Protective actions in acute chemical incidents: 
shelter or evacuate?

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Introduction

Fires and releases of airborne chemicals have the potential to adversely affect public health across wide areas.

Sheltering and evacuation are accepted and commonly implemented strategies to reduce public exposure.

The established and preferred protective action in the United Kingdom is to shelter during acute incidents: “Go in, stay in, tune in”

Public Health England (PHE) provides expert advice during acute chemical and radiological incidents – this presentation reflects some of our operational experiences.

From 2012-2013, PHE reviewed the literature related to sheltering, evacuation and associated interventions to protect public health – what is the evidence-base to support our sheltering and evacuation decision-making?
PHE review

Due for consultation and publication in 2013

Examined the following areas:

- Incidents involving sheltering and evacuation
- Factors affecting sheltering and evacuation effectiveness
- Exposure and risk assessment
- Decision-making and implementation
- Communication and the public response
- Emergency preparedness

This presentation discusses considerations associated with sheltering indoors from hazardous chemical releases
Sheltering effectiveness

- Outdoor dispersion
- Indoor infiltration

Outdoor exposure → Indoor exposure → Health effects

Population and infrastructure characteristics
- Incident characteristics
- Attenuation
- Exposure

Chemical properties
- Building characteristics
### Air exchange

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Indoor exposure: transient outdoor hazard

- Outdoor concentration
- 0.1 ACPH
- 1 ACPH
- 0.5 ACPH DRF
- 0.5 ACPH
- 1 ACPH DRF
- 5 ACPH
- 0.1 ACPH DRF
- 5 ACPH DRF

Time (minutes)

Concentration

Dose reduction factor
Need to vacate shelter

Concentration
$\text{mg/m}^3$
and
Cumulative Exposure
$(\text{mg-min})/\text{m}^3$

TIME (minutes)

Inside Cumulative Exposure
If unpressurized shelter not opened/left when plume passes

Outside Cumulative Exposure

Cumulative Exposure
If open/leave unpressurized shelter when plume passes

Outside Concentration

Inside Concentration
Timing

![Diagram showing timing of shelter-in-place actions](image)
Common scenarios

Continuously high outdoor concentrations over prolonged periods are uncommon

One-off releases are more common, producing transiently high outdoor concentrations as a chemical plume disperses

Emergency responders issue shelter advice and/or evacuate areas close to the source

For an exposure model to influence decision-making in these scenarios, it must be extremely rapid, able to deal with many variables and considerable uncertainty & often, local-scale dispersion in complex environments

Waste fires produce outdoor concentrations that can be highly variable – there may not be an immediate risk, but they may continue for days to weeks (or longer!)

In these scenarios, there is more time to consider shelter and evacuation, but no agreed approach to doing so
Fires: our most common scenario
Fires: exposure and risk assessment

National Air Quality Cell arrangements can be activated during prolonged fires.

Measured particulate matter (PM) concentrations are provided to PHE.

It is possible, but uncommon in practice, to predict environmental exposures if the source-term can be characterised.

Health effects associated with exposure to PM are well documented.

It is less clear whether a dependency on concentration rather than on dose controls adverse effects.

The risks presented by short-term peaks in particle concentrations are difficult to quantify and require further research.

Time-series studies on pollutants such as PM$_{10}$ tend to consider 24-hour average concentrations.
Research gaps

There is no agreed approach for predicting or assessing indoor exposures or for shelter and evacuation risk assessment and decision-making

Our capabilities for predicting exposure during incidents are currently limited

Few studies examine the effects of building attenuation processes (e.g., filtration, deposition, sorption, etc.) at high concentrations – we must account for these when predicting indoor exposure

Studies modelling or measuring indoor/outdoor concentrations tend to focus on ambient pollutants at ambient concentrations

Representative air exchange rates are required for different UK building types

Further work is required to explore how considerations identified in the report can be applied in real-life emergency preparedness and response work
Key points

Sheltering is likely to be an appropriate protective action in the majority of cases as many chemical incidents that we are notified of involve low-level short-duration releases.

Long-running fires are associated with their own particular considerations.

The key question is *when will sheltering become insufficiently protective?*

Given our current capabilities, this is a difficult question to answer during many incidents.

Research gaps and capability issues restrict exposure assessment and risk assessment: there are many areas where further research is needed.
Thank you for listening!

Feel free to contact me if you have further questions or wish to discuss the points raised in this presentation:

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