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Aims and scope

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Editorial

Dr Gai Murphy
Associate editor

The recent publication of the World Health Organisation's report on the Public Health Significance of Urban Pests serves as a timely reminder that, despite considerable scientific and social advances over the last century, many of the pests that caused disease and distress in the early 1900s continue to infest urban areas and act as vectors for emerging and re-emerging diseases. Last July I attended the 6th International Conference on Urban Pests (ICUP) where an impressive array of papers addressed the worldwide problems related to urban pests. Bedbugs, which at the previous five conferences (between 1993 – 2005), barely registered a mention, were the topic of several papers and a conference workshop, exploring their worldwide resurgence. Clive Boase delivered a very interesting paper tracking the history of bedbug infestations in the UK, quoting a Royal Commission report that concluded that in London 'in many areas all the houses are to a greater or lesser degree infested with bedbugs' (Ministry of Health, 1933). This finding, in part, led to the introduction, in the Public Health Act 1936, of provisions for Local Authorities to deal with 'verminous premises'. Between 1950-1990 bedbugs appeared to be in decline, with very few infestations reported. The worldwide resurgence in recent years has caught many by surprise. In this issue, Louisa Richards and colleagues provide a detailed account of the recent pattern of bedbug infestations in London.

Aedes albopictus (the Asian tiger mosquito) has shown a worrying ability to expand its traditional geographic range. This species was first reported in Europe in 1979 in Albania and is thought to have been introduced via used tyres, imported from China. Fifteen countries across Europe have now confirmed the presence of *A. albopictus* invasions. By the early 1990s it was an important pest species in areas of northern Italy and a serious pest in Rome. It is also thought to have vectored the 2006 Italian outbreak of Chikungunya the first recorded outbreak of this disease outside Africa. The research presented by Ian Hatherly and his colleagues demonstrates the importance of understanding mosquito biology and breeding behaviour when planning control programmes.

As with all good research – these papers raise many new questions. Is the reported cyclic pattern of bedbug infestations a London phenomenon, or are these cycles repeated in other UK cities? Could simple measures such as requiring tyre storage facilities to cut back vegetation provide an environmentally friendly alternative to using pesticides? The results in both papers underline the importance of adopting integrated pest management strategies and fit with the principles embodied in the recently agreed EU directive on the sustainable use of pesticides.

The findings of the first National Pest Advisory Panel's survey of Local Authority pest management services have highlighted the variability in their organisation and delivery, staffing levels, the extent of contracting out services, staff training and assessment of service provision. In the light of continued threats from both native and exotic pest species, effective and efficient pest management services have never been more important.

Mosquito breeding in tyre disposal sites in the West Midlands region of the UK

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Abstract

The recent fatal outbreaks of West Nile Virus in the United States have led to concern over the possibility of outbreaks occurring in the UK. It is important to determine potential breeding sites for mosquitoes so that control of insects can be rapid if required. Five tyre disposal sites were surveyed for the presence of mosquito species and to determine whether the proximity of vegetation had an impact on their presence and abundance in tyres. *Culex pipiens* was found at all sites and *Culiseta annulata* at two sites. The number of tyres with mosquitoes present decreased with increasing distance from vegetation. Within 1m of vegetation 60% of tyres sampled housed mosquitoes. In contrast, when vegetation was 10m away from tyres, only 3% of tyres had mosquitoes present. A similar trend was determined for the actual numbers of mosquitoes in each tyre. No natural enemies of mosquitoes were found within the tyres but a number of other aquatic species such as Chironomid non-biting midges were detected. It is recommended that tyres should be stored a minimum of 10m away from vegetation to significantly reduce the probability of them being colonised by mosquitoes. Alternatively, tyres at the perimeter of storage sites should be treated with insecticide or vegetation around the perimeter cutback to reduce mosquito numbers

Key words: *Culex pipiens*, *Culiseta annulata*, mosquitoes, tyres, West Nile Virus.

Introduction

The unexpected outbreak of West Nile Virus (WNV) in the United States in 1999 has led to discussion of the possibility of an outbreak of this disease in the UK, the potential for native mosquitoes to act as vectors and increased interest in the characteristics of mosquito breeding habitats. In 2002 the first comprehensive infectious disease strategy was produced by the UK Chief Medical Officer, Dr Liam Donaldson, in which he alerted the UK to the problem of "new and emerging infections such as West Nile Fever" (DOH, 2002). WNV is a member of the Japanese encephalitis serogroup of the genus *Flavivirus*, family Flaviviridae (Solomon *et al*., 2003).

Most mosquito-borne viruses tend to be transmitted by a few mosquito species; however WNV is transmitted by at least 75 species, covering 10 genera (Higgs *et al*., 2004). For a species of mosquito to act as a vector of WNV it must feed on humans and birds. There are 33 recorded species of mosquito in the UK of which 12 have the potential to transmit WNV either directly or by acting as bridge vectors (Higgs *et al*. 2004; Medlock *et al*., 2005). Of these there are four species (*Culiseta litorea* (Shute), *Culiseta morisitans* (Theobald), *Culex pipiens* (Linnaeus) and *Culex torrentium* (Martini) (Diptera: Culicidae) that are the most likely candidates for WNV enzootic transmission, *Cx. pipiens* being the most common species in the UK. A further eight, including *Culiseta annulata* (Schrank) (Diptera: Culicidae) have the potential to transmit WNV (Medlock *et al*., 2005). Currently, the risk of WNV becoming established in the UK is considered low, primarily as mosquito populations are very small (Crook *et al*., 2002).

The small pools of water that collect in stored automobile tyres are thought to create a particularly high risk environment for the development of disease-harbouring mosquito populations. Larval mosquito predators include amphibian tadpoles, fish, dragonfly larvae, aquatic bugs, mites, malacostracans, anostracans, cyclopoid copepods and helminths (Kumar and Hwang, 2006 for review). Such predators are likely to be absent or much reduced in tyres in urban storage sites. Work on *Anopheles gambiae* (Giles) (Diptera: Culicidae) has demonstrated that female mosquitoes will preferentially select oviposition sites that are absent of competitors and predators (Munga *et al*., 2006). The productivity of *A. aegypti* pupae and larvae living in tyres has been shown to be linked to the number of trees in the area, with more leaf litter in tyres helping growth (Barrera *et al*., 2006). The presence of algae and absence of fish increases the growth rate and survival of *Anopheles pseudopunctipennis* (Theobald) (Diptera: Culicidae) larvae (Bond *et al*., 2005). In an extensive survey of containers in American Samoa, *Aedes polynesiensis* (Marks) (Diptera: Culicidae) and *Aedes aegypti* (Linnaeus) (Diptera: Culicidae) were found in abundance in tyres and it was suggested that reduction of these species at source may be effective in disease control (Burkot *et al*., 2007). A similar study in Trinidad also revealed the presence of *A. aegypti* in tyres (Chadee, 2004) as did work in India (Mahadev *et al*., 2004) and the Philippines (Mahilum *et al*., 2005). In addition, the transportation of tyres may risk the introduction of disease-harbouring mosquitoes to new areas. Mosquitoes have been introduced into countries on tyres such as the introduction of *Aedes albopictus* (Skuse) (Diptera: Culicidae) into the US via tyres shipped from Asia (Craven *et al*., 1988; Reiter 1998). It is thought dormant eggs in tyres have aided the spread of *A. albopictus* around the world (Mitchell, 1995). The international trade in used tyres, coupled with the ability of *Aedes albopictus* to lay non-desiccating eggs, has facilitated its establishment in many new sites in different continents. It is felt that the biology of *Ae. albopictus* is such that it could become established in certain regions of the UK and thus pose a disease-spreading threat (Medlock *et al*., 2006).

Annual UK production of used tyres is 450,000 tonnes (Environment Agency, 2007). It is of particular interest to determine whether mosquitoes can breed in tyres at disposal sites within the UK as they may be a target for a control strategy for mosquitoes should an outbreak of a human disease occur. In large harbourage areas such as tyre storage sites, mosquitoes may be able to breed prolifically as natural predators are unlikely to be present. It is therefore of interest to survey tyre storage depots to determine which, if any, mosquito species are present as this could determine which diseases could potentially be carried.

This study aimed to determine whether tyre storage areas in the West Midlands are potential mosquito breeding sites and to investigate whether the distance of the closest vegetation to tyres had an impact on mosquito presence and abundance.

Materials and methods

Sampling sites

Sites were selected if tyres were left on site for a minimum of four weeks. Four tyre storage/recycling depots were sampled around Birmingham, UK. Additionally, a go-kart track was sampled and classed as a tyre storage site as tyres remained in the same position for months.

Sampling conditions

Samples were collected between 18 June and 20 July 2007. On all sampling days the temperature was around 15-18°C, overcast with occasional showers.

Sampling process

Where possible, sites were sampled using a transect approach. First, the perimeters of the sites were sampled, with a sample being taken every 10m where access was possible. Then, samples were taken at 5m intervals to the centre of the site. Where it was not possible to reach the centre of the site, samples were taken from as close to the centre as possible. The technique and distances employed for each site are shown in Table 1.0. The entrance of the site was classed as the 'South' side and sampling then described as either at the South, North, East or West side. All sites generally had some vegetation along two sides of the perimeter, with the site entrance onto a road and the remaining sides adjoining other industrial units. With the exception of site size and number of tyres present, there was very little difference between sites.

Five categories of vegetation distance were selected. Vegetation was either within 1, 1-2, 2-5, 5-10 or more than 10m away from the tyre.

To sample the water in the tyre, any debris/vegetation within the water was disturbed to cause mosquito larvae to move. After 20 seconds 400ml of water was scooped from the tyre in a single motion using a white plastic tray (15cm wide, 4cm deep). The water was decanted equally into two plastic containers (6.5cm wide, 7cm deep), labelled and returned to the laboratory where container lids were replaced with 75μm muslin (Lockertex, UK) to ensure the mosquitoes had enough oxygen. Two samples were taken from each tyre and 30 tyres were sampled at each site. Of the 30 tyres sampled, six tyres were sampled within each vegetation category for the five separate sites. Mosquitoes in each sample were scored as present or absent and the number in one scoop recorded for each tyre.

Insect identification

Larvae that were not thought to be 4th instar were kept in containers with water in the laboratory at 20°C, 16:8 LD until they reached 4th instar. Moulting between instars was identified by cast skins floating in the water. Any mosquitoes collected as pupae were kept in the laboratory until they emerged as adults and could be identified.

Fourth instar larvae and adults of each sample were killed by submerging them in 70% ethanol and identified using an appropriate taxonomic key (Cranston *et al*., 1987). During storage, all insects were kept in individual plastic tubes (3 x 1cm) in 70% ethanol. Other organisms found in the water samples were identified using taxonomic keys in Croft (1986).

Analysis

Generalised-linear models were used to determine whether distance from the nearest vegetation had any effect on either the percentage of tyres that contained

Site number	Site layout/description	Approx number of tyres on site	Sampling strategy
1	Trees around perimeter on N and W side. Site used for tyre storage and recycling.	80,000	Samples taken at 10m intervals along W, N side. Access to S and E not possible due to stacked tyres. Samples taken from perimeter to 20m from fence at 5m intervals. Access to centre of site not permitted.
2	Trees around perimeter on N and W side. Site used for tyre storage and recycling.	40,000	Samples taken at 10m intervals along all sides. Samples taken from perimeter to centre of site at 5m intervals.
3	N side fenced with tree line behind. Some vegetation around S side. Most tyres had been stored over many years, little turnaround observed.	1,000	Samples taken from N and S sides at 10m intervals. No access possible on E and W side. Samples taken at 5m intervals into centre of site.
4	Trees overhanging fence at N side. Tyre storage and shredding site.	20,000	Samples taken from N and E sides at 10m intervals. No access possible on S and W side. Samples taken at 5m intervals into centre of site.
5	Perimeter surrounded by grass bank. Bushes at S end. Long grasses, brambles at N end. Site was used as a go kart track and tyres remain there relatively untouched.	800	Samples taken along perimeter from all sides at 10m intervals and then in 5m intervals to the centre of the site.

Table 1.0
Site, site layout, number of tyres and sampling strategy for tyres sampled.

mosquito larvae or the numbers of larvae per tyre. Site and distance category were entered as factors; binomial errors with a logit link function were used with presence/absence data, Poisson errors and log link function for count data. The overall significance of distance was assessed by Chi Squared test between models with and without distance as a factor. All pairwise comparisons of distance categories were tested using Tukey's honestly significant difference (HSD).

All statistical tests were conducted using R version 2.4.1 (R Development Core Team, 2006) with the package Multcomp for post-hoc multiple comparison tests (Hothorn *et al*., 2007).

Results

All sampled sites had mosquitoes present and the species found are listed in Table 2.0.

Site	Species identified	Proportion (%)
1	*Culex pipiens*	100
2	*Culex pipiens* *Culiseta annulata*	90 10
3	*Culex pipiens*	100
4	*Culex pipiens*	100
5	*Culex pipiens* *Culiseta annulata*	76 24

Table 2.0
Mosquito species and proportion of mosquitoes found in tyre sites in the West Midlands.

Table 3.0 Terrestrial and aquatic specimens found in tyres. Numbers given are for 150 tyres sampled across 5 sites.

Terrestrial		Aquatic	
Common name	Number (in 150 tyres)	Common name	Number (in 150 tyres)
Beetle (Coleoptera)	2	Chironomid midge larva (at least 3 different species)	>53
Diptera (Fly – variety of species)	>30	Springtale (Collembola)	4
Spider	1	Crane fly adult (Tipulidae)	1
Wood Louse	4	Mosquitoes	416
Aphid (Homoptera)	9		

A list of other specimens found within the tyres during sampling for mosquitoes is given in Table 3.0.

Effect of vegetation distance on mosquito presence/absence

As the distance from vegetation increased, the percentage of tyres with mosquitoes present decreased (Figure 1.0). The mean percentage of tyres containing mosquitoes across sites at each distance category was 60, 56, 50, 26 and 3% at 0-1, 1-2, 2-5, 5-10 and greater than 10 metres away from vegetation respectively.

The overall effect of distance on presence/absence of mosquitoes was highly significant ($X^2_{4,141}$ = 35, p <0.001) and consistent between sites. One-tailed Tukey's post-hoc multiple comparisons indicated significantly fewer tyres had mosquitoes present when 5-10m compared to 0-1 metres from vegetation, and at >10m there were fewer tyres occupied than at 0-1, 1-2 and 2-5 metres (Table 4.0).

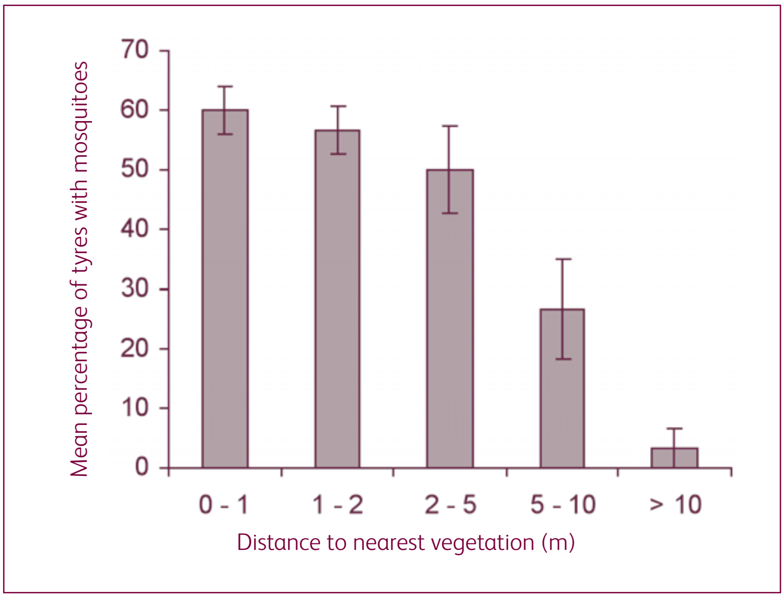

Figure 1.0 Mean percentage (± SE) of tyres sampled with mosquitoes present at varying distances to vegetation.

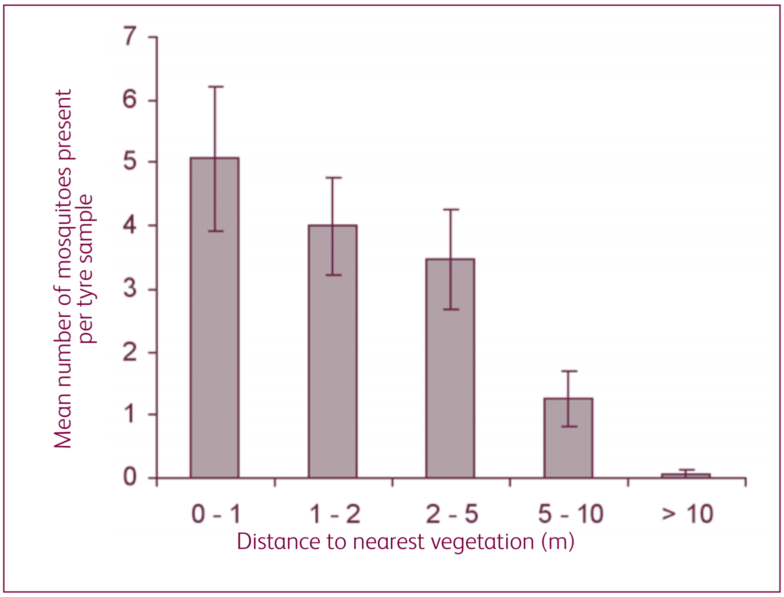

Figure 2.0
Mean number (± SE) of mosquitoes present per tyre sample compared with the distance of the closest vegetation to the tyre.

Effect of vegetation distance on mosquito numbers

As the distance of a tyre away from vegetation increased, fewer mosquitoes were detected per scoop sample, as shown in Figure 2. The mean numbers of mosquitoes found per tyre at each distance across all five sites was 5, 4, 3.4 1.2 and 0.06 for 0-1, 1-2, 2-5, 5-10 and greater than 10m away from vegetation respectively.

The overall effect of distance to the nearest vegetation on the number of mosquitoes found in tyres was again highly significant ($\chi^2_{4,141} = 243$, $p < 0.001$) and consistent across all sites. One-tailed Tukey's pairwise comparisons between distance categories were significant for all combinations except those between 0-1 and 1-2m and between 1-2 and 2-5m (Table 4.0).

Discussion

The most common specimen of insect found during the present study was mosquitoes. Chironomid midge larvae were relatively abundant within the tyres but nearly 10 times as many mosquito larvae were found, suggesting that the tyre environment is ideally suited to mosquitoes. Terrestrial specimens were assumed to have accidentally entered the tyres and died in the water and will not be considered any further.

In the present study *Cx. pipiens* was found at all sampled sites and was the most abundant of the species found. *Culex pipiens* is thought to be the least selective of the British mosquitoes when determining its oviposition sites. It exploits natural and artificial water spots to lay its eggs (Cranston *et al*., 1987; Snow 1990). In Britain *Cx. pipiens* populations differ physiologically, being either the 'typical' type (as found in the current study) or the *molestus* biotype. These are best separated by location of breeding sites with *Cx. pipiens molestus* (Forskal) larvae being found in underground water (Cranston *et al*., 1987). *Culex pipiens* feeds virtually exclusively on birds and feeding records from other animals including humans are very rare (Service, 1968b). However, *Cx. pipiens molestus* will bite humans frequently (White and Chase, 1980). *Culex pipiens molestus* is found mainly in cities owing to the abundance of dark wet areas such as sewers and tunnels. It infects the London underground system (Byrne and Nichols, 1999) and could pose a threat of WNV transmission from feral pigeons to humans (Medlock *et al*., 2005).

Culiseta annulata was found in two of the five sites sampled in the present study. At sites 5 and 2, 24 and 10 % respectively of mosquitoes found were *Cs. annulata*. Female *Cs. annulata* feed on bird and mammalian blood, including humans (Service, 1968b, 1968a). Eggs are laid in a variety of habitats, both natural and artificial. Sites include pools, ponds, ditches, drains and garden tanks (Cranston *et al*., 1987). Adults are frequently resident in

Table 4.0
Pairwise comparisons between 5 distance categories for the percentage of tyres occupied by mosquitoes and the number of mosquitoes per sample. Significance determined by one-tailed Tukey's Honestly Significant Difference.
$P < 0.05$*,
$P < 0.01$**,
$P < 0.001$***

Value at this distance (m) significantly lower	than the value at this distance (m)	Percentage of tyres occupied	Number of mosquitoes per sample
1-5	0-1		
2-5	0-1		**
2-5	1-2		
5-10	0-1	*	***
5-10	1-2		***
5-10	2-5		
>10	0-1	**	***
>10	1-2	**	***
>10	2-5	**	***
>10	5-10		***

houses where they readily feed on humans and are widespread throughout Britain (Snow, 1990). Both *Cx. pipiens* and *Cs. annulata* have been found in tyres in a recent large-scale survey in Spain (Roiz *et al*., 2007).

