

Chemical Hazards and Poisons Report

From the Centre for Radiation, Chemical and Environmental Hazards
September 2011 Issue 20



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Editorial

Editors: Professor Virginia Murray and Andrew Kibble

Associate Editors: Dr Laura Mitchem, Alec Dobney and Catherine Keshishian

**Centre for Radiation, Chemical and Environmental Hazards,
Health Protection Agency**

Over the years the Chemical Hazards and Poisons Report has emerged as an important source of advice and information on an increasingly broad range of topics from chemical incident management through to climate change. Our recent survey of users (pages 4 and 5) suggests that articles published in the report are clearly valued and of interest, with over 95% of respondents rating the report good or excellent. It was also clear that subscribers welcome electronic access to the Report and often forward it to colleagues via email. The Report is intended to be a platform for the rapid and timely dissemination of incident reports, lessons identified and summaries of new guidance and research to a wide range of professional groups, in order to improve multiagency response to chemical incidents and protect health.

One of the key roles of the HPA is to expand and strengthen the evidence base upon which we make health protection decisions. There is a surprisingly small amount of research underpinning health protection work in the field of chemicals and non-infectious diseases. This is the underlying theme with this issue of the Report, with articles highlighting the new HPA statement on landfills and health (pages 19 and 20); important new work and opinions on the health impacts of air quality and health (pages 21–28); the issues presented by the recovery phase of a large chemical or radiological incident (pages 10–12); new research projects on risk prioritisation and exposure characterisation (pages 29–31); and the impacts of issues such as heat stress and extreme weather (flooding and thunderstorms) (pages 40–55). The Report also contains our regular features such as incident management, which this time looks at the public health issues associated with spillages from domestic oil supplies (pages 6–9), and toxicology, which includes an article on the development of EU programmes on human biomonitoring (pages 32 and 33).

At a glance

The front cover shows an HPA scientist investigating the effectiveness of wipe sampling on a range of internal and external building surfaces. This work, with radiation colleagues, is looking at developing experimental methods to better understand the behaviour of chemical and radiological substances on urban surfaces following an industrial accident or CBRN incident. Does natural weathering have an effect on radionuclides on outdoor surfaces? Do heavy metals behave differently on porous and non-porous materials? Read more about this work and related work on chemical recovery in articles by Brown et al (pages 13–16) and Wyke et al (pages 10–12).

The back cover shows a typical landfill site in the UK. Macklin et al have summarised recently published advice from the HPA on landfill sites and health (pages 19 and 20).

The next issue of the report is planned for early 2012; guidelines for authors and a permission to publish form can be found on the website at www.hpa.org.uk/chemicals/reports. Please do not hesitate to contact us about any papers you may wish to submit on chapreport@hpa.org.uk, or call us on 020 7811 7141.

We are very grateful to Dr Naima Bradley, Mary Morrey, Andrew Tristem and Matthew Pardo for their support in preparing this issue. Thanks also go to Dr Graham Urquhart, Dr Sohel Saikat, Dr Gary Lau, Dr Toby Smith and James Stewart-Evans for their editing assistance.

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Survey Results

Thank you for your help

Catherine Keshishian

On behalf of the Chemical Hazards and Poisons Report editing team

When we published the spring edition of the Chemical Hazards and Poisons Report, we asked you, our readers, to tell us what you think – and what you would like to see in future editions. Thank you to all of those who took the time to respond. Here are the results!

How would you rate the report?

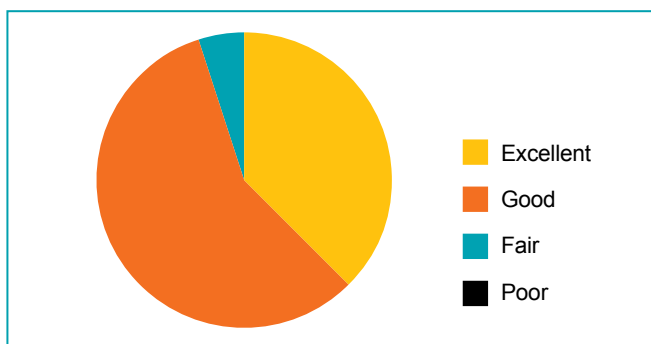


Figure 1: 95% of responders rate the report either 'excellent' or 'good' (n = 104), with no one rating it 'poor'

A key question for the editors of the report, as well as all the authors that have contributed to it over the years, was whether people actually like reading it. And it seems that our readers really do value it, with 95% of people saying they would rate the report either as excellent or good (Figure 1):

“Topics are relevant and useful.”

“It works well. Keeps things to the point and clarifies action points.”

“Very user friendly and visually attractive.”

“A very well put together report which is very accessible and a good source of sharing for incident response and lessons learned in particular.”

The majority of responders said that they use the report to give them an overview of work going on in other areas and by other organisations, with many also reading it to keep up to date on new developments in their own fields.

Who responded?

Hundreds of public health professionals, medical staff, local authority and emergency service staff, as well as HPA employees, subscribe to the report and we received responses from all of these groups. Interestingly, over 40% of those that responded actually don't subscribe directly but receive it from colleagues. Having it in an email format makes it easy for people to forward it on, and nearly half of you told us that you forward it to colleagues. This is great news, as it means the articles reach even more people than we thought!

Which parts and topics of the report do you like?

Figure 2 shows that, by far, chemical incident response articles are the most popular of the topics the report covers, and this was true of all of the professional groups who responded, except academics who preferred risk communication and perception. Surprisingly for us, risk perception and communication was actually the third most popular topic that people wanted to see in the report, and, taking on board some responders' suggestions for themed editions, we hope to make this the focus of an upcoming report. The other most popular subjects were decontamination, toxicology and new guidance and documentation. Articles covering climate change and natural hazards were added to the mix of topics covered by the report in 2008, as we recognise they affect all aspects of health and emergency response, including chemicals, and these topics particularly appealed to the medical and public health staff who responded.

Multiagency working and summaries of the roles and responsibilities of other organisations also scored very highly, and we feel that this is one of the strongest aspects of the report. Some responders particularly requested more information on this:

“More information from the emergency services about their procedures.”

“Joint training.”

“How to find advice when on scene.”

We are hoping to build on this and encourage more and more of our professional partners – local authorities, fire, police, ambulance, Environment Agency and others – to write for us and co-author incident response articles so that we get a truly holistic view of what went well and what could be done better in the future. If you have any incidents you'd like to write up for us, or have any other ideas for articles, or if you just have more comments to make, we'd be delighted to hear from you – please email them to chapreport@hpa.org.uk.

What could be improved?

Peer-reviewed publication

The Chemical Hazards and Poisons Report is intended as a platform for the dissemination of incident reports, lessons identified and summaries of useful information and research to a wide range of professional groups, in order to improve multiagency response to chemical incidents and protect health. Many of our articles therefore would not be suitable for peer-review, and this was recognised by survey responders:

“A good source of sharing for incident response and lessons learned in particular. There is no alternative source for much of this information that is as good.”

“I find the information invaluable in giving me the overview of incidents that occur nationally.”

Although not formally peer-reviewed, most articles are written by subject-matter experts, and every article is reviewed by a team of

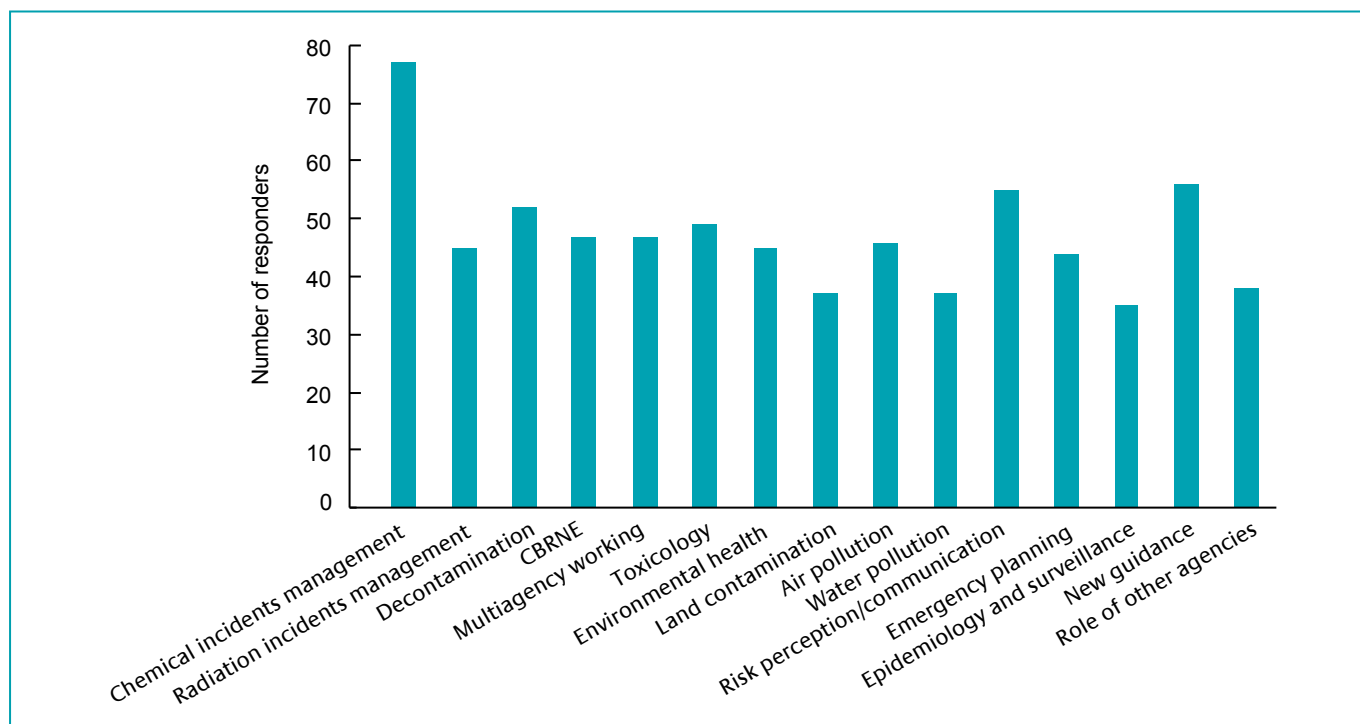


Figure 2: Topics of interest to survey responders (n = 100). The top 15 of 26 categories are shown; other popular topics included odours, exercise reviews and natural disasters

scientists within the HPA. We encourage authors from all backgrounds, including front-line responders who may not usually publish scientific articles, which means that the style of writing may vary, although the scientific quality remains high.

Shorter articles

Short and punchy articles were a definite hit with our readers, who wanted to be able to quickly find the information they were looking for. We have taken this feedback on board and are encouraging new authors to keep their pieces short and succinct, making the important public health lessons clear.

Index of previous articles

Six out of ten responders said that they either didn't know that the searchable index existed or did know but didn't use it. Every article that has been published in the Chemical Hazards and Poisons Report, as well as its predecessor the Chemical Incident Report, has been logged and keyworded in an MS Excel spreadsheet. This means you can search over 700 articles using whatever search term you like: tyre fires, mercury, smells, incinerators, etc. Instructions for its use are on the spreadsheet, and Figure 3 shows how it may look if you were searching for 'decontamination'. The index is available at www.hpa.org.uk/chemicals/reports.

Paper copies and dissemination

In 2010, we moved from sending out free paper copies of the Chemical Hazards and Poisons Report to an internet-only version. Although this decision was welcomed by many as being greener and easier to access and share, a few people expressed that they prefer having a hard copy. (One anonymous reader even stated they like to read it in the bath!)

We have decided to keep the current system of sending out email alerts when new issues are available online, which can be downloaded free of charge, but offer hard copies for those that are interested at £10.

Month	Year	Section	Article Title	Author(s) and Affiliation(s)	Keywords
April	2011	Incident Response	"Don't shoot the messenger." - Lessons identified in communicating with emergency departments during chemical incidents	Ian Guiney (Frimley Park Hospital, A&Es, Accident and emergency departments, contaminated casualties)	decontamination
April	2011	Incident Response	Report on the investigation of chemical leak from refrigerators in healthcare settings in London		
September	2009	Emergency Planning & Preparedness	Exercise Orpheus II, 16 July 2008. Hospital Emergency Departments		
September	2009	Emergency Planning & Preparedness	"Training the Frontline" - the CBRNE Pilot Course for Emergency Department staff March 2009, Homerton Hospital		
April	2009	Incident Response	Recent health protection issues in		

Figure 3: Customising the search terms in the article index (example search: decontamination)

The editing team try to reach as many professional groups as possible with the report and new issues are announced in various professional-body publications. If you have any ideas about how to increase circulation or know of any distribution groups that may be interested in receiving the report, we'd be delighted to hear from you. Please email chapreport@hpa.org.uk.

Thank you

The Health Protection Agency and its predecessor have been publishing the Chemical Hazards and Poisons Report for 12 years and over 700 articles have been read by hundreds of people in the UK and abroad. Originally set up to review chemical incident case studies and disseminate response guidance, over the years the report has grown to reflect current topics of interest with recent additions covering climate change and natural hazards. This survey has demonstrated that the diversity of the report is valued by a large range of professional groups, and we look forward to developing the excellent ideas suggested by the survey responders so we can provide an even more useful report in the future.

Incident Response

Domestic heating oil incidents

Evaluation of the usefulness of an action card for public health professionals

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Introduction

An estimated 1.2 million oil and fuel installations in England and Wales are located within domestic properties¹, with kerosene being the fuel most frequently used in domestic heating supplies. Kerosene is a complex liquid mixture of C9–C16 hydrocarbons produced from the distillation of crude oil, and will be referred to as domestic heating oil throughout this article.

The Health Protection Agency (HPA) is often contacted about domestic heating oil incidents (e.g. spills and leaks). Figure 1 illustrates the number and distribution of incidents involving domestic heating oil at residential properties between 2005 and 2010. The HPA is asked to advise on the health effects from vapours that have ingressed into a property and/or where heating oil has permeated through plastic water pipes and contaminated the potable water. Often the first indication of a problem at a property is an odour issue or the water has an oily taste or odour.

Overall the effective management of such incidents must be through a joined-up approach, usually led by the local authority with robust communication channels established between the agencies and other stakeholders that are involved. This is particularly important when communicating with the affected residents who require clear messages and reassurance on any potentially associated health issues.

In the past there has been limited information available to aid public health professionals who need to risk assess incidents involving domestic heating oil and make key decisions – for example, whether to evacuate

individuals from affected properties. Therefore, it was considered that an action card on domestic heating oil incidents should be made available, to help provide public health professionals with greater confidence in decision making and promote consistency and best practice throughout the HPA. This was achieved by providing action levels for air quality issues, as to when to evacuate and re-occupy a property and advice on when to use or not use contaminated water.

In October 2010, the action card was published by Centre for Radiation, Chemical and Environmental Hazards (CRCE), Chilton, with support from the Toxicology (General and Air Pollution) Team. The action card, which can be found on the HPA website at http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1284475799316, provides guidance on the health protection response to domestic heating oil incidents involving kerosene, which can impact on air or potable water quality at residential properties (see Figure 2 for a flow chart of the HPA activities surrounding a domestic heating oil incident). In conjunction with this document, information for the public was developed to aid the understanding of the roles of the agencies involved and potential risks to health.

It has now been over nine months since the heating oil action card was published, and during this time CRCE has been involved in eight domestic heating oil incidents. This article describes two case studies in which the action card has been used by HPA staff in responding to recent incidents. It aims to evaluate how effective the card has been and identify ways to improve the document.

Case study 1

The local Health Protection Unit (HPU) was alerted to a heating oil spill at a National Trust property in Shropshire, which was the result of a leak from an oil-fired central heating system. Following attendance of the fire and rescue service, the building was evacuated and the property



Figure 1: Regional distribution of domestic kerosene incidents in England and Wales between 2005 and 2010, requiring CRCE involvement (n = 72)

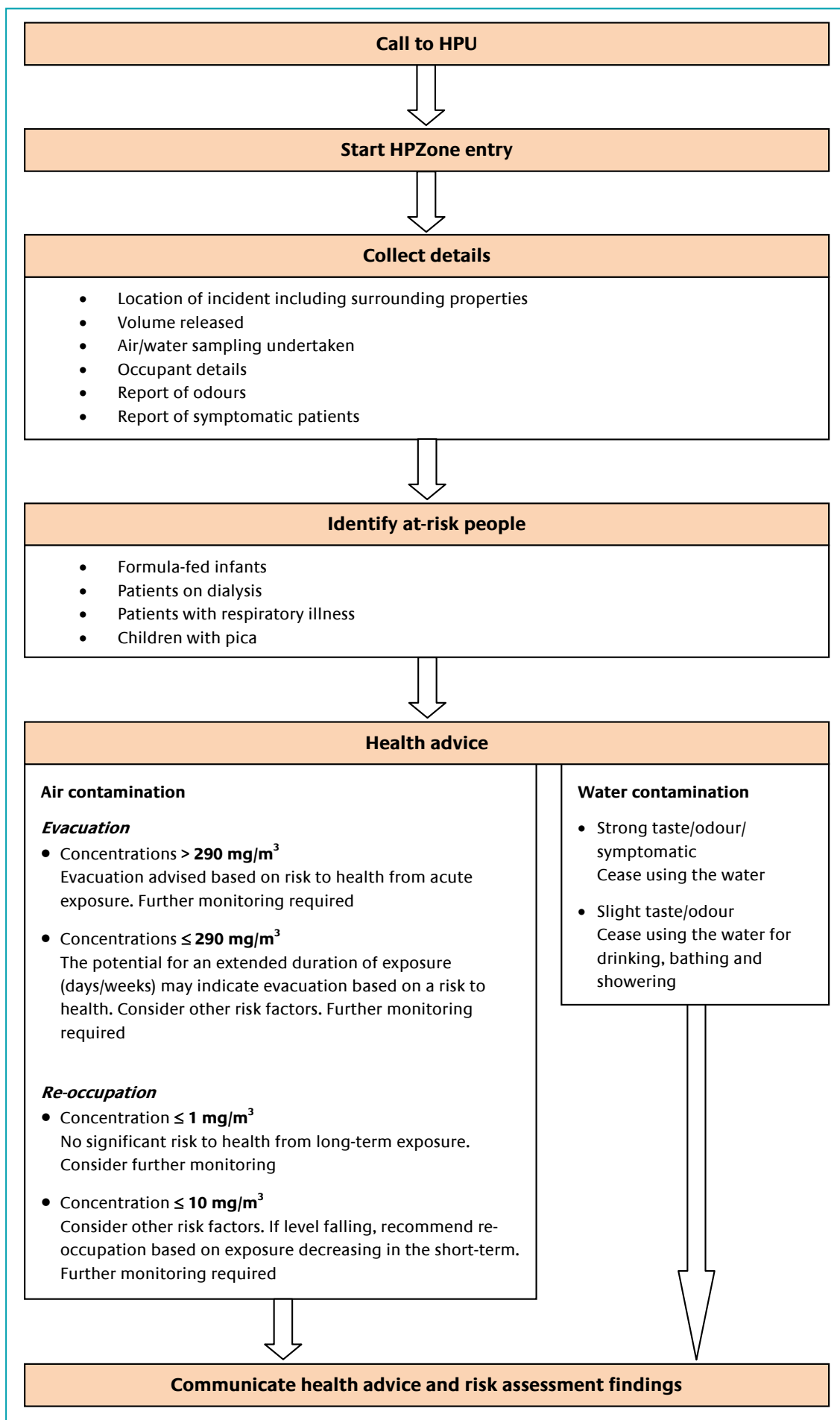


Figure 2: HPA activities around a domestic heating oil incident

manager was seeking advice regarding health risks to staff and if they could re-enter the property. While the initial query considered staff re-occupancy, it became clear that a number of residents had also been evacuated.

The local authority was contacted and confirmed the situation had been ongoing for a number of weeks. An estimated 1,200 litres of heating oil had been released at a distance from the property; however, during remediation the spill had migrated under the building. Following evacuation, residents were advised by environmental consultants involved in the ongoing remediation not to re-occupy the building until extensive air quality sampling had been completed, in order to ensure it was safe to re-occupy. The consultants on site had advised the property manager the building was safe to re-occupy based on a series of monitoring results taken within the property, with levels stated to have dropped below a 'safe level'. Confirmation was being sought from the HPA, by the property manager, regarding interpretation of this data.

CRCE provided the appropriate air concentration action levels, detailed in the action card, to the local HPU to support the risk assessment. The HPU expressed initial uncertainty, as levels were quoted in ppm not mg/m³ as stated in the action card, therefore clarification was requested from CRCE. In addition, it was initially difficult to obtain representative data for comparison with action levels. The HPA was requested to make health based decisions on initial air sample readings taken with a photo-ionisation detector (PID); however, on local authority and HPA insistence adsorption tube readings were provided to improve quality assurance and support the risk assessment. The incident highlighted the need for close multiagency working throughout an incident.

The air quality action level for re-occupancy was particularly useful in supporting decisions regarding re-occupancy of the property, as this provided a baseline which would be protective of health. However, following the weekend all agencies were surprised to learn that local residents had been allowed to re-enter the building, following advice from the property's loss adjuster, even though air concentrations exceeded those defined in the HPA action card. The rationale behind this decision was never shared with any of the agencies involved.

Following re-occupancy the local authority attended the scene to reiterate the HPA advice to the property owner and assess the property. The local authority was satisfied that re-evacuation of the residents was not required providing there were no odour complaints, ongoing ventilation and sampling continued, and the residents did not report symptoms associated with heating oil (kerosene) exposure. This incident exemplifies the difficulties which can arise when an owner wants a property re-occupied, a situation exacerbated due to the loss adjuster's contradictory advice.

Case study 2

CRCE was alerted about a Drinking Water Inspectorate notification at a single property in Herefordshire, where residents were complaining of taste and odour issues in their drinking water. A water sample was taken and this confirmed that hydrocarbons were present in the water supply. The cause of the contamination was believed to be a heating oil spill from a neighbouring property six months previously.

The water company issued a Do Not Drink notice to the affected residents. The Do Not Drink notice advised residents not to use the water for drinking or cooking until the affected plastic water pipes had been replaced with copper pipe work. Bottled water had been

provided to the residents as a goodwill gesture by the water company. It was noted that the water within the affected property, which was still being used for bathing and washing purposes, had a noticeably distinct odour. The water company confirmed that neighbouring properties were unaffected.

CRCE was asked to comment on the hydrocarbon levels reported in the water of 40 ng/L as the resident was concerned about potential health effects due to exposure. She was pregnant and there was also a small child resident at the property. As the reported levels were low, further clarification was requested. Following discussion with the relevant water company, hydrocarbon levels in the water supply were confirmed to be 40 µg/L, three orders of magnitude higher than that initially reported. On request the total petroleum hydrocarbon (TPH) range involved was provided to support the HPA risk assessment. In order to provide a risk assessment it is necessary to know the identity and concentration of the chemicals to which people are exposed. Heating oil is a complex mixture of a number of compounds and, therefore, knowledge of the TPH range will support the risk assessment.

The appropriateness of a Do Not Drink notice was queried. The hydrocarbon action card states: "If the residents are asymptomatic but there is a very strong taste or odour of oil in the water, residents should cease using the tainted water for all activities (including washing clothes and dishes), however contaminated water can still be used for flushing toilets." While the water company's risk assessment concluded the level of hydrocarbon in the water not to be a concern with respect to health, the issued notice was subsequently changed to a Do Not Use notice.

The CRCE General Toxicology Team supported the incident response by advising the levels present in the water were unlikely to cause adverse health effects. This statement is supported by the fact the World Health Organization² considers that taste and odour will, in most cases, be detectable at concentrations below those of concern for health. This information was provided to the member of the public via her GP, highlighting the need for reassurance to residents affected when responding to heating oil incidents.

Feedback from users of the action card

The authors contacted CRCE staff and some HPU staff involved in risk assessing domestic heating oil incidents since the action card was published, in order to identify the usefulness and potential improvements that could be made to the action card.

Overall the response to the domestic heating oil action card has been very positive, with public health professionals finding its style, format and content useful. In particular, staff have found useful: the provision of air quality concentrations to support evacuation and re-occupation of a property; the statements on odour/taste of water contamination and limiting the use of the water; and the stakeholders roles and responsibility section of the action card.

However, there are some suggestions for improvement which have been identified for consideration and we have sought to address each point separately below.

The conversion factor for mg/m³ to ppm is important when assessing analytical results, and therefore will be highlighted in the text of the main document.

The term 'heating oil' may be used to cover fuels other than kerosene – for example, bunker oil. Therefore, it has been suggested that equivalent advice on air and water contamination guidance for other fuel types would be useful for dealing with incidents. It is important to note that the fuel most commonly used as heating oil is kerosene. Although information on other fuels would be useful, there needs to be an investigation into the number of occasions the HPA has been asked to provide advice on alternative heating oil fuels. This is an important consideration as the development of additional action cards would require a substantial amount of further work and the need therefore must be assessed.

