mountain of supportive empirical evidence, which my original paper largely lacked. This is awkward for those still trying to impose their worldwide, neoliberal economic "reform" programme while anxious to preserve at least some appearance of social justice. All they have left is therapeutic nihilism, sold to our professions by Tom McKeown.[3] If medical care makes no measurable difference to public health, access to good care becomes a matter of appearance not substance. This view remains fashionable. Even such stalwarts for social justice as Richard Wilkinson[4] and the editor of this journal[5] have tied their hands by minimising the actual and potential contribution of clinical medicine to public health. McKeown's argument has been demolished in print by John Bunker[6] and many others. It is even more convincingly refuted by the behaviour of us all, nihilists included, when we suspect any serious threat to our own health. We seek the best medical advice available.

The inverse care law identified an important enemy. New ways to measure how this battle is going are useful; but a more important task is to win it, by eliminating this anomaly. Given sufficient political will and a great deal of hard work, this is certainly possible.[7] The inverse care law is not a law of nature but of dehumanised market economics. It could be unmade by a rehumanised society.

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Assessment of impact on health of residents living near the Nant-y-Gwyddon landfill site: retrospective analysis

H M P Fielder, C M Poon-King, S R Palmer, N Moss, G Coleman

Abstract

Objectives To compare indices of health in a population living near a landfill site with a population matched for socioeconomic status and to review environmental monitoring data.
Design Ecological study with small area statistics and environmental reports.
Setting Electoral wards in valleys of South Wales.
Subjects Populations in the five wards near the landfill site who had formally complained of odours (exposed population), and comparison populations in 22 wards in the same unitary authority within the same fifth of Townsend score.
Outcome measures Mortality, rates of hospital admission, measures of reproductive health (proportion of all births and stillbirths of infants weighing <2500 g; rates of admissions for spontaneous abortion; rates of all reported congenital malformations). Environmental data on site emissions.
Results There were no consistent differences in mortality, rates of hospital admissions, or proportion of low birthweight infants between the two populations. There was an increased maternal risk of having a baby with a congenital abnormality in residents near the site, both before its opening (relative risk 1.9; 95% confidence interval 1.3 to 2.85; $P<0.001$) and after (1.9; 1.23 to 2.95; $P=0.003$). Environmental monitoring showed that hydrogen sulphide from the site was probably responsible for odours.
Conclusions The area surrounding the landfill site has an increased rate of reported congenital malformations, which predated the opening of the landfill, although the cluster of cases of gastroschisis postdated its opening. Several chemicals emitted from the site, including hydrogen sulphide and benzene, were found in air samples in the nearby community. Further studies of the reproductive risk in such communities are needed to examine the safety of waste disposal sites.

Introduction

Recent work has suggested that women living near landfill sites that receive hazardous waste have an increased risk of having a baby with congenital malformations,[1] but the potential risk from sites that receive only domestic, commercial, and industrial waste has not been examined adequately.

In 1996 residents living in the wards near the Nant-y-Gwyddon landfill site voiced increasing concerns that odours from the landfill site were causing illnesses. Symptoms and diseases they associated with exposure included stress, fatigue, headaches, eye infections or irritation, coughs, stuffy nose, dry throat and nausea, sarcoidosis, asthma, gastroschisis, and spontaneous abortions.

The Nant-y-Gwyddon landfill site, covering 24 hectares, was opened in January 1988 within 3 km of a population of 20 000 (fig 1). The local authority licence allowed the disposal of household, commercial, and industrial waste, and by 1996 about 850 000 m^3 of waste, including calcium sulphate filter cake, had been deposited on the site.

We assessed the health of the population living near the site using existing available epidemiological and environmental data. At the same time further monitoring of site emissions was carried out. We assessed, firstly, whether there was a difference in age

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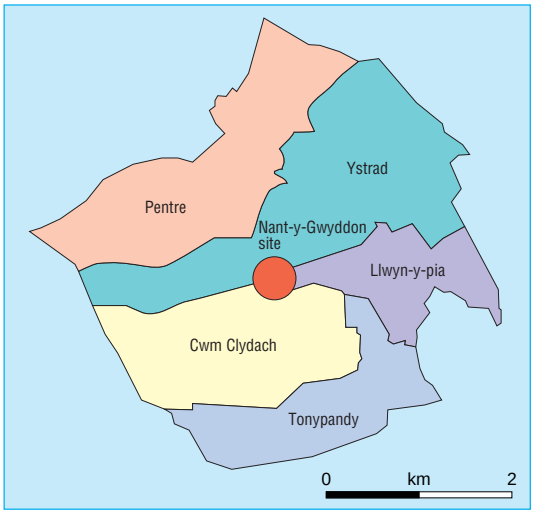