There are a number of oviposition cues for mosquitoes, one of which is food (Blaustein and Kotler, 1993). Aquatic vegetation is an important food source for mosquito larvae (Hall, 1972; Rejmankova *et al*., 1992; Marten *et al*., 1996; Tuno *et al*., 2006). The productivity of *Ae. aegypti* pupae and larvae has been shown to be linked to the number of trees in the area, with more leaf litter in tyres helping growth (Barrera *et al*., 2006). In the current study females may be selecting tyres with leaf debris to oviposit in as larvae were observed to be feeding on leaf and other debris at the bottom of pools of water within the tyres. This would explain why as the distance of tyres from vegetation increased the abundance of mosquitoes decreased. The closer a tyre is to a bush or a tree the higher the probability of leaves and other vegetation being blown into the tyre and forming a viable food source for the larvae.

In the event of a serious mosquito problem in the UK, treating entire tyre refuse areas for mosquitoes is unlikely to be a financially viable option. However, mosquito populations may be substantially reduced just by treating those tyres closest to vegetation. Significantly more tyres in the current study had mosquitoes present when vegetation was within 10m of the tyre than when vegetation was over 10m away. Only 3% of tyres (1 out of 30) sampled 10m away from vegetation had mosquitoes present, whereas 50% of tyres with vegetation within 5m had mosquitoes present. In terms of numbers of mosquitoes per scoop, there were significantly more present in tyres 0-1, 1-2 and 2-5m away from vegetation than tyres 10m away from vegetation.

The establishment of natural enemies may be limited in tyres owing to lack of vegetation and local population crashes caused by the tyre water supply drying up. In the present study no natural enemies of mosquitoes were found in the tyres. The predatory mosquito *Toxorhynchites theobaldi* (Dyar & Knab) has been shown to colonise artificial containers (Barrera *et al*., 2006). If predators were present in some of the tyres, female mosquitoes may select other tyres on the site as preferred oviposition habitats. Work on both *Culiseta longiareolata* (Macquart) and *Culex laticinctus* (Edwards) (Diptera: Culicidae) showed that oviposition was reduced by the presence of the predator, *Notonecta maculata* (Fabricius) (Heteroptera: Notonectidae) in artificial water pools (Blaustein *et al*., 2004; Eitam and Blaustein, 2004). *Anopheles gambiae* will preferentially select oviposition sites that are absent of competitors and predators (Munga *et al*., 2006).

West Nile Virus expansion has been attributed to migrating birds (Rappole *et al*., 2000). It is important to know whether it can circulate between resident birds and whether mosquito species are present in the UK that can carry the virus and therefore cause a threat to humans (Higgs *et al*., 2004). UK birds seem to have been exposed to the virus in the past, and these WNV strains are either avirulent or the birds have developed some form of immunity. However, the presence of neutralising antibodies against WNV in UK non-migratory birds implies that active virus transmission from migratory birds is occurring (Buckley *et al*., 2003). The risk of WNV in the UK is considered low, primarily as mosquito populations are very small (Crook *et al*., 2002). However, increased transmission of WNV in France is a concern as it is the closest geographical neighbour. While these increases are generally associated with extensive wetland marshes and high densities of birds and mosquitoes (Morgan, 2006) it shows that WNV is a current problem and the likelihood of it occurring in the UK should not be completely discounted.

Both *Cx. pipiens* and *Cs. annulata* have been found in individual tyres in the UK (Anderson *et al*., 2005); however, this study represents the first investigation into tyre disposal sites. Should WNV be introduced into the UK *Culex pipiens* could be involved in WNV transmission as enzootic vectors, whereas *Cs. annulata* is most likely to be a bridge vector for WNV as it feeds on birds and humans (Medlock *et al*., 2005).

Recent evidence suggests that other arboviruses may be present in the UK. Both Usutu and Sindbis virus have been shown to be present in UK birds (Buckley *et al*., 2003). Recent outbreaks of chikungunya in temperate regions of Italy are attributable to the introduction and establishment of *Ae. albopictus* mosquitoes in the region (Rezza *et al*., 2007). While there is no record of WNV or chikungunya as yet in the UK there are a number of pathogens that have the potential to be spread among the population in the UK by mosquito vectors (see Gould *et al*., 2006 and Medlock *et al*., 2007 for reviews).

While pathogen transmission is important when considering mosquito populations, the general discomfort and health risk posed by the biting nuisance should not be disregarded and can be considerable in some cases (Hutchinson and Lindsay, 2006). The health impacts of incessant biting can range from loss of sleep to stress and infection. Even though this study focussed on using WNV as a ‘model system’, the principles of reducing mosquito populations in tyres can be applicable as a tool to fight many pathogen outbreaks or reducing the impact of health hazards from biting nuisance.

While eliminating breeding habitats for mosquitoes would be an effective method of reducing mosquito populations, tyre recycling facilities now provide a valuable service in re-distributing and re-using old tyres. Treating sites with 80,000 tyres with insecticide to stop mosquitoes using the tyres as breeding sites is not a viable control method. There are a number of inexpensive methods that could be used at tyre disposal sites to minimise mosquito numbers in the event of a disease outbreak. The conclusions and recommendations from this study are:

- Tyres should be stored a minimum of 10m away from vegetation to significantly reduce the probability of them being colonised by mosquitoes.
- Alternatively, vegetation around tyre storage depots should be removed to reduce mosquito numbers.
- Once tyres fill with water, tyres around the edge of the perimeter could be emptied every two weeks between June and October to flush out and kill mosquito larvae.
- Tyres could be stored under cover to prevent water access.
- Local authorities (LA) should encourage their environmental health practitioners and pest control teams to log any potential mosquito breeding sites so the LA has an accurate map of where to target control in the event of a disease outbreak.
- Fly-tipped tyres should be removed quickly to reduce fire hazard and the tyre as a source for mosquito breeding.
- Where possible, mosquitoes collected should be identified to species level to determine whether it is a human biting species.
- In areas where mosquito bites are a problem, LAs should educate residents on how best to avoid being bitten.

It is hoped that simple steps can be undertaken to reduce mosquito numbers in tyre storage depots in the event of a mosquito-borne disease outbreak. The recommendations suggested should be disseminated as best practice to storage depots and LAs. This study has shown that mosquitoes can breed successfully in UK tyres and that their numbers are in part at least dependant on the proximity of the closest vegetation.

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References

Anderson M, Ware R and Murphy G R (2005). Population survey of mosquito species in proximity to an international airport and other urban sites in the UK, pp. 271-274. In: Lee C Y & Robinson W H [eds.], Proceedings of the Fifth International Conference on Urban Pests. Perniagaan, Malaysia, Singapore.

Barrera R, Amador M and Clark G G (2006). Ecological factors influencing *Aedes aegypti* (Diptera : Culicidae) productivity in artificial containers in Salinas, Puerto Rico. *Journal of Medical Entomology*, 43, 484-492.

Blaustein L and Kotler B P (1993). Oviposition habitat selection by the mosquito, *Culiseta longiareolata* – effects of conspecifics, food and Green Toad tadpoles. *Ecological Entomology*, 18, 104-108.

Blaustein L, Kiflawi M, Eitam A, Mangel M and Cohen J E (2004). Oviposition habitat selection in response to risk of predation in temporary pools: mode of detection and consistency across experimental venue. *Oecologia*, 138, 300-305.

Bond J G, Arredondo-Jimenez J I, Rodriguez M H, Quiroz-Martinez H and Williams T (2005). Oviposition habitat selection for a predator refuge and food source in a mosquito. *Ecological Entomology*, 30, 255-263.

Buckley A, Dawson A, Moss S R, Hinsley S A, Bellamy P E and Gould E A (2003). Serological evidence of West Nile virus, Usutu virus and Sindbis virus infection of birds in the UK. *Journal of General Virology*, 84, 2807-2817.

Burkot T R, Handzel T, Schmaedick M A, Tufa J, Roberts J M and Graves P M (2007). Productivity of natural and artificial containers for *Aedes polynesiensis* and *Aedes aegypti* in four American Samoan villages. *Medical and Veterinary Entomology*, 21, 22-29.

Byrne K and Nichols R A (1999). *Culex pipiens* in London Underground tunnels: differentiation between surface and subterranean populations. *Heredity*, 82, 7-15.

Chadee D D (2004). Key premises, a guide to *Aedes aegypti* (Diptera : Culicidae) surveillance and control. *Bulletin of Entomological Research*, 94, 201-207.

Cranston P S, Ramsdale C D, Snow K R and White G B (1987). Adults, larvae and pupae of British mosquitoes (Culicidae) – a key. Freshwater Biological Association.

Craven R B, Eliason D A, Francy D B, Reiter P, Campos E G, Jakob W L, Smith G C, Bozzi C J, Moore C G, Maupin G O and Monath T P (1988). Importation of *Aedes albopictus* and other exotic mosquito species into the United States in used tires from Asia. *Journal of the American Mosquito Control Association*, 4, 138-142.

Croft P S (1986). A key to the major groups of British freshwater invertebrates. AIDGAP – Field Studies Council, Shrewsbury.

Crook P R, Crowcroft N S and Brown D W G (2002). West Nile Virus and the threat to the UK. *Communicable Disease and Public Health*, 5, 138-143.

DOH (2002). Getting ahead of the curve. A strategy for combating infectious diseases, pp. 146. Department of Health.

Eitam A and Blaustein L (2004). Oviposition habitat selection by mosquitoes in response to predator (*Notonecta maculata*) density. *Physiological Entomology*, 29, 188-191.

Environment Agency (2007). Tyre Watch. Available online at: *www.environment-agency.gov.uk/business/topics/waste/35366.aspx* [accessed 04/02/09).

Gould E A, Higgs S, Buckley A and Gritsun T S (2006). Potential arbovirus emergence and implications for the United Kingdom. *Emerging Infectious Diseases*, 12(8), 549-555.

Hall T F (1972). Influence of plants on Anopheline breeding. *American Journal of Tropical Medicine and Hygiene*, 21, 787-&.

Higgs S, Snow K and Gould E A (2004). The potential for West Nile virus to establish outside of its natural range: a consideration of potential mosquito vectors in the United Kingdom. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 98, 82-87.

Hothorn T, Bretz F and Westfall P with contributions by Heiberger R M (2007). Multcomp: Simultaneous Inference for General Linear Hypotheses. R package version 0.992-1.

Hutchinson, R A and Lindsay, S W (2006). Perceived nuisance of mosquitoes on the Isle of Sheppey, Kent, UK. *Journal of Biological Science*, 38(5), 707-712.

Kumar R and Hwang J S (2006). Larvicidal efficiency of aquatic predators: a perspective for mosquito biocontrol. *Zoological Studies*, 45, 447-466.

Mahadev P V M, Fulmali P V and Mishra A C (2004). A preliminary study of multilevel geographic distribution & prevalence of *Aedes aegypti* (Diptera : Culicidae) in the state of Goa, India. *Indian Journal of Medical Research*, 120, 173-182.

Mahilum M M, Ludwig M, Madon M B and Becker N (2005). Evaluation of the present dengue situation and control strategies against *Aedes aegypti* in Cebu City, Philippines. *Journal of Vector Ecology*, 30, 277-283.

Marten G G, Suarez M F and Astaeza R (1996). An ecological survey of Anopheles albimanus larval habitats in Colombia. *Journal of Vector Ecology*, 21, 122-131.

Medlock J M, Snow K R and Leach S (2005). Potential transmission of West Nile virus in the British Isles: an ecological review of candidate mosquito bridge vectors. *Medical and Veterinary Entomology*, 19, 2-21.

Medlock J M, Avenell D, Barrass I and Leach S (2006). Analysis of the potential survival and seasonal activity of *Aedes albopictus* (Diptera: Culicidae) in the United Kingdom. *Journal of Vector Ecology*, 31(2), 292-304.

Medlock J M, Snow K R and Leach S (2007). Possible ecology and epidemiology of medically important mosquito-borne arboviruses in Great Britain. *Epidemiology and Infection*, 135, 466-482.

Mitchell C J (1995). Geographic spread of *Aedes albopictus* and potential for involvement in arbovirus cycles in the Mediterranean Basin. *Journal of Vector Ecology*, 20, 44-58.

Morgan D (2006). Control of arbovirus infections by a co-ordinated response: West Nile Virus in England and Wales. *Fems Immunology and Medical Microbiology*, 48, 305-312.

Munga S, Minakawa N, Zhou G F, Barrack O A J, Githeko A K and Yan G Y (2006). Effects of larval competitors and predators on oviposition site selection of *Anopheles gambiae* sensu stricto. *Journal of Medical Entomology*, 43, 221-224.

R Development Core Team (2006). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available online at: *www.R-project.org* [accessed 04/02/09]

Rappole J H, Derrickson S R and Hubalek Z (2000). Migratory birds and spread of West Nile virus in the Western Hemisphere. *Emerging Infectious Diseases*, 6, 319-328.

Reiter P (1998). *Aedes albopictus* and the world trade in used tires, 1988-1995: The shape of things to come? *Journal of the American Mosquito Control Association*, 14, 83-94.

Rejmankova E, Savage H M, Rodriguez M H, Roberts D R and Rejmanek M (1992). Aquatic vegetation as a basis for classification of *Anopheles albimanus* Weideman (Diptera, Culicidae) larval habitats. *Environmental Entomology*, 21, 598-603.

Rezza G, Nicoletti L, Angelini R, Romi R, Finarelli A C, Panning M, Cordioli P, Fortuna C, Borus S, Magurano F, Silvi G, Angelini P, Dottori M, Ciufolini M G, Majori G C and Cassone A (2007). Infection with Chikungunya virus in Italy: an outbreak in a temperate region. *The Lancet*, 370 (9602), 1840-1846.

Roiz D, Eritja R, Escosa R, Lucientes J, Marques E, Melero-Alcibar R, Ruiz S and Molina R (2007). A survey of mosquitoes breeding in used tires in Spain for the detection of imported potential vector species. *Journal of Vector Ecology*, 32, 10-15.

Service M W (1968a). Some environmental effects on blood-fed hibernating *Culiseta annulata* (Diptera – Culicidae). *Entomologia Experimentalis et Applicata*, 11, 286-&.

Service M W (1968b). Observations on feeding and oviposition in some British mosquitoes. *Entomologia Experimentalis et Applicata*, 11, 277-&.

Snow K R (1990). Naturalists' Handbook 14 – Mosquitoes. Richmond Publishing Co. Ltd, Slough.

Solomon T, Ooi M H, Beasley D W C and Mallewa M (2003). West Nile encephalitis. *British Medical Journal*, 326, 865-869.

Tuno N, Githeko A K, Nakayama T, Minakawa N, Takagi M and Yan G Y (2006). The association between the phytoplankton, Rhopalosolen species (Chlorophyta; Chlorophyceae), and *Anopheles gambiae* sensu lato (Diptera : Culicidae) larval abundance in western Kenya. *Ecological Research*, 21, 476-482.

White G B and Chase C A (1980). Eradication of a localised outbreak in London of the pest mosquito Culex molestus. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 74, 683-683.

Are bed bug infestations on the increase within Greater London?

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Abstract

The objective of the study was to determine whether the number of properties infested with bed bugs in Greater London is increasing. Data sets for seven boroughs within Greater London containing the number of telephone calls received by pest control teams from members of the public seeking treatment for bed bug and other major domestic pest infestations (cockroaches, fleas, mice, rats and Pharaoh's ants), from January 2000 to June 2006, were analysed. The absolute increase of calls concerning bed bugs increased from 2000-2006 by an average of 28.5 (95%CI: 6.9-50.3) per annum and the proportion of calls concerning bed bugs, as opposed to other major domestic pests, increased by an average of 24.7% (95%CI: 17.2-32.7) p.a. Calls followed up during July across each of the seven boroughs confirmed bed bug infestations. Twenty two adult specimens were collected and identified as the common bed bug, *Cimex lectularius*. Monthly data obtained from six boroughs identified the greatest number of bed bug calls in late summer (August and September) and cyclic peaks with periods of twelve, six and two months were also identified. In conclusion, the number of calls concerning bed bugs increased in Greater London from 2000-2006. This reflects a trend found in other major national and international developed cities. Contributing factors are likely to be passive dispersal owing to a growth in international travel and second-hand furniture sales, lack of awareness of bed bug infestations owing to the crevice-dwelling behaviour of bed bugs, and ineffective control owing to resistance to insecticides and a move from broad-spectrum insecticides. Within the UK, there is a need for additional monitoring and a code of practice for the control of public health pests including bed bugs.

Key words: Bed bugs; *Cimex*; Environmental health; Infestations; Pest control; London

Introduction

Bed bugs are blood-sucking ectoparasites that infest human habitations, and usually feed during the night when the host is sleeping (Thomas *et al*., 2004). They are capable of carrying typhus, kala-azar, anthrax, plague, relapsing fever, tularaemia, Q fever, hepatitis B virus and HIV; but are not incriminated vectors of disease (Usinger, 1966; Webb *et al*., 1989; Silverman *et al*., 2001). Clinical symptoms from bed bugs are caused by the bites, which can result in severe irritation, large weals, itching, inflammation and swelling of the skin (Tharakaram *et al*., 1999; Fletcher *et al*., 2002; Liebold *et al*., 2003; Thomas *et al*., 2004). Reaction to the bites varies with the individual ranging from no symptoms to hyper-allergic conditions, in a few cases (Sansom *et al*., 1992; Tharakaram *et al*., 1999; Fletcher *et al*., 2002; Liebold *et al*., 2003). Additional problems associated with bed bug infestations include lack of sleep, and psychological and social distress from society's stigma concerning pests (Thomas *et al*., 2004). Further difficulties occur because of the intrusive control measures that are used for treatment (Cleary & Buchanan, 2004).

Bed bug infestations were almost eliminated from properties in developed countries during the 1980s (Boase, 2004). The decline was thought to have been owing to decreases in people's tolerance of household pests, improvements in hygiene, and the widespread use of DDT in the 1940s and 1950s (Boase, 2004). Recent observations, however, suggest that the number of infested properties in urban settings has increased in the last 10 years (Paul & Bates, 2000; Boase, 2004; Doggett *et al*., 2004; Ryan *et al*., 2004; Hwang *et al*., 2005).

Awareness of changing pest dynamics is currently limited to anecdotal reports from private pest control companies, local council authorities, clinical reports and other involved in the control of public health pests. Although reports suggest there has been an increase in the number of bed bugs in the UK (Paul & Bates, 2000; Boase, 2004; Ter Poorten & Prose, 2005), there have been no precise data to attempt to quantify the extent of the resurgence (Harlan *et al*., 2008). The present study aims to provide quantitative evidence to support the hypothesis that bed bug infestations are increasing in Greater London.

Method

Data collection

Local authority pest control teams were chosen as the source of data, as each team is responsible for a fixed geographical area within Greater London and has statutory powers to enter infested properties. Furthermore, a direct comparison could be made with preliminary data on bed bug infestations collected from 1995 to 2000 from one Borough (Boase, 2004).

There are 32 boroughs within Greater London that are individually governed by local government council authorities. Each has a pest control team that independently deals with pest-related issues for residential and commercial properties within the borough. All 32 London Borough pest control teams were initially approached in July 2006 at a biannual pest control seminar for councils in Greater London. Data were obtained from seven London Boroughs (just over 20% of all boroughs) that initially responded and agreed to participation. Participating boroughs represented a wide geographical distribution across Greater London, from the north, east, south and west. There was little variation in population size between boroughs (200,000 average total number of people) (National Statistics Office, 2004) and little variation in recommended pest treatment policies described in borough websites at the time of the study (Direct Government UK, 2006).

From borough records, the annual and monthly telephone calls received for pest enquiries from members of the public (predominantly residential) seeking information on pest identification and control were collected from January 2000 to June 2006. The records contained the caller's name and address, pest/s of concern, date of enquiry and date of appointment.

Additional monthly data were obtained for: average temperature (°C) (Intellicast, 2009), numbers of overseas visitors to the UK (National Statistics Office, 2002), and number of UK residents going abroad (National Statistics Office, 2002).

Statistical analysis

Two analyses were performed: (1) to test whether there has been a significant increase in the absolute number of bed bug calls in all boroughs, and (2) to test whether any increase detected was independent of any general trends in calls concerning all pest types, i.e. in order to address the possibility that any increase in the number of calls recorded may simply be owing to improvements in public awareness or willingness to contact the pest control teams. Both analyses tested for interactions with boroughs to test whether trends differed significantly between boroughs.

In the first analyses, the outcome data were the monthly number of bed bug enquiries/borough (available for Boroughs 1-4, 6 and 7, see Table 1.0). Using repeated measures analysis the following components were tested: (1) a quadratic regression for trend, (2) trigonometric functions to describe cycles of different period lengths, and (3) interactions between both of these components. Specific regression parameters were estimated for each borough by incorporating interactions with a categorical borough effect and all non-significant terms were eliminated from the model using the Wald test (Payne *et al*., 2005). No transformation of the counts was required in order to approximate normality of residuals. Later, covariates for monthly values for average temperature (°C), number of overseas visitors to the UK, and number of UK residents going abroad were tested to verify their influence by individually incorporating them as a last component into the individual borough models and the general model using data from the six boroughs.