In one incident the local authority was concerned about the large difference between the values for considering evacuation (290 mg/m³) and re-occupation (10 mg/m³ and falling towards 1 mg/m³). There was particular concern over the re-occupation value being in their opinion quite low. An assessment of the public health implications from exposure to kerosene vapours is made difficult as there are no directly applicable environmental air quality standards. Until the scientific community undertakes further research into kerosene in order to improve upon the current toxicological information available, the values set out in the action card are the most applicable for a kerosene incident. It is also important to note that any decision about evacuation or re-occupation should not be solely based on vapour concentrations, but should take into account various other factors, which are discussed in the action card.

Local authorities and water companies may be reluctant to use the advice offered in the action card, for a variety of reasons including the lack of understanding that a heating oil spill can cause adverse health effects, the difference between the evacuation and re-occupation levels, and the local authority may not have access to suitable air quality monitoring equipment. Consequently, the action card could be strengthened to further engage local authorities. We will look at how this can be achieved in conjunction with some local authorities.

Interestingly, CRCE receive little feedback from other HPA staff about the usefulness of the advice, including documents provided during an incident. In order to be continuously improving, it is important that HPA staff are aware that CRCE values any constructive feedback to enable future improvement to the guidance provided.

Conclusions

The action card has been of use during domestic kerosene incidents and there are some improvements which can make it even more useful. Therefore, in addition to the comments discussed in this article we would appreciate further feedback from anyone using the action card – in particular, local authorities who have used the action card to respond to kerosene spills.

Please email feedback to louise.uffindell@hpa.org.uk.

Acknowledgments

The authors would like to thank Paul Harold, Peter Smith, Amanda Kilby and Charlotte Landeg-Cox for their input into this article.

References

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Emergency Planning and Preparedness

Developing the UK Recovery Handbook for Chemical Incidents and building the evidence base for recovery options

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Introduction

The Health Protection Agency (HPA), in collaboration with the Department for Environment, Food and Rural Affairs, Food Standards Agency, Home Office, Northern Ireland Environment Agency and Scottish Government, is developing a UK Recovery Handbook for Chemical Incidents. The UK Recovery Handbook for Chemical Incidents (UKRHCI) project was initiated in June 2009 and the handbook will be published in summer 2012.

The aim of the handbook is to provide a framework for choosing an effective recovery strategy following a chemical incident, and a compendium of practicable, evidence-based recovery options for inhabited areas, food production systems and water management areas¹.

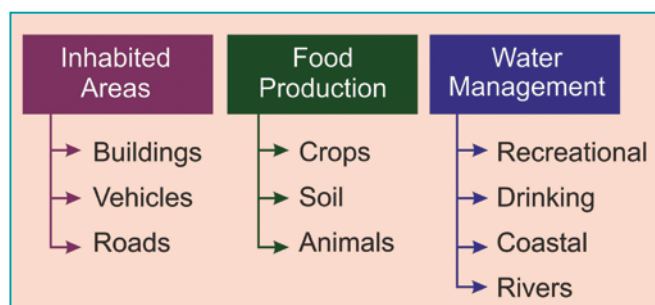


Figure 1: Structure of the UKRHCI

Developing the handbook has involved extensive consultation with stakeholders and technical experts with insight and experience in the work of recovery coordination groups and managing chemical incidents from a range of disciplines. Stakeholder workshops (see Table 1) have been crucial for the development of the handbook, providing end-users with an opportunity to constructively review the draft handbook to ensure that it is practicable.

Table 1: UKRHCI stakeholder workshops

Handbook section	Location, date
Inhabited Areas (1 st workshop)	London, May 2010
Water Management	London, July 2010
Food Production Systems	London, September 2010
Inhabited Areas (2 nd workshop)	Edinburgh, January 2011

This article summarises how the scope of the handbook has been further defined to better suit end-users following feedback from stakeholder workshops and the project steering group, and how the project team is building the evidence base for recovery options recommended in the handbook. Key definitions are provided in Box 1.

Box 1: Key definitions

Recovery The process of rebuilding, restoring and rehabilitating the community following an emergency, but it is more than simply the replacement of what has been destroyed and the rehabilitation of those affected

Recovery option An action intended to reduce or avert the exposure of people to chemical contamination.

Examples of recovery options:

- Temporary or permanent relocation of a population
- Chemical decontamination (e.g. use of foams, gels or bleaches)
- Physical decontamination (e.g. wet wiping or absorbent materials)
- Soil and vegetation removal

Recovery option sheet Detailed description of recovery option in the handbook, taking into account objectives, timing, effectiveness and constraints (i.e. public health, waste, social, environmental, technical requirements and cost)

Purpose of stakeholder workshops

The key aims of the stakeholder workshops were to:

- Inform stakeholders and future end-users about the UKRHCI project
- Introduce the participants to the decision framework and the information presented within the handbook
- Test the practicability of the framework by asking participants to work through the process using an example scenario (e.g. sulphur mustard release into a commercial district) and obtaining feedback
- Review the information provided in the 'recovery option sheets'
- Allow delegates to gain a greater knowledge and understanding of the challenges presented in recovering from major chemical incidents.

Attendees at the stakeholder workshops included colleagues from within HPA, government departments and agencies including the Food Standards Agency (FSA), Government Decontamination Service (GDS), Defence and Science Technology Laboratory (Dstl), the Environment Agency (EA), local authorities, Water UK, Chartered Institute of Environmental Health (CIEH), health and emergency services, environmental public health, and emergency planners.

Key feedback and outputs

Originally, the scope of the handbook was to consider 15 representative chemicals that the end-user could use as 'examples' (e.g. asbestos and lead) in applying recovery options. The choice of chemicals was questioned by stakeholders, and there were concerns that this approach would be too prescriptive; for instance, how could the handbook be used for chemical incidents that did not involve any of the handbook's 'example' chemicals?

Following this stakeholder feedback, and after consultation with experts (HPA and Customer Steering Group, GDS and Dstl), the following amendments were made to the scope of the handbook and the decision framework.

- The 15 original chemicals were removed and a physicochemical properties approach was adopted (e.g. persistence, volatility and partition coefficient) to enable the handbook to be applied to a wide range of chemicals. The end-user can now consider and refine the use of recovery options based on the physicochemical properties of chemicals involved in an incident
- A new selection table was developed to determine the effectiveness of recovery options for different surface material types such as porous surfaces (e.g. marble and concrete) and non-porous (e.g. glass)
- The decision-making process was revised by consolidating and reducing the number of steps and by developing a decision tree (flow diagram) to replace tables to produce a more user friendly handbook
- Text was added to emphasise that the handbook was not a substitute for expert technical advice. The handbook now includes steps where end-users are informed when to seek expert advice (e.g. to determine the physicochemical properties of the chemical of concern) when considering the site-specific implementation of recovery options
- Some similar recovery options were combined to be more generic (e.g. soil ploughing methods) to reduce the total of recovery options that require consideration in the overall process
- A few case studies were added describing the use of the recovery options in past incidents, and covering inhabited areas, food production systems and water management.

Recovery options database

An important step in the UKRHCI project involves building the evidence base for the recovery options recommended for consideration in the handbook. The project team is therefore building a database of recovery options containing information on the effectiveness of recovery options and the constraints associated with their implementation (e.g. time, cost, waste and social issues). It is envisaged that this will help refine the data given in the recovery option sheets in the handbook. As summarised in Box 2, three sources of information are being used to populate the database. Firstly, there is information from chemical incidents reported in the scientific literature relating to contamination of inhabited areas, food production systems and water environments. Examples include the release of dioxins following an industrial accident at Seveso, the terrorist attack in New York (9/11) and a number of smaller-scale incidents identified from the HPA Chemical Hazards and Poisons (CHaP) reports (see Figure 3). The database is also being populated with information from retrospective and prospective studies.



Figure 2: After-effects of the Ajka alumina sludge spill at the Ajkai Timföldgyár alumina plant in Veszprém County in Western Hungary

Box 2: Next steps in the UKRHCI project

Building the evidence base for recovery options

A recovery options database has been created to capture information from the literature review, retrospective and prospective studies. The database is being developed to demonstrate a hierarchy of evidence to ensure the recovery options recommended for consideration in the handbook are robust

Collaborating with the Department of Homeland Security, USA

Members of the project team have participated in a Department of Homeland Security (DHS) exercise involving the remediation of a contaminated airport. This was extremely useful and beneficial to the UKRHCI project providing insights into the complications of such an incident and in developing working relationships and potential future research collaborations with the USA

Engaging with wider network of stakeholders

A number of additional stakeholders have been identified for which the project team plan to get further input. Organisations such as Transport for London (TfL) and the Centre for the Protection of the National Infrastructure (CPNI) have been identified as important new stakeholders and further involvement from other specialist agencies (e.g. the Health and Safety Executive, Dstl and GDS) is also being sought

Retrospective study

The retrospective study aims to populate the database with incident recovery experience from internal (i.e. HPA) and external stakeholders (e.g. the FSA and GDS). The UKRHCI team is inviting relevant stakeholders to participate in this retrospective study. This will be conducted in two stages, comprising a short online questionnaire (taking no longer

Incidents	
Incident ID	12
Incident Name	Dioxins, Seveso
Date of contamination	10th July 1976
Date Reported	10th July 1976
Incident Description	At about midday on the 10th July, an accident occurred in ICMESA's chemical plant near the town of Seveso in Northern Italy. A reactor vessel used in the production of 2,4,5-trichlorophenol (TCP) had its safety plate rupture causing the release of a toxic...
Food <input checked="" type="checkbox"/> Inhabited <input checked="" type="checkbox"/> Water <input type="checkbox"/>	Circumstances: Accidental Industrial
Incident Location	
Residential <input checked="" type="checkbox"/> Commercial/ industrial <input checked="" type="checkbox"/> Drinking water <input type="checkbox"/> Food products <input type="checkbox"/>	Non-residential <input checked="" type="checkbox"/> Recreational <input checked="" type="checkbox"/> Other water environments <input type="checkbox"/> Agricultural <input checked="" type="checkbox"/>
Chemical 1	Dioxins
Chemical 2	
Chemical 3	
Chemical 4	
Key reference 1	Ramondetta M. and Repossi A. (1998) SEVESO: Vent'anni dopo. Dall'Incidente al Bosco delle Querce. Capitolo 3. Le Ricerche della Fondazione No. 32. Fondazione Lombardia per L' Ambiente
Key reference 2	Seveso, Italy; Bromley et al (1983). Remedial measures following accidental release of dioxin. Chemosphere 12 No 4/5 p687-703
Key reference 3	Fortunati, G. Umberto. The Seveso Lesson. Advances in Reclamation & Disposal Techniques. Chlorinated Dioxins & Dibenzofurans in Perspective. 541-553. Lewis, 1988

Figure 3: Screenshot of the recovery options database

than ten minutes), to be followed up with either a telephone or face-to-face meeting.

The purpose of the study is to obtain information on chemical incidents and the recovery options used that may not have been reported in the open literature. If you are interested in contributing to this study, please email the project team on chemical.recovery@hpa.org.uk.

Prospective study

A prospective study to evaluate recovery options implemented following any chemical incidents reported to HPA CRCE from June 2011 onwards is also underway. CRCE scientists are being asked to record as much detail as possible relating to recovery in the incident database to enable incidents to be followed up more efficiently.

Conclusions

The project demonstrates the importance of engaging with stakeholders at an early stage. The project team is currently undertaking literature reviews and retrospective and prospective studies to obtain further information on chemical incidents. This will be used to generate an appropriate evidence base for the recovery options that will be recommended in the handbook.

The project team intends to maintain and build on existing relationships with important stakeholders to help refine the handbook prior to publication in summer 2012.

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Development of experimental techniques to investigate the behaviour of chemical and radiological materials on urban surfaces

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Background

Following an industrial accident or chemical, biological, radiation or nuclear (CBRN) incident involving the dispersion of chemicals or radionuclides within an inhabited area, such as a city centre, contamination could become deposited on a range of outdoor or indoor building materials. The potential for exposure of the public to contaminated surfaces means the impact on public health should be considered, particularly in terms of likely exposures and the need for decontamination. However, there are significant gaps in the understanding of the behaviour of chemical and radiological substances on urban surfaces; this research aims to improve this understanding. An experimental capability has been developed to measure the removal of chemical and radiological substances through natural weathering, active decontamination and the use of wipe sampling for collecting representative environmental samples, focusing on a variety of indoor and outdoor building materials. This information will be used to inform decontamination strategies and environmental transfer models, supporting the UK Radiation and Chemical Recovery Handbooks^{1,2} and exposure and risk assessments.

Decontamination studies

Methodology

Decontamination of outdoor surfaces

Attenuation through natural weathering

An outdoor rig, shown in Figure 1(a), was constructed to investigate the retention of radiological substances on a variety of outdoor building materials, porous and non-porous, through natural weathering. Brick, concrete, roof tiles, metal cladding and glass were loaded with radioactive solutions of isotopes of heavy and inert metals, including americium-241 (²⁴¹Am), strontium-85 (⁸⁵Sr), cobalt-60 (⁶⁰Co) and cadmium-109 (¹⁰⁹Cd), selected for their chemical behaviour, and ease of analysis using gamma spectrometry.

Over a period of six months, weathering rates were monitored as a function of time and rainfall, through:

- Direct measurement of the surface contamination using portable gamma spectrometry equipment
- Measurement of the activity of removed substrate in the run-off water.

Simulated rainfall as a proxy for natural weathering

The feasibility of using simulated rainfall as a proxy for natural outdoor weathering experiments was investigated. Surfaces were again loaded with the radioactive solutions of isotopes of heavy metals and cumulative rainfall of 40 mm was simulated over a short period allowing drying of the surface between rainfall events. As for natural attenuation, the weathering rates were monitored directly and via run-off water.



(a)



(b)

Figure 1: (a) outdoor rig constructed to investigate natural weathering on a variety of building materials and (b) experimental rig used to investigate efficiency of pressure washing for decontamination

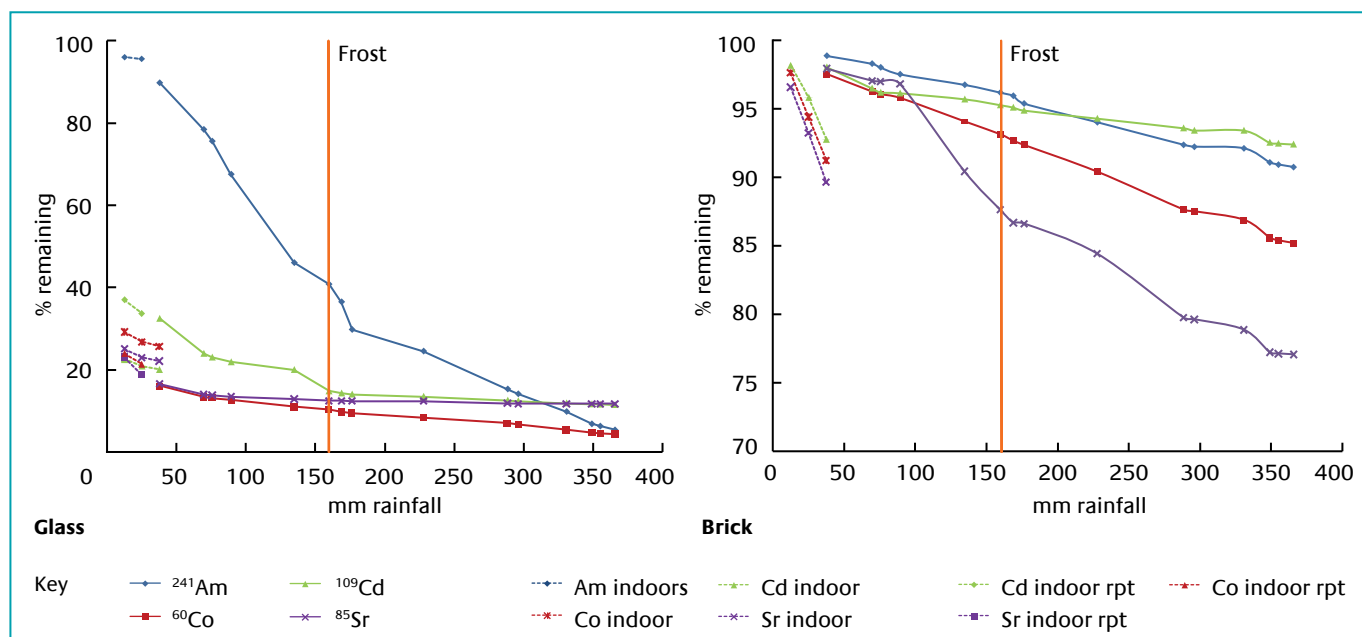


Figure 2: Natural and simulated weathering of building materials

Active decontamination

An experimental rig [see Figure 1(b)] was developed to investigate the efficiency of pressure washing in the decontamination of outdoor building materials. The rig was designed to ensure containment of all substances involved. A concrete slab and roof tile were contaminated with a radioactive solution of ²⁴¹Am, ⁸⁵Sr, ⁶⁰Co and ¹⁰⁹Cd and subjected to rigorous pressure hosing for 30 seconds using one litre of water, with and without the application of detergent. Surfaces were observed to be visibly cleaner after washing, with removal of surface material evident. Run-off water was collected, filtered and the radionuclide activity in the removed substrate and filtrate measured.

Results

Attenuation through natural weathering and simulated rainfall

The retention of radionuclides on glass and brick, as a function of cumulative rainfall, is shown in Figure 2. The solid line illustrates the natural weathering process, and the dotted line simulated rainfall.

Preliminary results indicate a clear variation between building material and radionuclide. Removal was found to be rapid for smooth surfaces compared to porous, rough surfaces such as concrete and brick. For example, for glass typically 70%–90% of the contamination was removed with rainfall over a six-month period compared to less than 20% for brick. While more was removed from metal and glass, differences were observed, again dependent on radionuclide. For example, americium was removed at a slower rate on glass compared to other elements, and strontium removal was noticeably higher for most surfaces. Initial evidence suggests that the hard frost experienced during the study period may have assisted in the removal of radionuclides from the surfaces; however, further investigation is required.

The feasibility of using simulated rainfall as a proxy for natural outdoor weathering was promising; however, further development is required. As can be seen, attenuation following simulated weathering was found to be quicker than the natural weathering process on surfaces where the contamination was not easily removed under natural conditions, indicating simulated rainfall does not mirror the physical and chemical

behaviour of the contamination on the surface over time with natural rainfall events and weather patterns.

Active decontamination

The results from the active decontamination studies are shown in Figure 3. In most cases high pressure washing was found to remove between 40% and 60% of the contamination. However, this was again dependent on radionuclide and surface with, for example, less than 10% of strontium being removed from concrete. These results indicate the need for further studies to inform decontamination strategies.

A second pressure wash removed only 2%–10% of the remaining contamination, questioning the benefits of repeating the process. In addition, no obvious benefit was determined from using detergent prior to pressure washing and in some cases removal was found to be lower. Further work is needed to attempt to clarify the chemical and physical properties affecting removal. The information on partitioning of the contaminant in the water and solid phase can be used to inform decisions on the management of waste arising and the quantities of contaminated waste produced in the event of clean-up following an incident.

Wipe sampling studies

Development of protocols and measurement of efficacy for collecting representative environmental samples

The average person spends 90% of their time indoors and therefore there is a growing need for information on contaminant levels within the indoor environment. A recent US Environmental Protection Agency (USEPA) review noted the potential of wipe samples to help identify contaminated areas following a chemical incident but acknowledged current gaps in the evidence base which future research could address³.

The efficacy of wipe sampling for the collection of representative environmental samples and the benefits of wipe sampling were investigated. The study was used to validate the potential for using the sampling protocol during a pollution or CBRN event to support the

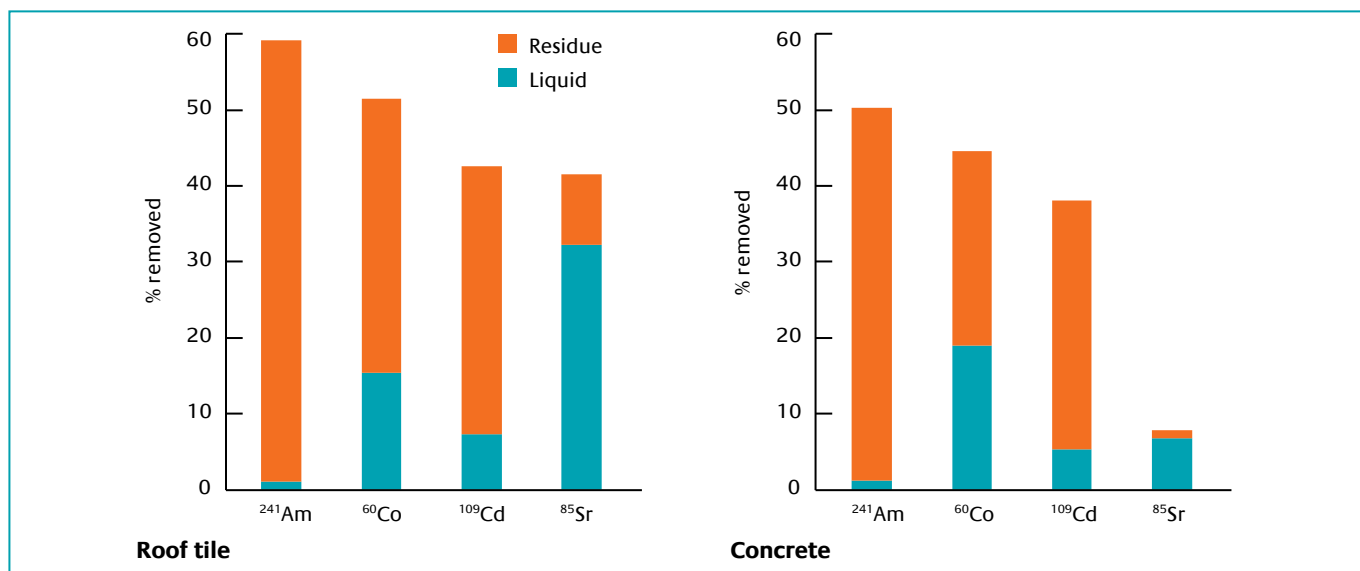


Figure 3: Efficiency of pressure washing in the removal of radionuclides

exposure assessment. The study was further used to refine analytical methods for trace element analysis within the Centre for Radiation, Chemical and Environmental Hazards (CRCE) and assess sample reproducibility between scientists.

Methodology

A variety of indoor building surfaces were spiked with radioactive solutions and standard reference materials (SRM), considered to be representative of wet and dry deposition respectively. SRM contain a range of metals of known composition. Ghost Wipes™ were selected for use in the study. These wipes meet all the criteria in the American Society for Testing and Materials (ASTM) method E1792 (2002a)⁴ and conform to USEPA, Occupational Safety and Health Administration (OSHA)⁵ and American Industrial Hygiene Association (AIHA)⁶ standards. Metals removed from the building materials through the wipe sampling procedure were analysed using inductively coupled plasma mass spectrometry (ICP-MS).

Results

Greater variability in sample recovery was seen with dry deposition compared to wet deposition. Surfaces spiked with SRM typically yielded recovery rates of greater than 90%, while recoveries from surfaces spiked with radioactive solutions were approximately 70%. This difference is thought to be due to contaminant behaviour and low sample loadings. As shown in Figure 4, initial results indicate variation due to surface roughness and porosity, with recoveries highest on less porous smooth surfaces. For example, recoveries on porous plasterboard were less than 1% for wet deposition owing to absorption into the material, while recoveries for dry deposition were greater than 60%.