Fig 1 Five wards surrounding Nant-y-Gwyddon landfill site in the Rhondda Valley, South Wales: the "exposed" wards

standardised rates of death (all cause, respiratory, and cancers), rates of hospital admissions (general medical and geriatric, all respiratory disease, and asthma), and indices of reproductive health between the population living in the five wards near the landfill site compared with 22 other wards of similar socioeconomic level in the same unitary authority, before and after the site opened, and, secondly, whether there was evidence from previous environmental monitoring or from the concurrent environmental study of site emissions reaching the community.

Methods

Formal complaints to the environmental department of the local authority and to the environment agency were reviewed, and residents belonging to RANT (residents against Nant-y-Gwyddon tip) were visited. Hypotheses were formed from the specific disease concerns of the residents. The exposed population was defined as residents living in the five electoral wards within 3 km of the landfill site and from which complaints had been received from residents (fig 1). The comparison population comprised 22 other electoral wards in the same local authority, matched by fifths of Townsend score calculated from the 1991 census. The mean Townsend score of 1.92 for the exposed wards indicated slightly less deprivation than in the unexposed wards (2.28). We sought to obtain the most recently available data and historical data back to 1981, which was seven years before the site opened (table).

Source of data for impact on health of living near landfill site

Content	Dates	Source
Congenital malformations	1983-96	Office for National Statistics (ONS)
Townsend scores population denominators	1991	ONS census data held by Bro Taf Health Authority
Total births	1988-96	Birth notifications to Bro Taf Health Authority
No with low birth weight	1988-96	
Congenital anomalies	1997	
Total births	1983-87	Small area health statistics unit
All cause deaths	1981-95	ONS death notifications held by the Welsh Health Common Services Authority
Respiratory deaths	1981-95	
Neoplastic disease	1981-95	
Hospital admissions	1991-7	Patient episode database for Wales
Therapeutic abortions	1992-6	ONS analysed by Welsh Office

Data collection

Mortality by electoral ward from all causes, respiratory disease, and cancers was directly standardised to the European standard population, and trends in mortality in exposed and unexposed wards were compared. Rates of hospital admission were analysed by primary diagnosis on death or discharge. By using the international classification of diseases, 9th and 10th revisions (ICD-9 and ICD-10), we compared the rates in the exposed and unexposed wards for all general medical admissions (Korner specialty code 300), respiratory disease (ICD-9 codes 485-519; ICD-10 codes J10-99), asthma (ICD-9 code 493; ICD-10 code J45-6), cancer (ICD-9 codes 140-239; ICD-10 codes C00-97), sarcoidosis (ICD-9 code 135; ICD-10 code D86), and spontaneous abortions (ICD-9 code 634; ICD-10 code 003).

All babies born with at least one recorded congenital malformation on the register of the Office for National Statistics[2] and born to mothers resident in the 27 wards were examined in the categories of all congenital abnormalities and anomalies of the abdominal wall (1983-96; ICD-9 code 756.7; ICD-10 codes Q79.2, Q79.3, Q79.4.) Before 1995 the coding of the congenital malformation data did not differentiate between gastroschisis, exomphalos, or prune belly, and all were coded as midline abdominal wall defects. In 1990 the Office for National Statistics changed the reporting categories of congenital malformation, leading to a subsequent fall in the number reported nationally.

Numbers of therapeutic abortions performed for grounds E of the Abortion Act 1967 (a legally induced abortion when there is a substantial risk that if the child were born it would suffer from such physical or mental abnormality as to be seriously handicapped) available for 1992-6 were reviewed by the data custodians of the Welsh Office.

Analysis

The χ^2 test was used to test the association between the incidence of congenital malformations occurring in live and stillborn babies in the exposed and unexposed wards for the years before and after the site opened. The expected number of midline abdominal defects was calculated from the incidence of notified congenital abdominal wall defects in England and Wales between 1987 and 1993.[3] The standardised ratio of observed to expected was calculated with 95% confidence intervals with CIA software,[4] and Poisson cumulative probabilities were also calculated.[5]

Diagnoses made in general practice or hospital outpatient departments are not routinely available, and up to date cancer registrations for Wales were not available. We examined prescribing data available for 1996-7, but these were recorded only by the prescribing practice, not by electoral ward, and are not presented here.