In the second analyses, the outcome data were the proportion of bed bug calls/borough/year, i.e. using the number of bed bug calls and the total number of calls for all pests per year (Boroughs 1-5 from Table 1.0). Logistic regression analysis, with a logit link, was used to test whether the proportion of bed bug calls had changed with time, making the assumption that the number of calls followed a binomial distribution, and interactions were incorporated in order to allow for differences between boroughs and years. The significance of each effect and their interaction was tested using an approximated F-test (Payne *et al*., 2005).

In all tests a significance level of 1% was used, and analysis was performed using GenStat 8 (Payne *et al*., 2005).

Specimen collection

During July 2006, properties of members of the public who called borough pest control teams with concerns about bed bug infestations were visited by the first author (LR) to (1) confirm whether calls concerning bed bugs could be interpreted as true bed bug infestations, and (2) determine which species of bed bugs were present in Greater London. The properties visited included those that were about to receive an initial treatment, and those that had previously been treated without success but where a re-treatment was required. Evidence of bed bug infestations included faecal spots, eggs, shed skins and live specimens found in cracks and crevices (Boase, 2004; Cleary & Buchanan, 2004). Live bed bugs were collected by brushing them into collection tubes from areas such as bed frames, sofas, mattresses and sheets, using a small paint brush, and an adult from each collection was later identified using appropriate diagrams or keys (Usinger, 1966; Newberry, 1989a).

Results

A summary of the data collected from pest control teams across Greater London is shown in Table 1.0. For anonymity, boroughs that provided data are numbered 1-7. The data demonstrate a significant increase in both the number of bed bug calls and the proportion of bed bug enquiries from 2000-2006. There was no increase

Borough	Year						Monthly data
	2000	2001	2002	2003	2004	2005	
1	58 1.85%	85 2.66%	92 2.56%	137 4.07%	0-1173 5.74%	191 6.39%	January 2000 to June 2006
2	- -	- -	143 1.60%	190 2.08%	200 2.33%	315 3.02%	April 2001 to March 2006
3	- -	93 1.65%	147 2.64%	251 4.78%	271 4.39%	263 4.43%	October 2000 to June 2006
4	29 0.82%	46 1.25%	80 1.70%	94 2.40%	124 2.98%	143 3.56%	January 2000 to June 2006
5*	- -	- -	240 8.63%	367 13.38%	806 17.39%	859 14.6%	- -
6	- -	- -	- -	- -	- -	104 2.03%	September 2004 to June 2006
7	- -	- -	- -	- -	- -	134 6.59%	September 2004 to June 2006

Table 1.0
Total number of bed bug calls per annum and the percentage of calls for bed bugs received by seven London Borough pest control teams for 2000-2005. Where available, monthly data for each borough are also presented.

** Monthly data were not available for this borough.*

for the total number of calls for the six main pests and no significant increase in the individual number of calls for fleas, Pharaoh's ants, mice and rats from 2000 to 2006; there was, however some suggestion of an increase in calls for cockroaches by an average of 12% p.a. (95% CI intervals:1-24%; p=0.030).

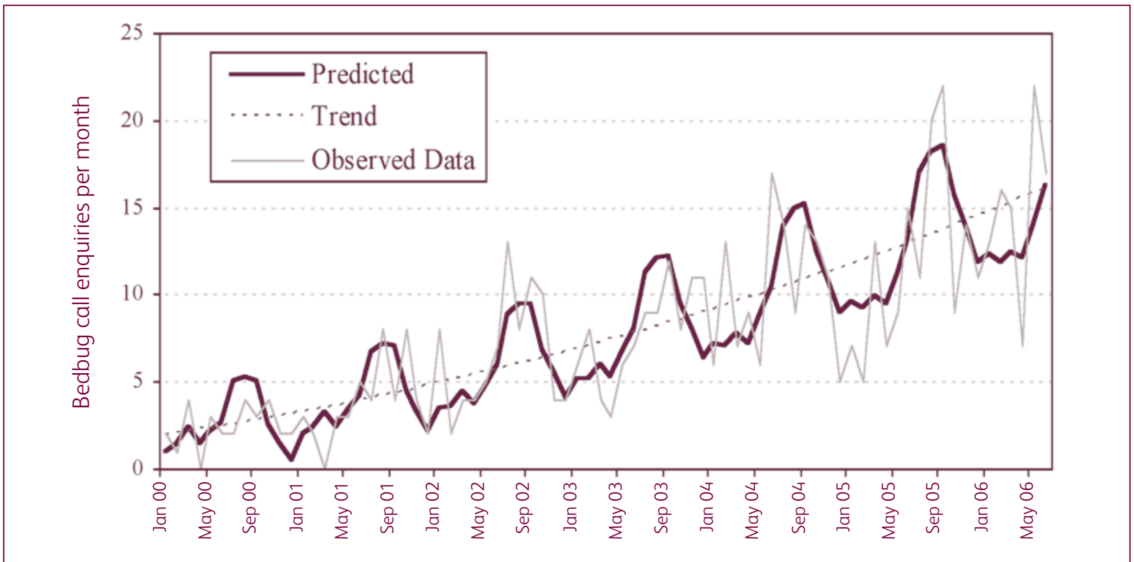

Figure 1.0
Borough 4, chosen as an example of observed data compared to the predicted monthly number of bed bug calls from January 2000 to June 2006. Lines were obtained using multiple linear regressions with repeated measures.

Table 2.0 Estimated parameters, followed by their standard errors, for the average model of monthly bed bug counts by London Borough pest control teams since 2000, based on six Boroughs (1-4, 6 and 7). The model considered a linear trend, and trigonometric functions to describe cycles and their interactions.

Parameter	Estimate	S.E.	Comment
α_0	1.1350	(4.7531)	Intercept
α_1	0.1978	(0.0763)	Linear trend
a_1	-1.3980	(0.3099)	12 months cycle
a_2	-0.6822	(0.3165)	6 months cycle
a_3	-0.6526	(0.6307)	2 months cycle
b_1	-0.4099	(0.6880)	12 months cycle
b_2	1.1120	(0.3169)	6 months cycle
d	-0.0493	(0.0136)	Amplitude with 12 month cycle

Figure 1.0 shows the observed data and the predicted trend in the absolute number of bed bug calls/month for Borough 4, as an example, as this was one borough that had complete monthly data available from 2000-2006. Interactions were found between boroughs and trends. The specific trend parameters for the five other boroughs for which monthly data were available (graphs not presented) suggest a similar positive linear trend for four boroughs (1, 3, 6 and 7) but a quadratic increase in two boroughs (2 and 4).

The predicted average trend for all six boroughs (figure 2.0), calculated using the parameters presented in Table 2.0, shows a steady monthly increase of bed bug calls between 2000-2006, which corresponds to an annual increase of 28.49 bed bug calls (95 % CI: 6.88-50.30). This value was obtained by averaging the predictions for a given year: i.e. multiplying the average slope for each month by 144 (12 times the annual prediction sums times 12 months/year). There were also significant cycles with periods of 2, 6 and 12 months, and an interaction between the 12 month cycle and time. The 12 month cycle peaks around August, and its range increased in later years. Furthermore, interactions were found between boroughs and trends and the 2 month cycle, but the average value of this parameter was not relevant.

The second set of analyses found that the proportion of all calls that were for bed bugs increased significantly between 2000 and 2006 by 24.7 % (95 % CI: 17.2-32.7; $p<0.001$) per annum. There was no significant effect of additional covariates for all boroughs used in the general model. However, when tested against single borough models, there were statistically significant positive associations with average temperature ($p<0.001$, $\beta=0.882$ calls/°C) and with UK residents going abroad ($p=0.003$, $\beta=2.391$ calls/million people) in Borough 3, and with overseas visitors to the UK for Borough 4 ($p=0.002$; $\beta=3.699$ calls/million people).

Bed bug infestations were confirmed in all 22 properties visited, and samples collected were all later identified as *C. lectularius*.

Discussion

Increase over time

The study demonstrates that the number of bed bug calls has increased in London, and supports findings from other major cities in developed countries including Australia, Canada, Denmark and the USA (Doggett *et al*., 2004; Hwang *et al*., 2005; Kilpinen *et al*., 2008; Potter *et al*., 2008). The fact that there is an increase in the proportion of bed bug calls, as well as in the absolute number of calls concerning bed bugs, supports the hypothesis that the increase is caused by true changes in bed bug infestations rather than general improvements in public use rates of the borough pest control teams. The general trend was linear apart from two boroughs where there was a quadratic increase, presumably owing to the variation in either: 1) property infestation densities

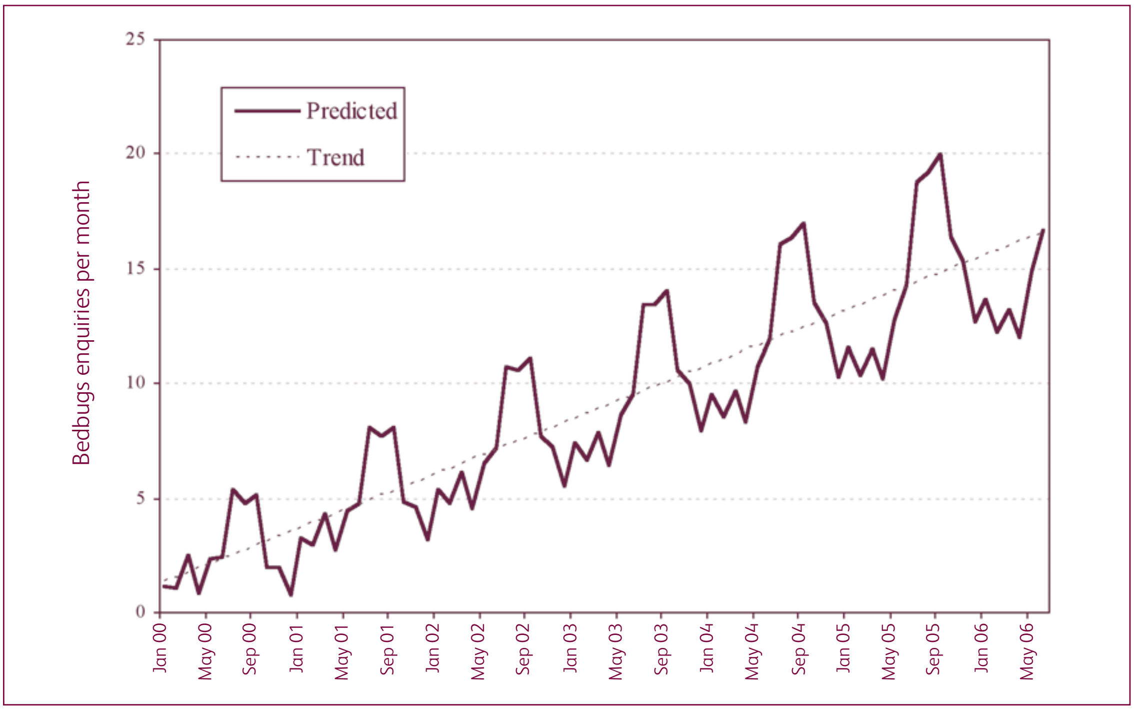

Figure 2.0
The general model for six Boroughs 1-4, 6 & 7 showing the predicted and linear trend using average monthly data for bed bug enquiries. Lines were obtained using multiple linear regressions with repeated measures. The predicted line was obtained using the model:

$$y_t = \alpha_0 + \alpha_1 t + a_1\cos(\frac{2\pi t}{12}) + a_2\cos(\frac{12\pi t}{12}) + a_3\sin(\frac{4\pi t}{12}) + b_1\sin(\frac{2\pi t}{12}) + b_2\sin(\frac{4\pi t}{12}) + d\,t\sin(\frac{2\pi t}{12}) + \varepsilon_t$$

where y_t and ε_t are monthly count, and residual at time t (with t=1 corresponding to January 2000), and α_0, α_1, a_1, a_2, a_3, b_1, b_2, d are the model parameters. The residual variance structure consisted of using a first and second order autocorrelation, which was estimated separately for each borough in a combined analysis.

and/or 2) effectiveness of treatments used between boroughs. There are a number of untested hypotheses suggesting reasons for the increase in bed bug infestations in developed countries (Boase, 2004; Reinhardt & Siva-Jothy, 2007, Boase, 2008). These include passive dispersal and control failure: bed bugs are dispersed passively (Paul & Bates, 2000; Newberry, 1989b), owing to business and holiday travel and purchases of used furniture (Harlan *et al.*, 2008), on items including personal possessions such as furniture and suitcases (Doggett *et al.*, 2004) aided by human migration (Doggett *et al.*, 2004; Masetti & Bruschi, 2007), and there is also recent evidence for insecticide resistance in bed bugs in addition to ineffective application techniques (Temu *et al.*, 1999; Myamba *et al.*, 2002; Karunatne *et al.*, 2007; Romero *et al.*, 2007; Harlan *et al.*, 2008; Potter *et al.*, 2008). Both factors are likely to contribute to the annual increase.

Annual cyclic patterns

The results indicate 2, 6 and 12 month periodic cycles for the number of call enquiries for bed bugs. The 12 month cycle peaked in August-September and reflects data from other studies showing the number of bed bug calls increasing during the summer and declining in the winter (Cornwell, 1974; Cleary & Buchanan, 2004; Doggett *et al.*, 2004; Ryan *et al.*, 2004; Kilpinen *et al.*, 2008). The 12 month cycle increased in amplitude for later years, which may suggest greater bed bug dispersal during the summer months, and greater optimal conditions for survival and reproduction (Omori, 1941). The 6 and 2 month cycles appear, however, to be specific to this study. There is evidence that suggests that some first and second time treatments may be ineffective (Ryan *et al*., 2004; Hwang *et al*., 2005). The 6 and 2 month cycles may reflect call back periods from members of the public to pest control services after initial treatment has failed, because the data did not differentiate between first time callers and subsequent calls received from the same household. Further studies would be necessary to confirm these findings.

Covariates

There was evidence for only one borough to suggest that outdoor temperature had an impact on the increase in calls concerning bed bugs. This is presumably because the majority of properties nowadays have central heating and double glazing, and maintain warm temperatures all year creating favourable conditions for breeding, survival and development of bed bugs.

In addition, although the effect of people's movements has been previously hypothesised to contribute to the cyclic numbers of bed bug infestations (Cornwell, 1974; Kilpinen *et al*., 2008), human movement only had a significant contribution in one borough. More evidence would be required to determine whether human movement influenced the number of bed bug infestations.

Specimen collection

All adult specimens collected were identified as the common bed bug *C. lectularius*. The dominance of *C. lectularius* in developed countries, rather than the tropical bed bug, *C. hemipterus*, has been found in other studies in the UK (Boase, 2001) and Australia (Doggett *et al*., 2003).

Conclusion

In conclusion, the study shows that for the selected seven boroughs investigated in Greater London, the number of call enquiries for bed bugs increased from 2000 to 2006. This rise is likely to arise from a combination of factors including greater dispersal of bed bugs and control strategies that are not fully effective. Cyclic patterns were identified every 12, 6 and 2 months with the greatest peak in August-September. This suggests that there is likely to be a higher number of reports for bed bugs during summer months. Current control of bed bug infestations relies on public recognition of the symptoms and recent evidence of widespread resistance suggests that public awareness will be important for control and dispersal. Members of the public, pest control operators and medical professionals should therefore be aware of typical symptoms and an integrated approach should be used for bed bug management involving inspection, detection, and education, and physical removal and exclusion as well as pesticide applications (Harlan *et al*., 2008). For example, the development and promotion of a Code of Practice for the control of bed bug infestations in Australia, and education of stakeholders, has been widely adopted in Australia (Doggett and Russell, 2008). Adequate surveillance of bed bug populations will be important for future monitoring and control, especially in Greater London in view of the possible increased movement of people predicted for the 2012 Olympic Games.

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References

Boase C (2001). Bedbugs – back from the brink. *Pesticide Outlook*, 12, 159-62.

Boase C (2004). Bed-bugs – reclaiming our cities. *Biologist*, 51, 1-4.

Boase C (2008). Bed bugs (Hemiptera: Cimicidae): an evidence-based analysis of the current situation, in W H Robinson and D Bajomi (eds) Proceedings of the 6th International Conference on Urban Pests, OOK-Press Kft., Hungary, 7-14.

Cleary C J and Buchanan D (2004). Diagnosis and management of bedbugs: an emerging US infestation. *Nurse Pract*, 29, 46-8.

Cornwell P B (1974). The incidence of fleas and bed bugs in Britain. *Int Pest Control*, 16, 17-20.

Direct Government UK (2006). Find out about pest control. Available online at: *www.local.direct.gov.uk/LDGRedirect/index.jsp?LGSL=431&LGIL=8&ServiceName=Find%20out%20about%20pest%20control* [accessed 05/01/09]

Doggett S L, Geary M J, Crow W J, Wilson P and Russell RC (2003). Has the tropical bed bug, *Cimex hemipterus* (Hemiptera: Cimicidae), invaded Australia? *Environ Health*, 3, 80-2.

Doggett S L, Merilyn J and Russell R C (2004). The resurgence of bed bugs in Australia: with notes on their ecology and control. *Environ Health*, 4, 30-8.

Doggett S L and Russell R C (2008). The resurgence of bed bugs, *Cimex* spp. (Hemiptera: Cimicidae) in Australia, in W H Robinson and D Bajomi (eds) Proceedings of the 6th International Conference on Urban Pests, OOK-Press Kft., Hungary, 407-25.

Fletcher C L, Ardern-Jones M R and Hay R J (2002). Widespread bullous eruption due to multiple bed bug bites. *Clin Exp Dermatol*, 27, 74-5.

Harlan H J, Faulde M K and Baumann G J (2008). Bedbugs, in X Bonnefoy, H Kampen and K Sweeney (eds) Public Health Significance of Urban Pests, World Health Organization Regional Office for Europe, Denmark, 131-153.

Hwang S W, Svoboda T J, De Jong L J, Kabasele K J and Gogosis E (2005). Bed bug infestations in an urban environment. *Emerg Infect Dis*, 11, 533-8.

Intellicast (2006). Hounslow historic weather averages. Available online at: *www.intellicast.com?Local?History.aspx/location=UKXX0069* [accessed 05/01/2009]

Karunaratne S H P P, Damayanthi BT, Fareena M H J, Imbuldeniya V and Hemingway J (2007). Insecticide resistance in the tropical bedbug *Cimex hemipterus*. *Pestic Biochem Physiol*, 88,102-7.

Kilpinen O, Vagn Jensen, K M and Kristensen, M (2008). Bed bug problems in Denmark, with a European perspective, in W H Robinson and D Bajomi (eds) Proceedings of the 6th International Conference on Urban Pests, OOK-Press Kft., Hungary, 395-300.

Liebold K, Schliemann-Willers S and Wollina U (2003). Disseminated bullous eruption with systemic reaction caused by *Cimex lectularius*. *J Eur Acad Dermatol Venereol*,17, 461-3.

Masetti M and Bruschi F (2003). Bedbug infestations recorded in Central Italy. *Parasitol Int*, 56, 81-3.

Myamba J, Maxwell C A, Asidi A and Curtis C F (2002). Pyrethroid resistance in tropical bedbugs, *Cimex hemipterus*, associated with use of treated bednets. *Med Vet Entomol*, 16, 448-51.

National Statistics Office (2002). Table 12.20: International travel by mode. Available online at: *www.statistics.gov.uk/StatBase/Expodata/Spreadsheets/D7248.xls* [accessed 05/01/2009]

National Statistics Office (2004). Table 14: 2004-based Sub National Population Projections London boroughs; summary of population, natural change, net migration and other adjustments for selected years by total persons. Available online at: *www.statistics.gov.uk/StatBase/Expodata/Spreadsheets/D9490.xls* [accessed 05/01/2009]

Newberry K (1989a). Biology and control of bedbugs. PhD thesis, University of Natal.

Newberry K (1989b). Changes in the relative frequency of occurrence of infestations of two sympatric species of bedbug in northern Natal and KwaZulu, South Africa. *Trans R Soc Trop Med Hyg*, 83, 262-4.

Omori N (1941). Comparative studies on the ecology and physiology of common and tropical bedbugs with special reference to the reactions of temperature and moisture. *J Formos Med Assoc*, 40:555-636.

Paul J and Bates J (2000). Is infestation with the common bedbug increasing? *Br Med J*, 320, 1141.

Payne R W, Harding S A, Murray D A, Soutar D M, Baird D B, Welham S J, Kane A F, Gilmour A R, Thompson R, Webster R and Wilson G T (2005). The Guide to GenStat Release 8, Part 2: Statistics. VSN International, Oxford.

Potter M E, Romero A and Haynes K (2008). Battling bed bugs in the USA., in W H Robinson and D Bajomi (eds) Proceedings of the 6th International Conference on Urban Pests, OOK-Press Kft., Hungary, 400-06.

Reinhardt K and Siva-Jothy M T (2007). Biology of the bed bugs (Cimicidae). *Annual Review of Entomology*, 52, 351-74.

Romero A, Potter M F, Potter D A and Haynes K F (2007). Insecticide resistance in the bed bug: a factor in the pest's sudden resurgence? *J Med Entomol*, 44, 175-8.

Ryan N, Peters B and Miller P (2004). A survey of bedbugs in short-stay lodges. *N S W Public Health Bull*, 15, 215-7.

