Certainties and uncertainties in the evaluation of health impact from waste management options

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Dipartimento di Epidemiologia ASL RME

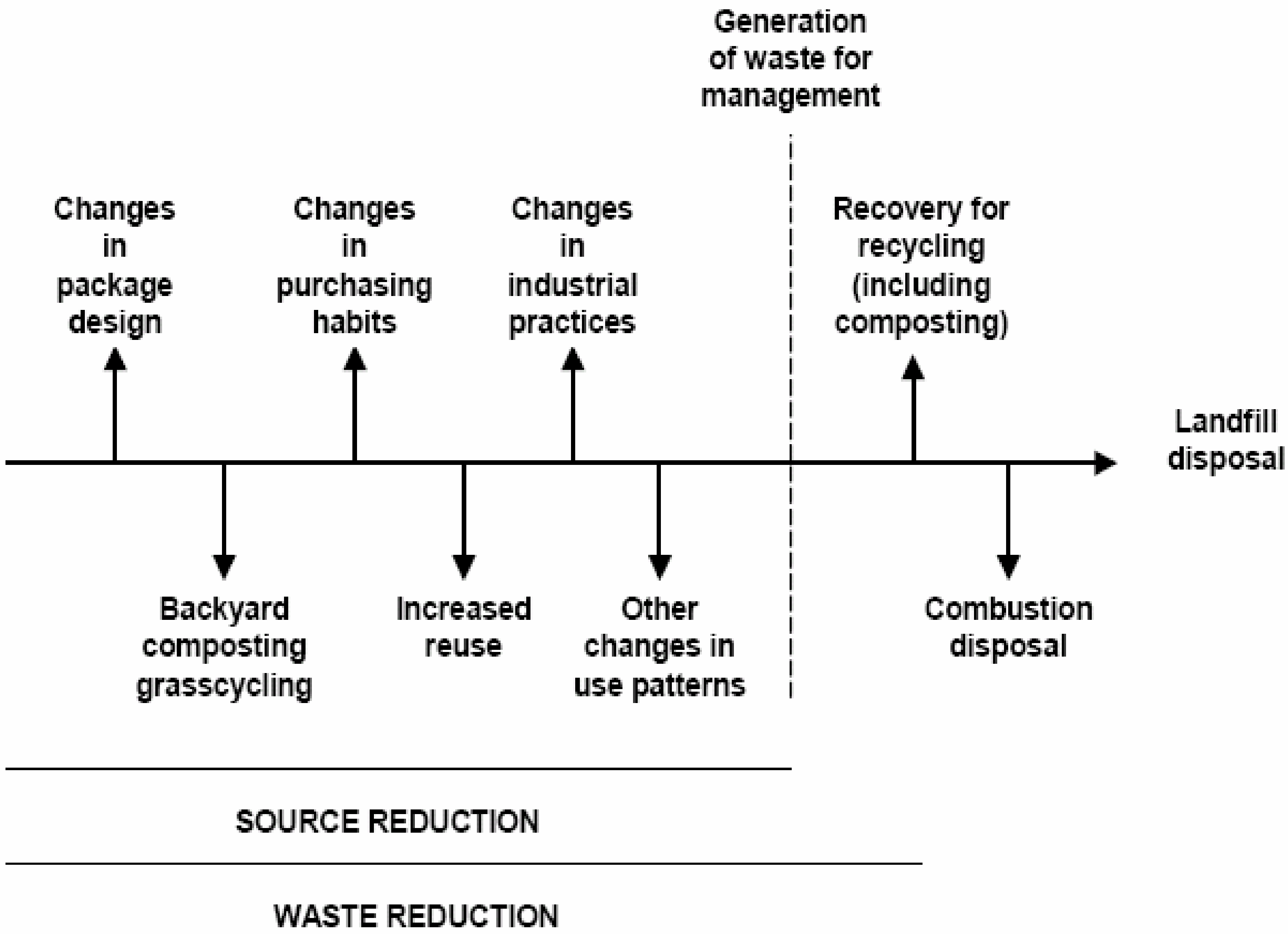
Issue framing

- Sources of waste: households,small manifactures, commerce, construction, demolition (hazardous waste) (sludge)
- Waste management: recycling, composting, gasification, incinerators, landfills,
- Emissions: lechates, gases, particulates, metals (mercury), dioxins, furans, HCL, HF, microbial agents
- Exposures route: inhalation, ingestion, dermal contact.
- Context: deprived areas, other industries, high comunity concern
- Health effects: birth defects, reproductive outcomes, cancer, respiratory disorders, psycosocial well-being

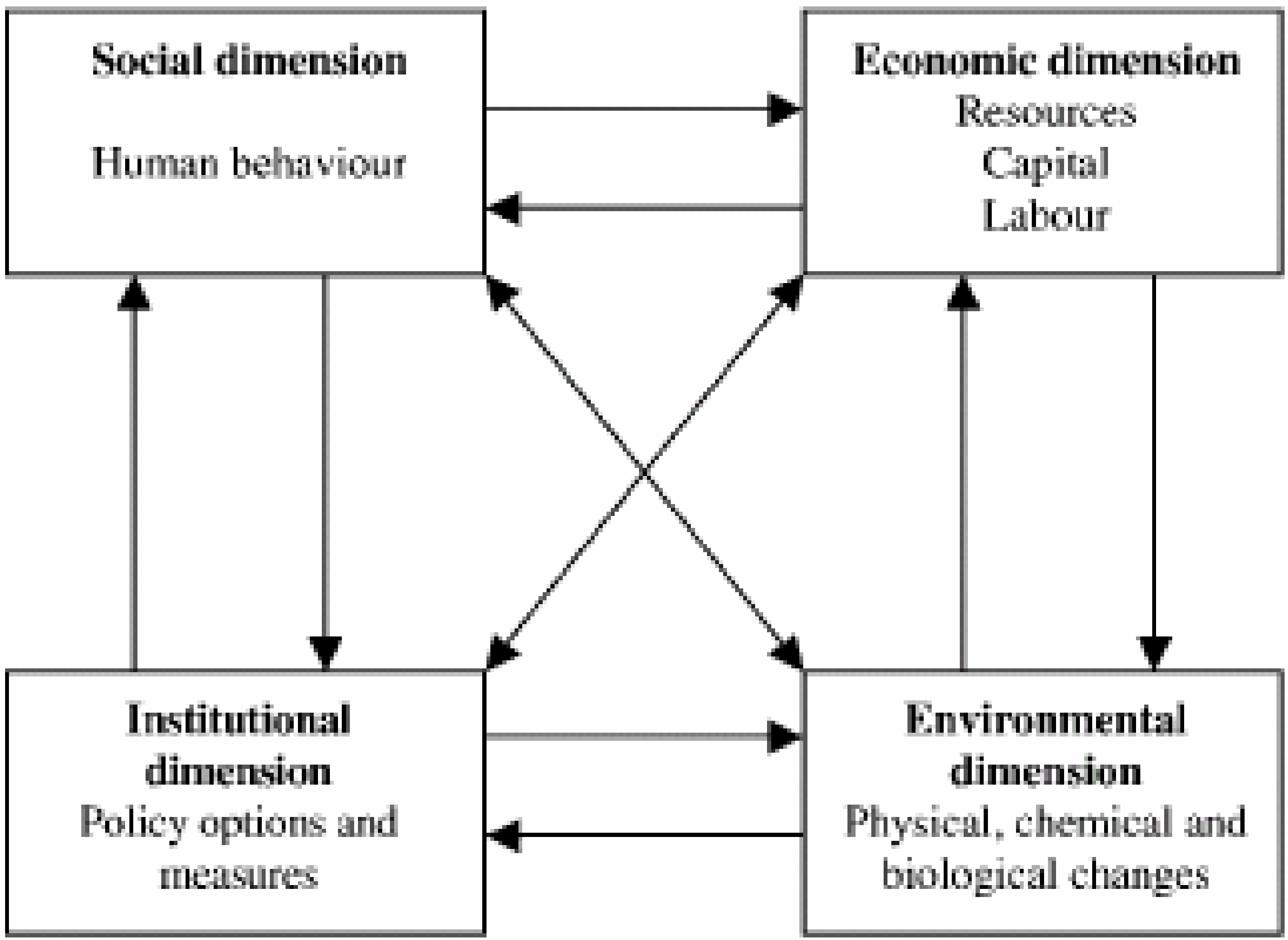
Reasons for concern

- “waste management” complex: generation, collection, processing, transport and disposal of waste
- large population groups and workers involved
- chemicals by way of inhalation of contaminated air, consumption of contaminated foods, water or dermal contact with contaminated soil
- many chemicals are known to be persistent, bioaccumulative, carcinogenic or endocrine disruptors
- Different stakeholders with competing interests