Environmental monitoring

Two previous environmental monitoring studies commissioned by the local authority were reviewed. In 1997 further environmental monitoring was commissioned by the environment agency to quantify

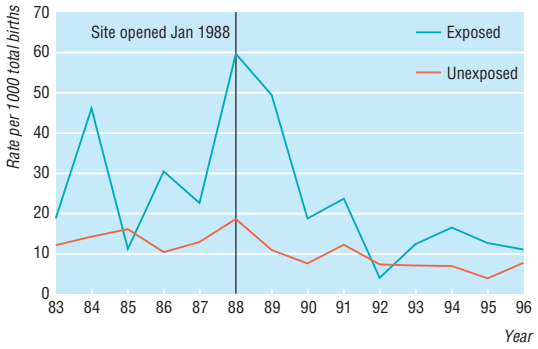

Fig 2 Rate of births with congenital malformation per 1000 total births in "exposed" and comparison wards

emissions from the landfill surface and to monitor air quality in the community during odour episodes.[6]

Results

From 1983-96 there were 302 children born in the 27 study wards with at least one registered congenital anomaly; the rate of congenital anomalies per 1000 total births in the exposed wards was higher in all but two years (fig 2). From 1983 to 1987 (before the site opened) and from 1990 to 1996 (after the site opened) the rate of congenital malformations in the exposed areas was 1.9 times the rate in the unexposed area (95% confidence interval 1.3 to 2.9, $P \leq 0.001$; and 1.2 to 3.0, $P = 0.003$, respectively). For 1988 and 1989, when the site was being developed and first used, the rate of congenital malformation in the five exposed wards was 3.6 times that in the unexposed wards (2.3 to 5.7, $P < 0.001$). The discrepancy in the rates of births with congenital malformation between the exposed and the unexposed wards was not accounted for by an increased number of abortions (on grounds E) in the unexposed wards.

In the study wards from 1983-96 there were nine cases of midline abdominal wall defect identified in the register of the Office for National Statistics, seven of these occurring since 1991 (four in the exposed wards and three in the unexposed). Of the seven cases recorded by the register since 1991, the original paper notifications reported five cases of gastroschisis (four in the exposed wards and one in the unexposed wards) and two cases of exomphalos in the unexposed wards.

The incidence of notified congenital abdominal wall defects in England and Wales indicated an expected number of 0.45 cases in the exposed wards between 1989-96. Four cases were noted in data from the Office for National Statistics, giving a standardised ratio of 8.89 (2.42 to 22.8). The Poisson cumulative probability was 0.001. There were three cases observed in the unexposed wards compared with an expected 2.38, giving a standardised ratio of 1.26 (0.26 to 3.68). The Poisson cumulative probability was 0.3.

Annual mortality for all causes, respiratory disease, and cancer from 1981 to 1995 did not differ between the exposed and unexposed wards, neither did rates of hospital admissions for general medical conditions, respiratory diseases, asthma, spontaneous abortions, or cancers from 1991-2 to 1996-7 nor did the proportions of infants with births with low birth weight.

Environmental monitoring at the site, commissioned by the Environment Agency (ENTEC report[6]), identified various odours in the raw landfill gas, dominated by high levels of hydrogen sulphide. Several other compounds in the raw landfill gas—styrene, dimethyl styrene, ethyl benzene, and C4 alkyl benzenes—were found at concentrations exceeding those reported at other UK sites.

Between 24 July 1997 and 22 September 1997 the Environment Agency received 106 complaints of odours, all from residential areas close to the site boundary. On 24 of these occasions community air samples were taken to measure hydrogen sulphide concentrations, and on four occasions when odours were verified on call out, air samples were sent for more detailed analysis. On three of these four occasions benzene exceeded the environmental assessment limits developed by the Environment Agency. Hydrogen sulphide was recorded above its odour recognition threshold (3.5 $\mu g/m^3$) on nine of the 24 call outs. The maximum concentration (20 $\mu g/m^3$) was above the World Health Organisation's sensory annoyance guideline (7 $\mu g/m^3$) but did not exceed its occupational exposure standard for non-occupational settings. Continuous monitoring of hydrogen sulphide was undertaken between 9 and 16 September and on 31 October and 1 November at two sites at 500-1000 m from the landfill. The WHO sensory annoyance guideline was exceeded during the evening of 15 September. The composition of the raw landfill gas and the community samples suggested that the landfill was the source of the hydrogen sulphide.