Reproducibility between scientists was high with variability of approximately 5% for wet deposition and less than 1% for dry deposition, indicating the potential for deploying scientists with limited environmental sampling experience, to obtain representative environmental samples. The majority of deposited material was

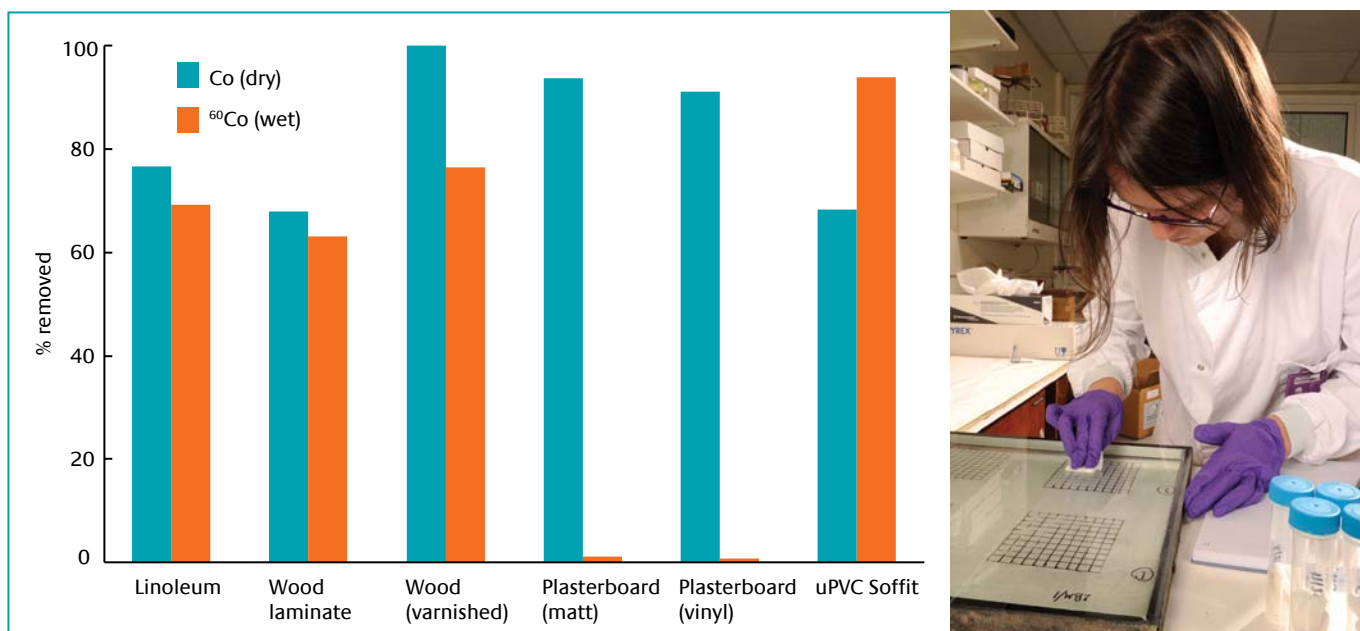


Figure 4: Comparison between wet and dry deposition for cobalt on a variety of indoor surfaces

removed by the first wipe, with the second and third wipes recovering only a small amount of material, suggesting that repeated wipe samples gave little additional benefit.

Conclusions and future work

Attenuation through natural weathering and simulated rainfall

Natural weathering results suggest contaminant retention is dependent on surface type and element. Future work will look to expand the dataset, and confirm these results, in particular focusing on determining surface retention characteristics of relevant substrates on a range of outdoor and indoor building materials. Initial results from the study using simulated rainfall as a proxy for natural weathering are inconclusive, and consequently future work will look at developing methodologies to expand this study to develop a surrogate for natural long-term outdoor weathering.

Active decontamination

The use of high pressure washing as a decontamination option found removal to be dependent on radionuclide and surface type. Questions were raised regarding the benefits of repeating the process and the application of detergent prior to pressure washing. Experiments will be extended to investigate the effectiveness of this decontamination technique on aged contamination, and also the effectiveness of alternative decontamination strategies.

Wipe sampling studies

A working wipe sampling protocol has been developed, piloted, evaluated and validated. The results have shown that, providing they are used correctly, wipe sampling can identify contamination levels on a variety of urban building surfaces. The protocol will be used by the HPA as part of its environmental monitoring capability to inform HPA advice following a CBRN event or industrial accident, in particular as part of the UK Radiation and Chemical Recovery Handbooks^{1,2}. It will be further used to quantify typical urban exposures to many metals in and around the home, identifying how wipe sampling can be used to assess exposure. For example, the transfer of contaminants into the home via footwear is thought to be a significant element of the exposure pathway for young children.

Variability was observed between dry and wet deposition results. The variability with deposition, substance and surface type will be further investigated. For example, the study will be expanded to include organics and CBRN materials. This will further inform the wipe sampling protocol, advising on surfaces to be sampled during deployment of sampling teams. The potential for using wipe sampling outdoors, to assess the effectiveness of decontamination strategies will also be investigated using an experimental rig similar to that used in the outdoor radionuclide studies.

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Cross-border Exposure Characterisation for Risk Assessment in Chemical Incidents



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Introduction

Chemical incidents do not respect national borders, and can affect communities a significant distance from the incident site. An accurate and timely assessment of risks to human health is a cornerstone of an effective response strategy. The Cross-border Exposure Characterisation for Risk Assessment in Chemical Incidents (CERACI) project aims to strengthen the public health assessment for the acute phase of a chemical incident by assessing the response to chemical incidents in European (EU) Member States, focusing in particular on the interoperability of exposure assessment guidelines, tools and practices.

The key questions which the project will address are:

- How do Member States undertake exposure assessment and risk characterisation during the initial phase of a chemical incident?
- How do Member States organise environmental modelling and monitoring and how is this used to inform the health risk assessment during the acute phase of a chemical incident?
- Which Member States collaborate nationally and cross-border on environmental modelling and monitoring?
- Which best practices, technical or organisational, can be further developed?
- Will harmonisation and collaboration improve Member States' capabilities and capacities to respond to acute chemical incidents (national and cross-border)?

The partners in the project are the Dutch National Institute for Public Health, and the Environment (RIVM), the Nofer Institute of Occupational Medicine (NIOM) of Poland and the UK Health Protection Agency (HPA). This paper discusses some of the findings of the information-gathering phase of the project. Later phases of the project will evaluate best practice for responding to cross-border incidents through the organisation of workshops. European Commission project databases^{1,2} were reviewed to identify projects relevant to exposure assessment in chemical incidents, paying particular attention to incidents where environmental modelling and monitoring data was used to inform a health risk assessment. The review also identified projects undertaken by established networks of experts employed in roles encompassing exposure assessment, and those which have run workshops using acute chemical incident scenarios to inform their work.

The primary methods for collecting information to contribute to the risk assessment model were considered to be: observation; field monitoring; laboratory analysis; emergency plans; modelling; risk mapping/geographical information systems; and risk characterisation

and communication. As expected, there is diversity in responding agency types, capabilities, risk assessment protocols and strategies. Some of the key areas of diversity are summarised below.

Information gathering

In each Member State, the primary sources of information about a chemical incident are typically provided by the emergency services responding to the incident and the site operators, with emergency plans, e.g. COMAH Plans, confirmed to be invaluable to risk assessors for obtaining relevant information.

Cross-border arrangements

A number of overarching European cross-border initiatives and arrangements have been identified at national level within Member States. These arrangements include the exchange of scientific and technical information; training; common research; logistical support; and exchange of relevant data on a regular basis. Bilateral and multilateral agreements to provide mutual assistance in civil protection or disaster and accident operations on EU territory exist between a number of Member States. For example:

- The Convention on the Transnational Effects of Industrial Accidents³ aims at protecting humans and the environment against industrial accidents, promoting active international cooperation between the contracting Parties, before, during and after an industrial accident
- The Civil Protection Mechanism⁴, established in 2003, facilitates cooperation in civil protection assistance interventions in the event of major emergencies
- The Major Accident Hazards Bureau⁵ provides research-based scientific support to the European Community on the formulation, implementation and monitoring of EU policies for the control of major accident hazards, chiefly the Seveso II Directive, 96/82/EC, concerning the processing and storage of hazardous substances.

Monitoring

The European Commission funds a number of projects that are developing chemical technologies to detect contaminants in food, water and air. Technological advances in field and laboratory monitoring, and information communication have the potential to improve the European capacity for exposure assessment, particularly where the validated methodologies are simple, inexpensive and rapid. Monitoring capability (including sensitivity and selection of monitoring equipment) and the rationale for deployment varies. The rationale for monitoring will affect how readily equipment is deployed, how quickly the data is obtained, and defines its usefulness from the perspective of exposure characterisation.

Monitoring capability was found to vary across the EU; however, a number of Member States were found to be well prepared, with the capability to deploy mobile laboratories to the scene of a chemical

incident or to the location of sensitive receptors to provide real-time data to inform human health risk assessments. A number of countries were also identified to have satellite software systems for automatic detection of fires. For example, the Bulgarian Aerospace Monitoring Centre has a system for automatically detecting forest fires using satellite data in near real-time and sends email alerts to responders, providing information about the affected area and intensity of the fire⁶.

Modelling

On-scene observations undertaken by fire and rescue services may be supported by chemical or meteorological modelling information provided by meteorological agencies. Ideally, the model should predict air concentrations, water concentrations or deposition rates with time such that sensitive receptor exposure can be estimated, based on the following inputs: release flux; meteorological conditions; physical and chemical properties of the released substance; and topography.

A number of specialist environmental meteorological sections and organisations have been identified, with the capability to model the transport and deposition of pollutants during a chemical incident. These include the Department of Environmental Meteorology, Austria, and the Environmental Monitoring and Response Centre (EMARC), UK. For cross-border incidents differences in mapping or dispersion modelling capabilities can lead to difficulties. For example, if the country where the incident occurs does not have accurate mapping knowledge of other countries affected, dispersion modelling will be difficult, highlighting that it is essential to have close cross-border working.

Ideally validation/correction of modelling results using monitoring results will provide greater accuracy and reassurance. Additionally many countries use geographical information systems (GIS) to map at-risk sensitive receptor populations and ideally this should be integrated with dispersion modelling.

Risk assessment and characterisation

The WHO Human Health Risk Assessment Toolkit: Chemical Hazards⁷, considers the criteria required for undertaking appropriate exposure assessments and presents a generic road map for use in the exposure assessment process. An accurate and timely assessment of human health risks resulting from an acute chemical release is at the core of chemical incident preparedness and response⁸, irrespective of the scenario or its underlying cause (accidental, intentional or geographical situation).

For cross-border incidents, information sharing can be hindered by: language barriers; differing operating procedures; training and preparedness; lack of informal or formal networks for communication; poor awareness of other countries' response structures and capabilities; differing availability of monitoring equipment and sampling rationales; use of differing dispersion models; and use of different risk assessment guidelines.

It is not always clear which organisation within a Member State's health structure takes the lead for exposure assessment and risk characterisation during an acute chemical incident or what guidance or trigger values – for example, to shelter or evacuate – it uses during decision making. For example, during emergencies there is an urgent need for responsible agencies to quickly decide which actions to take. Acute Exposure Reference Values (AERVs) can be useful in making these decisions, providing a rapid indication of the potential health

consequences of specific chemical exposures in the population. However, at present, there are several sets of acute guidance values available within the global arena for use during health risk assessment. Each set has different methodologies for its derivation. With no internationally accepted set of values, neighbouring countries may issue differing public health guidance based on the AERVs used. Projects have been identified which are looking at addressing this issue.

Progress

The CERACI project will be completed in 2012. The next phase of the study is a survey of experts to complete the information gathering phase for each Member State. For further information on the project, please see the project website www.rivm.nl/ceraci.

Acknowledgements



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See http://ec.europa.eu/echo/civil_protection/civil/prote/projects_2010.htm

We are grateful to the project partners for their input into this task.

Project website: <http://www.rivm.nl/ceraci>

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For a full set of categorised references, please contact the author.

Environmental Science and Toxicology

Impact on health of emissions from landfills

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The Health Protection Agency (HPA) has recently published advice on the impact on health of emissions from landfill sites.

Why?

Most waste in the UK has traditionally been disposed of to landfill sites and approximately 80% of people in the UK live within 2 km of a known open or closed landfill site. In the past few years the law on what materials can and cannot be landfilled has changed and, because of this, it seemed an appropriate time for the HPA to review claims about the risks to public health from such sites. Our advice principally covers all active landfill sites in the UK which operate under current environmental legislation. We have considered published health studies on landfill sites, both active and closed.

Clearly landfill sites can generate considerable public concern about the health effects of emissions and there have been suggested links to a range of health effects. The disposal of waste materials to landfill can undoubtedly present a pollution risk and a potential health hazard. However, modern landfills are subject to strict regulatory controls which require sites to be designed and operated such that there is no significant impact on the environment or human health. Improvements in landfill design and management, restrictions in the types of waste that can be handled, and environmental legislation designed to minimise pollution should all ensure that there is no significant risk to the health of the local population.

Our approach

An assessment of the health risks posed by landfill sites and other forms of waste management was published by the Department for Environment, Food and Rural Affairs (Defra) in 2004. The HPA has now carried out a review of more recent research into the suggested links between emissions from landfill sites and effects on health.

The report identifies the main types of landfills, explains recent changes in legislation governing what materials can now be landfilled, and identifies both the main sources of emissions from modern landfill sites and the key pollutants such as acid gases, toxic organic micropollutants (e.g. dioxins), volatile organic compounds, dusts, odours, leachate and bioaerosols. The report does not cover sites that contain radioactive waste or issues such as noise or vermin.

Over the years there have been many studies looking at pregnancy outcomes such as birth defects in women living near to landfill sites, including several studies in the UK, and these have been considered in the report. The HPA also sought the opinion of the independent Committee on Toxicity of Chemicals in Food, Consumer Products and



the Environment (COT). Findings of a major Environment Agency (EA) funded project which measured concentrations of chemicals, common air pollutants and biohazards at the boundaries of two landfill sites considered typical of those accepting household waste, have also been included. Over 60 chemicals or groups of chemicals were measured in the study and further measurements were also undertaken around another two landfill sites and two background sites to improve data on certain substances. The HPA also asked the COT to provide expert advice on the health implications of this project and its advice is summarised in the HPA statement.

Findings

The HPA recognises that landfills can generate public concern. There have been claims of links to a range of health effects including cancer and birth defects. We have looked at the available evidence and sought the opinion of the COT and this has enabled us to conclude that living close to a well-managed landfill site does not pose a significant risk to human health.

With regard to birth defects, the HPA has considered a number of published studies which have investigated this issue including several studies which report a small increased risk. Not all studies report a risk and, in those that do, the reported increased risk is very small and the studies may not have fully accounted for other factors such as family history of disease, life style factors, occupation and the way health statistics are collected, which may all account for any reported excess of birth defects. It is our considered opinion that any risk is negligible and we agree with the advice of the COT which, after reviewing the exposure study funded by the EA, found no significant risk to the health of pregnant women or those wishing to start a family who live in the vicinity of a landfill site.

The report highlights the fact that some landfill sites can cause odour problems and we know that people living near such sites often express concerns about possible health impacts from the odours they perceive. We have considered data on emissions from several typical landfills and, while levels of individual substances are low, sites can occasionally cause local odour problems.

An individual's response to odours is very variable and some people are especially sensitive and can experience symptoms such as nausea, headaches and dizziness. People can even experience symptoms at levels well below those known to cause a direct toxic effect. As is made clear in the report, the HPA expects landfill sites to be managed in such a way to ensure that odours do not affect local residents. However, since some sites do occasionally cause odour problems we are recommending that further research is undertaken to improve our understanding of the impact odours can have on people living near these sites.

Future work

Science is constantly evolving and to give the best possible science-based advice it is important to identify areas where further research could be undertaken to reduce uncertainty. The HPA continually seeks to review and extend the evidence base on which it forms its advice. Consequently the report has made some specific recommendations for future research to reduce some of the areas of uncertainty in our understanding of the potential for health risks from landfill sites.

It is important that research continues to inform the risk of exposure from UK landfill sites. This should include the development of more sensitive sampling and analytical methods for pollutants detected around landfill sites and, ideally, surveys of pollutant concentrations around more sites. It would also be valuable if more complete toxicological data were available for some of these pollutants. Detailed site-specific risk assessment should remain an important part of the permitting and management process.

The report also notes that a number of chemicals capable of causing odour problems have been measured at the boundaries of landfill sites and calls for further research to improve assessments of the impact that odours can have on the health of local residents.

Conclusions

The report concludes that a well-managed modern landfill does not pose a significant risk to human health. The HPA is aware that concerns about the health effects of landfill sites often stem from historic sites. However, it is not possible to provide definitive advice regarding historic or closed landfill sites which pre-date waste management regulation in the UK, owing to the large variability in wastes which entered these sites, and the variability in their design and operation when open. Where landfills are the subject of local concern, site-specific monitoring and/or modelling is needed to aid any risk assessment and address any uncertainty about the nature of any emissions.

However, the statement has considered health studies undertaken around both active and closed landfill sites and we are reassured that the studies overall do not indicate a significant impact on the health of people who live in the nearby vicinity of a landfill site (typically defined as within 2 km).

The report is free to download at www.hpa.org.uk/Publications/Radiation/DocumentsOfTheHPA/

Committee on the Medical Effects of Air Pollutants' review of the UK Air Quality Index

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Introduction

The Committee on the Medical Effects of Air Pollutants (COMEAP) is an advisory committee of independent experts that provides advice to government departments and agencies on all matters concerning the potential toxicity and effects upon health of air pollutants.

In 2009, COMEAP was asked by the Department for Environment, Food and Rural Affairs (Defra) to review the UK Air Quality Index (AQI) to ensure that it is fit for purpose. The current UK AQI has been in operation, essentially unchanged, for a period of around 12 years. Therefore, it was considered timely to review the index to determine its suitability, given the developments in the field of air quality since its publication.

In June 2011, COMEAP published its report 'Review of the UK Air Quality Index'¹ and this article is based on the executive summary of the report.

Current Air Quality Index

The AQI is used to communicate information about real-time and forecast levels of outdoor air pollution in the short term and is available on the UK Air Information Resource web pages of Defra². Forecasted air quality information, reported in terms of the AQI, provides advanced warning of potentially health-damaging air pollution events. With advanced warning of poor air quality, individuals who are sensitive to the effects of air pollution have the opportunity to modify their behaviour to reduce their exposure and consequently the severity of their symptoms. The AQI does not provide guidance on the effects of long-term exposure to air pollution.

The pollutants included in the current index are particulate matter (PM₁₀), ozone (O₃), sulphur dioxide (SO₂), carbon monoxide (CO) and nitrogen dioxide (NO₂). The index has four bands indicating 'Low', 'Moderate', 'High' and 'Very High' levels of air pollution. These bands are further divided into a ten-point scale to provide greater gradation of air pollution levels.

The current AQI was developed by COMEAP and is based on the health effects of short-term exposure to air pollution. The 'Low' band indicates air pollution levels where it is unlikely that anyone will suffer any adverse health effects of short-term exposure, including people with lung or heart conditions who may be more susceptible to the effects of air pollution. The 'Moderate' band represents levels of air pollutants at which there are likely to be small effects for susceptible people only. Values for the 'High' band are associated with significant effects in susceptible people. At 'Very High' levels of air pollution even healthy individuals may experience adverse effects of short-term exposure.



Approach to the review

The health evidence relating to the index pollutants was reviewed to assess whether the levels of the bands were appropriate. COMEAP looked at the coverage of the index and whether additional pollutants should be included. The review also took into account the current levels of pollutants in the UK, developments in European legislation and UK Air Quality Objectives.

COMEAP was keen to ensure that the review was centred on the requirements of the users of the index, namely the general public, particularly those more at risk of the adverse health effects of air pollution. In order to inform the review, dedicated research was commissioned to investigate the general public's current awareness and comprehension of air quality information, and to assess the challenges that exist to understanding and interpreting such material.

Several possible approaches to assessing and evaluating pollutant-specific evidence on health impacts that could be used in the revision of an index were considered. Other evaluations and additional information were also taken into account during the deliberations. An Expert Group of the World Health Organization (WHO) undertook a thorough evaluation of the evidence concerning air pollution and health effects, with the resulting revised WHO Air Quality Guidelines published in 2006³. In most cases, COMEAP proposes the adoption of the WHO values as proposed breakpoints between the bands. However, in some cases, the proposals do not adopt the WHO recommendations directly, for reasons which are explained in the report.

The implications of the proposed changes to the bands, summarised below, will be an increase in the number of Moderate and High pollution days, and a decrease in the number of Low days reported across the year.

Table 1: Proposed Air Quality Index

Band	Index	Ozone	Nitrogen dioxide	Sulphur dioxide	PM _{2.5} particles	PM ₁₀ particles
		Running 8-hour mean (µg/m ³)	1-hour mean (µg/m ³)	15-minute mean (µg/m ³)	24-hour mean (µg/m ³)	24-hour mean (µg/m ³)
Low	1	0–26	0–66	0–88	0–11	0–16
	2	27–53	67–133	89–176	12–23	17–33
	3	54–80	134–200	177–265	24–35	34–50
Moderate	4	81–107	201–267	266–354	36–41	51–58
	5	108–134	268–334	355–442	42–46	59–66
	6	135–160	335–400	443–531	47–53	67–75
High	7	161–187	401–467	532–708	54–58	76–83
	8	188–213	468–534	709–886	59–64	84–91
	9	214–240	535–600	887–1063	65–70	92–100
Very High	10	241 or more	601 or more	1064 or more	71 or more	101 or more

Summary of key recommendations

COMEAP recommends breakpoints between the bands of Low, Moderate, High and Very High for each of the index pollutants. It is recommended that the AQI be presented as a ten-point scale with colour coding to aid the interpretation of the index, as detailed in Table 1 above. With respect to the current AQI, the proposed bandings remain unchanged for sulphur dioxide (SO₂). The breakpoints for a change in band for ozone (O₃), nitrogen dioxide (NO₂) and particulate matter (of less than 10 µm in diameter, PM₁₀) are more stringent. Particulate matter of less than 2.5 µm in diameter (PM_{2.5}) has been added to the index, and carbon monoxide has been removed in view of the considerable reductions in outdoor levels of this pollutant.

COMEAP recommends that the information to accompany the new AQI comes in three parts and includes additional advice for susceptible individuals, together with advice for the general population:

- A Instructions on how the air quality index should be used**
- B Short-term health effects of air pollution and action that can be taken to reduce impacts**
- C Health advice linked to each band to accompany the air quality index**

These are detailed in Panels A–C below.

The use of ‘trigger’ values is also recommended to complement the proposed new AQI and allow for the prediction of episodes of elevated air pollution in real time as they emerge (Table 2). In the current index, with the averaging times of 24 hours for particulate matter and 8 hours for ozone, it is not possible to provide public information about an unexpected pollution episode until it is well established. Triggers have been derived to provide information to the public to warn of exposure as it is taking place at Moderate, High or Very High levels. These triggers can be used by organisations that operate real-time public information services.

Finally, COMEAP recommends that links to information on the long-term health effects of air pollution are provided together with the index, such as the 2009 COMEAP report entitled *Long-Term Exposure to Air Pollution: Effect on Mortality* (www.comeap.org.uk).

Acknowledgements

The authors would like to thank the members of COMEAP and its Subgroup, the Standards Advisory Subgroup, for their work on this report. The Subgroup is funded by Defra and has a joint secretariat provided by Defra and the Health Protection Agency.

Table 2: Suggested trigger thresholds based on two consecutive hourly mean concentrations, with the second one being greater than or equal to the first

Pollutant	Band	Trigger (µg/m ³)
Particulate matter, PM ₁₀	Moderate or above	67
	High or above	107
	Very High or above	176
Particulate matter, PM _{2.5}	Moderate or above	48
	High or above	74
	Very High or above	101
Ozone, O ₃	Moderate or above	82
	High or above	168
	Very High or above	Not determined

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A How to use the Air Quality Index (AQI)

- Step 1** Determine whether you (or your children) are likely to be at risk from air pollution. Information on groups who may be affected is given in the section on 'Additional information on the short-term effects of air pollution'. Your doctor may also be able to give you advice
- Step 2** If you may be at risk, and are planning strenuous activity outdoors, check the air pollution forecast
- Step 3** Use the health messages corresponding to the highest forecast level of pollution as a guide

B Additional Information on the Short-term Effects of Air Pollution

The air quality index has been developed to provide advice on expected levels of air pollution. In addition, information on the short-term effects on health that might be expected to occur at the different bands of the index (Low, Moderate, High and Very High) is provided here

Short-term effects of air pollution on health

Air pollution has a range of effects on health. However, air pollution in the UK does not rise to levels at which people need to make major changes to their habits to avoid exposure; nobody need fear going outdoors

Adults and children with lung or heart conditions It is known that, when levels of air pollutants rise, adults suffering from heart conditions, and adults and children with lung conditions, are at increased risk of becoming ill and needing treatment. Only a minority of those who suffer from these conditions are likely to be affected and it is not possible to predict in advance who will be affected. Some people are aware that air pollution affects their health: adults and children with asthma may notice that they need to increase their use of inhaled reliever medication on days when levels of air pollution are higher than average

Older people are more likely to suffer from heart and lung conditions than young people and so it makes good sense for them to be aware of current air pollution conditions

General population At Very High levels of air pollution, some people may experience a sore or dry throat, sore eyes or, in some cases, a tickly cough – even healthy individuals

Children need not be kept from school or prevented from taking part in games. Children with asthma may notice that they need to increase their use of reliever medication on days when levels of air pollution are higher than average

Action that can be taken

When levels of air pollution increase it would be sensible for those who have noticed that they are affected to limit their exposure to air pollutants. This does not mean staying indoors, but reducing levels of exercise outdoors would be reasonable

Older people and those with heart and lung conditions might avoid exertion on High pollution days

Adults and children with asthma should check that they are taking their medication as advised by their health practitioner and may notice that they need to increase their use of inhaled reliever medication

Adults with heart and circulatory conditions should **not** modify their treatment schedules on the basis of advice provided by the air quality index: such modification should only be made on a health practitioner's advice

Some athletes, even if they are not asthmatic, may find their performance is less good than expected when levels of a certain air pollutant (ground-level ozone) are High, and they may notice that deep breathing causes some discomfort in the chest. This might be expected in summer on days when ground-level ozone levels are raised. This does not mean that they are in danger but it may be sensible for them to limit their activities on such days

C Health Advice to Accompany the Air Quality Index

Air pollution banding	Value	Accompanying health messages for at-risk groups and the general population	
		At-risk individuals*	General population
Low	1-3	Enjoy your usual outdoor activities	Enjoy your usual outdoor activities
Moderate	4-6	Adults and children with lung problems, and adults with heart problems, who experience symptoms , should consider reducing strenuous physical activity, particularly outdoors	Enjoy your usual outdoor activities
High	7-9	Adults and children with lung problems, and adults with heart problems, should reduce strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also reduce physical exertion	Anyone experiencing discomfort such as sore eyes, cough or sore throat should consider reducing activity, particularly outdoors
Very High	10	Adults and children with lung problems, adults with heart problems, and older people, should avoid strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often	Reduce physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat

* Adults and children with heart or lung problems are at greater risk of symptoms. Follow your doctor's usual advice about exercising and managing your condition

Estimating the effect of pollutants on mortality: using long-term exposure to particulate air pollution as an example

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Introduction

Nobody knows how many deaths are in part, or wholly, caused by environmental pollutants. However, epidemiological studies can compare the risks of death between areas with high and low, or no, exposure. This can allow estimation of the effect pollutants have on mortality.