EU policy: The waste hierarchy



Rotmans and van Asselts, 2001



Typical characteristics of complex - uncertain - risks

- Decisions will need to be made before conclusive scientific evidence is available
- Potential impacts of ‘wrong’ decisions can be large
- Values are in dispute
- Knowledge base is characterized by large (partly irreducible, largely unquantifiable) uncertainties, multi-causality, knowledge gaps, and imperfect understanding;
- More research ≠ less uncertainty; unforeseen complexities!
- Assessment dominated by models, scenarios, assumptions, extrapolations

(Funtowicz & Ravetz)

Uncertainties

- Identify, assess, consider the consequences (dealing with uncertainties)
- Create, introduce, induce (fabricating uncertainties)
- Hide, negate (wiping out uncertainties)

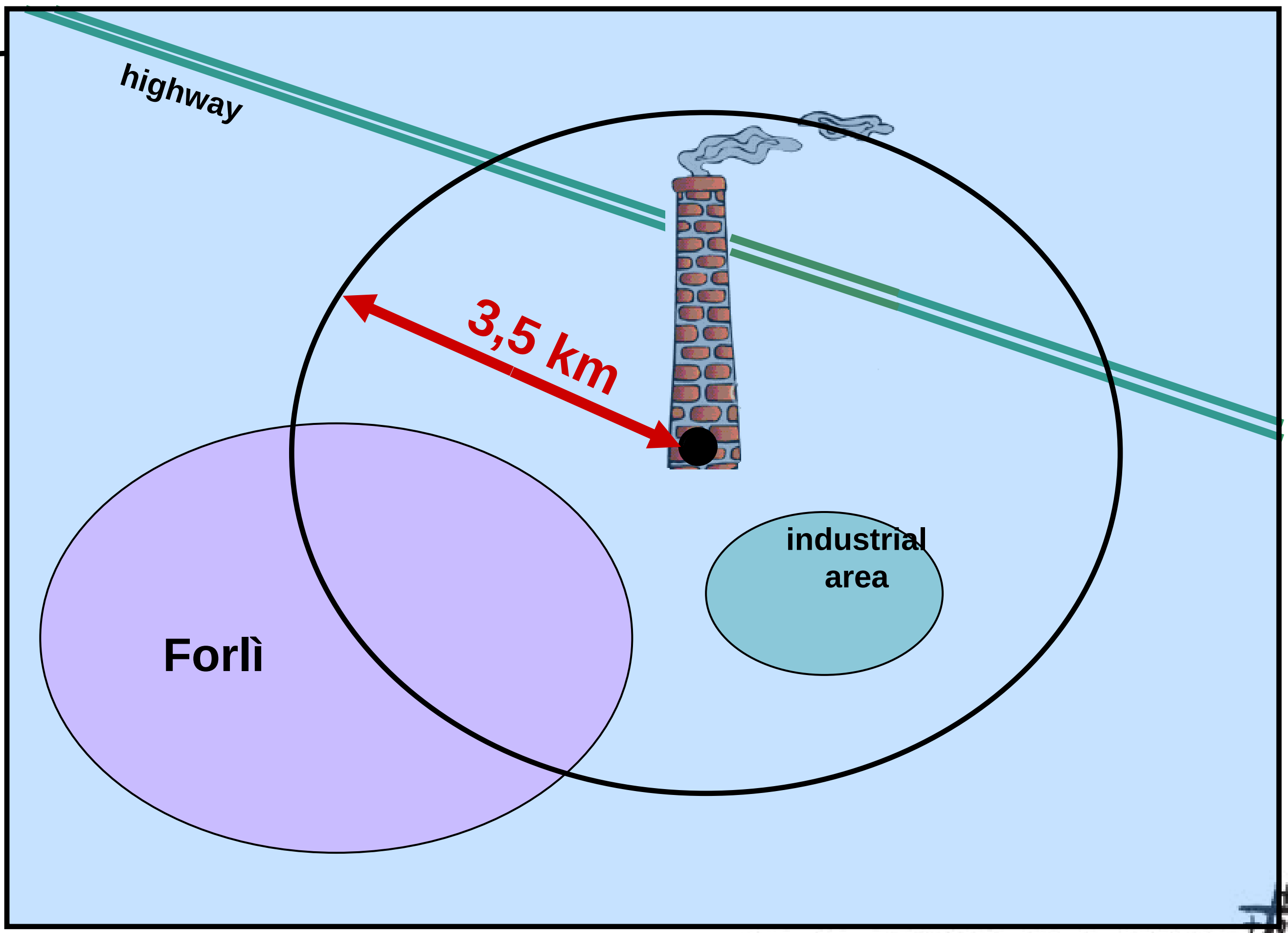
An Epidemiologic Study in the Area of Coriano (Forli')

Working Group:

ASL di Forlì,
ARPA Struttura di Epidemiologia Ambientale,
Registro Tumori della Romagna,
Dipartimento di Epidemiologia ASL Roma E

study area

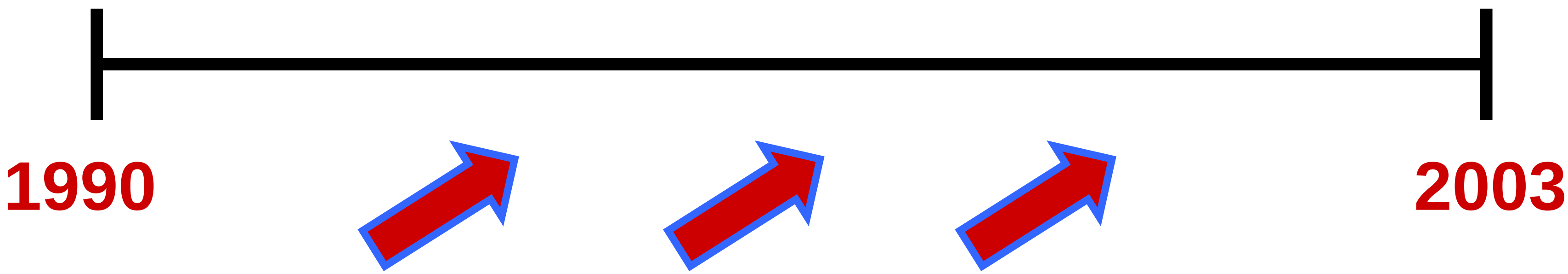
Coriano (Forlì)



area within the circle of 3.5 km radius from two incinerators located in the industrial area

cohort study

cohort of residents in Coriano on Jan 1,1990 and those subsequently entered in the area until Dec 31, 2003