Sansom J E, Reynolds N J and Peachey R D G (1992). Delayed reaction to bed-bug bites. *Arch Dermatol*, 128, 272-3.

Silverman A L, Qu L H, Blow J, Zitron I M, Gordon S C and Walker E D (2001). Assessment of hepatitis B virus DNA and hepatitis C virus RNA in the common bedbug (*Cimex lectularius L*). and kissing bug (*Rodnius prolixus*). *Am J Gastroenterol*, 96, 2194-8.

Temu E A, Minjas J N, Shiff C J and Majala A (1999). Bedbug control by permethrin-impregnated bednets in Tanzania. *Med Vet Entomol*, 13, 457-9.

Ter Poorten M C and Prose N S (2005). The return of the common bedbug. *Pediatr Dermatol*, 22, 183-7.

Tharakaram S (1999). Bullous eruption due to *Cimex lectularius*. *Clin Exp Dermatol* 24, 241-2.

Thomas I, Kihiczak G G and Schwartz R A (2004). Bedbug bites: a review. *Int J Dermatol*, 43, 430-3.

Usinger R L (1966). Monograph of Cimicidae. Maryland, USA: Entomological Society of America.

Webb P A, Happ C M, Maupin G O, Johnson B J B, Ou C Y and Monath T P (1989). Potential for insect transmission of HIV. Experimental exposure of *Cimex hemipterus* and *Toxorhynchites amboinensis* to human immunodeficiency virus. *J Infect Dis*, 160, 970-7.

The organisation of local authority pest management services in the UK

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Abstract

The National Pest Advisory Panel (NPAP) of the Chartered Institute of Environmental Health (CIEH) in the UK was established in 2001 to advise the CIEH on it pest control policy. As part of its work, a pest survey was developed to investigate the way in which pest management services within local authorities were operationalised and delivered in the UK. Questionnaires were distributed to all local authorities in England, Wales and Northern Ireland and a response rate of 67% was achieved. Although there is no statutory duty on local authorities to provide pest management services, only three of the local authorities that responded did not provide one. The survey found considerable variation in the way pest management services were organised and delivered, staffing levels, approaches to contracting out services, staff training and the assessment of service provision. In the UK, local authorities and water authorities should share responsibility for the control of rats in sewers. This survey found considerable variation in these relationships. The impact of these findings on the management and delivery of pest control services is considered.

Key words: Environmental health; Infestations; Local government; Pest management.

Introduction

The World Health Organisation's recently published report on the Public Health Significance of Urban Pests (Bonnefoy *et al*., 2008) highlights the continuing threats posed by urban pests across the globe and the need for effective policies to control pest species. Within the UK, the management and control of pest species falls under the remit of a number of local authority (LA) activities within the environmental service, not just those relating to 'pest control'. For example, the control of pest species forms an important element within the food safety regime, the regulation of health and safety at work and the regulation of conditions in residential accommodation.

In the United Kingdom, the National Pest Advisory Panel (NPAP) was established to provide advice and guidance on pest control policy to the Chartered Institute of Environmental Health (CIEH). Its first meeting took place in May 2001. Part of its mission was to ensure that pest management is undertaken or managed by its members in a professional way. The NPAP also exists to enable the CIEH to provide the necessary leadership and guidance to those in charge of LA pest control departments.

The objectives of NPAP are to:

- raise the profile of pest management in the UK, leading to better understanding of the need for good pest management.
- establish channels of communication throughout industry, government, local authorities and academics, leading to a greater awareness of problems and the need for priorities.
- improve the standards of pest management throughout the UK by promoting good practice, leading to reduced pest levels and pesticide use.
- provide expert advice to government departments and agencies via CIEH.
- identify and promote research needs into pest management issues.

The need for reliable data about the way in which LA pest management services across the UK were operationalised and delivered was clear. The NPAP commissioned a survey of LAs to establish the operation and management of pest control services. There is considerable variation in the pest management services provided by local authorities and provision is often related to local (often historical) views on the resourcing of the service. There was often a mixture of in-house services (both public health and commercial), contracting out, referral to third parties, the provision of advice only and/or enforcement action, depending on the pest species involved and the type of premises (e.g. private/council dwellings, other council properties, commercial food/non-food) where the infestation was found. This paper examines these complexities in relation to rodent control.

Methods

The NPAP questionnaire was divided into five main sections, dealing with:

General characteristics of the LA
Training and qualifications of pest control staff
Pests treated
Sewer baiting
Membership of Pest Liaison groups

The questionnaire was sent to all chief officers in England, Wales and Northern Ireland (n = 402) during

Table 1.0
Response rates from the 14 CIEH centres

CIEH centre	No. respondents	Total no. within the centre	Response rate (%)
North West	42	43	98
Yorks/Humberside	19	21	91
Northern	20	23	87
Southern	25	30	83
North Home Counties	22	28	79
Western	14	20	70
South East	25	37	68
Midlands	22	34	65
Eastern	12	20	60
South West	15	25	60
Greater London	19	33	58
East Midlands	21	40	53
Wales	10	22	45
Northern Ireland*	9 (5)	26	34
Total	**271**	**402**	**67**

* Five authorities combined their individual responses into a single return.

2002/03. Following this initial posting, a reminder was sent to all non-respondents.

Results

Two hundred and seventy one LAs returned completed questionnaires, providing a response rate of 67%. Response rates varied with 72% of English authorities and 45% of Welsh authorities responding. In N. Ireland establishing the response rate was more complex as five authorities combined their individual responses into a single return. Thus the five questionnaires returned from Northern Ireland represented nine of the 26 authorities (34%). At the time of the survey, local authorities in England, Wales and Northern Ireland were organised into 14 CIEH centres[1] (now Regions). Response rates from the local authorities within these CIEH centres are presented in Table 1.0.

Responses from the CIEH centres ranged from 34% (N. Ireland) to 98% (North West centre). The lowest response rate in England was from the East Midlands centre, with only 52% of LAs in that region responding.

LA size

Populations within the LA boundaries ranged from 10,000 to 1,000,000, with a mean of 149,000. The majority of LAs (58%) had both rural and urban areas within their boundaries. Twenty four percent of respondents stated their authority area was entirely urban and 18% stated it was entirely rural.

Organisation of pest management services

Although there is no statutory requirement placed on LAs to provide pest management services, only three respondents (two district councils within the South West centre and N. Ireland centre and a unitary council from the Southern England centre) did not provide one. All three of these LAs confirmed that they dealt with pest problems by giving advice and where necessary using

[1]Since this work the CIEH has reorganised the 14 centres into 11 regions reflecting government regions

	Range	Mean no.	Extrapolation for all LAs
Full-time managers	0 – 2	0.26	105
Part-time managers	0 – 2	0.71	285
Full-time supervisors	0 – 4	0.32	129
Part-time supervisors	0 – 4	0.30	121
Full-time operators	0 – 23	2.83	1138
Part-time operators	0 – 7	0.56	225
Full-time administrators	0 – 6	0.57	229
Part time administrators	0 – 11	1.57	631
Estimate of full time staff			**1601**
Estimate of part time staff			**1262**
Estimate of total number of full time and part time staff			**2863**

Table 2.0
Staffing levels within LA pest management operations (n = 266)

enforcement action. Seventy-eight percent of those LAs that did provide a pest control service, did so in house, 13% contracted out this service and 9% had a mixture of in-house and contracted-out services.

Respondents were asked about the organisation of their pest management services. Eighty-one percent of LAs confirmed that pest control was a stand alone service operating within the environmental health department. Nineteen percent stated that it was run as part of another service (such as animal welfare, cleansing and commercial services).

Only a small proportion (12%) of those LAs that provided in-house pest control services were fully supported by LA funding. The more common model (in 88% of cases) was one where pest control activities were either partly or fully underwritten by charged for pest control activities.

Fifty-nine LAs contracted out their pest control operations. Of these, 56% had fixed term/fixed price contracts, 30% had contracts based on the jobs done/number of properties treated and the remainder (14%) had a mixture of these two. Those with contracted-out operations were asked about the frequency with which these services were audited. Thirty-eight per cent stated that they were audited randomly, 13% were audited annually, 13% were audited quarterly, 13% had other arrangements in place and 22% stated that they did not audit the service. Where auditing did take place, only 25% used personnel with a specific pest management qualification.

Assessing levels of infestations

In many areas of environmental health work, LAs are required to make detailed returns about the inspection and enforcement activities they undertake. There are a number of common data platforms utilised for the management of this data, for example Northgate Environmental Health, Civica Public Protection (formerly Flare), and Uniform Environmental Health from CAPS Solutions Ltd. Such programmes allow for the reporting of returns and activities to government agencies (such as the Health and Safety Executive (HSE), the Food Standards Agency (FSA), the Environment Agency). Data from LAs are uploaded and aggregated, allowing transparent evaluation and review of environmental health activities. Pest management has been a neglected area of public health policy since the role of central government was reduced in the early 1980s. Until that time LAs were required to make an annual return to the Ministry of Agriculture, Fisheries and Food on their pest management problems and activities. While some of the data management programmes used by LAs often include the capacity for recording data on pest control, many LAs do not routinely collect this information locally. This is, in part, because there is no requirement to report pest management activities to central government departments and no common platform via which this information is recorded, making comparisons with other

Table 3.0
Analysis of EHO involvement in the pest management services within different authority types (n = 171)

Authority Type	EHO involvement Yes	No	% without EHO involvement
London Borough	9	7	44
Unitary Council	23	14	38
Metropolitan/City Council	23	10	30
District/Borough Council	116	19	14
Total	**171**	**50**	**23**

Table 4.0
Percentage of respondents with a structured training programme in place (by type of service/authority (n = 255)

Type of service	%	Type of Authority	%
In house	74%	London Borough	83%
Both in-house/contracted out	40%	Metropolitan District	80%
Contracted out	23%	Unitary Council	76%
		District Council	58%

authorities problematic. LAs reported that the most common means by which they assessed levels of infestation was by monitoring the number of enquiries made *and* the number of service requests (53%). Forty three percent monitored only the number of service requests and 2% monitored only the number of enquiries. The remainder either did not assess the levels or used other means (e.g. number of premises treated or the number of confirmed infestations).

Performance criteria

Respondents were asked about the performance criteria they used to judge the success of the pest control measures undertaken (n = 270). While two thirds did have measures in place, a sizeable proportion did not (34%). The use of performance criteria was consistent irrespective of the nature of the service provision (in-house – 66%; contracted-out – 60%, and services with a mixture of in-house and contracted-out – 64%). The two most common means of measuring performance were re-treatment visits and customer satisfaction surveys.

Staffing

Two hundred and thirty six respondents provided details about their staffing arrangements and results are presented in Table 2.0.

The number of staff working in LA pest management services varied considerably from a unitary authority with one part time operator and a part time administrator to a metropolitan authority with 27 full time staff. In order to establish an estimate of the total number of staff working within LA pest management services, a crude extrapolation of the means was calculated and suggested that approximately 1,601 full time and 1,262 part time local authority staff worked in pest management.

Respondents were asked about the number of EHOs that were directly involved in pest management services within their authority. Again, a crude extrapolation of the mean numbers suggested that in the 402 LAs in England, Wales and N. Ireland, 433 EHOs were directly involved in pest management. However, 50 of the authorities that had provided details about their staffing reported that they had no EHOs directly involved in this service (see Table 3.0).

Further analysis of this data confirmed a significant relationship between the type of LA and EHO involvement (χ^2 = 17.1; p = 0.001). EHOs were least likely to be involved in pest management services in the London Boroughs and unitary councils.

The survey also explored LA approaches to staff training in pest management and results are presented in Table 4.0.

Organisation undertaking sewer baiting	No.	%
Local Authority	93	52
Private contractor (for WA)	33	19
Water Authority	25	14
Other*	15	8
Don't know	7	4
Private Contractor (for LA)	5	3
Total	**178**	**100**

Table 5.0 Organisation(s) undertaking sewer treatments to control rats (n = 178)

* In most cases a combination of LA/WA/contractor(s)

Two thirds had a structured training programme in place for their staff. Both the type of service offered (in-house/contracted out/both) and the type of authority (London Borough/district Council/metropolitan/unitary council) had a significant influence on whether structured training programmes were present (Type of service: χ^2 = 34.2; p <.0001; Type of Authority: χ^2 = 12.1; p =.007).

Charging for pest management services

There was little uniformity in the way in which LAs dealt with their pest problems and the charges they levied for services. For example, 225 LAs offered treatments for domestic rodent infestations. Of these, 54% treated for rat and mouse infestations free of charge, 22% treated for rat infestations free of charge, but charged for services to eradicate mouse infestations and 22% charged for treatments to eradicate both rats and mice. There was evidence of differential charges depending on tenure and/or social circumstances. Previous research has highlighted the need for effective, consistent control strategies for rodents (Richards, 1989; Langton, 2001; Channon *et al*., 2000; Battersby *et al*., 2002, Murphy *et al*., 2005). Charging for pest treatments proved to be a complex area with little consistency in the approaches adopted and/or the criteria used to determine the level of charging.

Sewer baiting

Although brown rats can inhabit a variety of habitats (such as open fields, hedgerows, woodlands and refuse dumps), they appear to be particularly suited to life in the sewers. Respondents were asked about the arrangements for the control of rats in sewers within their authority boundaries. Two thirds (65%) confirmed that sewer treatments were undertaken, 27% stated that no sewer baiting was undertaken and the remainder (8%) did not know. In those authorities where sewer baiting was undertaken, respondents were asked to identify which organisation(s) carried it out and results are presented in Table 5.0.

Where respondents had identified water authorities (WAs) as being responsible, they were asked about how these treatments were undertaken. Just under half stated that the WAs contracted out their sewer baiting, a fifth did it in house and a third did not know about the arrangements WAs had made to bait the sewers. Where LAs carried out sewer baiting, WAs financed the operation in two thirds of the authorities, and in just under a third of LAs and WAs jointly financed it. Only 4% of LAs financed it solely themselves.

Respondents reported considerable variation in the amount spent on sewer baiting. Estimates of LA spending ranged from no spend to £61,000 per annum. WA spend ranged from no spend to £65,000 per annum. The data supplied were incomplete as many LAs were unable to provide information on spend by WAs. However, for those where data was available (n = 79) on both the size of the LA population and LA/WA spend on sewer treatments, the spend per capita ranged from 0.2p to 34p per annum with an average of 5p. Table 6.0 presents the variations in spend by CIEH Centre.

While the number of missing cases was large and some of the data provided on spending was incomplete, important information emerged. Sewer baiting carried out in the North West centre received the highest spend per capita per annum (8p) and those in the South West centre the lowest (0.9p). The amount spent in relation to

Table 6.0
Average per capita spend/annum by CIEH Centre
(n = 79)

CIEH Centre	No. valid cases	Average spend/capita	Range
North West	24	8p	1.4 – 34p
Wales	5	6.7p	4 – 9.4p
Northern	14	6.2p	1.8 – 11.7p
Western	4	4.9p	1.8 – 10.4p
East Midlands	10	3.1p	1 – 4.5p
South Eastern	3	3p	1.6 – 5p
Midlands	9	3p	.2 – 5.9p
Yorkshire and Humberside	2	2.7p	1.4 – 4p
Southern	5	2.2p	.3 – 4.2p
South West	3	0.9p	.3 – 1.3p
Eastern	0	Incomplete data	
Greater London	0	Incomplete data	
Northern Home Counties	0	Incomplete data	
N. Ireland	0	Incomplete data	
Total	**79**		

the timing of the control did not vary greatly with those providing proactive baiting spending 6.6p per capita, those providing reactive baiting spending 4.6p per capita and those adopting a reactive and proactive service spending 5.1p per capita. These results would appear to contradict the findings presented in the UK Water Industry Research (UKWIR) report (2000), which concluded that proactive sewer baiting was five times more expensive than reactive baiting. Approximately twice as much was spent per capita per annum on controlling rats in urban sewers (8.2p per capita) compared to rural sewers (4.6p). In authorities with both urban and rural areas, the average spend was 4.6p.

The Water UK protocol provides a mechanism for improved communication and co-ordination between LAs and WAs on the control of rats in sewers. The protocol states that:

1. Where a Water UK member commences a new sewer baiting activity, it should inform the relevant local authority;

2. Where a local authority commences a new baiting activity to combat rat infestation, it should inform the relevant Water UK member;

3. Where possible, sewer baiting to combat rat infestation should be undertaken in a complementary manner, by agreement between the local authority and the Water UK member.

Just over half of the 240 LAs that responded (52%) stated that they were aware of the protocol. However, a quarter (26%) were not and a fifth (21%) were unsure whether their LA was aware of it. A third of respondents reported that the water authority never liaised with them on sewer baiting. Where liaison did take place, a quarter reported regular, planned liaison, a quarter regular liaison as and when required and just under half stated it was irregular. The nature of the liaison between LAs and WAs was analysed and found to vary considerably between CIEH centres (see Figure 1.0).

Thus, in Yorkshire/Humberside 65% of respondents reported regular, planned liaison with the WAs. However, in Northern Home Counties, 65% reported no liaison with WAs.

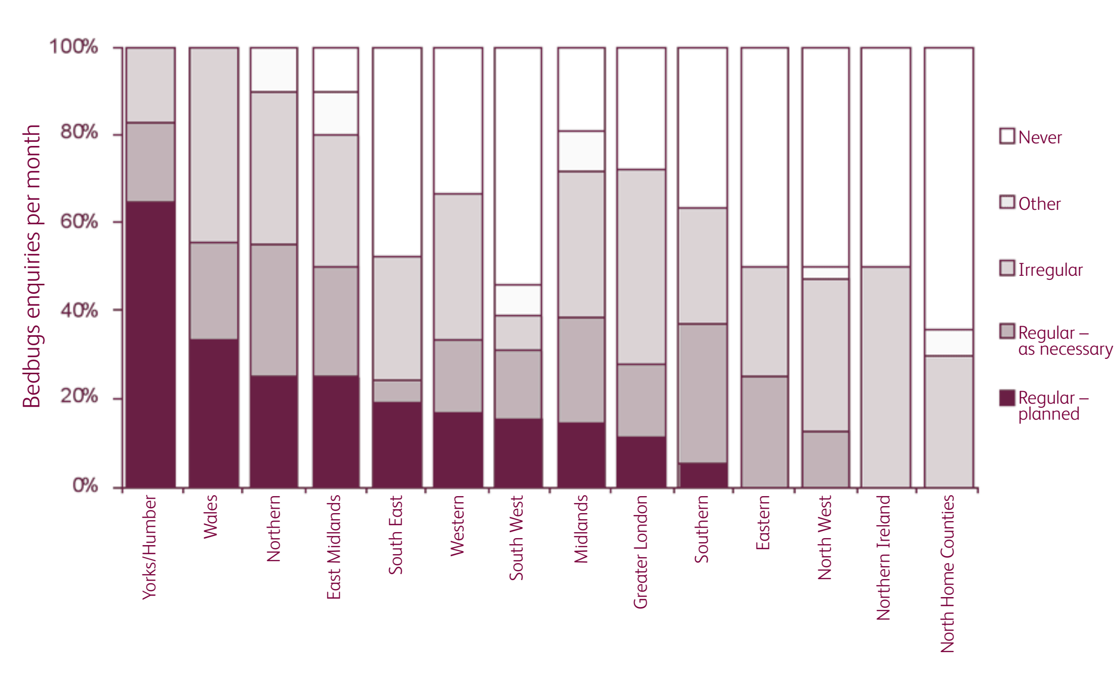

Figure 1.0
Variation in the nature of the liaison with WA by CIEH centres

Pest liaison groups

Pest liaison groups can provide a useful forum for LAs to discuss pest management issues, share good practice and ensure consistent and efficient delivery of services. Seventy percent of respondents (n = 266) reported that they were members of a pest liaison group. Membership within CIEH centres varied, with all respondents from the North West confirming they were members of a pest liaison group, but membership in the North Home Counties (45%) South West (36%) and Wales (10%) was low. Most (85%) of the authorities that were not members stated that they would like to join a pest liaison group.

Conclusion

The findings of the NPAP survey and the detailed responses given by the respondents have provided a rich source of information on the way in which pest control is managed and operationalised within LAs across England, Wales and N. Ireland. The findings confirmed that a large number of personnel were involved in the operation and delivery of pest control services within LAs. However, that does not always mean that there is effective pest management. While there were many examples of good practice and commitment to staff and clients, there were also areas of concern. Attempts to establish the consistency and effectiveness of the approaches adopted to pest management are problematic and at odds with the approach championed by Sir Peter Gershon (2004) where he recommended:

- simplification and standardisation of policies and processes
- adoption of best practice within each function
- sharing transactional support services to achieve economies of scale through clustering

Within pest management services, moving towards these principles has been thwarted by absence of a statutory imperative, resulting in a patchwork of local arrangements and policies with differing approaches to the management and auditing of provision. The first NPAP survey has highlighted a number of concerns that require further investigation, including:

- The nature and impact of an apparent decoupling of pest control services from core EH activities in some local authorities;

- The considerable variation in the provision of a structured training/development programme for staff;
- The complexities of the charging policies adopted for pest treatments;
- Assessment of the procedures and policies relating to contracted-out pest control services;
- The apparent variations in the nature and extent of the liaison between WA and LA to control rats in sewers;
- The inconsistencies in funding arrangements between WA and LA for sewer baiting;
- The variability in the membership of pest liaison groups.