For air pollution, it is known that long-term exposure to fine particles (monitored as particulate matter, $PM_{2.5}$) increases the risk of death of those over the age of 30 years. This finding comes from studies that compared the risk of death amongst adults living in cities or areas with high levels of $PM_{2.5}$ with the risk of death amongst adults living in cities or areas with lower levels of $PM_{2.5}$. The size of the effect can be best expressed as an increase in the normal, or usual, risk of death. The increase in risk is about a 6% increase in the baseline risk of death for every $10 \mu\text{g}/\text{m}^3$ increase in $PM_{2.5}$ ¹. So if the concentration of fine particles were $10 \mu\text{g}/\text{m}^3$, the risk of death for all adults aged over 30 would be increased by 6%.

This suggests an easy calculation to determine the size of the effect. For the UK in 2008:

Average population-weighted concentration of man-made $PM_{2.5}$
 = $8.97 \mu\text{g}/\text{m}^3$

Risk of death associated with $PM_{2.5}$ exposure
 = $6\% \times 8.97/10 = 5.4\%$

Annual number of deaths in people aged 30 and over
 = 570,000 (this includes the effect of air pollution)

Size of effect
 = number of deaths \times proportion of mortality risk associated
 with fine particulate air pollution
 = $570,000 \times 5.4/105.4 = 29,000$ deaths

What does a figure of 29,000 deaths mean?

We might say that 29,000 deaths in 2008[†] were caused by $PM_{2.5}$. This would be true if the pollutant, here $PM_{2.5}$, were the sole cause of death. However, this is considered unlikely because further analysis of the epidemiological evidence suggests that deaths associated with particulate air pollution are largely from cardiovascular disease. This

* The Committee on the Medical Effects of Air Pollutants (COMEAP) is an advisory committee of independent experts that provides advice to government departments and agencies on all matters concerning the potential toxicity and effects upon health of air pollutants. For more information visit www.comeap.org.uk.

† 2008 was used because this was the latest year for which data was available when COMEAP undertook its calculations.

group of diseases has many causes: smoking, obesity, lack of exercise and genetic factors are all known to play a part. About 200,000 adults aged over 30 die in the UK every year from cardiovascular disease; it is difficult to believe that amongst these there are 29,000 whose deaths have been caused solely by particulate air pollution. To accept this we would need to believe that these 29,000 people were unaffected by all the other factors known to play a part in causing cardiovascular disease: the 29,000 would have to be immune to all causes of cardiovascular disease, except particulate air pollution. This is implausible given what is known about the causes of cardiovascular disease. So instead it is speculated that air pollution, acting together with these other factors, could make some smaller contribution to death of up to a maximum of about 200,000 people².

So what does the figure of 29,000 deaths mean? It is a very commonly used way of representing the size of an effect of any factor which is discovered to increase the risk of death across a population. It is so widely used that amongst epidemiologists the number of deaths calculated in this way is referred to as the number of 'attributable deaths'. This term, 'attributable deaths', is perhaps an unfortunate choice given that, in common use, it suggests that the 29,000 deaths were caused solely by particulate air pollution. For example, nobody would talk about the number of deaths attributable to road accidents or murder. In these cases we would know precisely how many deaths we were talking about and the word 'attributable' would be redundant. Instead, in epidemiology, the term 'attributable deaths' is used when it is not known precisely how many deaths may be affected. This is an oddity of epidemiological terminology. What the term actually means is that the simple calculation outlined above leads to a number, in our case, 29,000, which represents the size of the effect of particulate air pollution.

To avoid the suggestion that particulate air pollution acts as a sole cause of death but to illustrate the size of the effect, COMEAP used the term 'an effect equivalent to 29,000 deaths in 2008' in its recently published report. This can be regarded as the mortality burden of particulate air pollution in 2008².

Comparison of effects – the importance of population survival time

Having established what the 'attributable deaths' or '29,000 deaths in 2008' represents, we come to the question of how we can use the information. It is useful when comparing the burden from different contributory factors to death so, coming back to the example of cardiovascular disease, it could be used to compare the effects of smoking, obesity, lack of exercise, genetic factors and air pollution, all of which contribute to the disease, if the number of deaths 'attributable' to each factor were calculated.

A note of caution needs to be added here. The number of deaths does not give the whole picture. Having derived the number of deaths attributable to particulate air pollution (equivalent to 29,000 in 2008),

Table 1: Effect on mortality in 2008 of anthropogenic PM_{2.5} air pollution in the UK population. UK totals are aggregates from the individual results presented (reprinted from the COMEAP 2010 report²)

Pollution included	Country	Population-weighted mean concentration (µg/m ³)	Number of 'attributable' deaths	Number of 'attributable' deaths per 100,000 people aged 30 years and over	Burden on total survival (life-years lost)
All anthropogenic	England and Wales	9.46	26,799	79	315,000
	Scotland	4.97	1,560	47	19,000
	Northern Ireland	6.02	502	48	6,000
	UK total	8.97	28,861	75	340,000
Anthropogenic >7 µg/m ³	England and Wales	3.90	11,228	33	132,000
	Scotland	0.21	67	2	1,000
	Northern Ireland	0.91	77	7	1,000
	UK total	3.50	11,372	30	134,000

we could compare these to the number of deaths resulting from road traffic accidents (3,201 in 2005 in Britain³). However, this does not reflect the fact that air pollution increases the risk of death at all ages above 30*, whereas for road traffic accidents, there is a disproportionate increased risk of death to younger people. The loss of life, in terms of years, associated with these deaths is very different.

To take this into account, we can add up the age-specific remaining life expectancies related to each 'attributable death', resulting in a population aggregate loss of life. This is a better reflection of the burden of mortality than 'attributable deaths' alone because it takes into account the age at death.

For man-made particulate air pollution, the loss of population survival has been estimated as a loss of 340,000 years of life in 2008 (Table 1). COMEAP recommended that population survival time, sometimes known as 'years of life lost across the population', should be included in any comparison of the effects on mortality of different risk factors².

The burden calculation is an approximation

Assessing the population burden from any pollutant looks fairly straightforward, providing we have the relevant data. Mathematically this is so. However, there are both uncertainties and assumptions that need to be recognised when carrying out such calculations.

For air pollution, the uncertainties centre around the risk coefficient used for the calculation, and also the concentration of the pollutant being considered. In the previous calculation, a coefficient of 6% increase in risk for a 10 µg/m³ increase in PM_{2.5} was used. However, COMEAP has suggested a 75% likelihood of the risk coefficient lying in the range 1–12% and recommended that, for quantification, a wider interval of 0–15% be considered (Table 2)². Additional uncertainty arises from extrapolating beyond the data in the study from which the risk coefficient derives. The lowest PM_{2.5} concentration measured in the study was 7 µg/m³, thus the confidence in the effects occurring below this level is lower than those above it. The estimates presented in Table 1 illustrate the burden from all man-made particulate air pollution and the burden of the particulate air pollution above a concentration of 7 µg/m³. The difference between these two results shows that approximately 60% of the calculated effects derive from concentrations below 7 µg/m³².

* The calculation is based on the population of at least 30 years of age because the study from which the coefficient is derived, included only adults aged 30 years or more, and so is not directly informative of effects in people younger than this.

Table 2: Effect of varying the coefficient on the estimation of the burden of all anthropogenic PM_{2.5} (9.46 µg/m³) in England and Wales (reprinted from the COMEAP 2010 report²)

Coefficient	Number of 'attributable' deaths	Burden on total survival (life-years lost)
1.00 (0%)	0	0
1.01 (1%)	4,682	55,000
1.06 (6%)	26,799	315,000
1.12 (12%)	50,801	597,000
1.15 (15%)	61,887	728,000

There are more difficulties when we ask: "What do we mean by the current effect or burden of pollution?" Do we mean:

- The effect of this year's exposure this year?
- or The effect of this year's exposure in all years to come?
- or The effect this year of all past years' exposure?

For particulate air pollution – bearing in mind we are looking at the long-term mortality burden, not the burden as a result of daily spikes in particle levels, i.e. acute effects – these are important but confusing questions. When working out the long-term effect of PM_{2.5} in the UK population (which has been exposed in the past, is currently exposed, and will continue to be exposed in the future), it is important to consider levels of pollution experienced by the hypothetical unexposed UK population it is being compared to.

The assumption made during the calculation must be:

- either particulate air pollution shows no lag in having its effect, i.e. all of the effects of exposure to PM_{2.5} occurred in 2008
- or the population experienced 2008 levels of pollution levels every year in the past
- and this population and the hypothetical unexposed population had the same size in 2008[†].

It is not likely that there is no lag of effects and it is known that exposure in the past was not constant at 2008 levels.

We would not be alone in making these assumptions but, as COMEAP highlighted, we must recognise that as a result the effects reported are approximations².

† This has to be assumed as a population which had not been exposed to particulate air pollution in the past would not be the same size as one which had experienced this exposure.

What happens when we reduce levels of pollution?

So far we have looked at estimating the current effect of the pollution, i.e. the burden imposed by particulate air pollution, on the current population; when considering the benefits that accrue as a result of reducing pollution, we speak of the impact of reductions.

Let us stay with the cardiovascular deaths example and imagine that one of the factors that contributes to this were taken away. The risk of death would decrease. People would live longer, life expectancy would increase, the total number of years lived by the population would increase, all because death is deferred. Of course everybody will die eventually and it would be incorrect to say that removing this factor had prevented deaths. As people live longer under this scenario, the size and age structure of the population would change.

Life-table approaches

We know, from national statistics, the baseline risk of death for all age groups. If, using our original example, $PM_{2.5}$ were to be abolished in the UK then the risk of dying at every adult age (≥ 30) would be decreased by 5.4%. A table showing the number of people alive at every age (i.e. the number of 30, 31, 32, 33, etc, year olds) can be constructed and, by using the baseline risk of death for each age group, how many will survive to the next age can be calculated.

To take into account the removal of pollution, the contribution of that pollution to the mortality rate (5.4% for man-made $PM_{2.5}$ in the UK) must be removed. This means that each year, more people would survive into the next age group than if pollution levels had remained the same as today.

It might then be attractive to report the number of fewer deaths there would be each year if pollution were reduced. However, this is not a constant number. Everybody will die at some point and the lower initial numbers of deaths in the reduced pollution scenario would eventually be compensated by a higher numbers of deaths in later years in the larger, older population. People would be living longer and would therefore die later than under current pollution levels. So for air pollution, if $PM_{2.5}$ were to be abolished there would not be 29,000 fewer deaths each and every year after abolition (see Figure 1c). This is an easy mistake to make and it

arises from not taking into account the change in size and age structure of the population after pollution is reduced.

Instead of deaths, it is preferable to use population survival time (life-years) when calculating the impact of reducing pollution. This reflects the accrual of life years by virtue of the delayed death and longer lifespan within the population exposed to less pollution (Figure 1a and b)².

For any pollutant, assuming we know:

the number of people in each age group,

the baseline risks of death for each age group,

and

the coefficient linking a change in the pollutant level to a percentage change in the risk of death at each age (for $PM_{2.5}$ we use all ages 30 and over),

we can calculate the impact of pollution reduction measures.

Although the arithmetic is easy, this takes time and so-called 'life-table' spreadsheets are available to calculate it⁴.

This process is very valuable, allowing us to calculate the effects of abolishing pollution in a thoroughly satisfactory way. It takes into account changes in the number of people in each age group and can even incorporate new births each year. As can be seen in Figure 1a and b, there is no end to the benefits that reducing pollution would have even into the future. In the COMEAP 2010 report, in line with current practice, the life-table calculation was cut off after 106 years (at the end of 2113). At this point it is predicted that all of the people alive in 2008 will have died. The results of these calculations for a variety of reductions are shown in Table 3².

Time lags and economic discounting

In addition to the uncertainties about the risk coefficient and extrapolating beyond the data available, for these calculations the time lag between reducing pollution and the reduction in the mortality risk has to be taken into account. The benefit of pollution reduction may be immediate or benefits may accrue gradually over a number of years; up to 30 has been suggested for air pollution, and a number of patterns can be proposed⁵. COMEAP investigated the impact of pollution reduction

Table 3: Life-years gained (rounded to the nearest 1000) over 106 years, by population, including new births, following specified reductions in $PM_{2.5}$. UK totals are aggregated from the individual results presented (reprinted from the COMEAP 2010 report²)

Pollution reduction	Country	Population-weighted mean concentration ($\mu\text{g}/\text{m}^3$)	Life-years gained	Life-years gained per 100,000 people aged 30 years and over
1 $\mu\text{g}/\text{m}^3$	England and Wales	1	3,604,000	10,597
	Scotland	1	353,000	10,687
	Northern Ireland	1	128,000	12,302
	UK total	1	4,084,000	10,651
All anthropogenic	England and Wales	9.46	34,059,000	100,151
	Scotland	4.97	1,754,000	53,113
	Northern Ireland	6.02	769,000	74,063
	UK total	8.97	36,582,000	95,394
Removal down to 7 $\mu\text{g}/\text{m}^3$	England and Wales	3.90	14,048,000	41,308
	Scotland	0.21	76,000	2,297
	Northern Ireland	0.91	116,000	11,179
	UK total	3.50	14,240,000	37,134

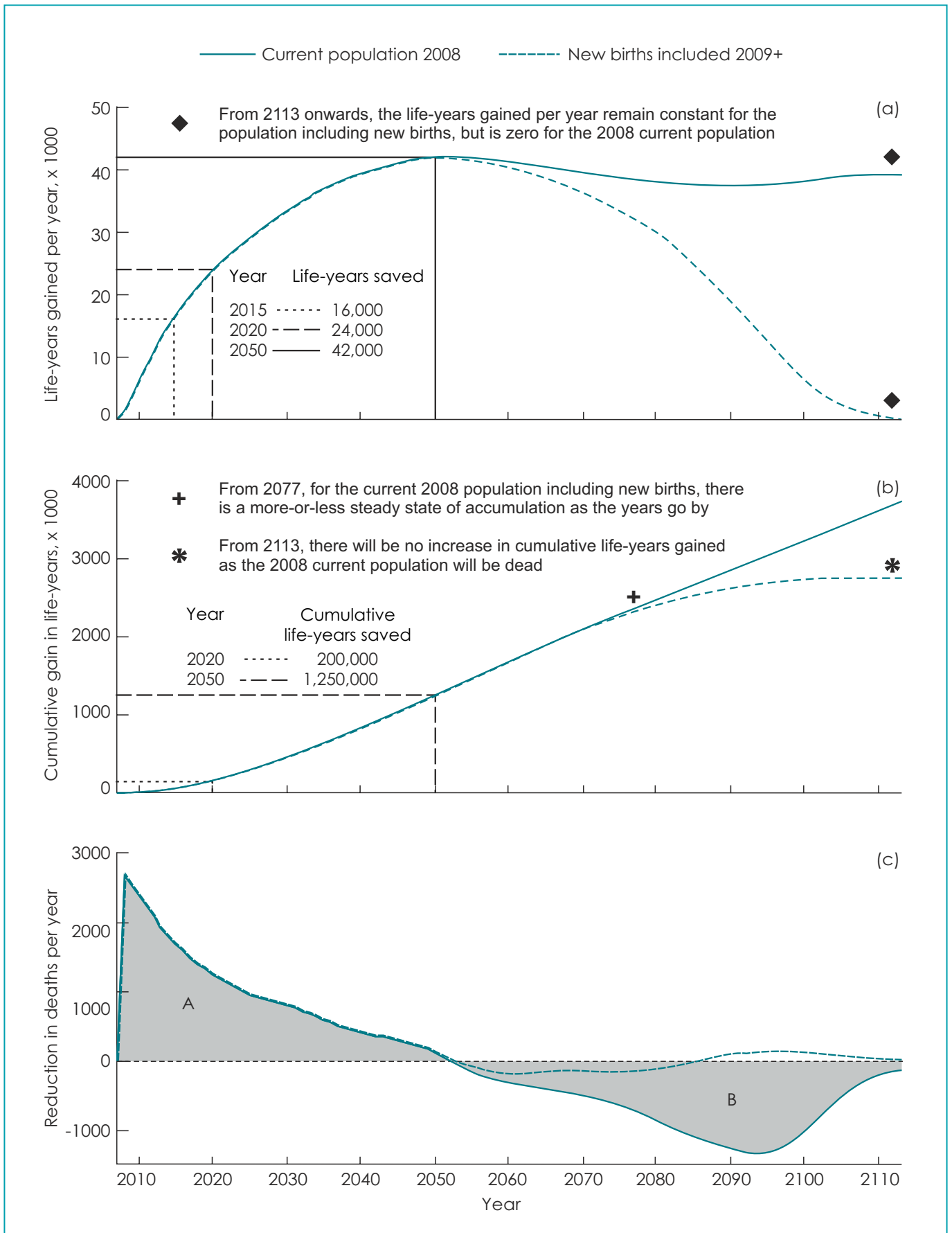


Figure 1: Patterns of impacts following a permanent reduction of 1 µg/m³ in annual average PM_{2.5} concentrations, impacting on all-cause mortality hazard rates for England and Wales; impacts expressed as annual (a) and cumulative (b) gains in numbers of life-years, and as annual reductions in numbers of deaths (c) (reprinted from the COMEAP 2010 Report²)

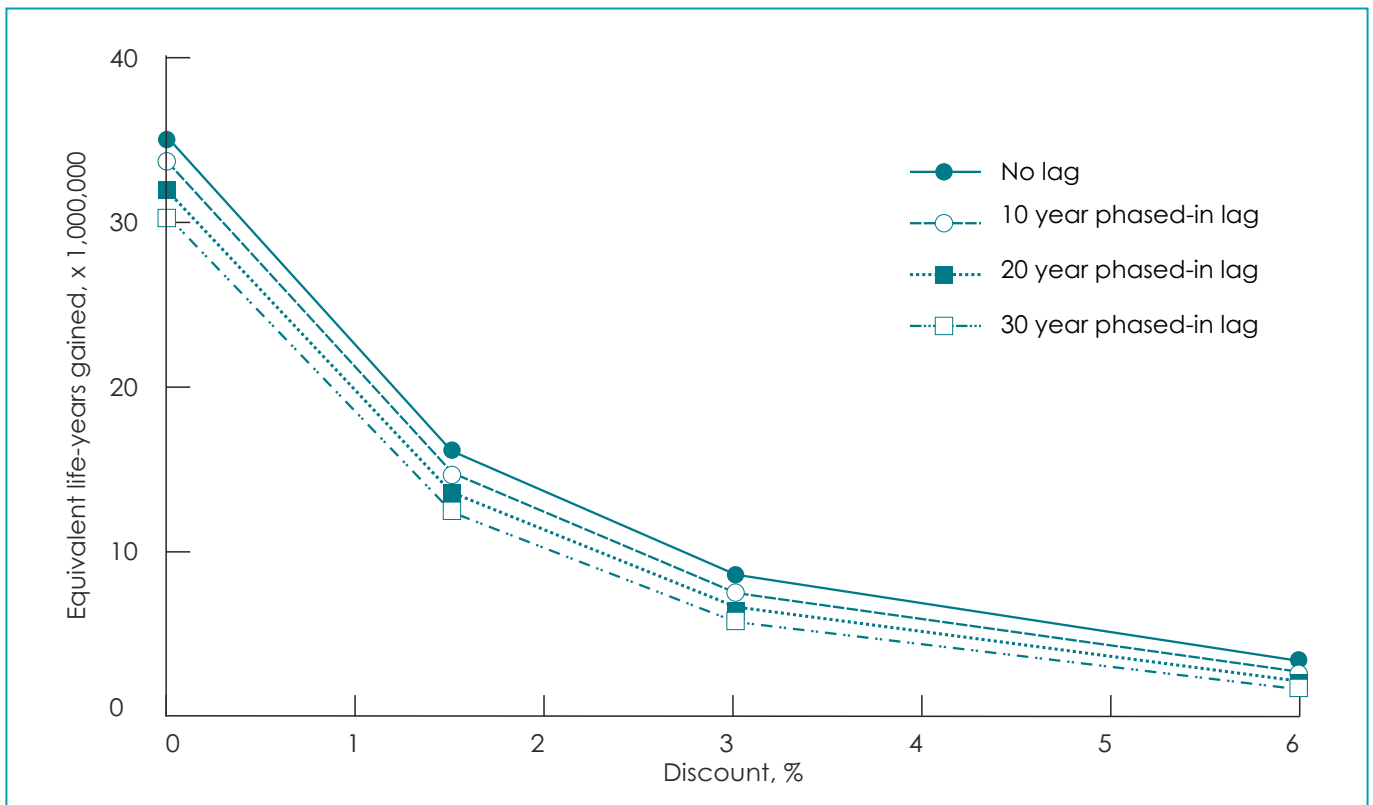


Figure 2: Effect of discount rates with different cessation lags on the value of the health impact of a reduction of all anthropogenic PM_{2.5} (9.46 µg/m³) in England and Wales (reprinted from the COMEAP 2010 report²)

using a number of different assumptions about the time lag before the mortality risks are reduced. As illustrated in Figure 2, the lag time selected makes only a small difference to the calculation².

However, COMEAP found that what does make a real difference to the calculations of benefits from reduced mortality risks, is the use of what economists call ‘discounting’, by which they mean that benefits which occur far in the future are not valued as highly as benefits occurring in the near future. The choice of discount factor, i.e. the percentage decrease in the economic value given to a life year, has a vast influence on the benefits, in terms of economic value, calculated as accruing over the next 100 or so years if air pollution is reduced (Figure 2)².

Summary

We have illustrated here that there are two ways of considering the effects of pollution on mortality. The burden, or current effects, is arithmetically straightforward to calculate, but is an approximation relying on some simplifying assumptions. Looking to the future, we can assess the impact of reducing pollution by means of a life-table approach. One thing is critically important however, explaining precisely what the calculations of the impact of policies or of the burden on health imposed by air pollution actually mean. This critically important point is, all too often, ignored.

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Modelling risk for prioritisation of interventions for environmental hazards to human health using multicriteria decision analysis

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Background

Burden of environmentally related disease

One of the goals of the Health Protection Agency (HPA) is to minimise the preventable burden of disease attributable to radiation, chemical, and environmental hazards.

The World Health Organization (WHO) Burden of Disease Programme described a method for estimating the proportion of any disease that is attributable to an environmental hazard¹. When applied to the UK, this method suggests that in the UK 18 out of 1000 Disability Adjusted Life-Years (DALYs)* can be attributed to environmental factors. This corresponds to 14% of the total burden of disease in the UK¹. Using similar methods, the HPA³ estimated the burden of disease associated with environmental pollutants at around 8–9% of the total burden of disease. This apparent discrepancy is due to different inclusion criteria in the two reports, The WHO¹ based its estimation on observed exposure levels combined with disease rates.

In 2000, the WHO developed standardised comparative risk assessment methods for estimating aggregate disease burdens attributable to different risk factors⁴ and evaluating the cost-effectiveness of environmental health interventions⁵. These contributed towards the work carried out by the HPA³ to quantify the burden of disease in England and Wales.

Amongst the key recommendations of the HPA burden of disease report³ was a call for development of an effective national environmental public health tracking system that links environmental, health, exposure and social factors, such as deprivation, to develop equitable and effective public health actions to minimise the risk of acute and chronic environmentally related disease.

Prioritising environmental public health tracking activities

The range and complexity of environmental hazards to which populations are exposed is vast and environmental effects on health are multifaceted. In order to capture potential hazards so that they can be compared and matched to exposures and health outcomes, a range of sophisticated tools, techniques and approaches is required. This will allow development of a risk assessment methodology for identification and prioritisation of hazards. This work will objectively assess environmental hazards and develop a methodology for prioritising the ‘most significant’

in order to focus scarce resources where the greatest benefit can be realised. It will also result in a prioritisation of environmental hazards that can be used to build up the future HPA Environmental Public Health Tracking (EPHT) Programme.