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data base

residence history

mortality follow-up

cohort enrollment

(registry office of the municipality of Forlì)

cancer incidence

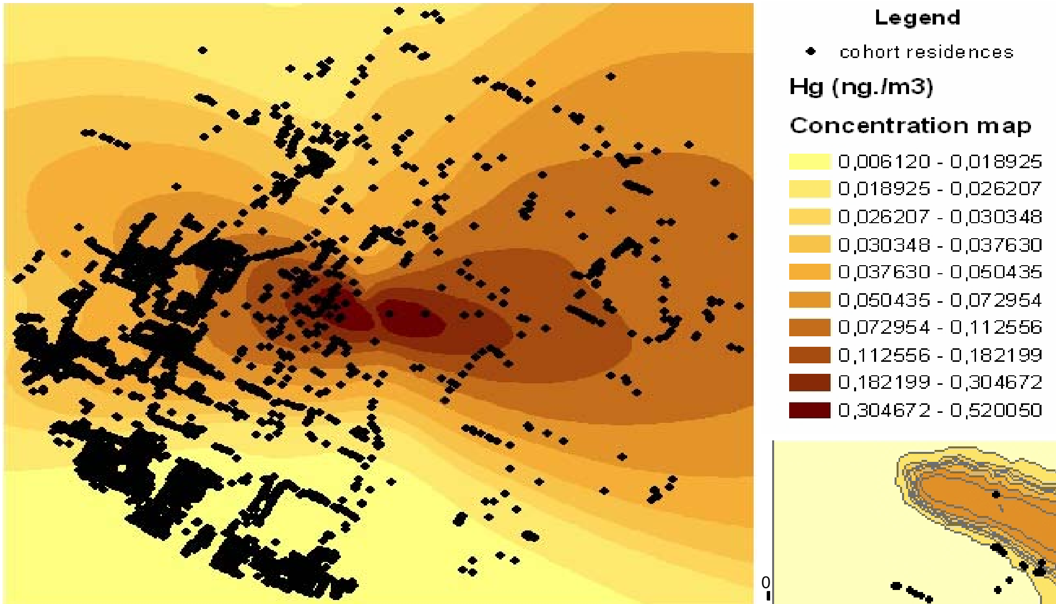
hospital admissions

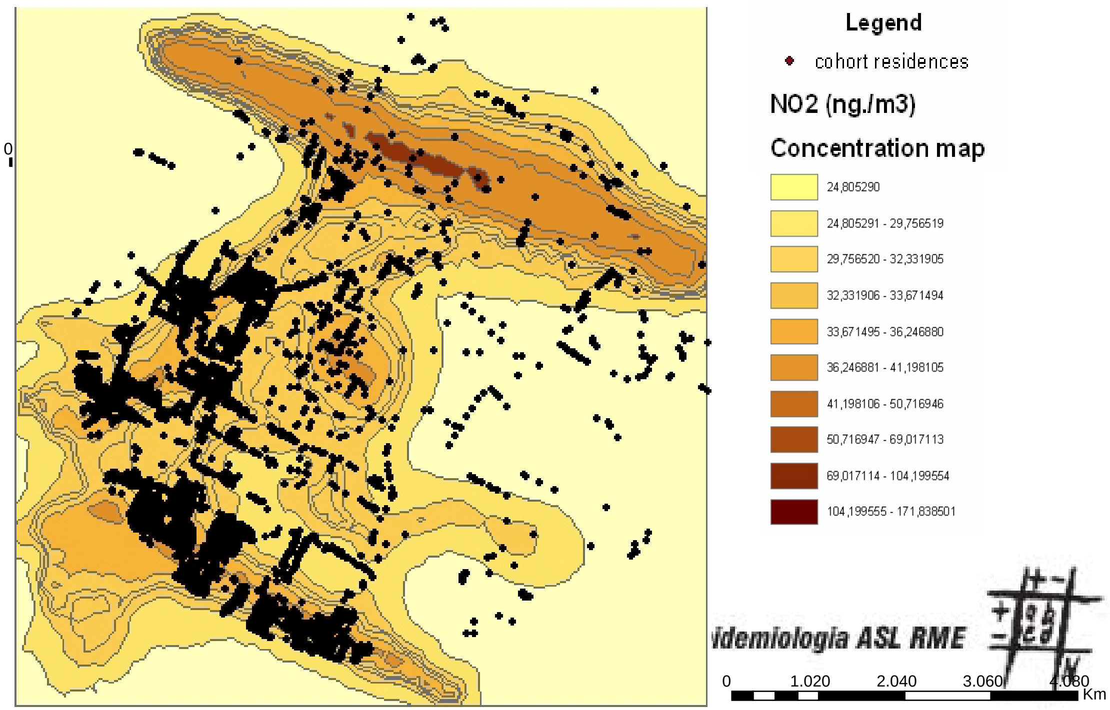
outcomes

outcome	period	source
mortality	1990 – 2003	Mort. Reg.
cancer incidence	1990 – 2003	Cancer Reg.
hospital adm.	1998 – 2003	HDR