While historically pest management has been viewed as a core function within environmental health departments, this view appears to be changing. Until the early 1980s MAFF provided advice to LAs and disseminated good practice. However, this has lapsed and the Department for Environment, Food and Rural Affairs (DEFRA) does not provide such advice. The provision of a pest management service that goes beyond a reactive treatment regime to include reactive and proactive environmental management is essential if the principles of integrated pest management outlined in the WHO report (Bonnefoy, 2008) are to be achieved. The rigour adopted in the approaches to the management, delivery and auditing of food safety and health and safety functions is at odds with the plethora of strategies and arrangements in place to provide pest management.

NPAP is intending to repeat this survey in 2009. This second survey will provide an updated snapshot of approaches to pest management across the UK and facilitate a review of how pest management services have changed since the last survey.

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References

Battersby S A, Parsons R, Webster J P (2002). Urban rat infestations and the risk to public health, *Journal of Environmental Health Research*, 1 (2): 57- 65

Bonnefoy X, Kampen H, Sweeney K (2008). Public Health Significance of Urban Pests. World Health Organisation (available on-line at *http://www.euro.who.int/document/e91435.pdf* [accessed 04/02/09].

Channon D, Cole M, Cole L (2000). A long-term study of *Rattus norvegicus* in the London Borough of Enfield using baiting returns as an indicator of sewer population levels. *Epidemiology and Infection*. 125: 441-445, Cambridge

Gershon P (2004). Releasing resources to the front line. Independent review of public sector efficiency, HMSO.

Langton S D, Cowan D P, Meyer A N (2001). The occurrence of commensal rodents in dwellings as revealed by the 1996 English House Condition Survey, *Journal of Applied Ecology* 38 (4): 699-709 London: British Ecological Society.

Murphy R G, Williams H and Hide G (2005). Population biology of the urban mouse (*Mus domesticus*) in the UK. In: Proceedings of the 5th International Conference on Urban Pests eds Lee C Y and Robinson W H. Singapore. pgs 343-349 (Contribution 70%)

Richards C G J (1989). The pest status of rodents in the United Kingdom. In: Putman R J, ed, Mammals as pests. London: Chapman & Hall Ltd.

UK Water Industry Research (UKWIR) Ltd (2000) Rodent Control in Sewers, Report Ref No 00/WM/07/4, London.

Smoking environments and adolescent smoking: evidence from the Liverpool Longitudinal Smoking Study

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Abstract

A variety of risk factors for adolescent smoking have been identified and explored, but few have focused on the influence of second-hand tobacco smoke on smoking initiation. Consideration of exposure to second-hand tobacco smoke, and the influence this has on smoking initiation, is particularly important in the home and the school environment, as this is where young people spend the majority of their time. The Liverpool Longitudinal Smoking Study (LLSS) is a unique study funded by the Roy Castle Lung Cancer Foundation, established to investigate children's knowledge, experiences and attitudes towards smoking using a wide range of innovative tools. The LLSS has tracked a single birth cohort of 253 young people from age five throughout their compulsory education. Using quantitative data from the secondary school phase of the study, this paper aims to address: Whether environmental smoking indicators (i.e. home smoking rules, perceived peer smoking and being in other smoky environments) predict (a) adolescents smoking trial, and (b) whether they have smoked in the last week. Data were analysed using Chi-Squared tests to test the strength of association, and logistic regression analysis to estimate the adjusted odds ratio and 95% confidence interval for each potential risk factor. Children who attended schools with higher deprivation scores and had household rules that advocated smoking were found to be significant predictors of smoking trial. Significant predictors of weekly smoking were found to be higher home deprivation scores and household rules that advocated smoking. Although public smoking bans may prove successful in reducing adolescent smoking trial, our findings suggest there is a need to target socially deprived groups. Smoke-free home interventions should be used and supplemented by school-based initiatives to reduce adolescent transition to regular smoking.

Key words: Smoking prevention, smoking interventions, adolescent health, second-hand tobacco smoke

Introduction

Most adult smokers begin to smoke regularly during their teenage years (McKinley, 2003); thus, gaining an understanding of the factors that predict smoking uptake during this period is a key public health priority. A variety of risk factors have been identified and explored, including socio-demographic influences (such as socio-economic status and gender), social learning factors (such as family and peer smoking) and personal factors (such as self-esteem and personality variables). However, few studies have focussed specifically on the influence of second-hand tobacco smoke, and the related predictors of, and influences on, smoking initiation. Those studies that have focused on second-hand tobacco smoke have tended to be cross sectional in nature (Jackson & Henriksen, 1997; Henriksen & Jackson, 1998; Farkas, *et al*., 2000; Wakefield, *et al*., 2000). Studies that have employed a longitudinal methodology were often limited to one follow-up (Huver, *et al*., 2006) or report limited findings (Engels, *et al*., 2005).

A number of interventions have been undertaken in an attempt to tackle the prevention and reduction in the incidence of smoking among adolescents, but it is evident that more research is required to create effective programmes to prevent and reduce smoking uptake among adolescents (Huver, *et al*., 2006; Thomas, *et al*., 2008). Although tobacco control policies in England and Wales have recently increased the legal age to buy cigarettes from sixteen to eighteen, and a complete smoking ban is now in place, it is crucial that the environments where exposure to smoke may influence adolescent smoking uptake are examined (Levy, *et al*., 2004).

Exposure to second-hand tobacco smoke is high among adolescents (Christophi, *et al*., 2008), and the health implications of this have been well documented (Vineis, *et al*., 2007; Carlson and Carlson, 2008). The home and the school environments have been identified as key arenas for exposure to tobacco smoke and the relationship between the influences of familial and peer smoking behaviours on smoking uptake have been established (Vink, *et al*., 2003).

Numerous studies have found support for the strong influence that parental smoking has on children's smoking initiation (Flay, *et al*., 1998; O'Loughlin, *et al*., 1998; Vink, *et al*., 2003) and the uptake of regular smoking (Leatherdale, *et al*., 2005). Household smoking practices have been found to significantly influence whether an adolescent's home environment advocates or inhibits smoking (Leatherdale, *et al*., 2006). Research has found that household smoking bans are significantly associated with reduced adolescent smoking prevalence (Farkas, *et al*., 2000). Furthermore, there is evidence to demonstrate that smoke-free homes may be a more important predictor of adolescent non-smoking than other smoke-free environments adolescents may encounter (Farkas, *et al*., 2000; Wakefield, *et al*., 2000). While smoking rules in

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households are predominantly subject to the smoking status of the parent (Kodl & Mermelstein, 2004), the rules themselves have been shown to influence smoking prevalence in adolescence regardless of their parents' current smoking status (Farkas, *et al*., 2000; Wakefield, *et al*., 2000; Huver, *et al*., 2006).

Research findings suggest the existence of a direct link between the prevalence of cigarette smoking and social disadvantage, with evidence indicating that parents living in areas of social deprivation have a higher probability of becoming a smoker (Milton, *et al*., 2004; Thomas, *et al*., 2008). Explanations for this include the use of smoking as a method of coping with stress, to relieve boredom and frustration (Bancroft, *et al*., 2003). The implications of these findings for the children who live and attend schools in socially deprived areas are likely to include a predisposition to experiment with cigarettes, potentially leading to regular smoking uptake (Lader & Meltzer, 2001).

The impact of smoking within the school environment also needs to be addressed in further depth. Significant associations have been found between peer influences and smoking behaviours (Vink, *et al*., 2003). It is important to consider the impact that perceived peer smoking has upon smoking uptake, and whether children and adolescents who observe smoking behaviours within their school environment subsequently view smoking as a positive entity, and consequently experiment with cigarettes or become smokers themselves (Vink, *et al*., 2003; Leatherdale, *et al*., 2006).

Evidence has shown that well-designed school smoking bans can reduce smoking prevalence (Pentz, *et al*., 1989; Reid, *et al*., 1995); however, this only occurs if restrictions are strongly enforced (Wakefield, *et al*., 2000). Some argue that leniency on school smoking rules may affect adolescents' perceptions, deeming smoking behaviours as more normal (Poulsen, *et al*., 2002).

Longitudinal assessment of the impact of second-hand tobacco smoke on adolescent smoking behaviours is an important step in understanding how smoking behaviours develop across time in order to design effective smoke-free health promotion initiatives. This study aimed to address: whether second-hand tobacco smoking indicators (i.e. home smoking rules, perceived peer smoking and being in other smoky environments) predict (a) adolescents smoking trial, and (b) whether they have smoked in the last week. Prospective analyses were carried out for all years of secondary education (aged twelve to sixteen) and accounted for the moderating influence of socio-deprivation scores (Index of Multiple Deprivation (IMD), 2007).

Method

Study sample

The study sample was drawn from the second phase of the Liverpool Longitudinal Smoking Study (LLSS). The LLSS was established in 1995, and has been funded by the Roy Castle Lung Cancer Foundation throughout. Between 1995 and 2001, the LLSS tracked 253 children within six primary schools across Liverpool. These schools were chosen to reflect the range of socio-economic conditions found in the city (Porcellato, 1998; Milton, 2002). In 2001 the participants moved to more than 30 secondary schools across Merseyside. This second phase of the study was undertaken between 2002 and 2006 when participants were tracked annually from age twelve until they were sixteen years old. Participation rates throughout primary school data collection were high, but attrition rates increased every year of secondary school for varying reasons such as absence from school on the day of the study, pupil exclusions and non-consent. Participant rates ranged from 215 (85%) at age twelve, to 109 (43%) at age sixteen, with the highest attrition rate occurring in the final year of the study.

Measures

The LLSS has employed a wide range of tools throughout the study, to enable the children to express their views through the research. Methods include self-report questionnaires gathering both quantitative (Thinking About Smoking) and qualitative (Describing Smoking Exercise) data that were administered to the whole class, one-to-one interviews, focus groups, parental questionnaires and a Draw and Write Exercise (Williams, Wetton and Moon, 1989). These methods evolved accordingly over time to reflect changes in the cohort's development and experiences, and to incorporate innovative techniques. This paper draws on the findings from the quantitative class questionnaires.

A semi-structured self-report questionnaire was administered with appropriate confidentiality measures in place. The questionnaire was divided into sections labelled 'About you', 'About your family', 'About smoking and you', 'About other people' and 'About your secondary school'. The same questionnaire was distributed in each of the study years. While each year introduced additional methodologies, for the purpose of this study we will focus on the 'core' questions asked every year.

Within the 'About smoking and you' section, the smoking behaviour questions asked were "are you ever offered cigarettes?"; "have you ever tried a cigarette?"; "how many times have you tried a cigarette?"; and "have you smoked a cigarette in the last week?" Socio-demographic questions were asked in the 'About you' section, including gender and postcode. There were categorical response choices for each question and options for further description of their answers. Similarly within the 'About other people' section, participants were asked "are people allowed to smoke in your home?" and "Are you ever in places, other than your home, where people smoke?" A further section labelled 'About your secondary school' included questions about other pupils smoking. All of the questions we are including in our analysis have categorical outcomes.

This article presents statistical analyses of quantitative data at five time points, collected between 2002 (T1), when the cohort was twelve years of age, and 2006 (T5), when the cohort was sixteen years of age. Data were analysed using Chi-Squared tests to test the strength of association and logistic regression analysis to evaluate the extent to which one variable predicts another, using SPSS (Version 11.0). Home and school postcodes were recoded into Index of Multiple Deprivation (IMD) scores. The IMD combines a number of indicators, chosen to cover a range of economic, social and housing issues, into a single deprivation score for each small area in England. This allows each area to be ranked relative to one another according to their level of deprivation. No differences were reported between the 2007 and 2004 IMD scores for the home and school postcodes; therefore the 2007 score was used for all of this analysis.

Results

At the beginning of the second phase of the study, 44% of the cohort was female and 56% was male. Despite the range of primary schools being selected in 1995, by T1 the data suggests that 74% of the cohort is within the highest deprivation quintile according to the Index of Multiple Deprivation (IMD Quintile 5). Findings at this stage showed that 35% of participants' mothers smoked and 36% of participants' fathers smoked, higher than the national statistics for men and women (Action on Smoking and Health, 2008). Furthermore, 57% of the cohort lived in households where people were allowed to smoke in the house and 85% spend time in places other than the home that they consider smoky. For 40% of these participants, the 'other' smoky place was another family member's house; for others smoky places included public transport, pubs and cafes and other public places. The majority of adolescents regularly saw pupils from their school smoking (76%, n=162).

Unsurprisingly, the number of adolescents experimenting with cigarette smoking increased annually. At T1 23% of adolescents had tried smoking and by T5 51% of the cohort had tried. The number of smoking trials each participant had experienced also increased. While 52% of triers had only tried once at T1 and none of the participants smoked weekly or daily, by T5, 34% of triers had tried at least two to five times and 28% of the cohort smoked every day.

Temporal associations with smoking trial

Chi-Square analysis was undertaken to examine the temporal associations between second-hand tobacco smoking factors at T1 and subsequent smoking behaviours at T2, T3, T4 and T5. Table 1.0 shows a significant association between people being allowed to smoke in the home at T1, and having tried smoking at T2-5. Spending time in smoky places at T1 was significantly associated with having tried smoking T2, but at no other ages. Seeing pupils smoking at school at T1 was significantly associated with having tried a cigarette at T2 but at no other age. School deprivation was significantly associated with having tried a cigarette at T3, T4 and T5. Strong associations were found between home deprivation and having tried a cigarette at all ages, with the strongest association at T4. Strong associations were also found between school deprivation and smoking trial, with the strongest association occurring at T5.

Temporal associations with weekly smoking

Table 2.0 shows that significant associations were found between smoking being allowed in the home at T1, and having smoked in the last week at T3 and T4. No significant associations were found between spending time in other smoky places or seeing pupils smoke at school at T1, and having tried smoking in the last week. Home deprivation levels were found to be significantly associated with having smoked in the last week at T5. Strong associations were found to exist between home deprivation and having smoked in the last week across all years; This association was however, only significant at

	Trial T1		Trial T2		Trial T3		Trial T4		Trial T5	
	X^2	V	X^2	V	X^2	V	X^2	V	X^2	V
Are people allowed to smoke in your home	3.59	0.13	5.79*	0.18	8.41**	0.23	8.77**	0.25	8.32**	0.29
Are you ever in places other than home where people smoke	1.12	0.07	13.72***	0.27	2.45	0.12	3.06	0.15	3.54	0.19
Do you see many pupils from your school smoking	2.33	0.11	5.81*	0.18	1.12	0.08	0.76	0.07	3.35	0.18
Home IMD2007 Score	50.7	0.48	45.95	0.47	45.31	0.5	43.17	0.53	28.27	0.51
School IMD 2007 Score	24.77	0.34	28.64	0.37	45.78***	0.51	38.22**	0.5	31.65*	0.54

*p<.05; **p<.01; ***p<.001

Table 1.0 Second-hand tobacco smoking factors temporally associated with smoking trial

Table 2.0 Second-hand tobacco smoking factors temporally associated with having smoked in the last week

T5. School deprivation was found to be significantly associated with having smoked in the last week at T4, and a strong association was found throughout all of the years, with the strongest occurring at T5.

Predicting smoking trial

A logistic regression analysis was carried out to determine which risk factors predicted subsequent experimentation across all ages of the study. A model incorporating IMD scores, and environmental variables including smoking in the home, external smoking environments and school smoking environment as predictors of smoking trial was constructed by entering all the variables in a backwards stepwise procedure.

The focus of the study was on which risk factor predicted subsequent behaviour. Table 3.0 shows estimates of the influence of each risk factor on the probability the adolescent will try smoking at different ages. At the age of thirteen the model highlights household smoking rules and spending time in other smoky places as

	Smoked in last week T1		Smoked in last week T2		Smoked in last week T3		Smoked in last week T4		Smoked in last week T5	
	X^2	V	X^2	V	X^2	V	X^2	V	X^2	V
Are people allowed to smoke in your home	0.19	0.06	0.27	0.06	3.97*	0.22	7.65**	0.32	2.28	0.21
Are you ever in places other than home where people smoke	0.13	0.05	0.94	0.11	0.003	0.006	0.06	0.03	0.03	0.02
Do you see many pupils from your school smoking	1.83	0.18	0.105	0.04	0.08	0.03	0.83	0.11	0.41	0.09
Home IMD2007 Score	9.67	0.42	28	0.56	39.7	0.66	38.95	0.68	37.13**	0.83
School IMD 2007 Score	14.97	0.52	24.56	0.52	25.6	0.53	31.37	0.61	21.84	0.64

*p<.05; **p<.01; ***p<.001

	Trial T2		Trial T3		Trial T4		Trial T5	
	OR	95% CI	OR	95%CI	OR	95% CI	OR	95% CI
Are people allowed to smoke in your home	.437*	(.227-.841)	ns	ns	.411*	(.193-.877)	.949**	(.916-.983)
Are you ever in places other than home where people smoke	.134**	(.030-.606)	ns	ns	ns	ns	ns	ns
Do you see many pupils from your school smoking	ns	ns	ns	ns	ns	ns	.211*	(.059-.757)
IMD2007 Score	ns	ns	ns	ns	ns	ns	ns	ns
IMD 2007 Score	ns	ns	.961***	(.941-.981)	.975*	(.957-.994)	.949**	(.916-.983)

*p<.05; **p<.01; ***p<.001, ns=non-significant

Table 3.0 Adjusted odds ratio (OR), and 98% confidence intervals (CI), of adolescents smoking trial in relation to environmental variables.

significant predictors of smoking trial. The model suggests that adolescents from households where smoking is advocated are 44% more likely to smoke and spending time in smoky places other than the home leaves them at 13% more risk of smoking trial. From age fourteen to sixteen IMD school score is a significant predictor of smoking trial, increasing the risk of trial by around 95%. During later adolescence household smoking rules also predict trial, particularly at age sixteen where rules increase the risk of trial by 95%. Perceived pupil smoking is only a risk factor at age sixteen when seeing other pupils smoking increases the risk of smoking trial by 21%.

Predicting weekly smoking

Table 4.0 shows estimates of each risk factor on the probability that adolescents will have smoked in the last week. None of the factors significantly predicted smoking at ages twelve, fourteen and sixteen. The table highlights two key predictors. IMD deprivation scores increase the risk of having smoked in the last week by 96% at age thirteen. Household smoking rules increase the risk of smoking in the last week at age fifteen by 17%.

	Smoked in last week T2		Smoked in last week T4	
	OR	95% CI	OR	95% CI
Are people allowed to smoke in your home	ns	ns	.177*	(.046-.677)
Are you ever in places other than home where people smoke	ns	ns	ns	ns
Do you see many pupils from your school smoking	ns	ns	ns	ns
Home IMD2007 Score	.962*	(.926-.999)	ns	ns
School IMD 2007 Score	ns	ns	ns	ns

*p<.05; **p<.01; ***p<.001, ns=non-significant

Table 4.0 Adjusted odds ratio (OR), and 98% confidence intervals (CI), of adolescents having smoked in the last week, in relation to environmental variables.

Discussion

Our findings illustrate that trying smoking is strongly influenced by a number of environmental factors, of varying degrees, at all ages of adolescence. Smoking trial at T2 (age thirteen) is most significantly associated with time spent in other smoky places, but also predicted by household smoking rules. From T3 (aged to fourteen) to T5 (age sixteen) household rules and school IMD scores show consistent and significant associations with trial and further predict trial. Findings for weekly smoking highlight home IMD scores and home smoking rules as key associations and having significant predictive value.

Smoking rules within the home are often dependent on the smoking status of the parent (Kodl & Mermelstein, 2004), and numerous studies have found support for the strong influence that parental smoking in general has on children's smoking initiation (Flay, *et al*., 1998; O'Loughlin, *et al*., 1998) and regular smoking (Simons-Morton, *et al*., 2001; Leatherdale, *et al*., 2005). However, research has illustrated that parents can reduce the prevalence of these influences by adopting an anti-smoking stance. Setting smoke-free household rules has shown to be effective in reducing the strength of these associations, even if the parents smoke themselves (Jackson & Henrikson, 1997). Our findings from the LLSS support previous studies that have found a relationship between household smoking rules and adolescent smoking prevalence (Chassin, *et al*., 1998; Farkas, *et al*., 2000). Some studies suggest this relationship is indirect, and that anti-smoking practices are associated with the adolescent cognitions that predict smoking behaviour (i.e. attitude, self-efficacy and expectations) (Huver, *et al*., 2006).

Therefore, growing up in a smoking environment may lead to the development of a normative smoking view. This normative view may subsequently increase the likelihood that an adolescent will try smoking and eventually become a regular smoker. However, our study has found that household rules also clearly act as direct predictors of smoking trial and weekly smoking. A recent review of family based tobacco control interventions concluded that there is a need for well designed and well executed randomised controlled trials in this area (Thomas, *et al*., 2008). Therefore, while existing interventions may focus on changing normative beliefs and attitudes, our evidence certainly suggests the focus should be more directly targeted towards the catalyst of those regular smoking cognitions, household smoking practices.