Other public health drivers

The Health White Paper ‘Equality and Excellence: Liberating the NHS’⁶ published on 12 July 2010 outlined the government’s plans to create a healthy nation, centred on a whole new approach. The policy statement ‘Healthy Lives, Healthy People: Update and Way Forward’, published in July 2011, highlights the progress made in developing the vision⁷.

The forthcoming Health Bill will support the creation of a new public health service. This service will integrate and streamline existing health improvement and protection bodies and functions. There will be an increased emphasis on research, analysis and evaluation, and primary care trust (PCT) responsibilities for local health improvement will transfer to local authorities who will employ the Director of Public Health. The proposed public health outcomes framework will support and guide strategic improvements of health.

The new Department of Public Health will create a ring-fenced public health budget and, within this, local Directors of Public Health will be responsible for health improvement funds⁷.

Development of a risk assessment and prioritisation methodology, as described above, will address the needs of local councils to be able to target interventions to match locally evidenced priorities for reducing the burden of environmentally related diseases.

Project aim and objectives

Aim

The aim of this project is to develop a practical tool to prioritise environmental health hazards for consideration in a public health service.

Objectives

- To determine a set of criteria to prioritise environmental health hazards for possible interventions to mitigate their health effects
- To develop a practical tool using multicriteria decision analysis (MCDA) to prioritise environmental health hazards
- To engage experts and stakeholders in parameterising and evaluating the MCDA tool.

Methods

To meet the needs for a methodology which will be applicable to the specific requirements of both the HPA EPHT programme and public/ environmental health providers in the local authority setting for prioritisation of resources for interventions, the approach must reflect the range and diversity of users and settings.

It is acknowledged that ranking often involves comparing different types of risks that are often incommensurate. Therefore it is important that the

* Disability-adjusted Life Years (DALYs) – The WHO² defines a DALY as a time-based measure that combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health.

whole process of risk assessment is transparent and coherent so that it can be clearly seen how the decision was reached.

This study uses multicriteria decision analysis (MCDA), which provides a systematic, analytical approach for integrating risk levels, uncertainty and valuation, and enables evaluation and ranking of many alternatives. The MCDA approach has been used to set priorities for health service interventions⁸ and environmental management problems⁹. It is being used here to prioritise environmental hazards for consideration for public health interventions.

Results

The work is divided into three stages given below. So far, the work around the steps involved in stage 1 is almost complete.

Stage 1 – preliminary screening, an MCDA approach is used to prioritise a list of potential environmental hazards. The approach consists of four steps.

- Step 1** Define the criteria against which the environmental hazards will be assessed and compared. The criteria could include, for example, the strength of the epidemiological evidence associating the hazard with disease-specific mortality and morbidity and the inequity of disease burden across population groups.
- Step 2** Identify potential environmental hazards and rate each against the set of criteria identified in the previous step.
- Step 3** Attach relative weights (relative importance) to each of the criteria.
- Step 4** Integrate the ratings of each hazard on each of the criteria with the relative weights of the criteria to provide an integrated score for each environmental hazard for comparing across all the hazards.

The DPSEEA (driving forces, pressures, state, exposures, health effects and actions) framework will be used to aid the MCDA exercise. The framework is a qualitative, multivariate, relational framework which represents the way assessment variables are linked and related¹⁰.

In **Stage 2**, the findings of the MCDA exercise will be reviewed by a panel of stakeholders and experts. The importance of consulting stakeholders and experts in any risk assessment process is well recognised.

A structured approach will be used to engage the experts and stakeholders on the choice of the criteria and the evidence used to rate the hazards against the criteria by using expert elicitation methods, such as the Delphi method¹¹; this consultation process can be used to increase the validity of the outcomes as well as making sure the process is transparent.

Finally in **Stage 3**, the environmental hazards on the top of the prioritised list will be subjected to detailed quantitative assessments.

The figure demonstrates the results of a pilot MCDA software tool used to construct and run an example for stage 1. In this example, the process ranks five hazards (A to E) in terms of five criteria ('robust evidence for risk', 'highly regulated', 'acceptance of risk', 'prospect of intervention' and 'acceptance of intervention'). The bottom panel gives the rating of each hazard on each criterion. The middle panel gives the relative weights that a policy maker or decision maker attaches to each criterion. A weight of zero means that the criterion is ignored and a weight of one

is the highest that can be assigned. Based on the data in the lower and middle panels (inputs to the MCDA), the top panel gives the overall score of each hazard (outputs of the MCDA). The tool integrates the ratings of the hazard on the criteria with the weightings of the criteria to give an overall score for the hazard. The hazard with the highest score (hazard A in this case) would have the highest priority.



Figure: Example of the output from the MCDA tool
(The MCDA tool was developed in Annalisa © Maldaba Ltd 2006–2011)

Discussion

It is becoming increasingly popular for many organisations to regularly rank or prioritise various hazards, to be able to focus resources most effectively. There may be consequences if resources are used on environmental hazards that are of a lower priority and are at the expense of higher priority risks¹².

A difficulty frequently experienced is that the ranking often involves comparing different types of risks that are incomparable¹³. It is important also to note that environmental health hazards chosen as priorities can change, therefore it is essential that the methodology is transparent and dynamic and as more data or evidence is available hazards can be updated and re-evaluated using the MCDA model¹⁰.

The aim of the HPA is to be transparent and clear in the criteria used to assess the relevance of specific environmental hazards and the process used to prioritise the hazards.

The model we are developing is an interactive tool that decision makers can use to compare alternatives to help decide the highest priorities. The model is not based around a particular risk assessment model, but instead has taken relevant aspects from various models that have previously been used^{14,15}. In practice, many studies have used various risk assessment approaches in combination in order to create a relevant, systematic and transparent framework for use.

The draft model constructed is structured in a tiered/staged approach; if hazards do not score adequately in the first stage then they will not proceed to the next stage. Several aspects have been taken from integrated environmental health impact assessment, such as the emphasis of clearly defining the hazard in the initial stage of the process, in addition to combining both qualitative and quantitative analysis and involving stakeholders in the decision making.

There are several important limitations to consider when setting priorities. Many of these priority setting methods and scoring systems are very simplistic and often the requirements that the systems must meet before being used are not very stringent – for example, there is currently no requirement that scoring systems produce effective risk management decisions before they are used widely.

The proposed MCDA approach for environmental health hazard prioritisation will be able to be applied at different levels, from local to regional as well as national levels. A similar approach may be applied to areas other than environmental hazards such as infectious diseases.

Stage 1 – the preliminary screening stage – is almost complete and is currently being tested and validated using specific examples. Stage 2, which is the reviewing of stage 1 by a panel of stakeholders, and the detailed quantitative assessments in stage 3 need further development following the finalisation of stage 1.

Summary

- In order to focus resources most effectively hazards need to be prioritised
- There is a need for a tailored risk prioritisation model which can assess a variety of hazards
- The model should be adaptable to assess hazards at local, regional levels as well as national levels
- The model must be fully transparent, systematic and rational in its approach.

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Human biomonitoring for Europe: a harmonised approach

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Introduction

Human biomonitoring (HBM) is the assessment of human exposure to environmental chemicals using body fluids (for example, blood or urine) or hair. This information provides a picture of the amount of a chemical actually absorbed into the body. HBM is an effective tool to assess human exposure to environmental substances and their potential health risks.

Across Europe there are numerous ongoing research and surveillance HBM projects at both national and local levels. However, study design across Europe differs and often precludes the comparison of the results from these studies. Improved comparability of European HBM data will allow cross-boundary evaluation of human exposure and support the elaboration of background levels and guidance values. This will facilitate, for example, the identification of potential high exposure populations or subpopulations and lead to policy interventions and focused research projects.

The Health Protection Agency (HPA) is a member of two sister European consortia, which aim to produce a standardised way of performing HBM studies across Europe. The Consortium to Perform Human Biomonitoring on a European Scale (COPHES)¹, funded by the European Union Seventh

Framework Programme is developing an EU HBM framework to enable the collection of comparable biomonitoring data throughout Europe. The Demonstration of a Study to Coordinate and Perform Human Biomonitoring on a European Scale (DEMOCOPHES)¹ is a collaborative pilot study funded by the EU Life+ Programme, which will test the protocols produced by COPHES by measuring the concentrations of cadmium, mercury, phthalates and cotinine in the general public.

COPHES



Starting from an inventory and analysis of similarities and discrepancies in existing and planned HBM studies in different EU Member States, COPHES has prepared an EU HBM framework and harmonised study protocols, which include:

- A training and capacity building programme
- An extended communication strategy targeting not only the scientific community and the individual participants in studies, but also policymakers, stakeholders and the population at large
- Integration of human biomarker data with environmental and health information
- Ethical aspects specific for the collection and storage of human material and biomarker data
- Cross-boundary evaluation of human exposure
- Elaboration of background levels and guidance values
- Support and evaluation of environment and health policy.

The harmonised protocols will be tested in collaboration with DEMOCOPHES and support, including a help desk and training, will be provided by COPHES to all countries participating in DEMOCOPHES.

DEMOCOPHES



The pilot study is a cross-sectional study of exposure of the European population to cadmium, mercury, phthalates and cotinine, using human biomarkers of exposure and questionnaire data. The coordinated approach will be tested in 16 European countries from a non-representative sampling of children aged from 6 to 11 years old and their mothers up to the age of 45 years old, to define preliminary reference values.

DEMOCOPHES will begin sampling in September 2011 and, in each country, 240 individuals (120 mothers and 120 children) will be sampled. The sample size calculation is based on recommendations of the International Federation of Clinical Chemistry². Although the number of samples will be limited, the sample will be sufficiently large to allow (minimal) statistical evaluations (preliminary reference values). In each country, mother-child pairs will be recruited from two locations, one urban area and one rural area, which must not be a commuter area of the urban area. Hair and urine samples will be collected from both mother and child and the mothers will be asked questions on personal

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data, living conditions, food intake, workplace and possible contact with chemical substances.

In the UK³, subject to ethical clearance, from September to December 2011, children aged 6 to 11 years old and their mothers up to the age of 45 years old will be invited to attend a local study centre to give small samples of urine and hair. The mothers will be asked questions in order to establish potential sources of exposure to cadmium, mercury, phthalates and cotinine. Two study centres will be used – one in London, to represent an urban location, and one in southwest England, Gloucester, to represent a rural location. Sixty mother-child pairs will be recruited from each location.

At the end of the study, DEMOCOPHES will report back the results and lessons learned to enable COPHES to prepare recommendations and conclusions for future European HBM studies.

The chemicals

The study will assess the levels of cadmium, cotinine and phthalates in urine samples and total mercury in hair samples. The compounds were chosen for a number of reasons: the participating EU Member States showed interest from a public health point of view, these compounds allow us to test many aspects from an analytical point of view, and there are differences in exposure patterns to these chemicals across Europe.

Cotinine is a metabolite of nicotine used extensively as a marker of secondary exposure to tobacco smoke. Across Europe there are differing exposures in the home and public areas, particularly for children, and so measuring cotinine is a good awareness-raising tool. The results will only reflect exposure as cotinine has no health-based guidance value.

Cadmium is an environmental pollutant. The largest sources of airborne cadmium in the environment are the burning of fossil fuels such as coal or oil, metal production and transport. Inappropriate disposal of cadmium-containing batteries is a potential source of environmental and public exposure. Smoking is another important source of cadmium exposure. Smokers have about twice as much cadmium in their bodies as do non-smokers. For non-smokers, food is generally the largest source of cadmium exposure.

Phthalates are a group of chemicals called phthalic acid diesters. They have a variety of industrial uses and are found in a wide range of household and consumer goods, such as plastic goods, some adhesives and some printing inks. Some foods may contain very low levels of phthalates due to the environmental persistence of phthalate esters. The main source of exposure is thought to be other plastic goods and potentially some personal care, cosmetic products.

There are health-based guidance values for cadmium and metabolites of di(2-ethylhexyl) phthalate (DEHP) for adults and children as developed by the German Human Biomonitoring Commission. These values will be used as a guide during the communication of results to the participants.

Mercury can be found as a contaminant in fish; populations with a high consumption of fish are known to have significantly higher levels of mercury in hair samples. However, the balance of these facts with the benefits of fish in a healthy diet is a factor that needs to be communicated responsibly. The results will be communicated to all participants with clear advice on diet and ways to reduce exposure by making educated choices in fish consumption, particularly for women of child bearing age.

Communication

Communication of the study objectives and dissemination of the results is key for HBM studies and COPHES is developing a dynamic communication strategy which is tailored for different audiences – the study participants, the general public, policy makers and the media – and which will encompass each stage of the project from planning and inception, through implementation and final conclusions and recommendations for a future EU-wide HBM project.

Interactive tools are useful to obtain feedback from the target audiences to evaluate the current methods of communication and ensure that the material is tailored to the appropriate audience. In the UK, two focus group sessions were arranged in order to gain insight into the general public's understanding of biomonitoring and to evaluate the communication material prepared for the mothers.

Mothers were invited to take part in one of two focus groups, one in London to represent an urban population and one in Exeter to represent a rural population. The groups were asked to comment on the recruitment material prepared such as the letter inviting participants to join the study and the information leaflet. The type of questions that would be used in the interview questionnaires was also discussed. Based on the feedback from the focus groups, the documents were amended – this included checking all communication material for the use of jargon (baseline, dataset, etc), providing an explanation of how the participants were selected, and providing more information about the chemicals that will be measured in the study (health effects, uses, etc).

Summary

This article provides a brief introduction to two very valuable projects which will ultimately improve our understanding of population exposure to key environmental pollutants. The lessons learned from the pilot study will be used to develop a truly representative UK HBM programme. Ideally this type of study should be linked to national health surveillance programmes such as the Health Survey for England⁴. These types of synergies will be explored.

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The global lead challenge

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Introduction

Lead is a cumulative toxin. Its effects on human health are well documented and include clinically observed, symptomatic poisoning at higher levels of exposure down to subclinical effects at lower levels. Children, including the unborn child, have a greater susceptibility to the toxic effects of lead than adults, in particular the neurotoxic effects^{1,2}. Childhood lead exposure can result in reduced IQ and behavioural difficulties and can therefore have a negative societal as well as personal impact.

Childhood lead poisoning is a preventable disease. In all cases of lead toxicity, prevention should be a primary public health objective³. This article provides a background to the health impact of lead on a global scale and the development of guidelines by international experts, and goes on to discuss what is being done to characterise the problem in the UK and Republic of Ireland.

International dimension of lead poisoning

The World Health Organization (WHO) estimates that lead is responsible for 143,000 deaths per year and 0.6% of the global burden of disease¹. However, prevalence rates for lead poisoning and the severity of outcomes vary greatly from country to country, with the greatest burden being in low income countries¹.

In many countries, including the UK, knowledge and understanding of lead and its effects on health have resulted in the establishment of health-based standards, such as for water, air, food and consumer products. Positive action has been taken in many countries globally to remove lead from known sources such as petrol⁴ and paint⁵. These population-based interventions, and in particular the removal of lead from petrol, are believed to account for the observed global reduction

in blood lead levels. Between 2000 and 2004 the global proportion of children with blood lead levels above 10 µg/dl has declined from 20% to 16%; however, of those children with blood levels above 10 µg/dl, it is estimated that 90% live in low income regions of the world^{1,2}.

The largest current use of lead is in storage batteries for cars and other vehicles, which accounts for 75% of global lead consumption⁵. Due to the demand for more energy efficient vehicles, the global consumption of lead continues to increase.

While in many developed countries lead exposure is no longer considered to be a significant problem, this is not the case in many developing countries where health-based standards for lead are absent or poorly enforced. Some common sources of lead exposure include the following:

- **Use of lead** in some paints, ceramics, toys, traditional medicines, cosmetics and consumer products²
- **Recycling** of used lead acid batteries, and other material such as electronic waste. Whilst in most developed countries such recycling is regulated and carried out in an environmentally sound way, this is not necessarily the case in low income countries where a large number of workers in formal and informal sectors are involved in separating lead, mercury and other metals from the waste for recovery and recycling with no or minimal environmental or occupational controls⁵
- **Industrial sites** where lead is processed or is a byproduct of production, e.g. mining and smelting, can create hotspots of lead exposure. These areas may continue to represent a hazard years after production has stopped⁵.

In those countries where lead from industrial sites and recycling activities presents a significant risk to health, contamination of soil and dust puts young children at particular risk of exposure because of hand-to-mouth behaviour; moreover children may be directly involved in some reclamation work – for example, of lead and lead salts from discarded batteries⁵. Environmental exposure to lead may result in severe poisoning and even death in young children⁶. Chronic, low level exposure to contaminated dust and soil in young children is associated with later educational difficulties and increased scores for antisocial behaviour and hyperactivity⁷.

There are other, less common – though still serious – sources of lead exposure. Over the last year the WHO has been working with a number of other agencies, in particular Médecins Sans Frontières (MSF), UNICEF, the Blacksmith Institute, TerraGraphics Environmental Engineering Inc, and the US Centers for Disease Control and Prevention, to assist the federal and state authorities in Nigeria to deal with a severe mass lead poisoning⁸. This has arisen as a result of informal gold mining and processing in a number of pastoral communities in the northwest of the country.

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Figure 1: Lead-rich ore being ground into a fine powder before being further treated to extract gold (courtesy: World Health Organization)



Figure 2: Pulverised rock is sluiced in a community pond to float off lighter particles (courtesy: World Health Organization)

As illustrated in Figures 1 and 2, people were exposed to lead through the grinding and milling of lead-rich ore to extract gold destined for the international markets. Technological advances in the (domestic) milling process resulted in increased exposure amongst the community. The issue came to international attention when an increase in child mortality and morbidity was observed in the region. The contamination was such that extensive environmental intervention, including land remediation, was required to prevent the community from being further exposed to lead following medical treatment^{8,9}. Unfortunately there remain villages in the region that are still heavily contaminated with lead and funding is being sought to continue the remediation work.

The WHO recommends that further global action is required to continue to reduce the use of lead and reduce environmental and occupational exposure to lead, in order to protect all citizens, and in particular children and women of child bearing age^{3,5,6}.

Defining international standards

To address the health challenge that lead presents, international experts met at WHO, Geneva, in July 2011 to discuss proposals for developing international guidelines for the prevention and management of exposure to lead.

The meeting, which included representatives from the USA, Africa, Asia, Europe, Latin America, Eastern Mediterranean and the UK agreed that guidelines should provide clear advice for Member States to support decision making and implementation of best practice for the prevention of exposure to lead and the diagnosis and treatment of poisoning.

The information should be targeted at public health and environmental health professionals, paediatrician, paediatric and clinical toxicologists, health ministries in Member States and others concerned with providing information and advice on reducing lead exposure.

WHO guideline development follows a structured process to ensure that any recommendations made are robust and derive from a sound evidence base, and in some circumstances from expert opinion. The next step will include a recommendation for the WHO to proceed with guideline development, that will allow the outputs from this initial scoping meeting to be used to direct a systematic review of the literature and inform future recommendations.

SLIC response to lead in the UK

In the UK, public health interventions have succeeded in removing most sources of lead from the environment. However, a small proportion of children continue to be exposed to harmful levels of lead. Therefore in 2010, the Health Protection Agency (HPA) established a surveillance study to look at children with elevated blood lead concentration¹⁰.

The **Surveillance of Clinically Recognised Elevated Lead Concentrations in Children in the UK and Republic of Ireland (SLIC)** is a collaborative project involving the British Paediatric Surveillance Unit (BPSU), National Poisons Information Service (NPIS), the Supra-Regional Assay Service (SAS) Trace Elements Laboratories and others. Collaborative partners include the UK devolved administrations in Northern Ireland, Scotland and Wales and the Health Service Executive in the Republic of Ireland¹⁰.

This three-year study aims to increase awareness and understanding of clinically relevant environmental lead exposure in children in the UK and Republic of Ireland. It employs the methodology of the BPSU to obtain case notifications of all newly recognised cases of children, up to the age of 16 years, with blood lead concentrations of 10 µg/dl and above, from paediatricians and consultant clinical toxicologists on a monthly basis through the BPSU active surveillance system¹⁰.

Key observational points

In the period 1 June 2010 to 31 March 2011, the study received twenty-two case notifications from the BPSU, of which eight were confirmed to meet the study definition. Other case reports were excluded, because in most instances the date of diagnosis was outside the study period¹¹. The number of children reported to the study in the first ten months was greater than that reported through existing surveillance systems, which rely upon ad hoc reporting to public health agencies, such as the HPA. Importantly, as children are not routinely screened for exposure to lead in the UK and the Republic of Ireland, the incidence is based on children who were selected by a clinician for testing based on symptoms.

Experience in the first year of the study suggests that not all children with elevated blood lead levels are managed by paediatricians or clinical toxicologists and some children appear to remain under the care of general practitioners¹¹. Approval is being sought from relevant organisations to allow the inclusion of these additional reporting sources, specifically cases reported directly to the HPA.

Parallel reporting from the SAS Trace Elements Laboratories, which process biological samples, has proved to be an important source of information. Twenty-four cases were reported to the study in this way, of which three matched cases reported by the BPSU¹¹. Further work is now required to establish the date of diagnosis for each reported case, which will determine whether they can be included in the SLIC study. It is envisaged that this methodology will assist with the development of a system for laboratory reporting of elevated blood lead concentrations and other environmental toxins to the HPA.

Further information from the SLIC study, along with update reports, will be published periodically. The final project report is expected to be published on completion of the study in 2013.

Advice and guidance for the public health professionals and the public

Raising awareness amongst public health professionals and the public in the UK and the Republic of Ireland has been an important aspect of the SLIC study to date. Resources for paediatricians¹², environmental health and health protection professionals, as well as the public, have been developed^{13,14}.

Resources and training material are now available on the HPA website, including case studies, action cards, legislative options and links to remediation guidance: www.hpa.org.uk/chemicals/lead

The WHO has published extensively on lead and its documents can be found on its website¹⁵. A recently published booklet, Childhood Lead Poisoning (2010), describes the nature, sources and routes of exposure to lead and summarises current thinking on lead toxicity and its effects on health³. A WHO training module on lead, intended to improving the capacity to diagnose, prevent and manage childhood diseases linked to the environment is also available on the WHO website¹⁶.

Further information

Details of the SLIC study can be obtained from the project website, www.hpa.org.uk/chemicals/slic, or the British Paediatric Surveillance Unit, www.rcpch.ac.uk/bpsu.

For WHO advice on public health and the environment, please visit www.who.int/phe/en/.

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Natural Disasters and Climate Change

Building community resilience

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The term 'resilience' is finding increasing use in the context of disaster risk reduction. It features extensively in UK Cabinet Office emergency plans, and internationally as a key element of the United Nations Hyogo Framework for Action on Disaster Reduction^{1,2}. This article introduces the concepts of resilience relevant to health protection, and addresses the problems of measuring and encouraging community resilience.

What is resilience?

In broad terms, the concept of resilience encompasses the intrinsic capacities of individuals, communities and infrastructure to resist and recover from disasters. It shifts emphasis away from the negative notion of vulnerability – and from externally applied disaster prevention and recovery measures – towards the social and structural features that make communities less likely to suffer adverse impacts from crises in the first place, and better able to recover if they do.

The term is widely used in a range of disciplines, including psychology, ecology and engineering, and reflects an array of related concepts (see Box 1). Yet there are recurring elements in the various descriptions of resilience. These include the importance of communication; learning and adaptability; risk awareness; social cohesion and trust (social capital); good governance; regional economic resources and economic diversity; the pre-existing health of a population; and existing emergency plans and preparations³.

Box 1: Resilience concepts³

Disaster resilience describes the capability of a community or society to resist and recover from a disaster

often used synonymously with

Community resilience, which describes the capability of a community to adapt and continue functioning in the face of disturbance^{4,5}

Ecosystem or social-ecological resilience describes the capacity of natural and social systems to absorb disturbance while remaining within the same functional state⁶

Infrastructure resilience describes the capacity of built infrastructure to continue functioning during disasters⁷

Psychological or individual resilience describes the capacity of individual people to cope with adversity and continue functioning⁸

There is substantial overlap between community/disaster resilience and social-ecological resilience. They are both holistic concepts capable of encompassing most other usages of the term. The social-ecological concept derives from ecology and systems theory, and introduces the idea of limits to a population's capacity to adapt: crossing these thresholds may result in abrupt changes to a community's structure and

identity. The United Nations International Strategy for Disaster Reduction (UNISDR) provides an inclusive definition of resilience that captures the important elements of these concepts:

“The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.”⁵

What is a resilient community?

Resilient communities are healthy communities, both in terms of the physical and mental health of individuals and families, and in terms of overall function. They are educated, economically secure, and cohesive, made up of people who trust each other and the authorities, and who are willing to help their neighbours in times of crisis. Good governance, fault-tolerant infrastructure, and effective contingency planning for emergencies remain vitally important, but these elements need to be considered within the broader context of the communities' mental, physical, social, economic and environmental health.