Environmental indicators

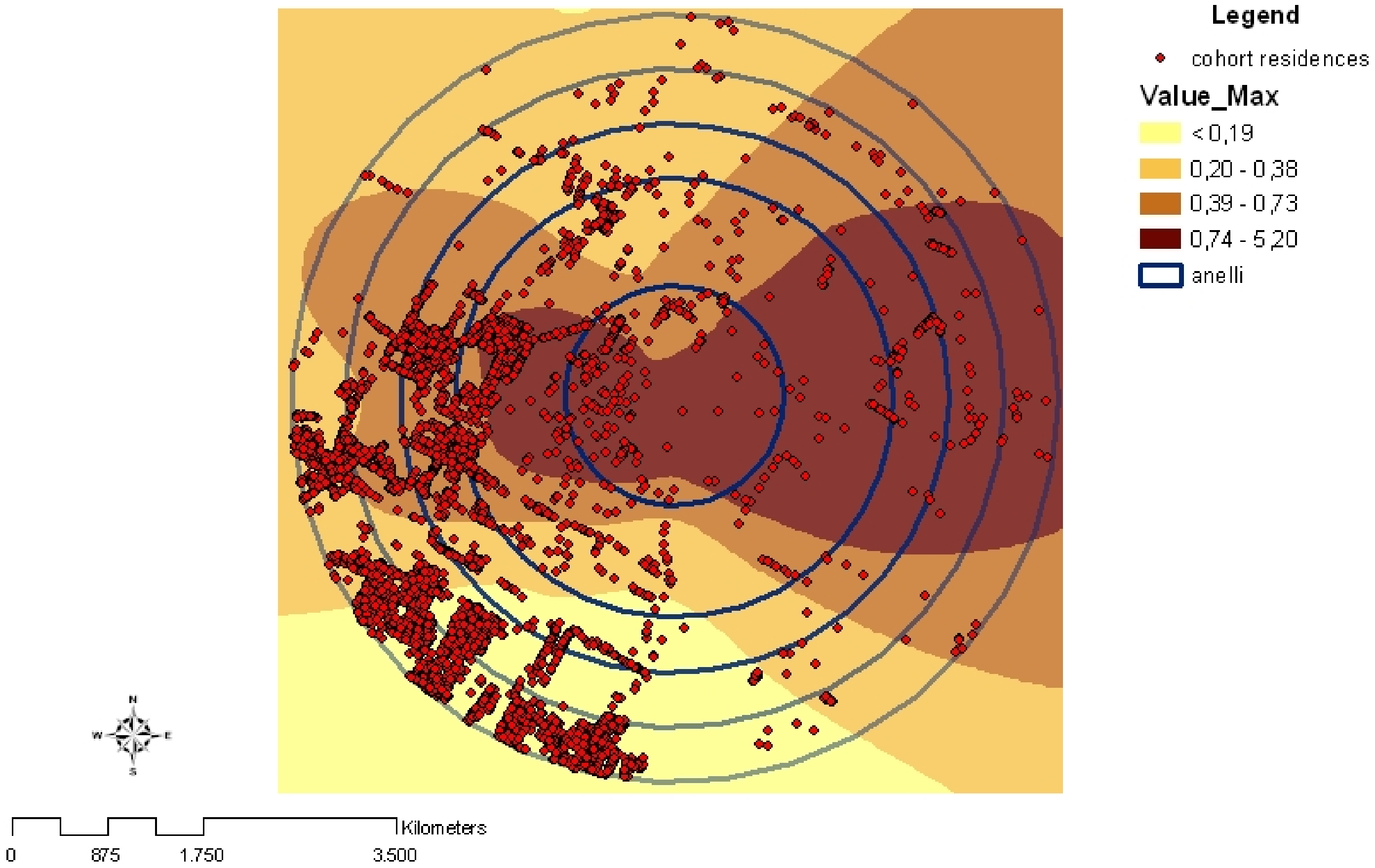
Incinerators





Total

Cohort of residents with 5 rings and Hg



socioeconomic level

results

% distribution by heavy metals

men
total cohort

	heavy metals			
socioeconomic level*	1	2	3	4
low	8.0	7.4	14.3	19.5
medium low	21.3	12.8	41.4	35.1
medium	27.1	23.1	30.6	28.5
medium high	31.7	31.0	13.0	16.9
high	11.9	25.7	0.7	0.0
total individuals (men)	6693	4833	5767	2114

*quintiles of total distribution (municipality of Forlì)

main results

- we observed an increase of soft tissue sarcoma among exposed to high levels of heavy metals, both for men and women

- moreover, only for women we observed:
  - an increase in all cause and all cancer mortality;
  - an increase in stomach and colon cancer incidence;
  - an increase in breast cancer mortality (but not incidence)

study design

→ retrospective cohort with individual data collection

→ complete follow-up

→ use of dispersion models allowed the evalutation of air pollution exposure (multiple sources)

limits

→ residential history <1990 not available

→ exposure data refer to a specific point in time (static measure)

→ lack of information on confounding factors (occupational history, smoking habit...)

INTARESE

Exposure and health impact assessment from waste management options