Discussion

In response to community concerns we reviewed the guidelines for conducting public health assessments near landfill sites, developed by the US Agency for Toxic Substances and Diseases Registry,[7] which recommend evaluation of the site for evidence of exposure to hazardous substances before any further work is undertaken. In the United Kingdom the availability of population based, routine health data offers a potentially important alternative public health approach. Indeed, the public usually expects an early analysis of these data.

Reproductive health outcomes

We consulted with the residents and local agencies to agree the categories of ill health to be studied. To control for the confounding effects caused by socioeconomic factors we compared the five wards nearest to the landfill site with 22 others in the same unitary authority matched for Townsend deprivation score. The main finding was an increase in rates of congenital malformations. Although the Office for National Statistics recognises that the data on congenital malformations are not always accurate or complete,[2] we have no reason to suppose that the data for the five exposed wards are any different in quality to those for the 22 unexposed wards. The incidence of all congenital malformations was raised in the exposed wards both before and after the site opened in 1988 (relative risk both 1.9). This is an important observation as other studies have noted an association between congenital malformations and living near hazardous waste sites.[1 8]

What is already known on this subject

Recent studies have noted an association between the birth prevalence of congenital malformations and living near hazardous waste sites

Few studies have examined municipal landfill sites

What this paper adds

This retrospective analysis showed that residents living near a landfill site had an increased risk of having a baby with a congenital malformation, not only after the site became operational but also before

There was also a cluster of gastroschisis

Protocols should be developed to measure community exposures systematically as public concern about environmental exposures and their health effects is increasing

One low powered case-control study near a municipal waste site did not detect any increased risk for spontaneous abortions, stillbirths, or birth defects,[9] but within 4 km of a large municipal waste site Goldberg et al found an excess of between 11% and 20% in low birth weight and between 8% and 13% more babies who were small for gestational age.[10] We agree with Dolk et al that there is an urgent need for further studies of landfill sites,[1] and we suggest examination of rates in the area both before and after a site becomes operational.

Community observations about an increase in gastroschisis were confirmed; the incidence of anterior abdominal wall defects (which include gastroschisis) was unusually high compared with the rest of England and Wales. All abdominal wall defects in the exposed wards since 1989 were confirmed as gastroschisis, whereas two of the three abdominal wall defects in the unexposed wards were exomphalos. Gastroschisis has a higher prevalence in young mothers,[11] but the occurrence of four cases in the exposed wards would be unusual even if all the births from 1989-96 had been to teenage mothers (standardised ratio 4.8; 1.6 to 11.1). We recognise that the identification of the cluster has limited implications as it resulted from a post hoc analysis but the findings justify further analytical study in the area. The birth prevalence of gastroschisis seems to be increasing nationally and internationally,[12] and further studies of aetiology are required urgently.

Community environmental exposures

The evaluation of any health effects was hampered by no direct measures of exposure, no biomarkers, and no community monitoring during the peak of the problem. The ENTEC study was carried out while the site was not accepting waste and while the landfill gas control systems were being modified. A number of potentially toxic chemicals, including sulphuretted and aromatic compounds, were identified at high concentrations in the raw landfill gas and the gas immediately above the site. Hydrogen sulphide is not known to cause developmental defects,[13] but the occasional high concentrations of hydrogen sulphide found in community air samples were consistent with complaints of headaches, eye irritation, and sore throats. The monitoring in the community that was undertaken was limited in scope as it measured only hydrogen sulphide on most occasions with detailed analyses undertaken on only four occasions. Modelling work on atmospheric dispersion undertaken by ENTEC, which used values after remedial work had started, suggested that landfill gas might contribute up to 1.1 ppb in the community air samples during monitored odour events. We recommend that protocols be developed to measure community exposures systematically near landfill sites.

We thank the staff within Bro Taf Health Authority who provided the data requested, especially Ms T Deacon, Dr A Mukerjee, Dr B Davies, Dr G Hayes, Dr J Layzell, and Dr S Monaghan; Rhondda Cynon Taff Borough County Council Environmental Services; residents against Nant-y-Gwyddon tip; and the Welsh Health Common Services Authority and the Environment Agency.