How can we apply resilience concepts?

The following examples show how resilience concepts can be applied in the health protection context, to influence health outcomes for the better.

The management of pandemic influenza demonstrates certain principles of community resilience. Sufficient economic and human resources are important to maintain business continuity during a pandemic⁹, while the underlying health of the population will have a role in determining mortality and morbidity rates. Contingency plans and good communication aid preparedness and recovery, while computer-based training programmes can promote the capacity of health workers to cope¹⁰. An effective response depends on people trusting the authorities and each other ('flu friends'), and may require key groups, such as healthcare workers, to be adaptable and put the needs of the population above those of themselves and their immediate families¹¹.

Heat wave planning demonstrates many of the same points: the commitment of financial resources to reduce vulnerabilities (installing air conditioning in nursing homes), effective contingency plans to cope with increased demand on health services, and the importance of good communication, public risk awareness and social cohesion (checking on elderly neighbours). Heat waves also provide an illustration of the social-ecological interpretation of resilience. Above certain temperature thresholds mortality levels will abruptly spike; however, this is not inevitable and varies between communities, reflecting both the physical and climatic characteristics of a region, and economic and social factors that limit the population's capacity to adapt to extreme temperatures^{12,13}. For example, failure to control residential temperature and lack of social interaction were both important predictors of mortality in the 1995 Chicago heatwave¹⁴.



Recent flooding in Oxfordshire

A community's vulnerability to other acute threats, such as extreme winter weather, natural hazards, terrorist acts or chemical incidents, can also be described within this framework. So too can overarching, 'rising tide' problems such as global warming, in which thresholds – limits in the capacity of natural or human systems to resist and adapt to climate change – become important. A critical difficulty lies in identifying the significant thresholds before they are crossed¹⁵.

Choosing policies and promoting actions that enhance society's overall resilience might be an appropriate response to this uncertainty. In the case of climate change, many of the actions intended to reduce carbon dioxide emissions, and therefore the frequency and severity of extreme weather events, also enhance both the health of a population (the 'health co-benefits')¹⁶ and its resilience: these include the development of a diversified, low carbon energy supply, the promotion of walking and cycling instead of car use, and other community-level initiatives that serve to promote both healthy living and social cohesion, as well as reducing carbon dioxide emissions.

The value of the resilience concept may lie particularly in settings where crises are broadly expected, but the nature and extent of the potential disaster cannot be well characterised. If communities and authorities focus too much on building 'specified' resilience towards well-understood threats, there is a danger that their 'general resilience' to unanticipated hazards may suffer¹⁷. A resilience approach therefore involves a degree of flexibility and operational redundancy, as well as consideration of the resources and capacities required for dealing with crises.

Can we measure resilience?

Currently there are few well-defined tools to measure resilience, and no agreed list of indicators that encapsulate the concept. Many proposed elements, such as 'communication', 'adaptability' or 'social cohesion', are tenuous and not readily amenable to quantitative methods of assessment. Recently, however, efforts have been made to quantify and evaluate disaster resilience in different settings (see Box 2).

When communities vary so widely in size and character, and face a diverse range of potential threats – from environmental hazards and infectious disease outbreaks, to complex multifactorial problems such as obesity or climate change – the relative contribution of factors towards a population's overall resilience will vary according to circumstances. Given these difficulties, it may be pragmatic to assess resilience qualitatively, or by using a mix of qualitative and quantitative methods.

Box 2: Approaches to assessing resilience

Characteristics of a disaster resilient community

The UK Department for International Development (DFID) has funded a guidance document on resilience for governmental and non-governmental organisations working in vulnerable communities across the developing world¹⁸. It groups the attributes of resilience into five thematic areas: governance, risk assessment, knowledge and education, risk management and vulnerability reduction, and disaster preparedness and response

Each thematic area is broken down into detailed tables of potential resilience components. While the document presents a comprehensive framework for considering resilience, the authors suggest that local organisations select and modify the different attributes according to circumstances. Although many users will assess resilience characteristics qualitatively, decisions on whether to translate a given component into a quantitative indicator can be made at project level¹⁸

Disaster resilience index

Cutter et al¹⁹ describe a method for quantifying a 'baseline resilience indicator for communities' in the South-eastern USA, by combining selected variables into composite indicators based on the following categories: social resilience, economic resilience, institutional resilience, infrastructure resilience and community capital

The composite indicators for each category are combined into a single disaster resilience index. This is calculated at county level, enabling resilience to be mapped on a regional basis. Variables are not weighted, and are selected for regional relevance (for example, indicators such as the percentage of the population with health insurance coverage – in the social resilience category – might be less relevant in a UK setting)¹⁹

Summary

The development of the resilience concept as an operational tool remains in its infancy, yet 'resilience thinking' provides a framework that draws conventional emergency planning together with efforts to improve public health and social cohesion. A number of international agencies involved in disaster relief are promoting and using the characteristics of a disaster-resilient community in the developing world, but the principles also apply to developed nations. The notion of resilience serves to broaden the scope of disaster risk reduction, so that wider psychological, socioeconomic and environmental factors are explicitly considered. The adoption of the term by the UNISDR signals its international acceptance, and its growing use in the UK suggests that the word, at least, is here to stay. However, a better understanding of the underlying concepts is an important step towards making our communities more resilient in practice, as well as in theory. Some key steps that will help encourage community resilience are shown in Box 3.

Box 3: How to encourage community resilience

Develop indicators to better characterise community resilience on national, regional and local levels (while accepting that a comprehensive and universal system of quantifying resilience may not be achievable)

Support efforts to improve public health and community cohesion, linking these interventions to the emergency planning agenda

Encourage links within and between community groups and authorities – and involve community groups in crisis planning

Improve communication, adaptability and operational redundancy in groups and organisations involved in emergency response and recovery

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Enumeration in the face of adversity: profiling flood-affected residents in Morpeth

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Summary

After a major flooding incident it is necessary to understand the number and characteristics of flood-affected residents in order to provide an appropriate health and welfare response. Not all those affected will notify the statutory authorities and so this profile information is not readily available. Here we outline an alternative method to profile the number and characteristics of affected residents following the extensive flooding experienced in Morpeth town in September 2008.

Residential address information from the National Health Service (NHS) general practice registration system was linked to a list of flood-affected addresses supplied by the Environment Agency. This was carried out in order to identify the number, age, neighbourhood locality and general practice attended by individuals living at flood-affected addresses within Castle Morpeth. The profile information assisted with efforts to ensure appropriate targeting of health and welfare information and support services across Morpeth.

This data linkage method was straightforward, timely and efficient. It could be employed in future major flooding incidents in the UK, and internationally where similar datasets are available.

Background

There is an ever-increasing risk of major flooding events in the UK as warmer, wetter and stormier weather is anticipated as a result of global warming¹. Flooding events not only pose an immediate risk to public health and safety but also have lasting health and welfare implications for people, such as the mental stress caused by temporary re-housing and disruption to local amenities, businesses and shops. Given the negative impact of major flooding events, it is essential to build a profile of an affected community in order for the local statutory and voluntary services to provide adequate and appropriate support.

Incident details

Morpeth is a small market town in Northumberland, North East England. The town is situated in a loop of the river Wansbeck with a population of approximately 16,000 people. On 6 and 7 September 2008 Morpeth experienced extremely heavy rainfall and flooding when the river Wansbeck burst its banks (see Figure 1). There were more than 1000 properties affected by floodwaters. Local amenities including the library and leisure centre were damaged. Health services were adversely affected, with the ambulance station and Morpeth Health Centre flooded. The health centre housed one of the three general practices in the town, community/district nursing services, the podiatry service, health visitor services and the family planning clinic.



(a)



(b)

Figure 1: (a) flooding in Morpeth High Street (reproduced by courtesy of the Environment Agency) and (b) flooding in a residential street in Morpeth (reproduced with permission from Parkin²)

Response

The situation was declared a major incident at 16.00 hours on Saturday 6 September. In the following days the local community recovery and restoration plan was instigated and a joint health and welfare working group convened. The roles of this group included:

- Maintain normal health services
- Establish extra health and welfare services, if required
- Monitor and mitigate any adverse health effects arising from the incident

- Coordinate psychological support and counselling where necessary to those affected
- Ensure the public and all those affected were informed about any health implications.

To provide an appropriate health and welfare response it was felt necessary to understand the number and characteristics of flood-affected residents. Although people were invited to notify the local authority if they moved house as a result of the flood, this was not a requirement. Furthermore, many individuals chose to remain in their homes during the clean-up operation. It was therefore impossible to build up an adequate profile of the affected community through self-notification alone. The aim was therefore to use an alternative technique to self-notification to profile the age, neighbourhood locality and general practice registration details of flood-affected residents in Morpeth in order to assist the health and welfare response to the flood.

Methods

We used two sources of data to identify flood-affected individuals in light of inadequate self-notification:

- A list of flood-affected addresses drawn up by the Environment Agency supplied by the Environmental Health Department of Castle Morpeth Borough Council
- The Exeter data system. This is a routine source of information which provides a record of the address and personal details of individuals registered at general practices. It is a live system and continually updated. A download from the system can be taken at a given point in time to provide a cross-sectional dataset of individuals' registration details. A download was obtained in early October 2008 (around a month after the flood).

Address details (first line of address and postcode) from the Exeter download were matched against the Environment Agency address list in order to obtain a list of individuals living at flood-affected addresses within Morpeth shortly after the flood.

Any addresses which failed to match between these two datasets were further investigated using the Strategic Tracing Service. This can be interrogated on a case-by-case basis and provides a record of an individual (NHS number, name, sex and date of birth). It is possible to look up an address on the system and establish retrospectively whether someone was living at the property and on what date they moved out. We used this service to identify anyone who was living at a flood-affected property on the date of the flood, but had subsequently moved home.

A Caldicott agreement was obtained in order to access individual-level, patient-identifiable information from the Exeter system and the Strategic Tracing Service system and to link this information to the Environment Agency flood-affected address list.

Using the linked dataset we produced a descriptive profile of the age of the affected community subdivided into four neighbourhood localities and by general practices. To quantify the potential relative impact on the three Morpeth general practices, we also calculated the affected individuals as a proportion of the total number of individuals registered at these practices.

Results

Data linkage process

At the end of the data linkage process there were 41 potential residential addresses which it had not been possible to link to any NHS patient information. These 41 addresses represented 4% of the original 995 addresses identified by the council, resulting in a data linkage accuracy of 96% overall (Figure 2).

Descriptive profile

- In total, 1539 individuals registered with a general practice lived at a flood-affected address
- Only 28 people moved house in the month following the flood and notified the health service of this change (28 individuals, 1.8% of all flood-affected individuals)
- The majority of affected residents (41%) lived in the Middle Greens area, to the east of the town
- A high proportion of older people were affected; the flooded area included sheltered accommodation and a nursing home
- Surgery C had the highest proportion of its patient population affected compared to the other Morpeth practices and the impact was concentrated in the oldest and youngest patient age groups (Figure 3). This was of particular significance because the surgery was itself flooded.

Data uses

The profile information assisted with efforts to ensure appropriate targeting of health and welfare information and support services across Morpeth. For example, the age profile information was used by the Educational Psychology Team in Northumberland to assist with planning adequate psychological support through the school system to affected children. Examining general practice registration information aided health service planning by indicating which general practices were more likely to experience increased workloads on account of a high proportion of their patients being affected by the flood.

Initially two people were trained to deliver 'mental health first aid' support to the affected community. The programme was then expanded, so the profile information was useful in indicating the distribution of the affected community for planning this service. In addition, a six-week stress control programme was run in Morpeth for members of the affected community who were either referred by their general practitioner or came on to the scheme by self-referral.

Discussion

Limitations

The dataset of 'flood-affected' residences supplied by the Environment Agency included properties with 'any degree of flooding', ranging from a build up of water in the back garden through to total destruction of the living accommodation. The list included whole blocks of flats, and upper floors which would not have been damaged by flood water. The implications of this for the analysis are that the number of individuals reported may be an overestimate of those affected by the flood. Nevertheless, neighbours (even if not experiencing damage to property due to flood waters) will still suffer in the short term from loss of power, and in the longer term from the loss of community infrastructure, and may still experience the psychological symptoms (stress and anxiety) which are common following a major incident.

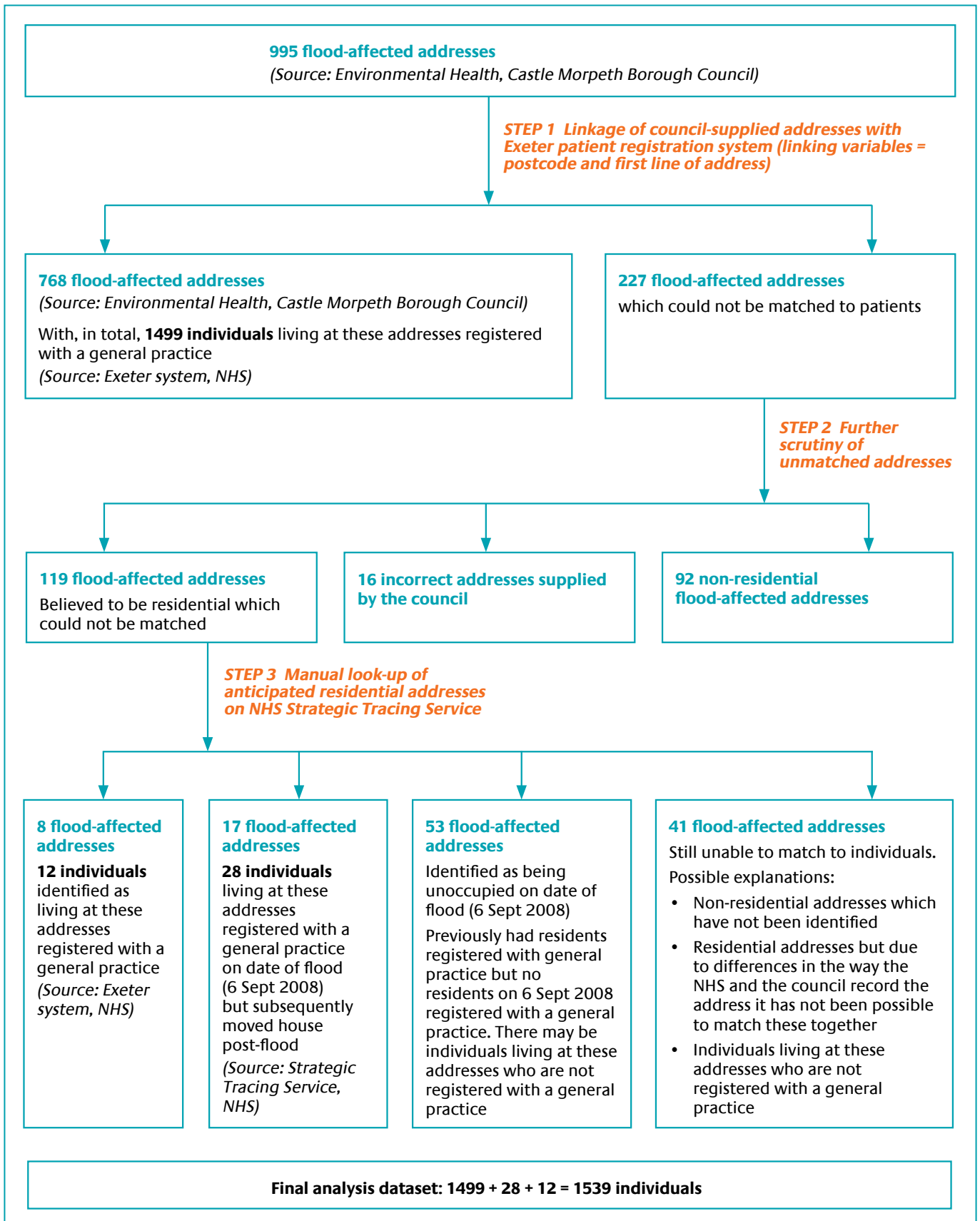


Figure 2: Identifying individuals living at flood-affected addresses in Morpeth

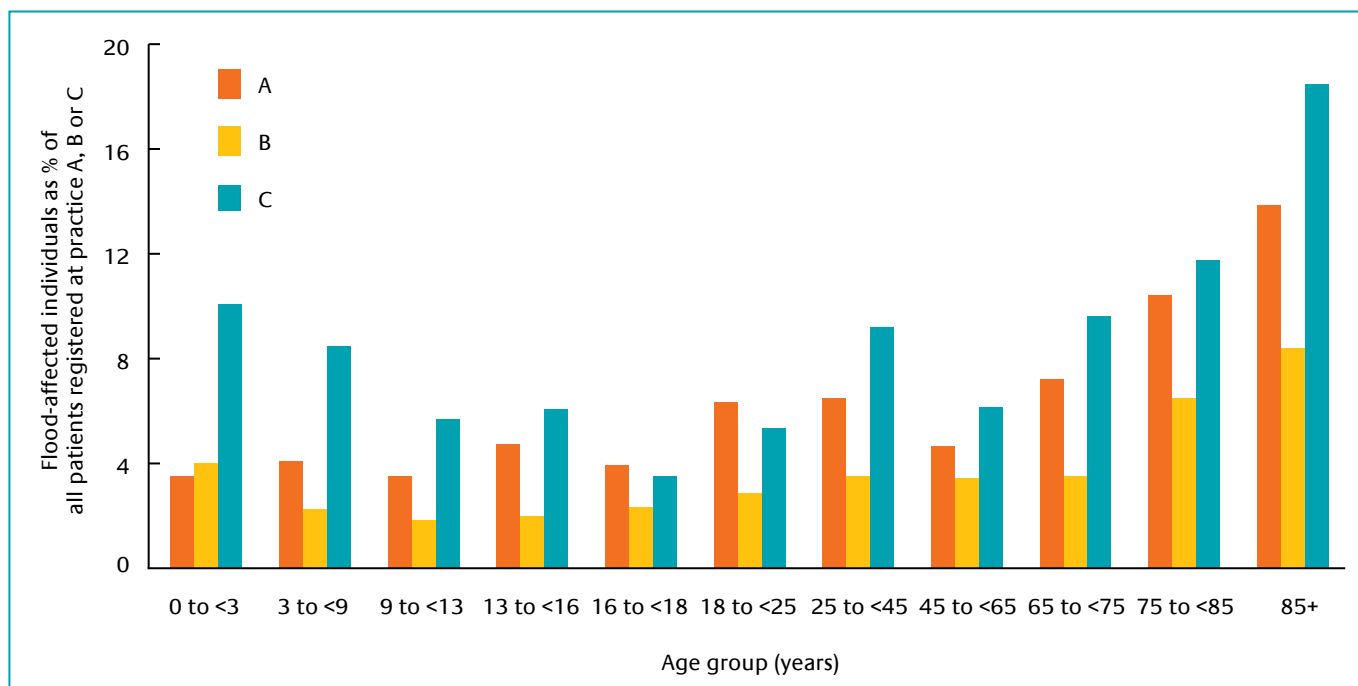


Figure 3: Flood-affected individuals* as a percentage of all patients registered† with Morpeth general practices A, B and C by age group

* Total number of flood-affected individuals registered with the three Morpeth general practices (n = 1527) (12 individuals were registered at practices other than the three in Morpeth).

† Patient registration information from the Exeter system at 31 October 2008.

The download of the Exeter system was not carried out until a month after the flooding event and people may have moved before then. The first data linkage step resulted in a high proportion of unmatched addresses (Figure 2), but further scrutiny of the unmatched addresses using the Strategic Tracing Service improved the completeness of the data matching. The other limitation to this method, for ascertaining flood-affected residents based on general practice registration information, is that anyone not registered with a general practice will be missed from the analysis. However, given general practice registration is the gateway to accessing NHS services, it is likely that very few individuals will be missed through non-registration. Furthermore, Morpeth has a relatively static population so there is no reason for the general practice registration information for Morpeth to be particularly erroneous or out of date.

Conclusions

The profile information assisted with efforts to ensure appropriate targeting of health and welfare information and support services across Morpeth. This data linkage method was straightforward, timely and efficient. It could be employed in future major flooding incidents in the UK, and internationally where similar datasets are available.

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Mapping of European flooding events 2000–2009

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Summary

Flooding is the most common form of natural disaster and public interest in European countries continues to increase, in particular, following flood events in 2002 and 2009 in Central and Eastern Europe, and in 2007 and 2009 in the UK.

At the request of the World Health Organization (WHO) Regional Office for Europe, the Health Protection Agency (HPA) has undertaken a project in 2009–2010 with the aim to improve public health preparedness and response to flooding.

As part of this, the epidemiology of flooding across Europe was considered. This includes:

- The definitions of flooding; practical so that flood plans may be activated but also epidemiological so that surveillance can be performed
- The incidence of flooding in Europe by analysing the EM-DAT database of natural and technological disasters and Dartmouth Flood Observatory's Global Active Archive of Large Flood Events. Flood events have been mapped, rates of flooding calculated and impact considered in terms of rates of individuals killed and affected by floods
- A review of web searches and other flooding reports.

Increases in recorded flooding are hard to quantify but the main causes are thought to be better reporting and changing land use across the continent. As flooding is likely to increase in the future, the health impacts are likely to become more significant. Knowing what constitutes a flood and where they are will help with health protection's role in mitigating the effects pre-, peri- and post-flood.

Introduction

The Health Protection Agency (HPA) was asked by the World Health Organization (WHO) Regional Office for Europe to produce a report on protecting health from floods. Part of this report focuses upon the definitions of floods and mapping where they have occurred in Europe, which is the focus of this paper.

This was achieved by a qualitative survey sent to countries within the World Health Organization Regional Office for Europe, review of the relevant literature, interrogation of two flooding databases (EM-DAT global database on natural and technological disasters and the Dartmouth Global Active Archive of Large Flood Events) and review of other internet sources.

Definitions of flooding

It has become apparent that defining what constitutes a flood is difficult; furthermore, what defines a flood that activates an emergency health response is also equally complex.

Flood definitions are useful for assessing the health impacts of floods and the infrastructure and financial toll they can cause; as well as providing a trigger for the activation of an emergency response. Examples of currently used definitions include:

- Flood – the presence of water in areas that are usually dry, and for flood disaster – a flood that significantly disrupts or interferes with human and societal disaster¹
- Flood – any case where land not normally covered by water becomes covered by water (Flood and Water Management Act, 2010). Further, these new definitions of flood and coastal erosion issues describe flood risk as the relationship between the probability of occurrence with the associated consequences. These are then listed with health as the first concern, followed by social and economic welfare. The Act reflects that floods can be caused by:
 - a heavy rainfall
 - b a river overflowing or banks breached
 - c tidal waters
 - d groundwater
 - e anything else (including a combination of factors).

Three ways of defining a flood for health purposes have arisen: through scientific thresholds, descriptions of population effects and temporal perspectives. These are:

- Scientific thresholds:
 - a depth of water – a specified level reached determines the qualification of a flood
 - b temporal and spatial – the length of time and/or the area that land is flooded for
- Population effects:
 - a broad – medical, social, economic disruption to normal life
 - b specific – numbers of deaths or people affected
- Temporal health perspective²:
 - a immediate outcomes – during or immediately after the flooding
 - b short-term outcomes – in the days or early weeks following the flooding
 - c long-term outcomes – may appear after and/or last for months or years.

So far as health effects are concerned, the temporal health perspectives are probably most helpful. However, all these definitions reflect the complexity of finding an adequate way to describe holistically the impacts of flooding from a health perspective.

There is an issue about defining a death from flooding. It is suggested that a flood fatality or flood-related fatality is a fatality that would not have occurred without a specific flooding event.

A flood fatality raises questions regarding timing of death. Indirect and direct are not useful terms: however some deaths are immediate (drowning) and others could be delayed (deaths due to psychological effects). Therefore, to accommodate possible separation between the flood disaster and the potentially associated death, flood disaster could be categorised into three phases: pre-impact, impact and post-impact¹. From this paper it has been postulated that two-thirds of deaths from flooding worldwide are from drowning and one-third is from physical trauma, heart attack, electrocution, carbon monoxide poisoning or fire. Seventy per cent of deaths are males¹.

Current flood risk

There are wide variations between European countries about estimates of the proportion of the population living in flood-prone areas. For example, 3.5% in France and 4.8% in the UK compared to 50% in the Netherlands³.

In the UK about 5 million people are at risk from floods³. They live in around 2 million homes valued at over £200 billion. The average annual flood loss is estimated at £1.4 billion. London's floodplain alone has around 16 hospitals, 200 schools and 500,000 properties on it. New housing developments continue to be proposed upon floodplains: in southeast England one-third of the proposed 200,000 homes are in flood-prone areas. The increasing pressure to develop on floodplains and the forecast effects of climate change may mean that the costs of flood defences and insurance become unattainable.

Mapping flooding events

Quantifying the level of flooding in the WHO European region is difficult. Two databases that collect information about flooding were analysed to see which countries had been flooded between 2000 and 2009, and assess the impact of these floods.