WP 3.6 Waste

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The INTARESE Partnership

- 33 partners, in 14 countries, including:
  - Universities
  - National research institutions/centres
  - National governmental agencies
  - IGO
  - Industry
- Co-ordinated by Imperial College London and ICON
- Advisory board including users from:
  - Research/science (other EU projects)
  - EU institutions (EEA, JRC)
  - Industry

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For More Information

Visit the INTARESE Web Site

www.intarese.org

A 5-year Integrated Project

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INTARESE WP 3.6 Waste

To assess potential exposures and health effects from solid wastes trhoughout their lifecycle

Key objectives

1. **To review the estabilished and suspected health effects of exposures deriving from the waste management cycle**

2. **To identify gaps in knowledge and methodology for effective characterisation of the health impact of waste disposal in Europe**

3. **To develop tools and methods for exposure and health risk assessment**

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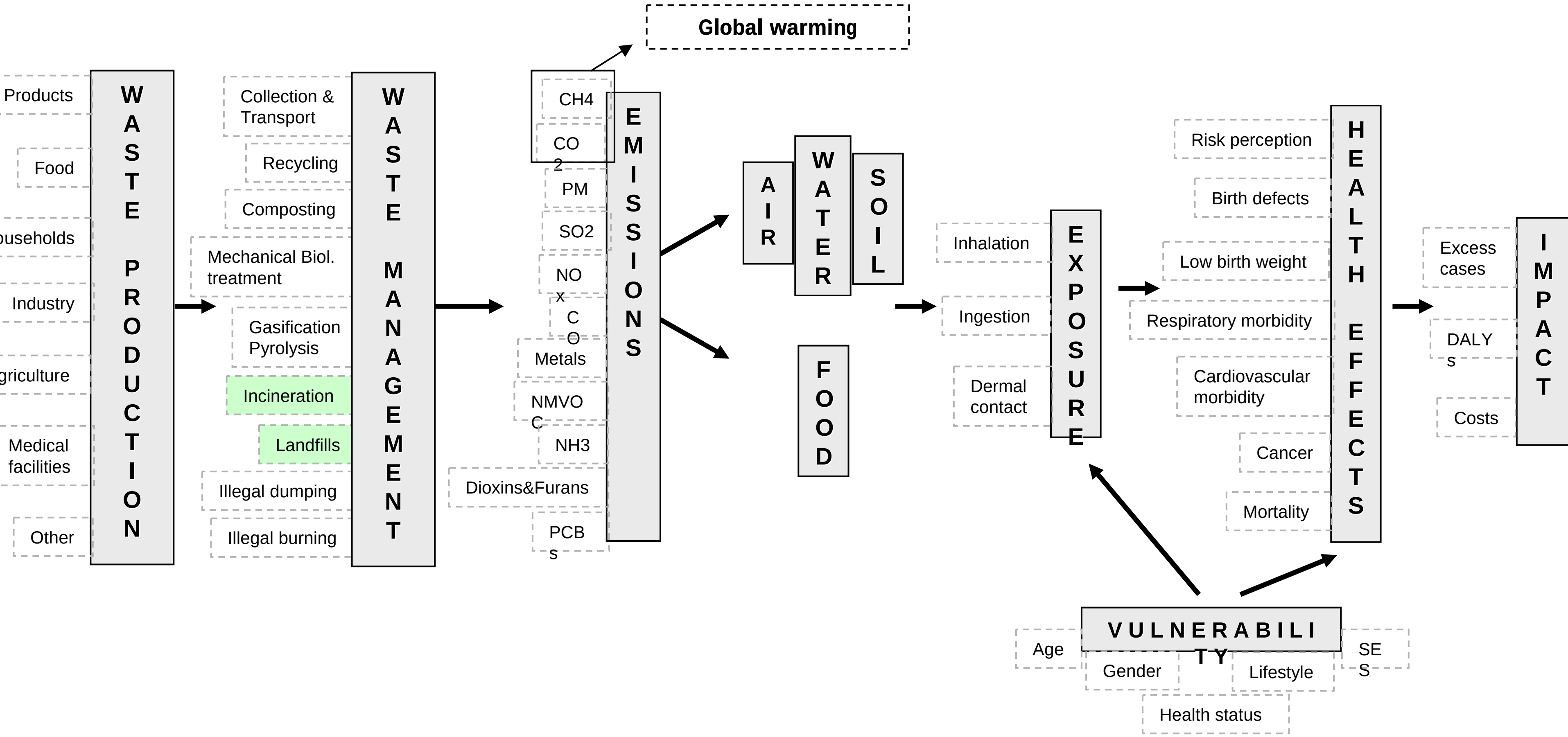
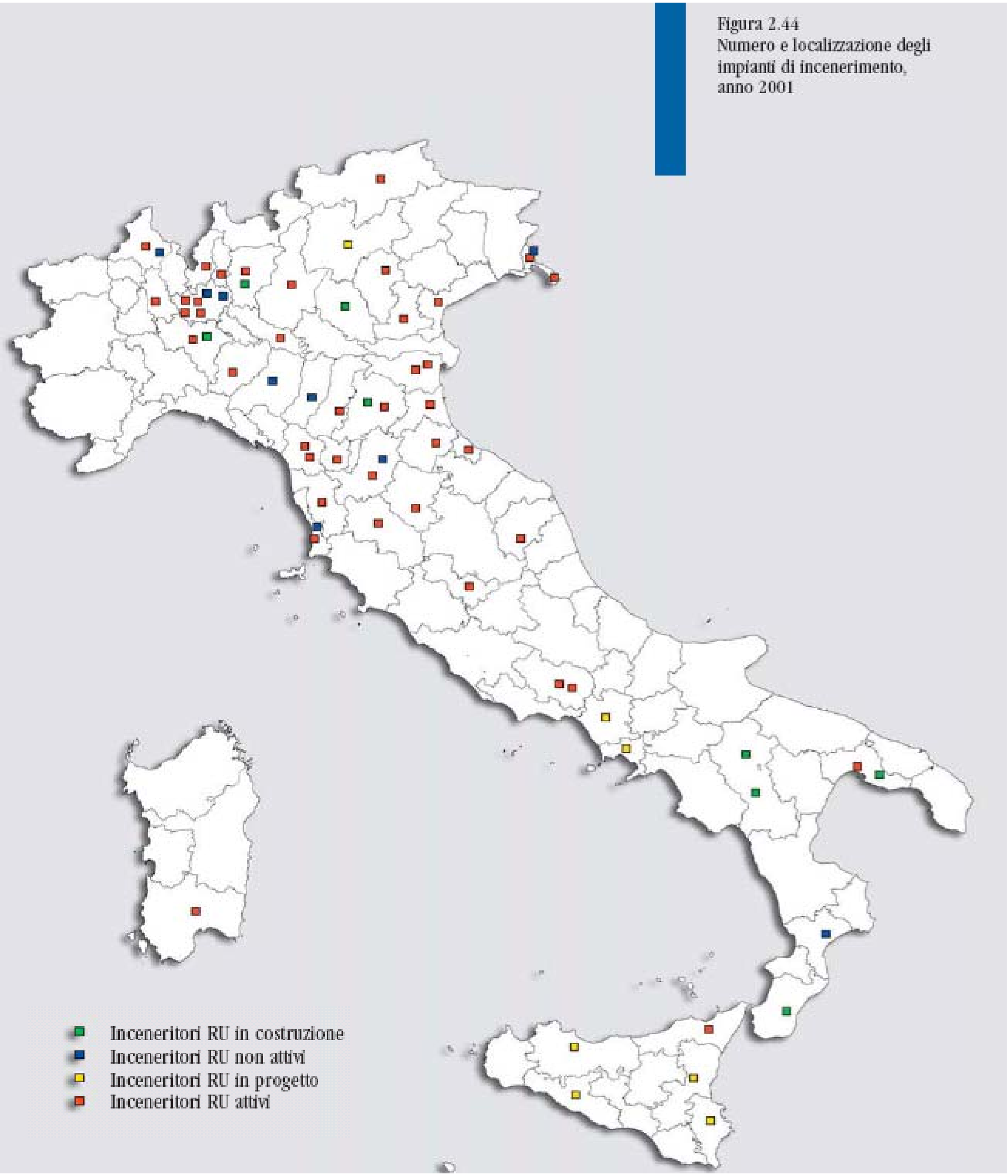
The full chain approach - from waste production to health effects