Perceptions of peer smoking did not consistently predict smoking trial and did not predict weekly smoking. These findings support the results of previous research, which concluded that observing peers smoking does not significantly influence smoking trial or regular smoking (Poulsen, *et al*., 2002). However, our findings did distinguish an important increase in the number of adolescents reporting seeing pupils smoking at school, increasing from 76% at T1, to 99% at T5 (aged sixteen). As group sizes for analysis were small, however, it is likely there was not enough statistical power to render significant findings.

Our study did not account for the influence of teachers as role models, and how their smoking behaviours may have impacted upon the adolescents. Poulsen, *et al*., (2002), found that exposure to teachers smoking outdoors was a significant predictor of adolescent daily smoking. However, the authors of this study report a lenient attitude towards smoking in their sample of Danish schools and this leniency may also have an impact on teacher smoking prevalence. Future studies examining the impact of environmental factors should consider the influence of teachers smoking behaviours, the smoking rules within the school and the extent to which these rules are adhered to. A review of the effectiveness of school-based smoking interventions concluded that many studies had failed to detect any positive intervention effects (Thomas & Perera, 2006). Our findings show that the school has a fundamental influence on smoking trial, but not necessarily on the uptake of regular smoking, suggesting that while school interventions shouldn't be the focus of new adolescent prevention programmes, new approaches within schools are required to address trial, especially in light of the limited success of existing interventions.

The majority of our cohort lived in households classified as within the most deprived IMD quintile and over half of the cohort live in households where smoking rules are not in place. Our findings illustrate the important relationship between deprivation and cigarette smoking, not just in the home, but also in the school, and are in keeping with previous studies (Dorsett & Marsh, 1998; Lader & Meltzer, 2001; Milton, Cook, Dugdill, Porcellato, Springett & Woods, 2004). A recent review of the effectiveness of tobacco control programmes highlighted the significance of the existing relationship between social inequalities and smoking, and concluded that smoking interventions should be specifically directed at disadvantaged areas of society, a stance that our findings support (Thomas, *et al*., 2008).

Our study relied on the self-reported smoking status of the participants. This information would have been enhanced if another test for smoking status was used to validate the self-reported responses. Researchers have successfully used measures of cotinine in saliva samples to verify self-reported smoking status (Montalto & Wells, 2007).

This longitudinal study provides valuable information, which has facilitated a more complex exploration of the environmental factors associated with smoking attitudes and behaviours. Furthermore, the LLSS data has enabled the identification of progressions and key elements of change that has been unattainable in previous studies. Previous evidence has demonstrated that school-based intervention and education programmes are not efficient in the prevention or reduction of smoking in the longer term. Our findings show that the majority of pupils see other people smoking at school, and that over half have tried smoking by the age of sixteen, supporting the notion that existing smoking and health education programmes are not effective. We suggest that smoking trial is influenced by school-related environmental factors, whereas regular smoking is influenced by home smoking practices, and that deprivation plays a fundamental role in this. Given the strongly significant influence that parental smoking has on children's smoking initiation (Vink, *et al*., 2003; Leatherdale, *et al*., 2005), tobacco control initiatives should reflect the need to target socially deprived groups and introduce a focus on smoke-free home interventions, supplemented by school-based initiatives. Public smoking bans may prove successful in reducing adolescent smoking trial, as could the development of new initiatives looking at the school environment, but our findings strongly suggest that smoke-free home initiatives are necessary to reduce the transition to regular smoking.

Conclusions

- Deprivation at both home and school (Index of Multiple Deprivation (IMD), 2007) has a significant association with cigarette smoking among adolescents.
- Smoking trial is influenced by school-related environmental factors.
- Smoking trial at age thirteen is most significantly associated with time spent in smoky places, and also predicted by household smoking rules.
- From age fourteen to sixteen household smoking rules and school deprivation (IMD, 2007) predicted smoking trial.
- Regular smoking is influenced by home smoking practices.
- Home smoking rules and home deprivation (IMD, 2007) are significant predictors of weekly smoking.
- Public smoking bans and school-based initiatives may reduce adolescent smoking trial; however our findings suggest that smoke-free home initiatives are required to reduce the transition to regular smoking.

References

Action on Smoking and Health (2008). Essential information on smoking statistics: who smokes and how much. Available online at *www.ash.org.uk/files/documents/ASH_106.pdf* [accessed 04/02/09].

Bancroft A, Wiltshire S, Parry O & Amos A (2003). "It's like an addiction first thing…afterwards it's like a habit": Daily smoking behaviour among people living in areas of deprivation. *Social Science and Medicine*, 56, pp1261-1267.

Carlson K H & Carlson K C (2008). Respiratory effects of tobacco smoking on infants and young children. *Pediatric Respiratory Reviews*, 9 (1) pp11-20.

Chassin L, Presson C, Todd M, Rose J, & Sherman S (1998). Maternal socialization of adolescent smoking: The intergenerational transmission of parenting and smoking. *Developmental Psychology*, 34, pp1189-1201.

Christophi C A, Kolokotroni O, Alpert H R, Warren C W, Jones N R, Demokritou P, & Connolly G N (2008). Prevalence and social environment of cigarette smoking Cyprus youth. *BMC Public Health*, 2, pp190.

Dorsett R & Marsh A (1998). The Health Trap: Poverty, Smoking and Lone Parenthood, London: Policy Studies Institute.

Engels R C M E, Knibbe R A, Drop M J & de Hann J T (1997). Homogeneity of smoking behaviour in peer groups: Influence or selection? *Health Education and Behaviour*, 24, pp801-811.

Farkas A, Gilpin E, White M & Pierce J (2000). Associations between household and workplace smoking restrictions and adolescent smoking. *Journal of American Medical Association*, 284, pp717-722.

Flay B R, Hu F & Richardson J (1998). Psychosocial predictors of different stages of cigarette smoking among high school students. *Preventive Medicine*, 27, pp9-18.

Henrikson L, & Jackson C (1998). Anti-smoking socialisation: relationship to parent and child smoking status. *Health Communication*, 10, pp87-101.

Huver R M E, Engels R C M E, & de Vries H (2006). Are anti-smoking parenting practices related to adolescent smoking and cognitions and behaviour? *Health Education Research*, 21, pp66-77.

Jackson C, Henriksen L, Dickinson D, Messer L, & Robertson S (1998). A longitudinal study predicting patterns of cigarette smoking in late childhood. *Health Education and Behaviour*, 25, pp685-698.

Kodl M M & Mermelstein R (2004). Beyond modelling: Parenting practices, parental smoking history, and adolescent cigarette smoking. *Addictive Behaviours*, 29, pp17-32.

Lader D & Meltzer H (2001). Smoking Related Behaviour and Attitudes, 2000, London, ONS.

Leatherdale S T, Cameron R, Brown S, Jolin M A & Kroeker C (2006). The influence of friends, family, and older peers on smoking among elementary school students: Low-risk students in high-risk schools. *Preventive Medicine*, 42(3), pp218-222.

Leatherdale S T, McDonald P, Cameron R & Brown S (2005). A multi-level analysis examining the relationship between social influences for smoking and smoking onset. *American Journal of Health Behaviour*, 29, pp520-530.

Levy D T, Chaloupa F, & Gitchell J (2004). The effects of tobacco control policies on smoking rates: A tobacco control scorecard. *Journal of Public Health Management and Practice*, 10, pp338-353.

McKinley A (2003). Providers issue brief: Youth access to tobacco: Year end report. Issue Brief Health Policy Track Serv, 31, pp1-16.

Milton B (2002). A Longitudinal Study of Liverpool Schoolchildren's Experiences of Smoking Aged 9-11. PhD Thesis. Liverpool John Moores University.

Milton B, Cook P A, Dugdill L, Porcellato L, Springett J & Woods S E (2004). Why do children smoke? A longitudinal analysis of predictors of smoking uptake during preadolescence. *Public Health*, 118, pp247-255.

Montalto N J, & Wells W O (2007). Validation of self-reported smoking status using saliva cotinine: A rapid semiquantitative dipstick method. *Cancer Epidemiology Biomarkers and Prevention*, 16, pp1858-1862.

O'Loughlin J, Paradis G, Renaud L & Sanchez-Gomez L (1998). One-year predictors of smoking initiation and of continued smoking among elementary schoolchildren in multiethnic, low-income, inner-city neighbourhoods. *Tobacco Control*, 7, pp268-275.

Pentz M A, Brannon B R, Ventura L, Barrett E J, MacKinnon D P, & Flay B R (1989). The power of policy: the relationship of smoking policy to adolescent smoking. *American Journal of Public Health*, 79, pp857-862.

Porcellato L (1998). Perspectives on Smoking of Liverpool Primary School Children in their Early Years. PhD Thesis. Liverpool John Moores University.

Poulsen L H, Osler M, Roberts C, Due P, Damsgaard M T & Holstein B E (2002). Exposure to teachers smoking and adolescent smoking behaviour: analysis of cross sectional data from Denmark. *Tobacco Control*, 11, pp246-251.

Reid D J, McNeill A D, Glynn T J (1995). Reducing the prevalence of smoking in youth in western countries: an international review. *Tobacco Control*, 4, pp266-277.

Simons-Morton B, Haynie D L, Crump A D, Eitel P & Saylor K E (2001). Peer and parent influences on smoking and drinking among early adolescents. *Health Education and Behaviour*, 28(1), pp95-107.

Thomas R, Baker P & Lorenzetti D (2008). Family based programmes for preventing smoking by children and adolescents. Cochrane Database of Systematic Reviews, 2, pp1-48.

Thomas S, Fayter D, Misso K, Olgivie D, Petticrew M, Sowden A, Whitehead M & Worthy G (2008). Population tobacco control interventions and their effects on social inequalities in smoking: systematic review, Tobacco Control Online. Available online at: *http://tobaccocontrol.bmj.com/cgi/content/abstract/tc.2007.023911v1* [accessed 04/02/09].

Thomas R & Perera R (2006). School based programmes for preventing smoking, Cochrane Database of Systematic Reviews, 3, pp1-166.

Vineis P, Hoek G, & Krzyzanowski M, *et al***,** (2007). Lung cancers attributable to environmental tobacco smoke and air pollution in non-smokers in different European countries: a prospective study. *Environmental Health*, 6, pp1-7.

Vink J M, Willemsen G and Boomsma D I (2003). The association of current smoking behavior with the smoking behavior of parents, siblings, friends and spouses. *Addiction*, 98, 923-931.

Wakefield M A, Chaloupka F K, Kaufman N J, Orleans, C T, Barker, D C & Ruel E E (2000). Effect of restrictions on smoking at home, at school, and in public place on teenage smoking: cross sectional study. *British Medical Journal*, 321, pp333-337.

Williams D T, Wetton N and Moon A (1989), A Way In: Five Key Areas of Health Education, Health Education Authority, London.

Industrial emissions and health hazards among selected factory workers at Eleme, Nigeria

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Abstract

The objective of this study was to measure the levels of selected atmospheric contaminants and assess their possible association with the prevalence of several self-reported respiratory and dermal symptoms among workers in the refinery and petrochemical complexes at Eleme.

PM_{10}, lead (Pb) and polycyclic aromatic hydrocarbons (PAH) were determined in the atmosphere at Port Harcourt Refining Company (PHRC) and Eleme Petrochemical Complex Ltd (EPCL) and the pollution levels were related with the health hazards to the workers. The study was preliminary, descriptive and laboratory based. A high volume sampler with PM10 inlet was used to collect six air samples from three locations in each industry. Questionnaires were administered to 400 randomly selected subjects from the industries. Five year hospital data were obtained. The data were analysed for logistic regression using SPSS software.

At PHRC, the highest PM_{10} level of $130.3 \pm 3.32 \mu g/m^3$ was recorded at a location within the environment department. The highest Pb level (0.20 ± 0.03 mg/m^3) was recorded at the safety unit and the highest concentration of benzo (a) pyrene ($1.63 \times 10^2 ng/m^3$) was recorded at the maintenance section. At EPCL, the highest Pb level (0.16 ± 0.09 mg/m^3) was recorded at the polypropylene plant while the highest concentration of benzo (a) pyrene (1.61×10^2 ng/m^3) was recorded at the production unit. All the PAH levels observed in these locations were higher than the WHO limit of $1.0 \times 10^2 ng/m^3$. Exposure to dust and smoke was found to be significantly associated with respiratory symptoms among 65 (65.7%) of PHRC and 52 (57.1%) of EPCL workers ($P<0.05$). Also eye and skin conditions were reported. Exposure to industrial emissions containing mixtures of compounds could present potent risk factors for the onset of dermal and respiratory disorders among the workers.

Key words: Air pollutants; Environmental Health; Health hazards; Industrial workers; Nigeria; PM_{10}; Workplaces.

Introduction

Each year, industrial facilities discharge into the environment large amounts of chemicals leading to respiratory, neurological, developmental and reproductive disorders, and cancers. Yet, communities living within and around such industrial facilities, especially in developing countries, seldom know the extent to which these discharges may be affecting their health.

Industries such as petroleum refineries are a major source of hazardous and toxic air pollutants including benzene, toluene, ethylbenzene, and xylene (BTEX compounds), particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO), hydrogen sulphide (H_2S), and sulphur dioxide (SO_2). Refineries also release less toxic hydrocarbons such as natural gas (methane) and other light volatile fuels and oils. Some of the chemicals released are known or suspected cancer-causing agents, responsible for developmental and reproductive problems. They may also aggravate certain respiratory conditions such as childhood asthma and can result in worry and fear among residents of surrounding communities (US DOE, 1998).

Air emissions can come from a number of sources within a petroleum refinery including: equipment leaks (from valves or other devices); high-temperature combustion processes in the actual burning of fuels for electricity generation; the heating of steam and process fluids; and the transfer of products. Many thousands of kilograms of these pollutants are typically emitted into the environment over the course of a year through normal emissions, fugitive releases, accidental releases, or plant upsets. The combination of volatile hydrocarbons and oxides of nitrogen also contribute to ozone formation, one of the most important air pollution problems globally (US DOE, 1998).

In the Republic of China, nine serious air pollution events occurred in petrochemical municipalities between 1971 and 1990, making scientists consider the petrochemical industry as the main source of industrial air pollution (EPA, China, 1992). The pollutants released by the petrochemical industries include vinyl chloride monomer and polycyclic aromatic hydrocarbons (PAHs), both of which have been recognised as environmental carcinogens (Vainio and Wilbourn, 1992). Subsequent to these events, public concern has been elevated regarding possible increased cancer risks for residents in petrochemical municipalities.

Studies carried out by Abbey *et al.,* (1993) on long-term ambient concentrations of Total Suspended Particulates (TSP), ozone, sulphur dioxide and respiratory symptoms in a non-smoking population indicated that there were statistically significant relationships between ambient concentrations of TSP and ozone, but not sulphur dioxide, with several respiratory outcomes. In a related study, TSP was significantly associated with increased daily mortality in Poisson regression analyses controlled for season and temperature and that an increase in particulates of 100ug/m^3 was associated with a 4% increase in mortality (Schwartz and Dockery, 1995). Exposure to particulate matter (PM) was strongly associated with morbidity (Dockery *et al*., 1982) while acute exposure to airborne particles was associated with increased mortality (Schwartz and Marcus, 1990). Exposure to different heavy metals is associated with different health outcomes. For instance, some of the most important health effects associated with low-level lead exposure are the complex of neurological deficits particularly in children, modest elevations in blood pressure in adults, and developmental problems (Schwartz and Dockery, 1992). High blood lead (PbB) concentrations cause frank brain damage and slowing of nerve conduction (Seppalainen *et al*., 1983). Intelligence quotience (IQ) deficits in children have been associated with PbB levels as low as 10-15ug/l (US EPA, 1986). Elevated PbB levels are also associated with developmental abnormalities including foetal neurological damage (Bornshein *et al*., 1985), reduced birth weight (Bornshein *et al*., 1989), reduced stature (Schwartz *et al*., 1986) and reduced attainment of developmental milestones (Schwartz and Otto, 1987).

In Nigeria, the petroleum refinery and petrochemical industries are expected to expand in the coming years with the potential for environmental pollution to increase with corresponding effects on the health of the communities within, and those residing near the industrial plants. The objective of this study was to measure the levels of selected atmospheric contaminants including lead and PAHs and assess their possible association with the prevalence of several self-reported respiratory and dermal symptoms among workers in the refinery and petrochemical complexes at Eleme.

Methodology

Description of study area

Eleme Local Government Area, the most industrialised in the Niger Delta, is where the refinery and petrochemical industries are found and is located about 20km away from Port Harcourt city, Rivers State, in Southern Nigeria.

The Port Harcourt Refining Company (PHRC) has a refining capacity of 210,000 barrels per day. It is located on a parcel of land jointly owned by Eleme/Okrika Local Government Areas of Rivers State. The refinery uses crude oil transferred through a 55km pipeline from Bonny terminal. The major products obtained from the crude distillation and catalytic processes are liquefied petroleum gas (LPG) as cooking gas, dual-purpose kerosene (DPK) for aviation/household uses, premium motor spirit (PMS), petrol and automotive gas oil (AGO) and diesel and fuel oil.

The refinery has staff of about 2,000 who facilitate diverse industrial processes located in various units of the plant complex. These units include crude distillation (CD) unit; catalytic reforming (CR) unit; fluid catalytic cracking (FCC) unit (this unit was not operational during the period of investigation); hydrofluoric alkylation (HA) unit and complete refining plant. The various processes mentioned produce wastes, which include particulates from combustion of fossil fuels in heaters, flares and incinerators; hydrocarbon vapour from oil spills, evaporation from tank hatches etc, gaseous products of various combination from fossil fuels and from crude oil refining process such as volatile hydrocarbons, H_2S, NOx, SOx, phenol and its derivatives.

The petrochemical complex is located on a parcel of land jointly owned by Akpajo/Agbanjia/Aleto communities in Eleme Local Government Area. It occupies an area of about 900 hectares and is approximately 15km from Port Harcourt City. The plant complex is made up of units such as olefin, polypropylene, polyethylene and butene-1 plants, as well as the utilities and offsite facilities. Others include the retention pond, administrative building, auditorium, operations and technology building, laboratory, maintenance workshops, spare parts warehouse, chemicals/catalysts warehouse, laundry, industrial clinic, communication facilities, fuel depot, fire station, and pipelines to and from Port Harcourt refining company.

The major feedstock for the complex is natural gas liquids (NGL), supplied by pipeline from the Nigeria National Petroleum Corporation (NNPC)/AGIP/PHILIPS joint venture NGL extraction plant located at Obiafu/Obrikom about 80km from the complex. The NGL provides 100% and 45% of the ethylene and propylene requirements, respectively. The fuel requirements of the complex for power generation and heating are carried by a separate pipeline from the Obiafu/Obrikom NGL plant. The olefin plant cracks the NGL to produce ethylene (300,000 tons/annum) and propylene (126,000 tons/annum) while the polypropylene plant (with a capacity of 80,000 tons/annum) produces 40 different grades of polypropylene resins. The polyethylene plant on the other hand, with a capacity of 270,000 tons/annum, produces 140 different grades of polythene

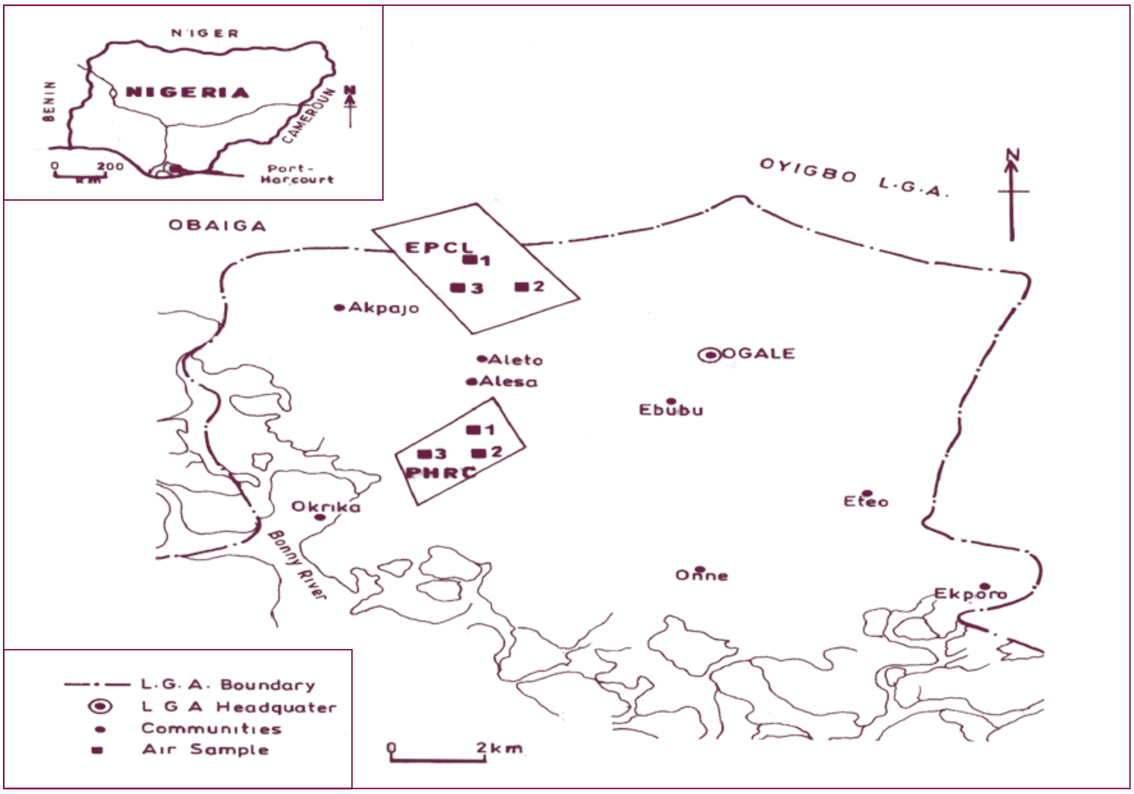


Figure 1.0
Location map showing sampling points at EPCL and PHRC

resins (both linear low and high density types). The butene–1 plant, with a capacity of 22,000 tons/annum, produces the butene–1 co-monomer.