EM-DAT

The Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université Catholique de Louvain in Brussels maintains the Emergency Events Database: EM-DAT⁴. EM-DAT has been running since 1900 and has recorded over 17,000 disasters, both man-made and natural.

The EM-DAT criterion for defining a flood is a significant rise of water level in a stream, lake, reservoir or coastal region and include general river floods, flash floods and storm surges or coastal flooding.

There are also criteria that a flood (or any other type of disaster) must meet for it to be classified as a disaster or flood event by EM-DAT: either 10 or more people killed; 100 or more people affected; declaration of a state of emergency and/or a call for international assistance. This means that only the largest disasters are captured on the database.

The database is compiled from various sources, including UN agencies, governments, non-governmental organisations (NGOs), insurance companies, research institutes and media agencies. Priority is given to data from UN agencies, governments and the International Federation of Red Cross and Red Crescent Societies. EM-DAT argues that these sources are generally highest in quality and most likely to be complete.

As well as counting the number of floods, the numbers of deaths, numbers affected and damage done by the floods is also recorded.

Dartmouth Flood Observatory

The Dartmouth Flood Observatory (DFO) (based at Dartmouth College in the USA) maintains the Dartmouth Global Active Archive of Large Flood Events⁵. This is a global database of flood disasters which contains information derived from a wide variety of news and governmental sources. The DFO surveys online news reports, governmental and international relief agency websites and other electronic data sources for reports of flooding. Satellite and airborne images of flooding are used to map where the flooding has occurred.

Only floods that appear to be 'large' are included by the DFO. This is defined as significant damage to structures or agriculture, long (decades) reported intervals since the last similar event, and/or fatalities. The DFO does not appear to specifically define what constitutes a flood and appears to base its definition on reports of flooding combined with a criterion of recording only large events.

The DFO does consider the main cause of the flood. In this case it is likely to capture more flood events than EM-DAT as any large flood event is recorded as a flood, whereas EM-DAT may classify it as another type of disaster. It is worth noting that (tropical) storms are included only where they also cause flooding.

The DFO also records the number of fatalities and the damage caused by the floods.

Limitations

Both databases make a distinction between floods of any size (all floods) and flood events/disasters which are the larger-scale floods that they record. This should improve ascertainment (large-scale events are easier to count) and so should ensure a more complete dataset. However, the totality of the effects of flooding also needs to consider smaller-scale events but they are harder to measure as there is no clear agreement on which of these constitute a 'flood'.

There are problems of ascertainment, however: both databases focus upon events reported by governmental organisations, insurers, NGOs and the media. Many small-scale floods may not be reported or even recorded by such organisations, particularly if the governmental organisations are discouraged from reporting or if NGOs or international media are not operating on the ground in such countries. The DFO states that more developed countries tend to report more rapidly and in greater detail than less developed countries. Also, the amount and type of media and other coverage is not necessarily proportionate to the size of the flood event. The figures therefore of the flood events should be considered indicative.

Both databases use country-level data. Disasters affecting many countries simultaneously are entered multiple times into the database in EM-DAT (but with the same identifier) and as a single entry by the DFO. At a country level, they obviously need to be treated as separate events but on a European level they are a single event. This can also lead to problems of multiple counting of the same event.

A further potential limitation of the EM-DAT dataset is how it classifies disaster events. For example, windstorms can cause flooding as can tsunamis, and floods themselves may cause landslides. For any given event,

it is important to know what criteria were used to classify the event and whether or not there has been any random or systematic misclassification which in turn could lead to over- or under-counting of events.

Both datasets consider flooding at a country level. However, a better measure of flood risk would need to consider specific place and person risks. For instance, categorising risk on a country basis may be too broad. An individual's risk is likely to vary depending upon whether or not they live on a floodplain or in a coastal area. Similarly, an individual's vulnerability to flooding may also depend upon their age or sex. Types of flood may also shift these risk profiles¹. Therefore, with the current data, making further inferences beyond the numbers of floods and the numbers killed is difficult and, as described above, the definition of a flood death is complex.

Financial damages associated with the flood events were not analysed, despite data being available from both the DFO and EM-DAT. Barredo⁶ argues that flood losses are in effect a proxy marker for development and are more closely correlated with gross domestic product (GDP) rather than as a marker of the severity of the flood, so limiting their usefulness.

These limitations aside, it is possible to map the larger flood events and disasters that have affected the WHO European region over the previous ten years.

Numbers of floods

The numbers of flood events from both datasets were analysed (Figure 1). The DFO recorded more flood events between 2000 and 2009. For most countries, it also records more flood events. This may in part be due to the fact that the DFO uses a looser definition of what constitutes a flood event and also does not have the issue EM-DAT has with the classification of a disaster type.

Using the DFO figures (as they are likely to have better overall ascertainment), this data can also be represented in geographical form (Figure 2) (the maps were drawn using ESRI ArcGIS 9.3.1 software). This shows that there has been flooding across most of the European region. However, there would appear to be a number of countries that have few if any floods including those in Scandinavia and the Baltic and the Netherlands. The lack of flood events in the Netherlands is surprising given the nation's previous history of flooding. However, it may be that the extensive flood defences that are in place have prevented any significant flooding during the last decade.

There also appears to be no and few floods in Turkmenistan and Uzbekistan, respectively. However, in view of the severe flooding in the area during the 1990s (see the table below) this may well be due to poor ascertainment rather than a lack of significant flood events.

Large numbers of floods are noted in the Russian Federation, Romania, Turkey and the UK. However, these countries also have some of the largest populations in the WHO European region. This raises the question as to whether or not there is a relationship between population size and number of floods. This is an area where further investigation would be warranted. For instance, it might be that other factors, such as population density, are the key question, with, say, increased population living upon the floodplain or increased urbanisation and change of land use.

To try to account for population effects, rates of flooding will be considered in the maps below (Figures 3–5). The denominator used will be the total population of each country. The population data is taken from the WHO Regional Office for Europe, European Health for All Database (HFA-DB), mid-2005 population estimates^{7,8}.

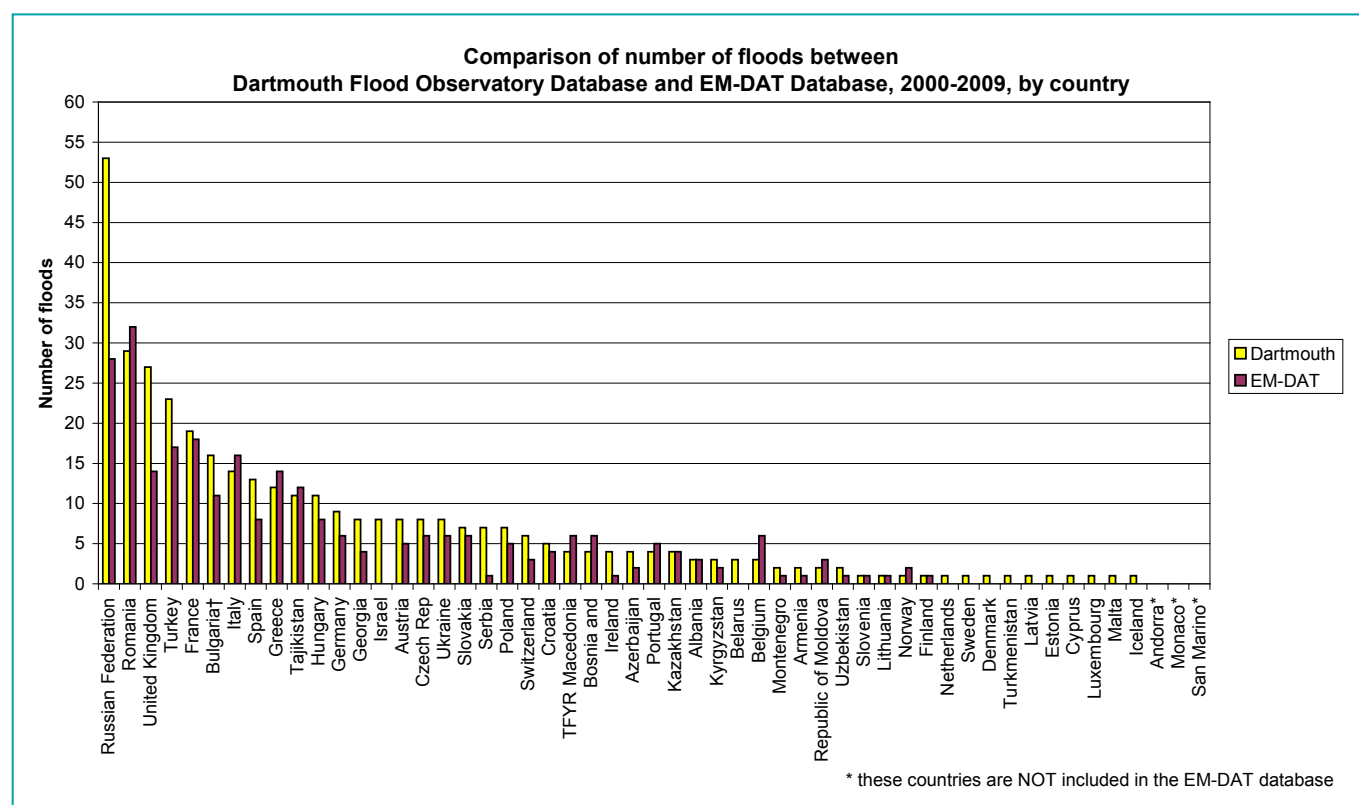


Figure 1: Comparison of number of flood events between DFO and EM-DAT, 2000–2009, by country

Table: Most severe flood events in terms of fatalities for the periods 2000–2009 and 1990–1999 (source: EM-DAT)

Countries affected	Date of flood	Number of deaths
2000–2009		
Russian Federation	June 2002	117
Russian Federation	August 2002	59
Austria, Czech Republic, Germany, Hungary	August 2002	55
Turkey, (Syria)	October 2006	46
Republic of Moldova, Romania, Ukraine	July 2008	40
Kyrgyzstan, Tajikistan, (Afghanistan)	June 2005	39
Italy, Switzerland	October 2000	37
Bulgaria, Republic of Moldova, Hungary, Romania	August 2005	34
Turkey	July 2002	34
Poland	July 2001	30
1990–1999		
Tajikistan	April 1998	203
Tajikistan	April 1992	200
Turkey	February 1992	200
Italy	May 1998	148
Kyrgyzstan, Uzbekistan	July 1998	93
Spain	August 1996	85
Italy	November 1994	83
Romania	July 1991	71
Turkey	November 1995	62
Poland	July 1997	54

This assumes that the whole population of a country is at equal risk from flooding, whereas this is patently not the case. A more sensitive analysis would use population numbers weighted for potential exposure to the flooding: those individuals living on floodplains and in other flood-prone areas would count more than those living in areas considered to be at low risk of flooding.

The effects of small numbers within the data also need to be considered, in particular with regard to the number of flood events. For instance, Montenegro has a population just over 600,000 (2005 mid-year estimate) and two floods were recorded by the DFO. Increasing or decreasing the number of floods by one has a significant effect upon the rate of flooding in Montenegro, exacerbated by having a small population relative to some of the other countries in Europe. It should be noted that 32 of the 53 countries in the region reported five or fewer flood events during the ten-year period.

Rates of flooding in Europe

Figure 3 examines the rate of flood events in the WHO European region. DFO numbers of floods have been used as the numerator and HFA-DB 2005 mid-population estimates have been used for the denominator.

Comparing Figures 2 and 3, a different picture emerges. The rates of flood events appear to be highest in Central Europe in Figure 3 as opposed to the Russian Federation, Romania and the UK in Figure 2: Montenegro has the highest with 0.32 flood events per million population per year. The river Danube flows through many of these countries and has a drainage area affecting many more, which may help explain the concentration of flood events. Flood rates also appear higher in many of the southern states of the former Soviet Union than indicated by the simple counts shown in Figure 2. Figure 3 suggests that there is a sub-regional picture to the rates of flooding events across Europe.

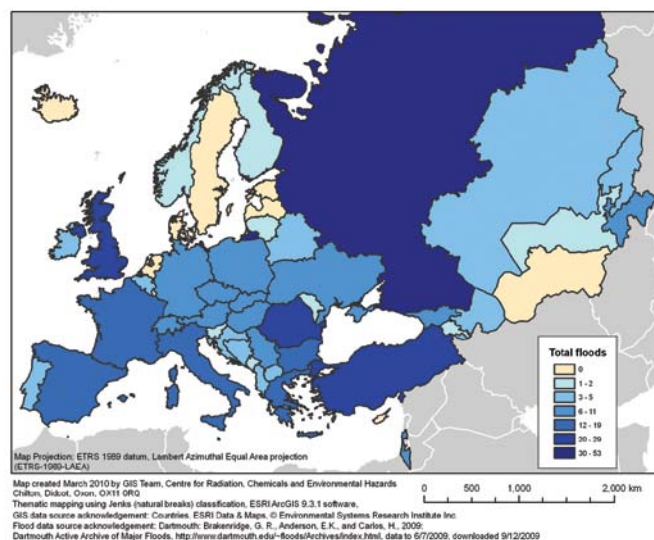


Figure 2: Total number of flood events in the WHO European Region 2000–2009

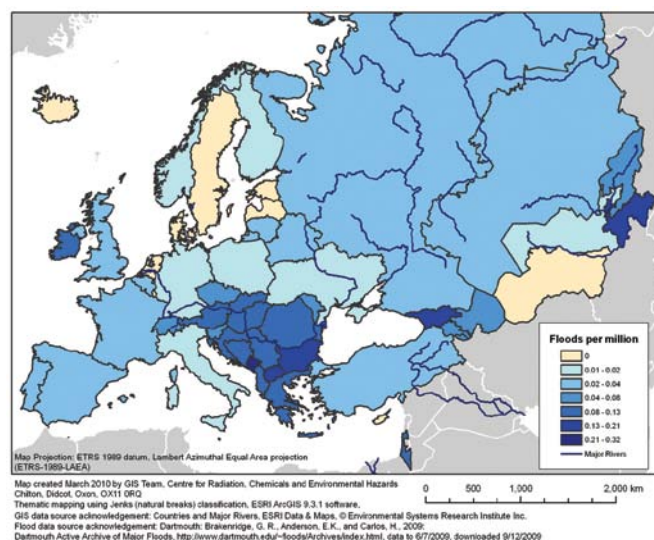


Figure 3: Flooding events per million population, WHO European Region, annual average 2000–2009

Death rates associated with flooding

Flood death rates can be used as a proxy measure for flood severity on the assumption that the more severe a flood, the more fatalities it is likely to cause. Death is usually a good marker to use as it is a relatively hard endpoint. However, in terms of flood deaths, classifying which deaths are actually associated with the flood can be difficult. Immediate flood deaths, likely to be traumatic, will be the best recorded. However, it is unclear from the datasets whether or not deaths associated with

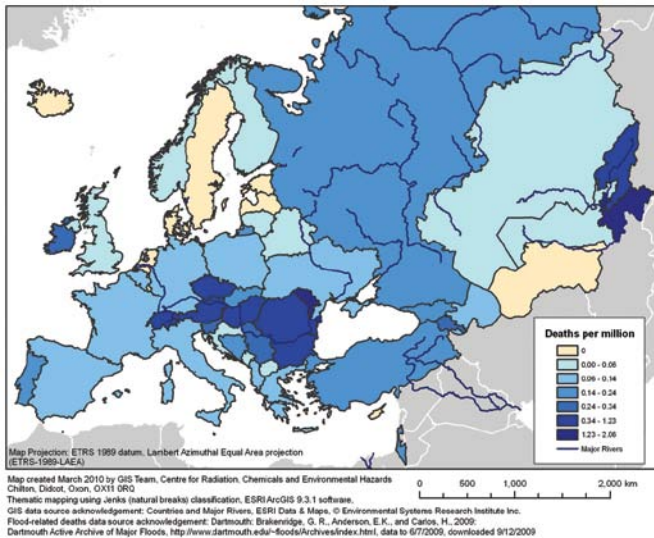


Figure 4: Flood-related deaths per million population, WHO European Region, annual average 2000–2009

the clean-up or any longer-term mortality associated with the flooding are recorded.

Both EM-DAT and DFO record the number of fatalities associated with a given flood event. Figure 4 considers the death rates associated with flooding using the DFO dataset as ascertainment of the flood events themselves which have caused these deaths is likely to be higher. Again, these appear highest in Central Europe and the former Soviet Republic states. This raises the question as to whether or not population exposure is greater within these countries or the response itself to the flood event is less effective.

Numbers affected by flooding

Another marker that could be used to estimate severity is the rate of the total number of people affected by the flood (Figure 5). Data from EM-DAT has been used as the DFO does not record this information. EM-DAT defines this as all those injured, homeless, displaced and evacuated and requiring immediate assistance during the emergency.

However, these would appear to be much less definitive endpoints than fatalities. As suggested previously, drawing any further inferences from these data becomes difficult. The rates of those affected by flooding seem much harder to categorise, with less of a sub-regional picture emerging. It may be that the marker itself is not useful for comparing countries as the inclusion criteria are much wider and open to greater interpretation.

Trends in severity over time

Making meaningful predictions about flood severity over time is difficult. The table (using data from EM-DAT) lists the most severe flood events in terms of fatalities for the period 2000–2009 and also 1990–1999. The countries (except for Turkey) affected by the most severe events differ between the time periods. This may suggest that whilst there are determinable causal factors associated with flooding, there is also considerable random variation between countries and over time, making the prediction of future flood events difficult.

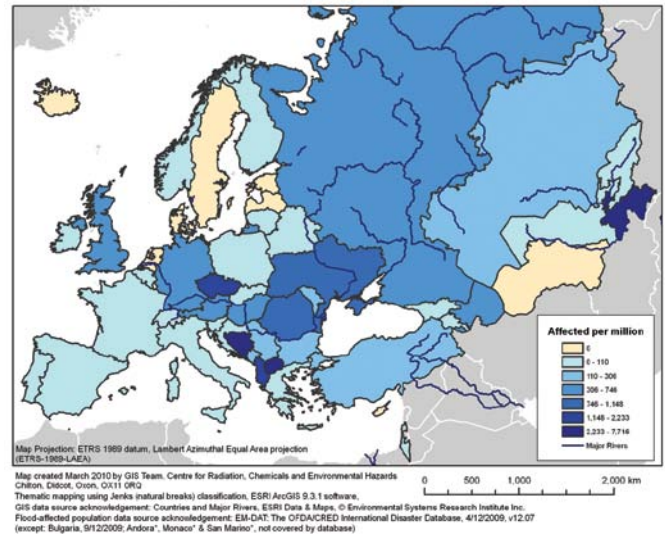


Figure 5: Numbers affected by flooding per million population, WHO European Region, annual average 2000–2009

Media reports

There are also large numbers of media reports about flooding. Searching BBC News, Google and other internet sources shows that most countries in the WHO European Region have had floods in the previous ten years. However, this does not take into consideration the extent of the flood; flood disasters and events are included along with 'other' floods. Further research is needed to compare the media reporting of floods with the data held by both EM-DAT and DFO to help assess the completeness of both datasets.

Discussion

In categorising flood risk across the WHO European Region, 50 of the 53 countries have experienced flooding of some degree in the preceding ten years (2000–2009) and many have had severe flooding associated with a number of fatalities. Detailing these events and their severity is a much more complex task.

Rates of flooding are predicted to rise across Europe due to better ascertainment of flood events (as sensor networks are developed and better reporting mechanisms are brought online) but also as a consequence of more flood events.

The European Environment Agency⁸ lists a number of key points highlighting the future flood risks that are likely to affect Europe:

- A significant trend in extreme river flows has not yet been observed; however, twice as many river flow maxima occurred in Europe between 1981 and 2000 than between 1961 and 1980
- Since 1990, 259 major river floods have been reported in Europe, of which 165 of these have been reported since 2000. This is thought likely to be due to better reporting and changing land use (more development on floodplains); however, if the land use trends continue then increased rates of flooding are likely
- Climate change is projected to increase the occurrence and frequency of flood events in large parts of Europe, although estimates of changes in flood frequency and size remain highly uncertain.

Conclusions

It would appear that development on flood-prone land and population pressures, along with the increased chance of flooding associated with climate change, will increase the risk of both the number and severity of floods and flood events in the future.

Considering and addressing some of these risks offers the opportunity to mitigate and reduce the potential impacts of future floods. As part of this, further work is necessary on the epidemiology of flooding. Agreed definitions both for the activation of flood plans and separately for the surveillance of floods and flood events are needed. Further work is also necessary to identify which individuals, communities and populations are at most risk from flooding.

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Thunderstorm asthma

A review of the literature and implications for public health

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Introduction

Epidemics of asthma have been observed following thunderstorms (herein referred to as 'thunderstorm asthma') on multiple occasions, in both England and other countries. In addition to asthma patients, individuals with hayfever but no previous history of asthma, have also been affected.

Thunderstorm asthma has been observed on several occasions in England including June 1994, July 2002 and June 2004 with further reports of such episodes in other countries. The 24–25 June 1994 thunderstorm asthma event has been particularly well documented in medical literature.

Thunderstorms affect Southeast England and the East Midlands for up to 20 days per year. In contrast, they are less frequent in western coastal districts and central and northern Scotland, occurring less than 5 days per year. The western coast of Great Britain has few seasonal patterns in thunderstorms, while the rest of the Great Britain is mostly affected during the summer¹. The exact mechanism by which thunderstorms cause asthma epidemics is not well understood although various mechanisms have been postulated.

Episodes of thunderstorm asthma have been studied in terms of affected persons, impact on health services and possible relationships with meteorological factors and aeroallergens. Understanding these relationships and identifying potential precipitating factors for thunderstorm asthma might help inform practical early warnings, advice to patients and health service preparedness.

Aim

The aim of this paper is to summarise published information on thunderstorm asthma in terms of patient characteristics, possible mechanisms of effect, impact on health services and to make recommendations for preparing for thunderstorms.

Search strategy

A literature review was undertaken to identify relevant published research. The bibliographic databases MEDLINE, EMBASE and CINAHL were searched for English language publications containing the keywords 'thunderstorms' and 'asthma'.

Findings

Of 29 relevant articles identified from the literature search, full text was obtained for 19 articles. All identified publications were undertaken in developed countries, with the majority occurring in the UK (11), followed

by Australia (3), Canada (3), USA (1) and Greece (1). Of the UK studies, 7 related to thunderstorm asthma associated with one event on 24–25 June 1994. All of the identified studies were retrospective in nature.

Patient characteristics and impact on health services

Descriptive studies of thunderstorm asthma highlight the large scale of these storms and their impact on local populations. The thunderstorm of 24–25 June 1994 is one of the best described.

During the 1994 thunderstorm event Davidson and co-workers¹ identified that there was a significant increase in number of asthma attendances to Emergency Departments (EDs) (640) compared with the number expected (66). The mean age of attending asthma patients during this increase in cases was 32 years. Most of the patients (78.7%) were able to be discharged home and a smaller proportion (16.4%) was admitted. However, there was a significant impact on operational capacity with essential supplies exhausted in 5 of 11 EDs for nebuliser face masks, 1 of 11 for peak flow meter mouthpieces, 4 of 11 for B₂ agonist nebulisers, 6 of 11 for B₂ agonist inhalers, and 8 of 11 for prednisolone tablets. Exhaustion of medication, nebuliser and peakflow meter mouthpiece supplies was also reported in another paper².

For a significant proportion (44.2%) of thunderstorm asthma patients this was their first ever asthma attack². This was also observed by Wardman et al³, where 61% were not known to be asthmatic previously but 52% were known to suffer from hayfever or allergies. In the same study, thunderstorm asthma patients tended to be male (65%), resident in an area adjacent to grassland (42%), not taking regular asthma medication (80%), suffer from one or more of asthma, hayfever or other allergies (78%) and had been outside at the time of the thunderstorm (78%).

Campbell-Hewson⁴ also described the impact of the 1994 thunderstorm in the Peterborough area, with 39 patients attending acute hospital services for asthma symptoms, compared to just one patient during the same period in the previous year. Of 38 of these patients, 22 were hayfever sufferers and 13 were not previously diagnosed as asthmatic.

It was also observed in Luton, Bedfordshire, that, following the same thunderstorm, a large proportion of patients attending general practice (GP) deputising services, an ED and a GP surgery, were asthma patients, prompting the author to consider if there is an association between thunderstorms and asthma⁵. However, no information was presented in relation to expected proportions of asthma presentations, so it is therefore not possible to identify the magnitude of increase in asthma presentations which occurred. On a national basis, half of the regional health authorities in England observed a six-fold increase in asthma attendances at EDs⁶. Eleven district health authorities also reported difficulty in service provision in EDs, following the thunderstorm, which was suggested to be a consequence of thunderstorm asthma.

Relationship between frequency of asthma attendances and thunderstorms

A number of different approaches have been used to determine if there is an association between thunderstorms and asthma. Most of these use routine data on patient visits to health services including EDs and general practice. Several studies have reported increased asthma presentations to EDs. One Canadian publication reported increased proportions of ED visits, and urgent care medical centre visits, for asthma of 5% and 17% on two epidemic days, compared to 1% on the day before the thunderstorm⁵.

