

A Bayesian spatio-temporal model for policy evaluation: A novel method for the evaluation of waste incineration regulations on birth outcomes in England, Wales and Scotland

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Objective

To propose a Bayesian spatio-temporal model for the analysis of time-series small area data to evaluate whether waste incineration regulations (**European Union Waste Incineration Directive (EU WID)**) to reduce emissions had a measureable impact on birth outcomes for mothers living close to a Municipal Waste Incinerator (MWI) in the UK.

Data

The study will include 22 MWIs in England, Wales and Scotland in operation from 2003. We used Office for National Statistics (ONS) maternity data covering the whole of England. Outcomes investigated will be counts of infant and neonatal mortality, stillbirths and multiple birth occurrences between 1996 and 2012 for each Middle Layer Super Output Area (MSOA) (Table 1).

Table 1. Summary statistics of birth outcomes at Middle Layer Super Output Area (MSOA) for 1996-2012.

(n=6779)	Definition/ Exclusions	Median over the entire time period (10 th – 90 th centile)
Infant Deaths	Infant mortality (<=365 days)	6(2-15)
Neonatal Deaths	Neonatal mortality (<=28 days)	4(1-10)
Still births	>24 weeks gestation	7(3-14)
Multiple births	Two or more births	43(25-69)

Table 2. Incinerator commissioning dates and, where applicable, year of changeover to adoption of the EU WID

Incinerator	Number of MSOAs within 10km (2011)
Opened to the WID (Total number of MSOAs=372)	
Allington	46
Chineham	25
Crymlyn Burrows	41
Grundon	96
Isle of Wight	13
Marchwood	61
Newlincs	26
Portsmouth	64
Adopted the WID (Total number of MSOAs=419)	
Bolton	96
Coventry	62
Dudley	142
Dundee	Scottish data requested
Eastcroft	84
Edmonton	259
Kirklees	69
Portmellon	1
SELCHP	303
Sheffield	90
Stockton-on-Tees	57
Stoke-on-Trent	54
Tyseley	147
Wolverhampton	55

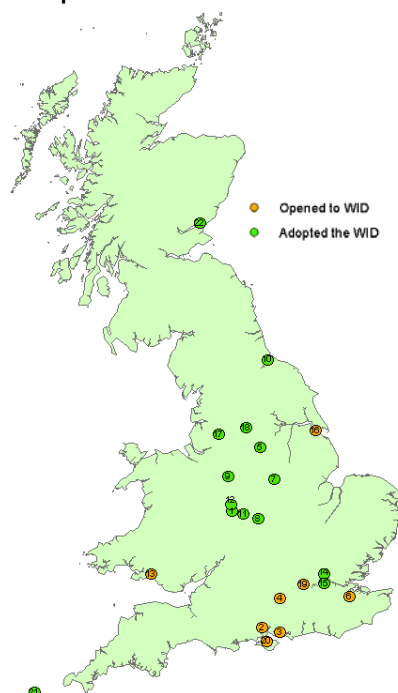


Figure 1. Incinerator locations coloured by whether opened to the WID or adopted the EU WID

Strategy for Evaluation

We will compare reproductive and infant health rates before and after implementation of EU WID after adjustment for systematic changes in reproductive and infant health rate in other non-MWI areas -> **use of a matched case-control design.**

We will use "control" areas to set the reference trend for the before-after comparison which helps to differentiate how much of the change is due to the EU WID and how much to other external factors (Table 2).

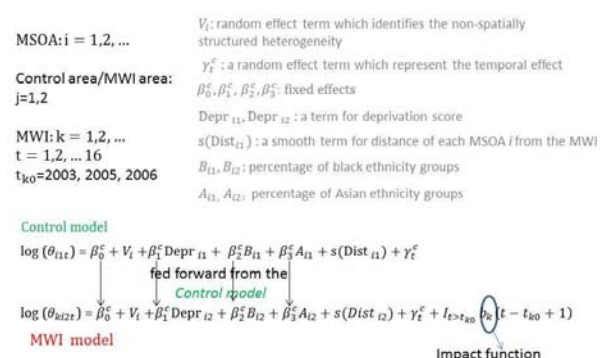
Table 2. Control areas are selected to have similar national, regional and local characteristics to MWIs areas

Control Criterion	Description
1 (National Level)	All the MSOAs in England, Wales and Scotland (excluding those that are included in the MWI area within 10km of an MWI)
2 (Regional Level)	All the MSOAs within the Government Office Region (GOR) of the MWI region (excluding those that are included in the MWI area within 10km of an MWI)
3 (Local Level)	The control area is matched to MWI (case) areas based on "similar" size and socio-economic deprivation scores.

We want to deal with sparsity of the data (i.e. small number of reproductive and infant health events) (Table 1), temporal trends and hierarchical structure across areas (Figure 1) -> **Our aim is separate signal from noise**

Our modelling approach is to fit a **Bayesian hierarchical spatio-temporal model²** embedded within a **matched case-control** framework adjusted for potential confounders at MSA level.

Bayesian hierarchical spatio-temporal model



Conclusions

Bayesian hierarchical spatio-temporal model allows borrowing of strength across MWI areas -> **enables evaluation of local impacts even when data are sparse**

Joint estimation of common trend and local trend models -> **enables full propagation of uncertainty**

A novel method which has potentially wider applications -> **enables other studies to assess health impacts of policy changes**

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