Contributors: HF was responsible for preparing protocol design, data collection, analysis, and writing the paper. CP-K was involved in the initial project design, liaison with members of the public and statutory agencies, and data analysis and contributed to the paper. SP initiated the core ideas of the project and assisted with the interpretation of the data and writing of the paper. NM assisted with data collection, analysis, and interpretation and contributed to writing the paper. GC initiated and discussed the core ideas of the project, was responsible for reviewing environmental reports, and contributed to writing the paper. HF and SF are guarantors.

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Competing interests: None declared.

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Endpiece

What is a medicine?

Every medicine we make is nothing more than concentrated knowledge.

Richard Sykes, chief executive, GlaxoWellcome, October 1999

Commentary: Impact on health needs assessing from different angles

Helen Dolk

At present it is not possible to distinguish usefully in the literature between types of landfill in terms of the presence or extent of risk[1] in any attempt to put the results of Fielder et al in the context of "comparable" landfill sites to Nant-y-Gwyddon. Age of waste and gas and leachate control systems in place may be more important determinants of the potential for contamination than the types of waste deposited. Furthermore, classification of sites and definitions of what is and is not a "hazardous waste site" vary from country to country.

The environmental monitoring done near Nant-y-Gwyddon was limited in extent. Assessment of the impact on health of environmental exposures are at least as dependent on environmental data as on health data, and the authors rightly recommend that protocols for assessment of exposure should be developed and implemented in these settings.

Environmental monitoring did confirm higher than acceptable levels of odour from hydrogen sulphide, caused by the particular mixture of wastes accepted and the inadequate emission control system in place.[2] Residents may identify smells to be of concern in their own right—as unpleasant and leading to stress and stress related symptoms or disease—or they may perceive smells as indicators of the degree of contamination of air by gases, some of which (whether odorous or not) may be toxic. An assessment of impact on health thus needs to take into account the potential for stress related to smell, stress related to fear of direct toxic effects of pollutants, and direct toxic effects.

As this study was based on routinely collected health data it was limited to the range of outcomes on which data were available and by the quality of these data. A supplementary survey based on attendance at survey clinics investigated self reported symptoms and found a higher frequency among residents closest to the site.[2] Among sources of routine data, the congenital malformation register of the Office for National Statistics has been subject to particular scrutiny with regard to quality, as the authors recognise. A large proportion of affected live and stillborn babies are not notified to the register, and this proportion depends on the motivation of reporting units in districts. It is therefore difficult to exclude the possibility of variation in case ascertainment as an explanation for the differences in prevalence of congenital anomaly between the exposed and unexposed wards near Nant-y-Gwyddon. Furthermore the use, as in this study, of data on statutory notification of abortions for congenital anomaly to plug the gap in the register regarding many prenatally diagnosed cases has never been formally validated. The establishment in 1998 of a multiple source register of congenital malformations in Wales (CARIS) should allow a better assessment of local geographical differences in prevalence in the future.

A single site study is limited in its statistical power to detect excess risks for rarer health outcomes. This study would not have had the power to detect the low levels of excess risk of birth defects found in multisite studies with positive results.[3 4] This lack of power was obscured by the further difficulty of detecting any change in risk in exposed wards against a background of unexplained difference in prevalence between exposed and unexposed wards before the site opened and of decline over time in prevalence of birth defects due to changes in reporting criteria.

The possibility in this study of exploiting a "natural experiment" by comparing risk before and after the site opened was important, showing that the nearly twofold excess of birth defects in exposed wards could not be causally related to the landfill. Similar comparisons have been informative in previous studies, either strengthening[5] or reducing[6] the likelihood of a causal link with landfill sites. Unfortunately, it is often not possible to exploit this natural experiment. Many landfill sites are old and much of the available health data are quite recent or not comparable with older health data.

What of the cluster of gastroschisis? The aggregation of cases was confirmed as unusual, one which one in a thousand similarly sized communities would observe by chance. It was confined to exposed wards after the site opened, but at present there is no other supporting evidence that such a high increase in risk (ninefold) and its restriction to gastroschisis only is a potential health effect of landfill sites. Pinning down a single local cause, if any, of such a cluster is notoriously difficult.

We should do more research about the health impact of landfill sites and about the causes of congenital anomalies including gastroschisis. We should also act effectively to put into practice existing knowledge for the optimal and equitable distribution of risks and benefits of waste disposal.

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Endpiece

Einstein on science

Put your hand on a hot stove for a minute, and it seems like an hour. Sit with a pretty girl for an hour, and its seems like a minute. That's relativity.

Albert Einstein