A similar effect was observed in Derby, UK, following a review of thunderstorms and health effects dated 1993–1996. Here increases in same-day asthma visits and increased admissions one day later were noted, although the increases were not significant outside of the grass pollen season⁷. Other studies have also identified associations between increased asthma visits to EDs and thunderstorms; in particular, one study identified that a one celsius degree decrease in temperature prior to the thunderstorm was associated with a statistically significant increase of 1.09 asthma cases in the ED⁸.

In Australia, increases in asthma patients attending EDs and hospital admissions for asthma were also identified in relation to two thunderstorms in 1987 and 1989⁹. Increased ambulance calls for asthma compared to the expected daily averages were observed on both occasions. Researchers in New South Wales, Australia, also identified significantly increased odds of thunderstorms within 80 km and thunderstorm outflows on epidemic asthma days compared to non-epidemic days¹⁰.

Grundstein studied thunderstorms in conjunction with other meteorological features in Atlanta, Georgia, USA, recorded by automated weather systems and compared this data to local ED visits for asthma¹¹. Associations between thunderstorms and asthma visits were only significant for thunderstorms with rainfall and thunderstorms with moderate wind speed (9.4–14.3 m/s).

Outside of EDs, a positive association was identified in the UK between the June 1994 thunderstorm and GP asthma consultation rates for adults, children and the elderly, one day later¹².

However, there have been studies in both Canada¹³ and Athens¹⁴ which have failed to identify an association between thunderstorms and asthma presentations to EDs.

Relationship between aeroallergens and epidemic asthma during thunderstorms

Aeroallergens may also have a role in the pathogenesis of thunderstorm asthma as there is immunological evidence of an allergic mechanism. In 2002, Wark et al¹⁵ demonstrated that thunderstorm asthma patients have significantly increased levels of IL-5 (interleukin-5) in their sputum compared to other patients with allergies and acute asthma. IL-5 is a natural molecule in the body which is associated with the immune response to allergic conditions, supporting the idea that thunderstorm asthma results from a combination of weather conditions and allergic responses.

The association between specific aeroallergens in the environment and thunderstorm asthma has been investigated by several researchers. Increases in air levels of different aeroallergens have been observed



Lightning © Paul Davies

from the day before the thunderstorm, to the day of the thunderstorm⁴. These aeroallergens included algae (increased 25-fold), *Amaranthaceae* (12-fold), *Chenopodiaceae* (12-fold), *Myxomycetes* (7-fold), *Stemphyllium* (6-fold), *helicomycetes* (3-fold). Other studies have also identified increases in airborne fungal spores during thunderstorm asthma epidemics in Canada¹⁶. A detailed environmental study of fungal spores in thunderstorm-affected areas during the June 1994 thunderstorm identified increases¹⁷ in *Cladosporidium* and *Ustilago segetum* and ascospores following rain including *Phaeosphaeria nigrans* and *Diatrypaceous*. Other ecological studies have identified a possible role of pollen grains, both independently¹¹ and in combination with lightning¹⁸.

However, a major limitation to many of the previously mentioned studies is that they fail to consider all potentially relevant aeroallergens in the same study. Indeed, many of those studies do not take affected patients' sensitivity to the aeroallergens into consideration.

A few higher quality studies have addressed both aeroallergen levels and sensitivity among patients. Venables et al¹⁶ identified a six-year high in pollen prior to thunderstorm asthma and increased *Cladosporium* in two, and increases in *Phaeosphaeria nigrans* and *Diatrypaceae*, in thunderstorm affected areas; counts of *Sporobolomyces* increased the day after storms. Sixteen patients suffering from thunderstorm asthma during this period underwent allergy testing; 12 had very high IgE levels for pollen and two were negative. There was no comment on sensitivity to the identified fungal spores.

However, a limitation to some of these study designs is that the range of allergens tested in cases and controls does not always reflect the wide range of aeroallergens identified in the literature relating to thunderstorm asthma.

Additionally, research in Australia has identified increased odds of sensitisation to rye grass and *Cladosporium* among thunderstorm asthma cases, compared to controls¹⁹. Among all symptomatic patients there was an increased risk of onset of symptoms with exposure to the outdoor environment, compared to being indoors with the windows closed.

There is clearly much variation in the observed aeroallergens related to different thunderstorm asthma episodes, between different studies and between different countries. This may be influenced by the range of testing undertaken by different researchers, with few studies testing for the complete range of relevant aeroallergens identified in the literature. Furthermore, no single publication examined the widest range of identified aeroallergens in addition to meteorological factors.

Can thunderstorm asthma episodes be predicted in order to provide early warnings?

In 1998, Newson et al²⁰ studied epidemic asthma episodes and their association with thunderstorms to identify characteristics that could accurately predict thunderstorm asthma episodes. They were unable to predict thunderstorm asthma episodes with sufficient specificity; however, this study only considered pollens and not any of the other identified aeroallergens. The potential application of a wider range of aeroallergens to early warning for thunderstorm asthma requires further assessment.

Summary

Thunderstorm asthma has been shown in several studies to significantly increase asthma presentations to health services including Emergency Departments and general practices, and this has been widespread across the country. This has led, on some occasions, to exhaustion of essential supplies for the treatment of acute asthma.

Thunderstorm asthma patients have tended to be young adults but have included patients who were not previously known to be asthmatic. There is limited evidence that sheltering indoors with the windows closed will reduce the risk of suffering from thunderstorm asthma.

More detailed analyses have indicated potential roles of rainfall, wind speed and temperature changes in thunderstorm asthma. Studies of varying quality have identified that levels of aeroallergens such as closed and ruptured pollen grains and airborne fungal spores are elevated during episodes of thunderstorm asthma. The exact aeroallergens identified appear to vary with the local setting under study. Higher quality studies have detected increased probability of aeroallergen sensitisation among thunderstorm asthma cases compared to other allergic controls.

Thunderstorm asthma epidemics therefore appear to result from a complex interaction between meteorological conditions, levels of aeroallergens and individual susceptibility.

Implications for public health

Thunderstorm asthma can pose significant challenges for health services:

- The peak season for most of the country, for thunderstorms, is in the summer
- Asthma patients sensitive to known thunderstorm-related aeroallergens may be advised to shelter indoors and close windows during thunderstorms; they should also seek advice from their own doctor/asthma nurse practitioner about how to deal with acute asthma, following thunderstorms
- A proportion of thunderstorm asthma patients will never have suffered acute asthma before; health services should therefore consider developing resilience plans for increased asthma-related presentations following thunderstorms
- The health protection benefits of educating those with hay fever and other allergic conditions, potentially at risk from developing thunderstorm asthma, should be considered.

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Summary Report – National Cold Weather Plan Workshop Friday 1 July 2011, London

Convened by the Extreme Events and Health Protection Section (HPA) and the Department of Health in association with the Met Office (UK)

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Background

As part of his 2009 Annual Report, the previous Chief Medical Officer (CMO), Sir Liam Donaldson stated that England's annual winter death toll averages around 25,000 people and costs the NHS over £850 million as a result of treating disease due to cold private housing¹. Finland which is much colder, has an excess winter death rate close to half that of the UK¹.

Typically, mortality rises 18% during the winter months in England which is approximately 2500 people per week between December and March¹. Many more people present to GPs and hospitals with a range of cold weather related conditions.

Each one degree celsius decrease in average winter temperature results in 8,000 additional winter deaths in England. The majority of these deaths occur amongst older people, especially women, and those with underlying health problems. Most are due to increased cardiac death, strokes and respiratory problems, not hypothermia¹.

To address the issue of excess winter mortality, the previous CMO called for a National Cold Weather Plan (CWP) to be developed¹. The Department of Health, the Extreme Events and Health Protection Section (EEHPS) of the Health Protection Agency, the Met Office, public health champions and various stakeholders have worked together on this since then.

The draft CWP was piloted in a number of regions during the winter of 2010/2011 alongside a Met Office 'Cold Watch' alert system, with a view to having the CWP in place for the winter of 2011/2012.

The aim of the CWP is two-fold:

- 1 Reduce winter mortality** – to avoid winter deaths through raising public awareness and triggering actions by those in contact with people known to be vulnerable to cold related illness and death
- 2 Reduce health system pressures** – a secondary positive outcome is the potential for reduced pressures on the health and social care system during the busiest months of the year, through better anticipatory actions with vulnerable people.

It was recognised that to be effective, the CWP needs to have good links to and be consistent with other winter programmes run by the DH. These include the annual seasonal influenza vaccination programme. Last winter, the Government also ran a new website service, 'Winter Watch', as well as its annual 'Keep Warm Keep Well' Campaign which

provides advice on staying warm over the winter and staying in touch with people who may be vulnerable during cold weather. It also needs to link with the wider work on winter pressures and resilience which take place in the NHS over the winter months.

We hope that the CWP will be useful for individuals, communities, professionals and local and voluntary groups who play an important part in raising awareness and supporting vulnerable people in their homes during the winter period.

As part of the testing, reviewing and development process, the HPA, DH and the Met Office have sponsored a number of activities in support of developing the CWP. These include:

- 1** Two interactive workshops to bring together those in public health, social care, emergency response and planning, government departments, NHS, academic institutions, frontline services and those representing vulnerable groups to feedback on the plan
- 2** The setting up and development of syndromic surveillance to allow early alerting and near real-time reporting of health conditions
- 3** Establishing a mortality surveillance system to provide timely data on deaths during cold periods
- 4** A winter pressures table top exercise
- 5** A literature review into the attendance during cold weather to Emergency Departments
- 6** Group feedback sessions from those within the HPA, DH and the pilot regions.

The following section will summarise the recent workshop that was held to discuss the plan.

Aims and objectives

This was the first of two workshops aiming to bring together stakeholders from a wide range of fields to discuss, debate and reflect on the current draft National Cold Weather Plan. A total of 50 representatives from academic, policy making, government, clinical and social care sectors were invited to take part in the one-day interactive workshop which included key presentations and discussion topics. The second workshop, due to be held in September 2011, will aim to invite stakeholders from the voluntary sector and those who work with vulnerable groups.

The main aim of the workshop was to determine whether the current draft plan provided an effective platform for action, reflected the lessons identified from the pilot period (winter 2010/2011) and effectively incorporated the analyses provided by the DH, HPA and Met Office. It also served as an important opportunity to hear what additions and changes could be made and hear the comments from people who will support its implementation.

Both workshops were jointly organised and held by the DH (lead, Professor Yvonne Doyle) and the HPA (lead, Professor Virginia Murray). The workshop was opened and chaired by Professor Yvonne Doyle (DH) who is the national sponsor of the CWP.

Presentations

The six presentations from key organisations were:

- 1 Highlighting of the public health burden of cold weather and the need for a National Cold Weather Plan – national sponsor of plan, *Professor Yvonne Doyle (DH)*
- 2 How the alert system operates in practice and what is proposed by the Met Office for a Cold Weather Watch system – *Patrick Sachon (Met Office)*
- 3 Reflection on the pilot period of winter 2010/2011, how the plan was implemented and what the extent of the problem is in Cumbria – *Frank Whiteford (NHS North West)*
- 4 A summary of the work conducted by the HPA which included the development and delivery of a real time syndromic surveillance system, mortality surveillance system, winter pressures table top exercise, literature review on Emergency Departments and admissions and HPA feedback on the plan – *Professor Virginia Murray (HPA)*
- 5 A review of the work currently being undertaken by the World Health Organization (WHO) (Regional Office for Europe) and commentary on the wider European context of cold weather and health – *Professor Virginia Murray on behalf of the WHO (Regional Office for Europe)*
- 6 A summary of the recently published report 'The Health Impacts of Cold Homes and Fuel Poverty' – *Dr Jessica Allen (The Marmot Review Team)*

Discussion topics

There were four key questions identified to serve as debate topics for the break-out groups. These were then opened to the wider group for discussion:

- 1 Use of the alert system
- 2 How the plan links to other existing plans
- 3 How can we evaluate the plan and what further research is needed?
- 4 How can we make the plan more operational?

Summary of feedback

Overall, the implementation of the CWP was very well supported, with many representatives agreeing to endorse the plan.

Other key points included:

- Publishing and releasing the plan as soon as possible to allow organisations, agencies, government departments and individuals time to prepare for winter
- Emphasising the preparedness sections of the plan
- The importance of future proofing the plan and having clear leadership to enable smooth transition as we move towards Public Health England (PHE).

The alert system:

- Some delegates thought the alert system covered an area which was too wide at present and needed to be refined and focused so it was only applicable to a very specific location. However, others disagreed stating that in view of business continuity planning, it is vital you are aware of what is happening in areas at or slightly beyond your own boundaries. This is because, although the local area may not be affected by cold weather, staff and patients may be affected and this knowledge is essential for planning services

- The alerts need to be timely, appropriate, clear, simple to understand and easy to interpret. This was felt as having been achieved by those who piloted the plan and used the alerts last year
- Dissemination of the alerts needs to go to key groups (as opposed to individuals) who are aware of their roles and responsibilities in relation to their own organisations cascade system. An effective cascade system described was that of the London Ambulance Service who have clear lines of communication when alerts are received
- Careful evaluation of the alerts was highlighted as an important step to identifying and protecting against any consequences of false positive or negative alerts.

Linking to other plans:

- To make clear links with existing plans which include (but not restricted to) – GP service continuity, escalation (command and control), critical care, paediatric, pandemic flu, mortuary, business continuity, surge capacity, major incident, escalation, local resilience forum, social care, flooding, fire, rescue and community plans
- Including a diagram as an appendix to the CWP was suggested as a good idea of how to show where all the different winter plans sit and how they would be related to one another.

Making the plan more operational:

- A number of tools were suggested by delegates as a way of how organisations could utilise the evidence and information imbedded in the plan. These included action cards, monthly planning and developing time tables for actions. These ideas will be considered
- The importance of communicating with and incorporating social, community and faith groups was highlighted as important. They will often access, spend time or work with hard to reach groups as well as having a trust and dialogue with them. Discussion covered the importance of the valuable community resources that are already present and their inclusion in planning and health protection.

Evaluation:

- Evaluating the CWP was seen as an essential component of its implementation and something that should be written into the plan itself and be included in the planning
- However, the difficulty of evaluation due to the number of confounders was recognised and debated at length
- A number of suggestions were offered on the number of available data sources that could be incorporated into any evaluation. Some of these included related websites, benefits, government departments, ambulance and critical care data.

Conclusions

The feedback, suggestions and comments will be taken into consideration by the team working on reviewing the CWP and be used to update the existing draft. The valuable information that was gained at the workshop will form an essential component of making the current plan operational for practice. The next draft will be disseminated to stakeholders ahead of the second workshop with the aim of further amendments and improvements being made before the launch.

Acknowledgements

On behalf of the HPA and the DH, we would like to thank all those who have contributed, attended the workshop, presented their work and offered their feedback on the draft plan.

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New HPA Programme Board: Climate Change and Extreme Events

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Background

Worldwide, the impacts of climate change and extreme events are increasingly apparent¹. These create conditions that will have increasing significance for human health. Because the UK is a wealthy country in a temperate zone with a well-developed national health service and health protection infrastructure, the public health impact of climate change and extreme events is expected to be less than in developing countries. Nevertheless, even in the UK, the health impacts may be significant², and there is also a risk of international aspects of climate change impacting on the UK population³. Health impacts in the UK are likely to include:

- Injuries and morbidity from extreme weather events, such as:
 - ◊ flooding and its consequent hazards such as drowning, electrocution, carbon monoxide poisoning, psychological stress
 - ◊ heat including heat stress, dehydration, heat related disease exacerbation and potentially more severe moorland or forest fires
- Respiratory illness associated with rising concentrations of ozone
- New or increased incidence of vector-borne diseases
- Increased exposure to ultraviolet radiation leading to increased incidence of skin cancer
- In addition, and although winters in the UK are likely to become less cold, periods of cold weather continue to have a significant effect on health.

The HPA needs to develop a shared expectation with stakeholders about its role in responding to climate change. It also needs a management platform for agreeing priorities and coordinating climate change work within HPA. This is now being done through a Programme Board on Climate Change and Extreme Events with Dr John Cooper (Director of the HPA Centre for Radiation, Chemical and Environmental Hazards) as Programme Chair and Dr Jill Meara (Associate Director) as Programme Manager. Professor Anthony Kessel (Director of Public Health Strategy and Medical Director at the HPA) was appointed as an Executive Sponsor, and Professor Sir Andy Haines (London School of Hygiene and Tropical Medicine) as HPA Chief of Climate Change and Health Protection. There are also external representatives from the Department of Health and other attendees can be invited (e.g. Met Office and the devolved administrations). The first meeting of the Climate Change and Extreme Events Programme Board took place on 24 March 2011 and meetings occur quarterly.

Functions and roles

The Climate Change Programme Board is accountable to the HPA Directorate and is intended to carry out the following functions:

Priorities To identify gaps in climate change and extreme events activities relevant to protection of public health (for the country and for the HPA) and to promote appropriate projects/collaborations to fill these gaps

Output To identify key deliverables for HPA climate change and extreme events activities and work towards ensuring their timely delivery and appropriate recognition

Coordination To maintain an overview of all HPA activities on climate change and extreme events and to promote cross-HPA communication, coordination and collaboration

Stakeholder relations To identify the needs and activities of local, regional, national and international external stakeholders, as appropriate and to engage with them in order to develop mutual and appropriate expectations of the HPA role with respect to climate change and extreme events

Communication To develop and communicate the focus and priorities for HPA activities in relation to climate change and extreme events

HPA sustainability To coordinate with the HPA Sustainability Strategy Group to promote sustainability within HPA and to support cross-government department action on climate change

Advocacy To identify examples of excellence in mitigation and sharing best practice in the public and private sectors, and to seek ways for promoting best practice within the HPA and health sector.

Initial work programme

At the first meeting of the Board, several work streams were established to act as a basis for facilitating the work of the HPA on climate change and extreme events. The idea of work streams was to appoint staff to drive work, make recommendations and report back to the Board. Early projects undertaken by the work streams included the identification of existing databases and resources and potential gaps relevant to climate change and extreme event work at the HPA, identification of relevant potential and existing external stakeholders, and an initiative to ensure the delivery of relevant knowledge to local government groups.

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Leading a sustainable health system in a resource constrained world

Towards environmental, social and financial sustainability

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“The nation behaves well if it treats national resources as assets which it must turn over to the next generation increased, and not impaired in value”

Theodore Roosevelt

The health sector as a whole has recognised climate change and resource depletion as being one of the greatest threats to the health and wellbeing of current and future generations. Strong leadership to address these threats within the health system itself is key to successfully ensure public health of the UK population.

In light of this acknowledgement, the first ever international Sustainability Leadership Programme for the Health Sector – ‘Leading a Sustainable Health System in a Resource Constrained World’ – took place in Cambridge, UK, in March 2011. This two-day workshop was developed and delivered by the Cambridge Programme for Sustainable Leadership (CPSL) and the NHS Sustainable Development Unit for England (NHS SDU). Two alumni HPA consultants reflect on this pilot event.

“Imagine knowing that we have done our best to improve health and minimise our impact on the environment.”

Sonia Roschnik

The event succeeded to bring together high level representatives from a broad range of health disciplines including the Department of Health, the Chief Medical Officer for Wales, Royal College of General Practitioners, Royal College of Nursing, London School of Hygiene and Tropical Medicine, University of Exeter and the WHO Regional Office for Europe. International perspectives were provided by participants from the USA, Australia and New Zealand.

The workshop programme consisted of plenary master classes, round table discussions, ‘buzz groups’, leadership action groups and carousels. These aimed in particular to:

- Bring together health sector leaders who are involved in large scale change in their organisation, sector or clinical area to share the knowledge, policy context and skills necessary to deliver a sustainable future health service
- Share the potential solutions to the challenges faced by health care organisations and professionals to bring about the relevant changes
- Create networks and alumni of strategic, operational, and thought leaders in sustainable healthcare.

“Sustainability isn’t about projects, but about how we do business, how we create value, how we discuss quality generally.”

Sonia Roschnik

During these skilfully delivered interactive sessions the participants were made aware of the latest research, policy changes and case studies on sustainable models of health care, set in a rapidly changing social, financial and environmental climate. Unilever provided experiences from the private sector perspective and shared their leadership lessons learned during the development of the Unilever Sustainable Living Plan.

This particularly improved the participants’ understanding of the benefits associated with implementing sustainable actions and creating so-called win-win situations, e.g. NHS trust procurement of food directly from local producers, reducing both carbon footprint of meals and supporting the local community of food producers, or cycling-to-work-schemes which reduce carbon emissions and encourage physical activity of staff. The leaders of tomorrow were encouraged to seek out actions applicable to their own organisations which not only enhance environmental sustainability but also improve health and enable financial savings.

Moreover the distinguished speakers highlighted how sustainability can be embedded into the quality agenda of organisations and thus is seen as a solution, rather than a burden, in addressing the multitude of challenges facing health services globally.

In general, the following ‘Sustainability Leadership Lessons Learned’ were shared:

- Develop a vision where sustainability is a solution and not a problem
- Frame issues to facilitate collective response
- Look for common cause across policy and practice and deliver in partnership
- Be ready for change: it’s constant, it threatens models of reality, it requires new behaviours, it means taking risk and seizing opportunities
- Communicate to encourage action
- Lead by example – individuals matter.

“Causes and solutions for health and sustainability are linked – healthy people on a healthy planet.”

David Pencheon and Fiona Adshead

Following the workshop a number of activities have been identified to ensure that the HPA maintains and strengthens its national and local leadership role around sustainability within the transition to Public Health England (PHE).

Since the event the HPA has already worked with the NHS SDU to provide input to the paper ‘Sustainability and Public Health England’ for the PHE Transition Team. Furthermore the HPA is engaged in the development of sustainability metrics for healthcare settings, work that is being led by the NHS SDU Sustainability Development System Governance and Metrics Steering Group.

It is paramount that the HPA continues to work closely with the NHS SDU and the CPSL to enhance its leadership role for sustainability, including the development of training, building an evidence base and acting as advocate for sustainable development in health protection.

“Leadership is a composite of courage and character: courage to take one’s society from where it is to where it has never been; and character to withstand the assaults with which the familiar defends itself.”

Henry Kissinger

Interested? The next Sustainability Leadership Programme for the Health Sector is planned to take place on 20–21 March 2012 in Maddingley Hall, Cambridge, UK. Further details can be found at www.cpsl.cam.ac.uk/Executive-Programmes/Sustainability-Leadership-Programme-for-the-Health-Care-Sector.aspx

The European Masters in Disaster Medicine

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Introduction

The European Masters in Disaster Medicine (EMDM) is a Level 2 one-year Masters offered jointly by the University of Piemonte Orientale, Novara, Italy, and the Free University of Brussels, Belgium. The course, delivered throughout in English, is supported by institutions at the forefront of the field in Sweden, USA, UK and Switzerland. The course is designed for medical professionals and is currently attended by delegates from Emergency and Internal Medicine, Public Health, Nursing, Epidemiology and the Commercial Pharmaceutical Sector. Over 300 participants from 32 countries have attended the course since it began ten years ago.

Learning objectives

The course aims to provide its students with the knowledge and tools to 'organise a health system adapted to a disaster situation'.¹ The course introduces the history and position of disaster medicine in the current climate, focussing on the specifics of disaster response to a wide range of possible hazards. Although much of the research in disaster medicine has originated in the developed world, significant time is given to complex humanitarian emergencies in the developing world.

Examples of the topics covered by the course include:

- Assessment of the epidemiological impacts of disasters
- Organisation and management of the psychosocial support of victims and rescuers in disaster situations
- Moral aspects of disaster medicine
- Disaster mental health
- Legal and ethical aspects of disaster medicine.

With a strong academic theme running throughout the programme, students are provided with the knowledge and skills required to advance research in the field.

Pedagogic methods

The course is delivered through a range of training modalities embracing adult learning principles and reflecting the fact that many of the students are working in parallel to study for the EDMD. The majority of the knowledge transfer utilises videoconferencing and written materials, accessed through an online learning portal. The portal contains published summary documents written by experts and supported by a selection of the most up to date literature and publications. Students interact with tutors and each other, discussing their thoughts and sharing experiences, through forums within the learning portal.

A two-week residential course, held in Italy midway through the year, provides a forum for discussion facilitated by the tutors on the course. It also provides an opportunity to test some of the newest computer based disaster simulation tools available and culminates in a full scale disaster simulation. This year's scenario involved 400 participants from all the emergency services working together to respond to an earthquake, with one hundred simulated casualties and an inflatable field hospital. Following the residential course, the focus of the Masters shifts to the dissertation where students are required to look deeper into agreed research topics.

Opportunities

The entire course presents vast opportunities to network with the experts to develop projects and share experiences. The EDMD has a very strong alumni organisation which facilitates interaction and cooperation with practitioners all over the world, long after the course is completed. An academic group is aligned to the EDMD called the EDMD Academy, based in Geneva, which is dedicated to research and education.

Reference

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