Incinerators in Italy, 2001



Relevant issues for risk assessement

- **Estimate the impact from past exposure conditions**
  - **what is the impact (today and tomorrow) of incinerators operating during the ‘70 and the ’80?**
- **Estimate the impact from current exposure conditions**
  - **what is the impact (today and tomorrow) of incinerators operating today?**
- **Estimate the impact from future exposure conditions**
  - **what will be the impact (tomorrow) of new incinerators operating in the future?**

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Approaches to risk assessement

Time of exposure	Exposure data	Health data
Yesterday	no quantitative data, only distance from the source (retrospective dispersion modelling?)	health data available but no dose response functions, only relative risks
Today	Exposure distribution for air pollutants from modelling, population data available	dose response functions available for some pollutants, time dimension uncertain
Tomorrow	Exposure distribution for air pollutants from modelling, population data uncertain	Uncertainties for some dose-response functions, time dimension uncertain

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Step 1: yesterday

- **Estimate the impact from past exposure conditions**
  - **e.g. what is the impact (today) of incinerators operating during the '70 and the '80?**
  - **Easy!!!:**
    - **estimate population size (GIS)**
    - **derive relative risks(RRs) from the literature**
    - **apply RRs to the population and get expected cases**

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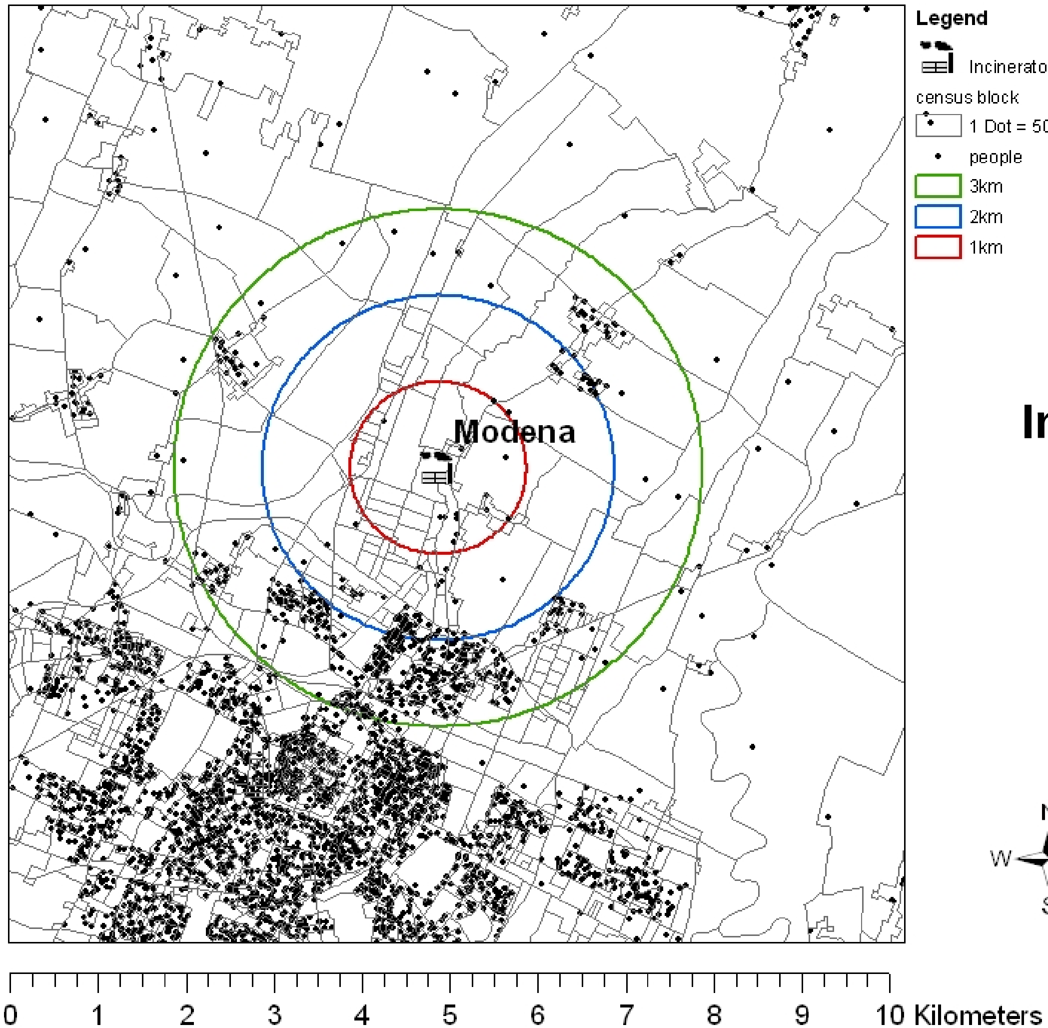
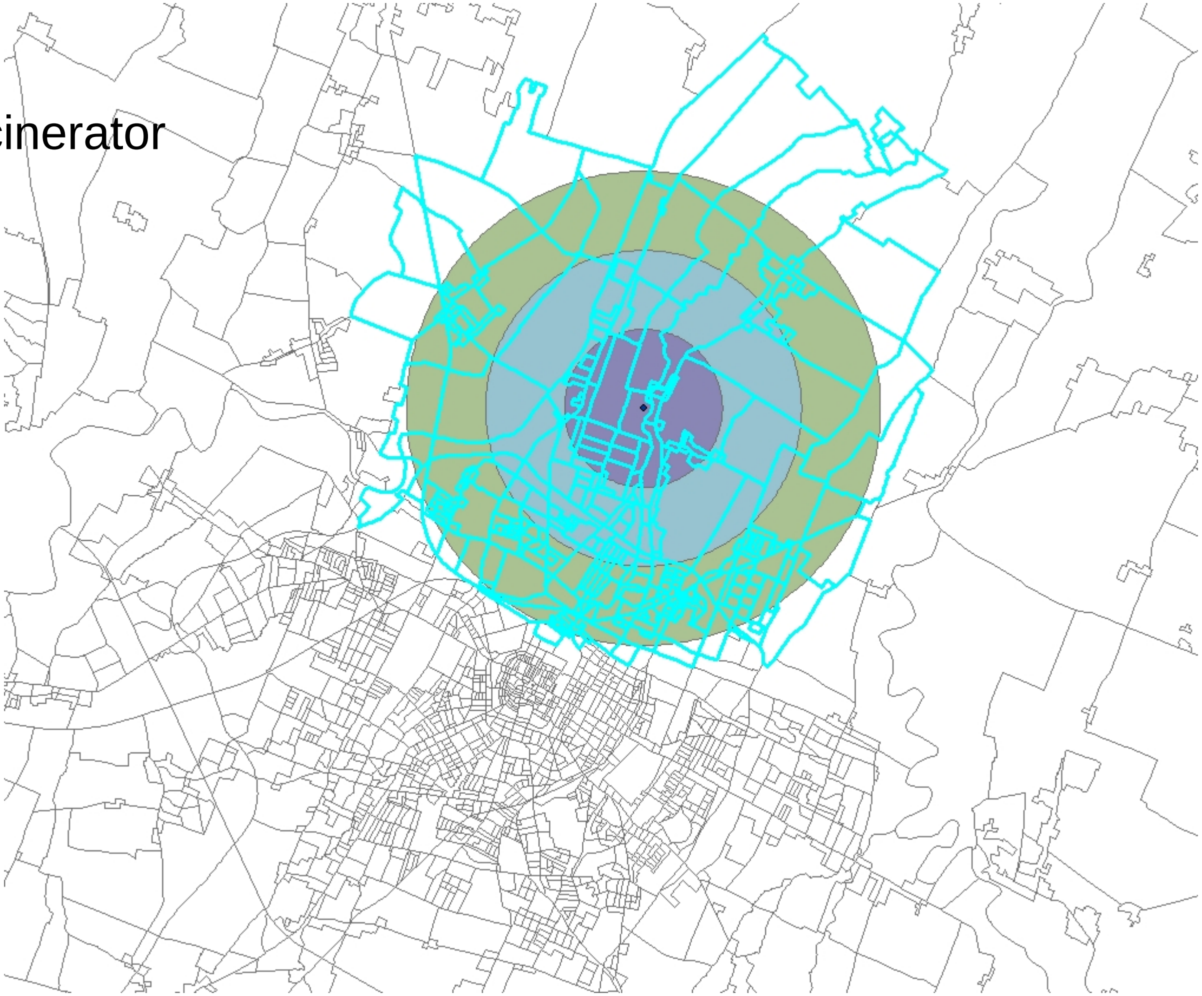


Incinerator located near Modena

Estimate of the population
All census blocks within 3 km from the plants

Modena incinerator



Systematic review of epidemiological studies on health effects associated with waste management

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AIM

To assess potential exposures and health effects arising from municipal solid waste:

- cancers (stomach, colorectal, liver and lung cancer, soft tissue sarcoma, kidney and bladder cancer, non Hodgkin's lymphoma, childhood cancer)

- birth outcomes (congenital malformations, low birth weight, multiple births, abnormal sex ratio of newborns)

- respiratory, skin and gastrointestinal symptoms or diseases

METHODS (1)

Relevant papers were found through:

- Computerized literature searches on the MEDLINE e PUBMED databases, using the MeSH terms "waste management", "waste products", "health effects" → 427 papers
- FREE SEARCH, with several combinations of relevant key words "waste incinerator or landfill or composting or recycling", "cancer or respiratory effects or birth outcome or health effects" → 224 papers
- references listed in 8 previous REVIEWS

from 01/01/1983 through 31/12/2006

METHODS (2)

Were not included

- Articles in languages other than English
- studies on industrial, toxic or hazardous waste
- on sewage treatment
- on biological monitoring
- studies conducted at municipality level

↓

total papers reviewed: 42

METHODS (3)

Papers have been grouped according to the following criteria:

- Waste management technologies (recycling, composting, incinerating, landfill)
- Study population (general population or workers employed in waste management plants)
- Health outcomes (e.g. cancers, birth outcomes, etc.)

METHODS (4)

For each paper :

- results with respect to the quantification of the health effects studied
- the potential sources of uncertainty in the results due to design issue have been reported

SOURCES OF UNCERTAINTY

The possibility that selection bias, information bias, confounding could artificially increase or decrease the relative risk estimate has been noted using the plus/minus scale

PLUS/MINUS SCALE

	- - -	- -	-	+	++	+++
%	50	20	0	20	50	

Final evaluation

OVERALL EVALUATION OF EVIDENCE (IARC, 1999):

Inadequate: available studies of insufficient quality, consistency, or statistical power to decide the presence or absence of a causal association

Limited: a positive association has been observed between exposure and cancer, but chance, bias, or confounding could not be ruled out with reasonable confidence.

RELATIVE RISKS:

Only when the evidence is at least "limited", extract the relative risks from the relevant studies

ASSESS THE DEGREE OF UNCERTAINTY OF THE RELATIVE RISKS:

use of a scale "degree of uncertainty" (very high, high, moderate, low, very low).

RESULTS: environmental exposure

Communities living near LANDFILLS:

- limited evidence of an increased risk of congenital malformations (moderate level of uncertainty)
- limited evidence of an increased risk of low birth weigth (low level uncertainty)

RESULTS: environmental exposure

Communities living near INCINERATORS:

- limited evidence of an increased risk of liver cancer, non Hodgkin’s lymphoma and soft tissue sarcoma (low level of uncertainty)
- limited evidence of an increased risk of stomach, colorectal and lung cancer (moderate level of uncertainty)
- limited evidence of an increased risk of some subgroups of congenital anomalies (moderate level of uncertainty)

Evaluation

HEALTH EFFECT	LEVEL OF EVIDENCE	
	Landfills	Incinerators
All cancer	Inadequate	Limited
Stomach cancer	Inadequate	Limited
Colorectal cancer	Inadequate	Limited
Liver cancer	Inadequate	Limited
Larynx cancer	Inadequate	Inadequate
Lung cancer	Inadequate	Limited
Soft tissue sarcoma	Inadequate	Limited
Kidney cancer	Inadequate	Inadequate
Bladder cancer	Inadequate	Inadequate
Non Hodgkin's lymphoma	Inadequate	Limited
Childhood cancer	Inadequate	Inadequate
Total birth defects	Inadequate	Inadequate
Neural tube defects	Limited	Inadequate
Orofacial birth defects	Limited	Limited
Genitourinary birth defects	Inadequate	Limited
Abdominal wall defects	Limited	Inadequate
Gastrointestinal birth defects	Inadequate	Inadequate
Low birth weight	Inadequate	Inadequate
Respiratory diseases or symptoms	Inadequate	Inadequate

