuperscript{11}

A possible causal association with landfill should also be considered. Given the large heterogeneity between landfill sites a greatest close to the sites,\textsuperscript{33} causal effects related to particular landfill sites might have been greatly diluted. None the less, findings, and there is considerable uncertainty as to the extent of any possible exposure to chemicals found in landfills.\textsuperscript{8} Further research is needed in order to help interpret the epidemiological findings.

\section*{Acknowledgments}

We thank the Office for National Statistics, the Department of Health, and the Information and Statistical Service for providing data on congenital anomalies, births, stillbirths, and hospital admissions. We thank the Scottish Environment Protection Agency for providing data on landfill and for their help in resolving discrepancies. The views expressed in this publication are those of the authors and not necessarily those of the funding departments, data providers, or of Of Richard Arnold and Alex Lewin for their help in preliminary analyses. We thank the authors and not necessarily those of the funding departments, data providers, or of Of and Richard Arnold for their help in preliminary analyses and Alex Lewin for help in the statistical analysis.

\section*{Contributors:} PE and LJ initiated the project and, with DB and SM, drafted the paper. DB, CdH, CH, and IM performed the analysis of landfill sites. SM, and Richard Arnold for their help in preliminary analysis.

\section*{Footnotes}

Funding: The Small Area Health Statistics Unit is funded by a grant from the Department of Health; Department of Health; De Affairs; Environment Agency; Health and Safety Executive; Scottish Executive; National Assembly for Wales.

Competing interests: None declared.

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