The products of the utilities and off site facilities include 250 metric tonnes per hour of steam generation, 130 megawatts of electric power generation, 2,000 cubic metres per hour raw water treatment, 34,500 cubic meters per hour of cooling water circulation system, plant and instrument air system, 4,400 normal cubic meters per hour nitrogen plant, storage tanks, effluent treatment facilities, flare system and solid waste incinerator.

The complex has a total staff establishment of more than 2,000 workers.

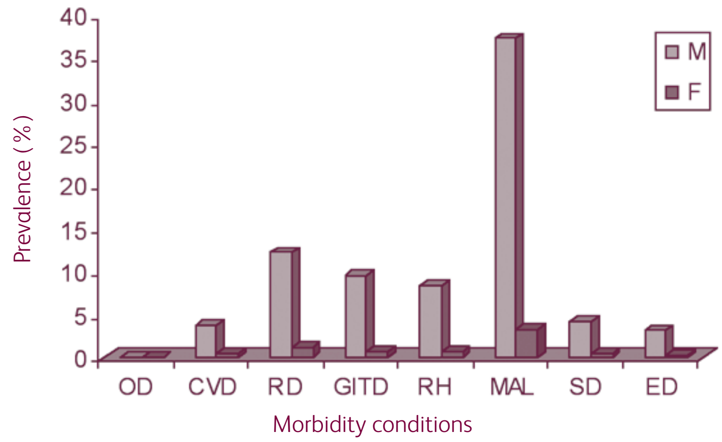
Air sampling

A total of six particulate air samples were collected purposively and cross sectionally for four hours from three locations (see Figure 1.0), each from the refinery and petrochemical complexes using an Anderson Model High volume sampler with PM10 inlet. At the refinery, samples were collected near the air stack of the old and smaller refinery from a location designated as area 5 close to the environment department (PHRC 1), a location near the air stack of the new and larger refinery designated as area 3 close to the safety unit (PHRC 2) and a location close to the wastewater treatment plant by maintenance department (PHRC 3). At the petrochemical complex, samples were collected from a location by effluent treatment point (EPCL 1), a location close to the off-site area (EPCL 2) and a location within the polypropylene plant (EPCL 3). At the time of sampling within the PHRC complex, one of the major air polluters in the facility, the FCC unit, was down. The emissions from this unit would probably have added to the particulate load in the ambient air.

Determination of TSP in ambient air

From the samples of air collected, the concentration of total suspended particles (TSP) was determined gravimetrically after proper equilibration and

Figure 2.0
Prevalence of dominantly occurring morbidity conditions at PHRC



Cuts/Fractures (CF), Occupational Dermatitis (OD), Cardiovascular Diseases (CD), Respiratory Disorders (RD), Gastro Intestinal Tract, Disorders (GITD), Rheumatism (RH), Malaria (MAL), Skin Disorder(SD), Eye Disorder(ED)

conditioning of the 20.3 x 25.4cm (8x10in) glass-fibre filter paper cat No: 1882 866 EPM 2000. Prior to the commencement of the analysis, the equipment was calibrated and standardised.

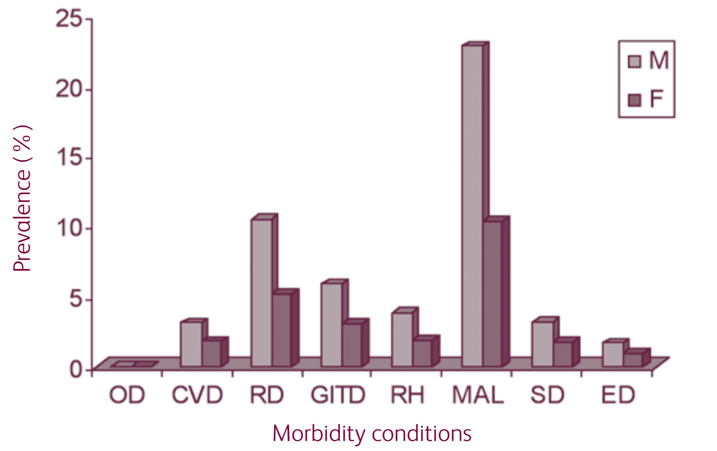
Determination of heavy metals in ambient air

The concentration of heavy metals in the air was determined using standard methods (Dorn *et al*., 1975) but with modifications to suit laboratory conditions at R&D, Nigeria National Petroleum Corporation (NNPC). A proportion of the exposed filter paper was split into tiny fragments to increase its surface area after which a twenty cubic centimetre mixture of concentrated hydrochloric acid and nitric acid (in a ratio 3:1) was added for digestion to take place. The digest was recovered and made up to 100ml. The concentration of heavy metals such as Ni, Cd, and Pb was determined using an atomic absorption spectrophotometer (AAS) model 929 made in Cambridge, London. The equipment was calibrated and equilibrated accordingly using one to five standards. Appropriate hollow cathode lamps (HCL), specific for the different metals, were used and nitrous oxide/acetylene flame (3,000°C) was utilised. The concentration of heavy metals in air is expressed in mg/m^3.

Determination of PAHs in ambient air

This involved extraction using methanol, purification/ solvent exchange and concentration stages. After sampling, the particle-impregnated filter paper was properly stored under dark and cool temperature conditions prior to further processing. Before solvent extraction, the filter paper was reduced to tiny fractions to increase it surface area. This product was introduced as chips into a thimble for extraction using Soxhlet extractor based on a modified standard method (Lee *et al*., 1979). According to this method, 150ml of methanol was used for the extraction process, which lasted 1 hour. This was repeated and the combined extract recovered for the purification and concentration stages. The extract was purified, and concentrated and analysed using HPLC.

The HPLC used is made up of an auto sampler of model Waters 717, a pump of model Waters 610 for both the fluid unit and valve station and Waters 6.00E for the pump system controller; a photodiode detector of model Waters IM 996, a fluorescence detector of model Waters 470, all made by Millipore. The software Millennium 32 was used and the method of operation was of the isocratic/gradient type with a combination of acetonitrile and deionised filtered water as the mobile phase and a stationary phase made up of silica gel loaded in 5µm HPLC column, SUPELCOSILTM LC-PAH col: 12435-007 of dimensions 15cm x 4.6mm. The samples were run against a previously calibrated set of standards particularly for benzo (a) pyrene and indeno(1,2,3-cd)pyrene. The concentration of the PAH components is expressed in ng/m^3.



Cuts/Fractures (CF), Occupational Dermatitis (OD), Cardiovascular Diseases (CD), Respiratory Disorders (RD), Gastro Intestinal Tract, Disorders (GITD), Rheumatism (RH), Malaria (MAL), Skin Disorder(SD), Eye Disorder(ED)

Figure 3.0 Prevalence of dominantly occurring morbidity conditions at EPCL

Health survey

Information regarding the health of the plant workers was collected through a questionnaire survey and from health records. A 75-item semi-structured, validated and pre-tested questionnaire divided into five sections including occupational history, perceived environmental characteristics and health conditions were self administered to 200 plant workers each at EPCL and PHRC respectively.

Data from clinics within the industrial premises were collected from prepared records forms for morbidity and mortality cases within the period 1995-1999. Information concerning common morbidity cases including respiratory, skin, eye, and GIT disorders, rheumatism, poisoning and cancer were documented. Records comprising both male and female subjects aged at least 30 years were obtained from these facilities.

Data analysis

Data obtained from laboratory analysis were processed statistically using mean and standard deviation, range as well as Mann-Whitney test for quantitative variables. Data from the questionnaire and hospital records were analysed using descriptive statistics, Chi Square test and logistic regression.

Results

Ambient PM_{10} levels within PHRC and EPCL plants at Eleme

At the refinery, the highest PM_{10} level (130.3 ± 3.32µg/m^3) was recorded at PHRC1 (Area 5 close to the environmental department). The other locations viz PHRC 2 (Area 3, close to the safety unit) and PHRC3 (close to the maintenance department) recorded 36.5 ± 1.27µg/m^3 and 27.9 ± 2.33µg/m^3, respectively. At the petrochemical complex the highest PM_{10} level (81.3 ± 4.31µg/m^3) was recorded at EPCL1 (close to effluent treatment plant) while locations EPCL2 (offsite area) and EPCL3 (within the polypropylene plant) recorded 50.3 ± 3.32 µg/m^3 and 28.9 ± 2.05 µg/m^3 respectively. The average PM_{10} levels at PHRC were higher than that recorded at EPCL.

Lead and other heavy metals in air within PHRC and EPCL plants at Eleme

The results indicated that the highest Pb level of 0.20± 0.03 mg/m^3 was recorded at the PHRC2, while the highest Ni level (0.86± 0.34 mg/m^3) was recorded at PHRC3 (see Table 1.0). At the petrochemical complex, the highest Pb level (0.16± 0.09 mg/m^3) was recorded at EPCL3 while the highest Ni level (0.05±0.02 mg/m^3) was recorded at EPCL1 (Table 2.0). Overall, the average heavy metal concentrations were higher at PHRC.

Table 1.0
Levels of atmospheric emissions at PHRC Eleme

Parameter	PHRC1 (Mean ± SD)	PHRC2 (Mean ± SD)	PHRC3 (Mean ± SD)	Average/ Location	Guideline Limits
PM_{10} (μg/m³)	130 ± 3.32	36.5 ± 1.27	27.9 ± 2.33	64.8	100(FMENV)
Pb (mg/m³)	0.16 ± 0.12	0.20 ± 0.03	0.11 ± 0.10	0.16	–
Cd (mg/m³)	0.008 ± 0.002	0.003 ± 0.001	0.009 ± 0.006	0.007	–
Ni (mg/m³)	0.004 ± 0.002	0.009 ± 0.004	0.86 ± 0.34	0.291	–
Benzo (a) pyrene ng/m³	–	–	1.63×10^{2}	54.3	<0.1–100ng/m³ (WHO, 1997)
Indeno (1,2,3–cd) pyrene ng/m³	1.53×10^{-3}	2.53×10^{-3}	–	0.0014	<0.1–100ng/m³ (WHO, 1997)
^{T}PAH*(ng/m³)	1.53×10^{-3}	2.53×10^{-3}	1.63×10^{2}	54.3	<0.1–100ng/m³ (WHO, 1997)

* Total PAH {sum of benzo(a)pyrene + indeno(123-cd)pyrene}

Ambient PAH concentrations within PHRC and EPCL plants at Eleme

The highest concentration of benzo (a) pyrene (1.63×10^{2}ng/m³) was recorded at PHRC 3 (Table 2.0) while the highest concentration of benzo (a) pyrene (1.61×10^{2} ng/m³) was recorded at EPCL 3, which is in the production unit of the industrial complex. However, the total PAH concentration taken as the sum of benzo(a)pyrene and indeno(123)-cd pyrene was found to be higher at EPCL when compared with PHRC.

Reported health conditions at PHRC and EPCL based on survey findings

Based on the questionnaire findings 70.8% workers at PHRC as compared to 67.2% at EPCL reported poor air quality conditions. In both cases, the major cause was attributed to gas flaring. In both locations, symptoms associated with exposure to fumes and sprays such as respiratory disorder were widely reported among 40.8% respondents at PHRC and 27.6% at EPCL. There were reports of respiratory symptoms associated with exposure to dust and smoke, which causes irritation among 65.7% PHRC and 57.1% EPCL workers. Both the eyes and the skin were among other parts of the body also affected by the irritation. Cancer incidences were generally low with cases reported among 10.5% PHRC and 5.3% EPCL family members.

The results of the Chi Square analyses indicate that the duration of stay of PHRC workers in their residential communities was significantly associated with respiratory health problem (p=0.000), with cancers (p=0.000). Exposure to hazards within the industrial facility was significantly associated with painful body outgrowth (p=0.000) with miscarriages (p=0.000) and with cancer (p= 0.03). The result of the logistic regression indicated that at PHRC, smoking habits were significantly associated with painful body outgrowth (p=0.054, β= 0.402, OR = 1.49).

At EPCL, the duration of residence in the community was significantly associated with miscarriages (p=0.000), with deformed children (p=0.000), with symptoms related to health effects from air contaminants (p= 0.000) and with cancers (p = 0.000). Also, inadequate use of safety apparels was significantly associated with respiratory problems (p =0.03). Exposure to industrial hazards was significantly associated with respiratory problems (p= 0.03) and with painful body outgrowth (p = 0.000). The logistic regression analysis indicated that consumption of common aquatic food was found to have significant relationship with parts of the body affected by cancer (p= 0.026, β= 0.522, OR = 1.69).

Although the questionnaire outcome did not indicate which sex was more vulnerable to the health effects, this was strongly elucidated by the outcome of the hospital records. The latter did not only show a higher reporting

Table 2.0 Levels of atmospheric emissions at EPCL Eleme

Parameter	EPCL 1 (Mean ± SD)	EPCL 2 (Mean ± SD)	EPCL 3 (Mean ± SD)	Average/ Location	Guideline Limits
PM_{10} (µg/m^3)	81.3 ± 4.31	50.3 ± 3.32	28.9 ± 2.05	53.5	100(FMENV)
Pb (mg/m^3)	0.11 ± 0.08	0.14 ± 0.04	0.16 ± 0.09	0.14	-
Cd (mg/m^3)	0.008 ± 0.004	0.007 ± 0.005	0.002 ± 0.003	0.006	-
Ni (mg/m^3)	0.05 ± 0.02	0.02 ± 0.01`	0.02 ± 0.01	0.03	-
Benzo (a) pyrene ng/m^3	1.41 x 10^1	–	1.61 x 10^2	58.4	<0.1–100ng/m^3 (WHO, 1997)
Indeno (1,2,3–cd) pyrene ng/m^3	–	1.10 x 10^1	–	3.67	<0.1–100ng/m^3 (WHO, 1997)
^{T}PAH*(ng/m^3)	1.41 x 10^1	1.10 x 10^1	1.61 x 10^2	62.03	<0.1–100ng/m^3 (WHO, 1997)

* Total PAH {sum of benzo(a)pyrene + indeno(123-cd)pyrene}

rate of morbidity for males in both factories but an increased prevalence in most of the reported ailments including respiratory and skin disorders.

Morbidity conditions at PHRC and EPCL based on clinic records

A total of 80,958 cases were studied at PHRC industrial location during the period 1995-1999 of which 73,877(91.3%) were males and 7081(8.75%) females. The distribution of morbidity conditions at PHRC indicates that cuts/scalds, respiratory conditions and other industrial accidents were among the most prevalent occupationally related health effects. Apart from malaria, which recorded the highest proportion, morbidities with fairly high proportions among males (M) and females (F) were respiratory disorders M: 123/1000 and F: 10.9/1000; GIT disorder M: 96.5/1000 and F: 7.6/1000; rheumatism M: 84.3/1000 and F: 6.50/1000; cardiovascular disorder M: 38.2/1000 and F: 4.10/1000 and skin conditions M: 42.1/1000 and F: 4.50/1000. In all these cases, the highest proportion was recorded among the males, who constituted the major work force in the industry. The records from PHRC indicated that there were more mortality cases among the male workers. The most reported causes of death were attributed to Road traffic accidents (RTA) and carcinoma.

At the petrochemical industrial complex, a total of 48,896 cases were studied during the period 1995-1999 of which 32,241 (65.9%) were males and 16,655 (34.1%) females. A distribution of the morbidity pattern indicated, as at PHRC, malaria recorded the highest proportion. Other reported health conditions such as cuts/fractures, occupational dermatitis and respiratory conditions also recorded high proportions. High proportions were recorded for morbidities such as GIT conditions M: 59.1/1000 and F: 30.8/1000; respiratory disorder M: 105/1000 and F: 30.4/1000; rheumatism M: 38.1/1000 and F: 18.6/1000 and skin infections M: 31.7/1000 and F: 17.4/1000. The mortality rate was higher among the male workers than the females both at EPCL and PHRC. The most reported causes of death were attributed to cardiac disorders, hepatitis and other factors whose etiologies were not established.

Discussion

The outcome of this investigation is preliminary in nature. The results of the air quality assessment showed that average PM_{10} levels within the PHRC were higher than the values recorded at EPCL but lower than the guideline limits stipulated by the Federal Environmental Protection Agency (FEPA, 1991), which is the national guideline. Although guideline values for heavy metals in air in Nigeria were not readily available, all the heavy metals determined including lead were relatively low. The low level of these substances notwithstanding may have health implications depending on the duration of exposure.

Of all the 16 PAH components measured, only two: benzo (a) pyrene and indeno (1,2,3-cd pyrene) were eluted and found to occur in the air within the PHRC and EPCL industrial premises. The benzo(a)pyrene concentrations at PHRC3 and EPCL3 were both higher than the WHO guideline limit. Incidentally, the average total PAH levels recorded at EPCL were higher than the values obtained at PHRC even though more PM_{10} concentration was observed for the latter. This may have been associated with the breakdown of the highly polluting FCC unit in PHRC which was not operating during the study. However, both average total PAH levels recorded at PHRC and EPCL were lower than the WHO guideline limits of 0.1-100 ng/m^3 (WHO, 1997)

Studies carried out by Ana *et al.,* (In Press) revealed that TSP and PAH levels observed in the communities that surround these industrial complexes were higher than the values reported in this particular study and most of these values were higher than the stipulated guideline limits. This suggests that the burden of these toxicants is higher in the residential community areas than within the industrial premises.

The outcome of the survey had indicated that some of the staff in these industries occupy quarters located within these adjoining communities to PHRC and EPCL. It is therefore logical to find adverse health outcomes reported among the plant workers, even though their prevalence would be expectedly lower than the general population (Michael *et al*., 1974)

This was corroborated by the outcome of the clinic data, which indicated respiratory morbidity as the most prevalent ailment (after malaria) among both PHRC and EPCL workers. This revelation is further supported by a report from other studies (Abbey *et al*., 1993). The low level of smoking in the two populations also reduces the confounding factors. This perhaps also explains the reportedly high prevalence of respiratory morbidity and skin disorders among the plant workers from clinic data.

Overall, the trend in health outcomes indicates that male workers in PHRC and EPCL recorded the highest prevalence for all categories of morbidity cases documented throughout the five-year study period. This phenomenon could be explained by the fact that both industries have more male than female workers, and that the male workforce are involved in more risky and hazardous job specifications in the plants than their female counterparts. Similar studies by Ana *et al.,* (2005) also support this assertion.

Conclusions

The burden of atmospheric emissions for PM_{10}, heavy metals and PAH indicated that their average concentrations per the industrial locations were within permissible limits stipulated by regulatory bodies like FMEnv and WHO.

Chronic exposure to life time and low doses of atmospheric pollutants coupled with inadequate utilisation of personal protective equipments (PPE) may aggravate diverse deleterious health outcomes particularly pulmonary and dermal disorders as reported in this study.

In view of the outcome of this study it would be imperative to:

- Carry out a comprehensive environmental audit (EA) of the PHRC and EPCL facilities;
- Ensure that the EA involves an in-depth assessment of all other forms of atmospheric toxicants and a human exposure assessment employing appropriate checklists and biomarkers;
- Establish causality between the exposure factors and the identified health outcomes so as to reveal some of the unknown etiologies;
- Intensify regular environmental and health education and awareness programmes among the plant workers to enlighten them on the dangers inherent in exposure to hazards and their health consequences;
- Direct environmental education messages mostly at the male workers, the most vulnerable group in the industry.

Acknowlegements

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References

Abbey D E, Peterson F, Mills P K, Benson W (1993). Long-term ambient concentrations of total suspended particulates, ozone and sulphur dioxide and respiratory symptoms in a non-smoking population. *Archives of Environmental Health*. 48(1):33-46.

Ana G R E E, Sridhar M K C and Olawuyi J F (2005). Air pollution in a chemical fertiliser industry in Nigeria: Impact on health of plant workers. *Journal of Environmental Health Research*; 4(2): 57-62.

Ana G R E E, Sridhar M K C and Bamgboye E A (In Press). Environmental risk factors and health outcomes in selected communities of the Niger Delta area, Nigeria. *Journal of the Royal Society for the Promotion of Health*.

Bornshein R L, Hammond P B, Dietrich K N, Succop N, Krafft K, Clark S, Begger O, Pearson D,and Que Hee, S (1985). The Cincinnati prospective study of low-level lead exposure andits effects on child development; protocol and status report. Environ. Res.38:4-18.