Relative Risks

Outcome	Distance from the source	Relative Risk (Confidence Interval)	Level of uncertainty
Landfills			
Congenital malformations (Elliott et al, 2001)			
All congenital malformations	Within 2 km	1.02 (99% CI = 1.01-1.03)	Moderate
Neural tube defects	Within 2 km	1.06 (99% CI = 1.01-1.12)	Moderate
Hypospadias and epispadias	Within 2 km	1.07 (99% CI = 1.04-1.11)	Moderate
Abdominal wall defects	Within 2 km	1.05 (99% CI = 0.94-1.16)	Moderate
Gastroschisis and exomph alos[1]	Within 2 km	1.18 (99% CI = 1.03-1.34)	Moderate
Low birth weight (Elliott et al, 2001)	Within 2 km	1.02 (99% CI = 1.052-1.062)	Low
Very Low birth weight	Within 2 km	1.02 (99% CI = 1.03-1.06)	Low
Incinerators			
Congenital malformations (Cordier et al, 2004)			
Facial cleft	Within 10 km	1.30 (99% CI = 1.06-1.59)	Moderate
Renal dysplasia	Within 10 km	1.55 (99% CI = 1.10-2.20)	Moderate
Cancer (Elliott et al, 1996)			
All cancer	Within 3 km	1.035 (99% CI = 1.03-1.04)	Moderate
Stomach cancer	Within 3 km	1.07 (99% CI = 1.02-1.13)	Moderate
Colorectal cancer	Within 3 km	1.11 (99% CI = 1.07-1.15)	Moderate
Liver cancer	Within 3 km	1.29 (99% CI = 1.10-1.51)	Low
Lung cancer	Within 3 km	1.14 (99% CI = 1.11-1.17)	Moderate
Soft tissue sarcoma	Within 3 km	1.16 (99% CI = 0.96-1.41)	Low
Non Hodgkin's lymphoma	Within 3 km	1.11 (99% CI = 1.04-1.19)	Low

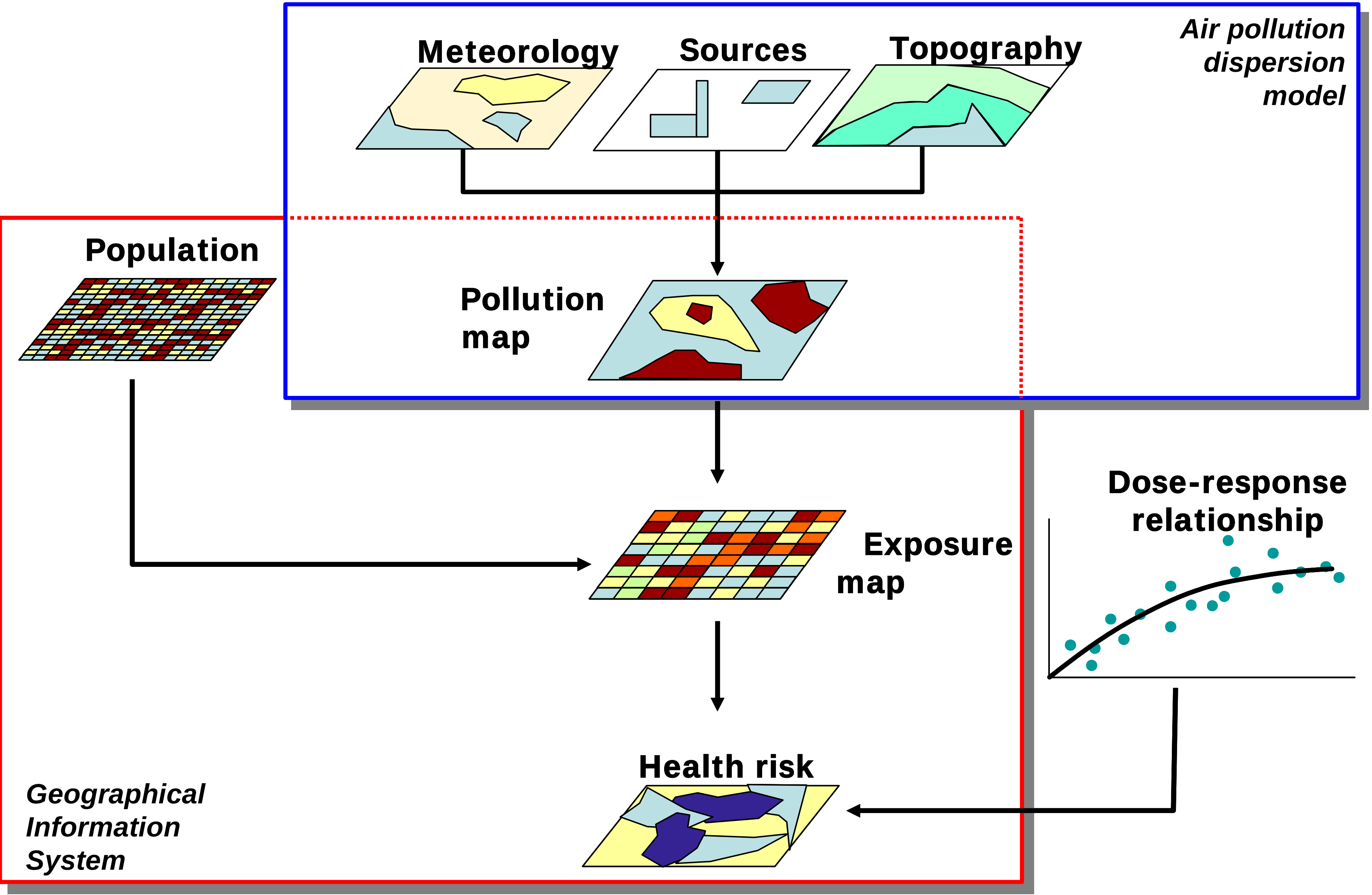
Step 1

- **Estimate the impact from <u>past</u> exposure conditions**
  - **e.g. what is the impact (today and tomorrow) of incinerators operating during the ‘70 and the ’80?**
  - **Easy, but consider duration/latency dimension. E.g. for cancer**
    - **0-10 years: RR*0**
    - **11-20 years: RR*0.5**
    - **21-30 years: RR*1.0**
    - **31-40 years: RR*0.5**

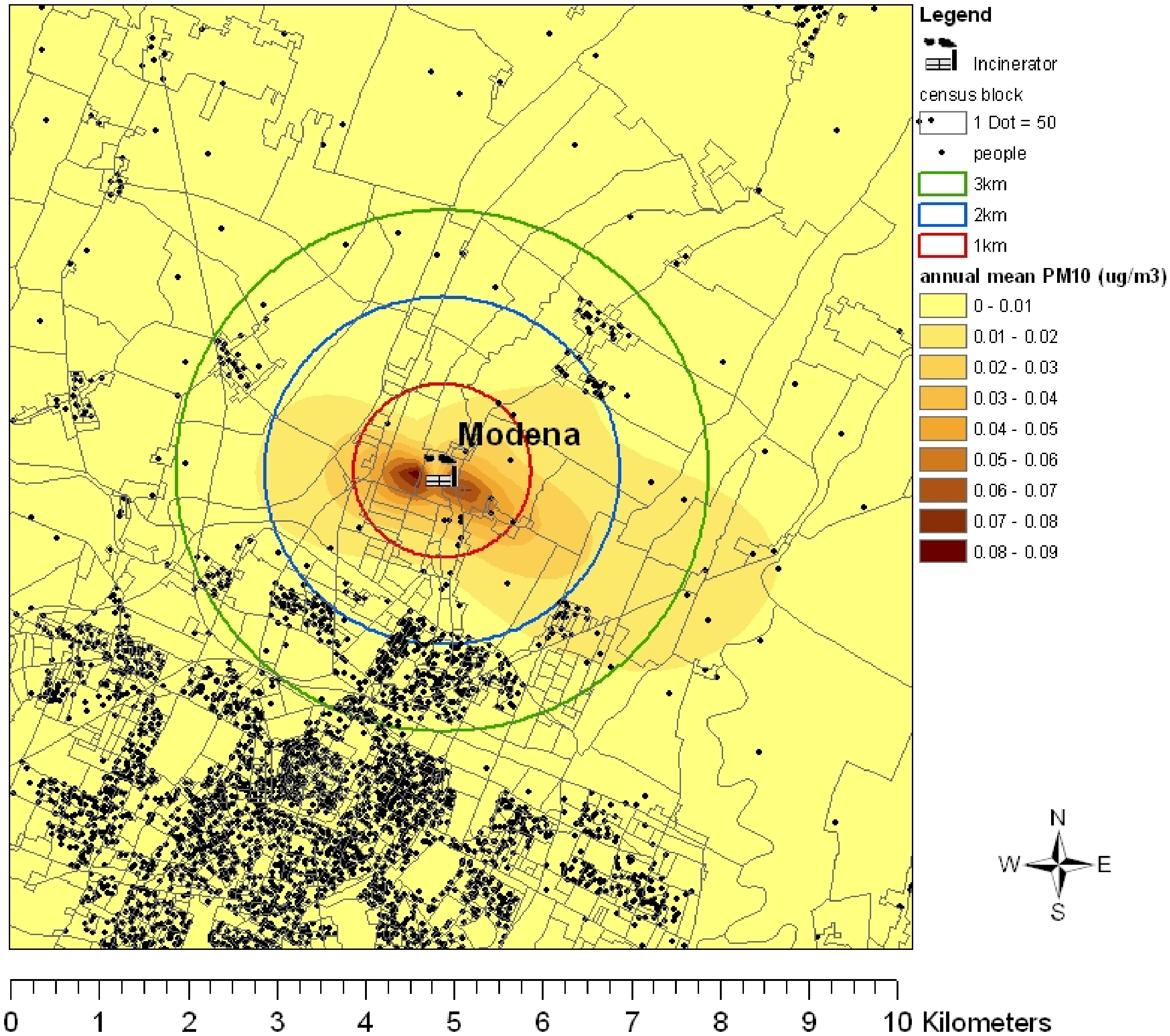
Step 2: today

- **Estimate the impact from current exposure conditions**
  - **e.g. what is the impact (today and tomorrow) of incinerators operating today?**
  - **Easy!!!:**
    - **run dispersion model and estimate population distribution of exposure (GIS)**
    - **derive dose-response functions from the literature**
    - **apply dose-response functions and get expected cases**

Exposure modelling and dose-response for classical pollutants

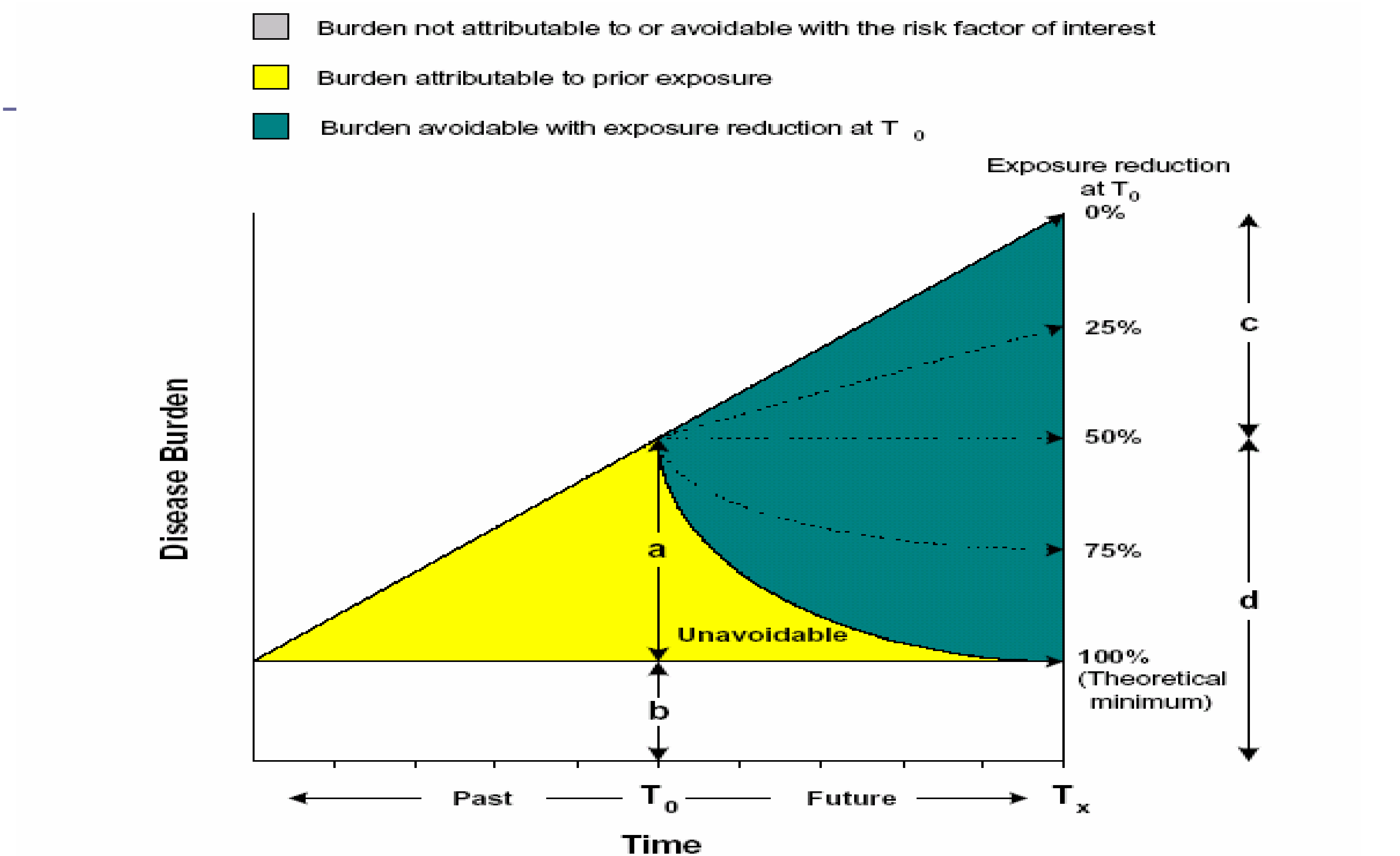


Exposure map: PM10



Step 2

- **Estimate the impact from current exposure conditions**
  - **e.g. what is the impact (today and tomorrow) of incinerators operating today?**
  - **Easy, but consider time dimension.**
    - **When the 3-4% increase in mortality per 10 ug/m3 PM10 will start to operate? Constant with time? When a decline of the effect is estimated?**



Time, intervention and diseases burden (Murray et al, 2003)

Conclusions

- New epidemiological studies based on individual data, good exposure assessment, control of confounding, multisite protocols (e.g.Moniter)
- Integrated risk assessment should consider the time dimension of exposure and of the health effects
- GIS (distance, old) and Dispersion modelling (new) methods should be combined
- More research tends to increase uncertainty: reveals unforeseen complexities

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