Bornshein R L, Grote J, Mitchell T, Succop P A, Dietrich K N, Krafft K M and Hammond P B (1989). Effects of prenatal lead exposure on infant size at birth. In: Lead Exposure and Child Development – An International Perspective (M A Smith, L D Grant, and A I Sors, Eds.), Kluwer Academic Press, Bost.pp307-319.

Dockery D W, Ware J H, Ferris B G, Speizer F E, Cook N R and Herman S M (1982). Change in pulmonary function in children associated with air pollution episodes. *J. Air Pollut.Control Assoc.* 32:937-942.

Dorn C R, Pierce J O, Chase G R and Philips P E (1975). Environmental contamination by lead, cadmium, zinc and copper in a new lead-producing area. *Environmental Research*. 9:159-172.

Environmental Protection Administration, Republic of China (1992). Annual Report of Air Pollution in Taiwan, 1983-1990. Taipei, ROC.

Federal Environmental Protection Agency (FEPA, 1991). National Interim Guideline and Standards for Industrial Effluents. *Gaseous Emissions and Hazardous wastes*; pp33-63.

Lee M L, Novotny M & Bartle K D (1979). Gas chromatography/mass spectrometric and nuclear magnetic resonance determination of polynuclear aromatic hydrocarbons in airborne particulates. *Anal Chem.* 48:1566-1572.

Michael M C, Spirtas A J and Kupper I L (1974). An epidemiologic study of mortality within a cohort of rubber workers (1964-72). *J. Occup. Med***.** 16:458.

Schwartz J, Angle C and Pitcher H (1986). Relationship between childhood blood lead levels and stature. *Pediatrics.* 77:281-288.

Schwartz J and Dockery D W (1992). Increased mortality in Philadelphia associated with daily air pollution concentrations. *Am. Rev. Respir.*145:600-604.

Schwartz J and Marcus A (1990) Mortality and air pollution in London: a time series analysis. *American Journal of Epidemiology* 131:185-194.

Schwartz J and Otto D (1987). Blood lead, hearing thresholds and neuro-behavioural development in children and youth. *Arch. Environ. Health.* 42:153-160.

Schwartz T S and Dockery D W (1995). Particulate air pollution and daily mortality in Steubenville, Ohio. *American Journal of Epidemiology*.141(7):87.

Seppalainen A M, Hernberg S, Vesanto R, and Kock B (1983). Early Neurotoxic effects of occupational lead exposure: a prospective study. *Neurotoxicology*.4:181-192.

US Department of Energy (DOE) (1998). Energy and environmental profile of the US petroleum refining industry. Office of Industrial Technologies.

US Environmental Protection Agency (1986). Air quality criteria for particulate matter, lead and sulphur oxides. EPA-600/8-82-029aF-cF, EPA-600/8-83/028aF, Environmental Criteria and Assessment Office, Research Triangle Park, NC.

Vainio H, Wilbourn J (1992). Identification of carcinogens within the IARC monograph program. *Scand J Work Environ Health*.18 (suppl 1):64-73.

WHO (1997) Non-heterocyclic Polycyclic Aromatic hydrocarbons. Geneva, World Health Organization, International programme on chemical safety. *Environmental Health Criteria*, 202.

Petroleum hydrocarbons, JP-8 spillage, environmental contamination, community exposure and multi-agency response

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Abstract

Petroleum hydrocarbons are an integral part of modern developed society, as evidenced by the global petrochemical industry. The various petroleum fractions provide essential resources for energy, transportation, agricultural feed stock and the synthesis of plastics.

Accidental release of petroleum hydrocarbons is not uncommon. When such accidents do occur, widespread environmental contamination is likely and owing to the toxicological properties of petroleum hydrocarbons significant detrimental impacts on public health may arise.

In the incident reported here, a spillage of chemically complex aviation fuel – jet propulsion 8 (JP-8) – occurred in rural Pembrokeshire, Wales, UK. The spill resulted in widespread contamination of the environment including groundwater, a surface stream and the sewage system, and the pooling of petroleum hydrocarbons on lawns was observed. Several residents complained of symptoms consistent with exposure to petroleum hydrocarbons.

The response to the incident involved a co-ordinated, multi-disciplinary/multi-agency response. The Welsh Assembly Government convened a Health Advisory Group, consisting of all major allied organisations and agencies in Wales to provide holistic and integrated advice on the management of the incident. Thus, as part of a multi-disciplinary, multi-agency approach to chemical incidents in Wales, the local public health strategy was enhanced by access to authoritative advice on clinical, toxicological, risk assessment, chemical and environmental issues.

A suite of public health measures was instigated. Environmental monitoring detected raised levels of kerosene vapours in several houses. Clinical examination demonstrated that the reported symptoms were transient. Monitoring of the public water supply led to a temporary potable supply being provided for one household. The risk was communicated to the public by means of posters and letters, supplemented by direct community meetings. Advice was provided on possible food contamination, especially home grown vegetables, and residents in the worst affected houses were advised to ventilate their properties and were offered temporary accommodation.

Environmental decontamination was carried out together with the deployment of in-stream interceptors, the placement of oil absorbent booms and pads and the pumping out of contaminated water.

Key words: Aviation Fuel; Chemical Incidents; Environmental Health; Integrated Emergency Management; Petroleum hydrocarbons; Public Health Response.

Introduction

Petroleum is found in many sedimentary rocks, the product of the decomposition of organic matter at high temperature over a period of millions of years, resulting in a complex mixture of gaseous, solid and liquid hydrocarbons. Processed petroleum products contribute up to 50% of the world's total energy, transportation, electrical utility and heating requirements. Petroleum products are also utilised for the production of lubricants, solvents, the surfacing of highways, waterproofing, and in the manufacture of a range of plastics and feed stocks (ATSDR, 1998).

The aviation sector is a significant consumer of petroleum products. Jet-Propulsion 8 (JP-8) is the product of distillation, the exact chemical composition varying according to the crude petroleum from which it is refined, but is typically composed of kerosenes, consisting of aliphatic and aromatic hydrocarbons, paraffins (aliphatic alkanes) and napthalenes (cycloalkanes), while aromatic hydrocarbons constitute less than 20% and olefins comprise less than 1% of such mixtures (ATSDR, 1998). More than 200 hydrocarbon constituents may be identified analytically. The addition of anti-oxidants, static and corrosion inhibitors, thermal stabilants, lubrication improvers, icing inhibitors and biocides add to its toxicological complexity (ATSDR 1998, IARC 1989a).

The physico-chemical properties of such mixtures are not surprisingly, extremely complex. Lighter fractions volatilise readily following release, hydrophilic and amphipathic fractions dissolve in water and lipophilic fractions are likely to be bound to soil particles, vegetables and crops and stream sediment. Therefore, it is likely that the inadvertent release of petroleum hydrocarbons will result in all major environmental compartments becoming contaminated. This, coupled with the potential toxicity of such mixtures, illustrates the complex nature of such releases and the potential for serious impacts on public health following any inhalation, ingestion and dermal contact (Health Protection Agency, 2006a).

This paper describes a specific incident involving the petroleum product JP-8 as a consequence of a spillage at

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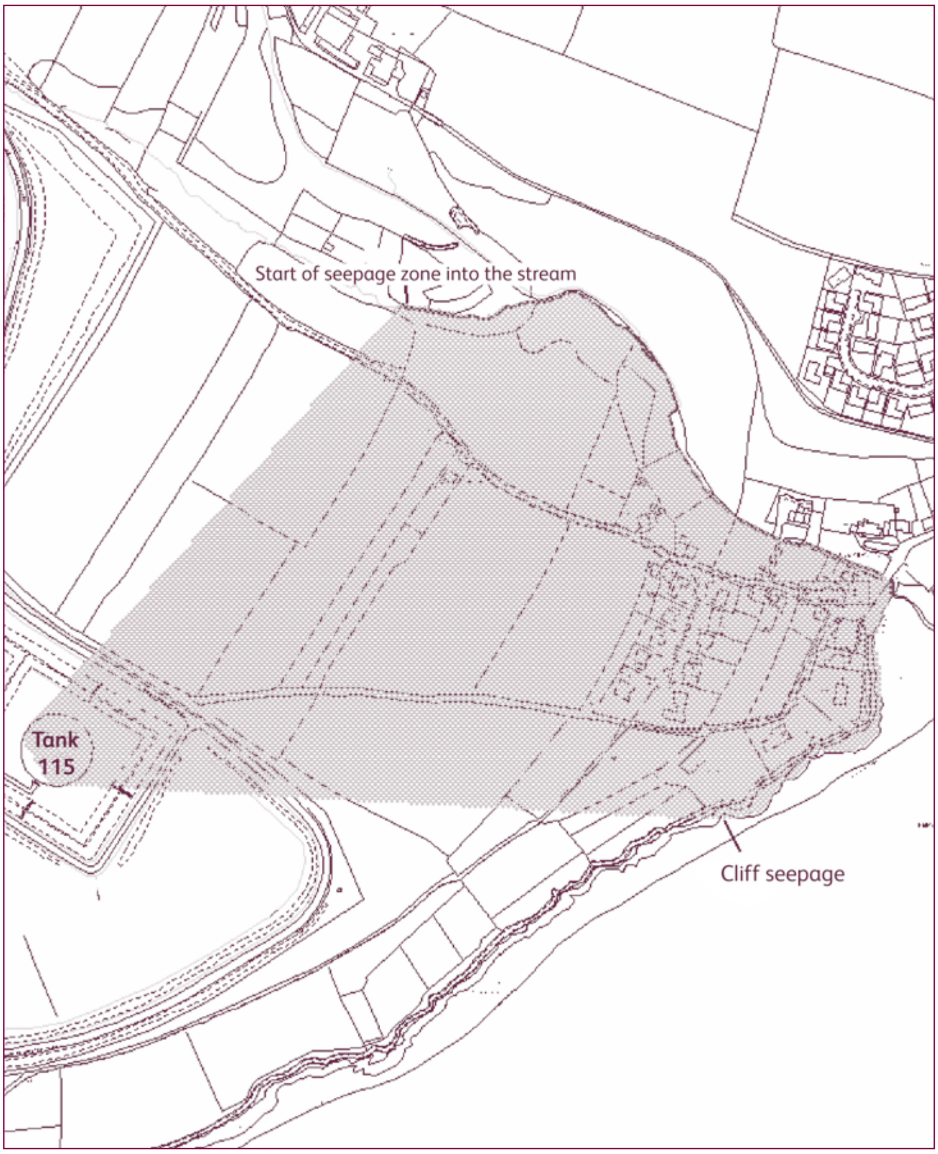
Figure 1.0
Predicted plume dispersion (hatched area) of JP-8 following its release from Tank 115 at Petroplus, adjacent to the village of Hazelbeach, Llanstadwell (Scale 1 in 4000; Map courtesy of Pembrokeshire County Council).



a refinery in Pembrokeshire, Wales, UK. It highlights the multi-disciplinary, multi-agency response to the incident, together with the public health risk assessment undertaken and the subsequent communication of risk to members of the public potentially exposed. The multi-disciplinary/agency public health response model that has been developed in Wales for providing advice and support on the acute and chronic public health implications of such chemical incidents is described.

The incident

On Tuesday 2 August 2005 a leak was reported from a fuel storage tank facility at Sem Logistics Milford Haven Limited, Llanstadwell. This resulted in the spillage of approximately 600 tonnes of JP-8. JP-8 migrated through ground water in highly-fissured rock, migrating north-eastward to contaminate a nearby stream, the beach which it flowed through and emerging at a cliff outfall at

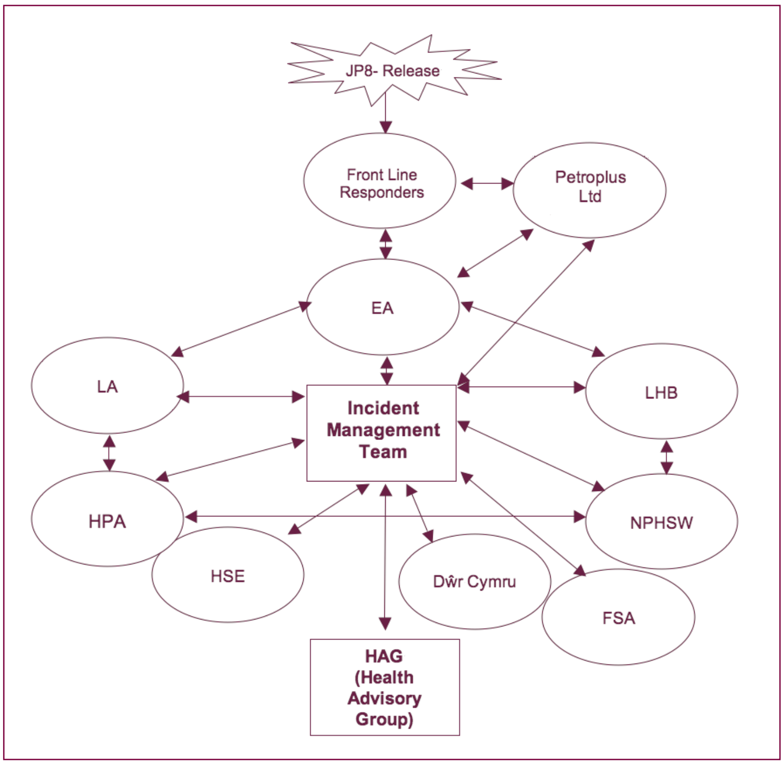


Figure 2.0
Schematic of multi-agency approach to the incident

nearby Milford Haven. In addition, there were sightings of hydrocarbon films on residential lawns and ponds in the small village of Hazelbeach; the movement of the plume in an easterly direction is depicted by Figure 1.0.

Air quality sampling for kerosene as total petroleum hydrocarbons (TPHs) by photo-ionisation detector (PID), undertaken by the local authority adjacent to the stream, gave readings of approximately 150,000μgm^{-3}, while 3-4m away concentrations were <10,000μgm^{-3} and street concentrations were recorded as being 2-3000μgm^{-3}. Migration into the sewerage system resulted in a large number of homes being affected by odour. Several homes in the village had elevated indoor concentrations of kerosene measured as TPHs, with reported levels as high as 200,000μgm^{-3} in one home, where the property had been extended over a manhole cover. Occupants were offered alternative accommodation.

The sampling of mains water by the utility company (Dwr Cymru/Welsh Water) and subsequent analysis by gas-chromatography-mass spectroscopy did not detect elevated concentrations of total petroleum hydrocarbons or kerosene, whereas sampling by the local authority for total petroleum hydrocarbons (TPH) using infra-red spectroscopy identified levels ranging from 17-55μgl^{-1} at four properties sampled from 1-3 September. One resident complained of a foul odour and an oily film on the surface of tea made from the household public drinking water supply. A water bowser was supplied to the house in question, but no kerosene was detected. There were no recorded abstraction points for private water supplies.

Over the course of the following few weeks, several residents complained of symptoms including nausea, vomiting, headache and dizziness. All symptomatic patients were offered a referral to a clinical toxicologist for assessment. Three patients were assessed, but further clinical effects were not apparent and the patients were subsequently discharged.

A suite of public health measures were put in place, following the convening of a multi-agency incident management team, by the local health board following advice received from the National Public Health Service for Wales (NPHS) and the Chemical Hazards and

Poisons Division (CHaPD) of the Health Protection Agency. Accordingly, affected residents were advised to open windows and ventilate the properties in question and were temporarily re-housed. All local public water supplies were located to ascertain potential contamination. Coupled to this, reports of odours were investigated, as kerosene may migrate via groundwater underneath houses, thereby exposing occupants to vapour. Under such circumstances, indoor air monitoring and water sampling was undertaken. If the indoor levels exceeded 10,000μgm^{-3}, temporary re-housing of residents was considered and re-occupation was not considered until levels fell to <1,000μgm^{-3}, although one household was extremely eager to return to the property and did so when levels fell below 100,000μgm^{-3} – see later for an explanation of how these figures were arrived at.

Public notices were posted and letters written to all residents informing them of the need to stay away from contaminated areas, including the local beach and stream, not to consume local cockles, the need to wash and peel locally grown produce and to inform the local authority of persistent odours. This approach was supplemented by direct meetings with the public, initially on a weekly basis, and included representation from local public health staff. A member of staff from the local authority provided a consistent on the ground presence, both monitoring ambient air levels and responding to questions of individuals.

Further public health advice was sought by also convening a multi-disciplinary, multi-agency public health advisory group (HAG), with representatives from Welsh Assembly Government, The Wales Centre for Health, The Environment Agency, Pembrokeshire County Council, Local Health Boards, HPA, NPHS, Petroplus Ltd and The Health and Safety Executive. This advice was fed into the local incident management team (Figure 2.0).

It was concluded that the incident had been appropriately managed and that environmental monitoring should continue to determine the extent of kerosene contamination of air, water and soil, but that epidemiological follow-up was inappropriate on the basis of the initial population exposure assessment.

Environmental decontamination was carried out together with the deployment of in-stream interceptors, the placement of oil absorbent booms and pads and the pumping out of contaminated water.

Discussion

Petroleum hydrocarbons

Chemical incidents involving petroleum hydrocarbons are not uncommon. Public health surveillance data collated over a five year period from 1999 indicates that there were 240 reported incidents in the UK as the consequence of spillages, leaks, fires and explosions (Health Protection Agency, 2005).

The potential public health significance of such incidents is graphically illustrated by the incident at Buncefield, Hertfordshire, UK in December 2005, where catastrophic failure resulted in the largest post-war explosion in Western Europe. The incident resulted in a dense black plume consisting of products of combustion, soot and particulates approximately 10km across and dispersed in a south-easterly and south-westerly direction and resulting in multi-agency, multi-disciplinary emergency response (Health Protection Agency, 2006b).

Spillage of petroleum hydrocarbons at sea has also been reported and with consequent public health implications. In 1993, the Braer oil spill in Shetland in 1993 resulted in exposed individuals having significantly higher rates of headache, sore throat and itchy eyes compared to controls (Campbell *et al*., 1993, 1994). Similarly, the spillage of 72,000 tonnes of crude oil in 1996, from the Sea Empress in Milford Sound, Pembrokeshire, Wales resulted in significantly greater self-reporting of physical and psychological symptoms in communities residing in the vicinity of the incident (Lyons *et al.,* 1999).

In the current incident, widespread contamination of a local stream, pooling of kerosene on lawns and gardens and contamination of ambient and indoor air were all noted. Therefore, incidents involving petroleum hydrocarbons may contaminate all environmental media and have a significant public health impact. Such contamination of environmental media has major potential implications for public health, with human receptors being potentially exposed through inhalation of contaminated air, ingestion of contaminated water and crops and through dermal contact (Ritchie *et al*., 2003). This is borne out by the findings of the present incident, in which contamination of a local stream, pooling of kerosene on lawns and gardens and contamination of ambient and indoor air were all noted.

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Toxicology

The toxicology of environmental petroleum hydrocarbons is complex as these substances are present in the environment as complex mixtures, containing many hundreds of individual compounds, each with its own toxicological properties (IARC, 1989b; ATSDR, 1998).

The symptoms of nausea, vomiting, headaches and dizziness reported following the Petroplus incident are consistent with exposure to petroleum hydrocarbons. Accordingly, ingestion of hydrocarbon mixtures are recognised as inducing coughing, nausea, vomiting and diarrhoea, while inhalation is associated with headache, dizziness, drowsiness and inco-ordination (Health Protection Agency, 2006); higher concentrations are recognised as inducing cardiac arrhythmias, convulsions and coma (ATSDR,1998).

Air quality

In the described incident, elevated concentrations of TPHs were measured in both indoor and outdoor air. Interpretation of the public health implications of the air quality, however, is problematical, as there are no derived environmental standards for kerosenes. Rather, *occupational* standards based on a 10-hour weighted exposure have been derived, with a value of $100mgm^{-3}$ (NIOSH, 2005). Therefore, for the purposes of deriving a working exposure level for community exposure and thus public health, this standard was arbitrarily divided by an uncertainty factor of 100, thereby providing an 'environmental standard' of $1000ugm^{-3}$. This is consistent with the reference concentration (RfC) value of $1000ugm^{-3}$ derived for total petroleum hydrocarbons, defined as "the level of continuous inhalation exposure that is likely to be without appreciable risk of deleterious effects during a lifetime", (TPHCWG, 1997). Therefore, a measured indoor level of $10{,}000ugm^{-3}$ was considered a hazard to health and occupants were offered alternative accommodation; mass evacuation was not considered necessary or appropriate.

Water contamination

Water contamination was a potential issue: Local authority data obtained by infra-red spectroscopy suggested that groundwater was contamination with kerosene while gas chromatography-mass spectroscopy (GC-MS) analysis undertaken by the water company could not corroborate this. This apparent anomaly may be explained by the fact that the two methods use different principles of measurement – GC-MS is widely regarded as being both sensitive and specific, whereas IR does not allow hydrocarbon banding or identification of petroleum hydrocarbon fractions and may suffer from poor accuracy and precision (TPHCWG, 1998). GC-MS is therefore the industry standard method, endorsed by the Water Research Council and the Standing Committee of Analysts (SCA). Even if it is assumed that the IR measured values of up to $55\mu gl^{-1}$ are accurate and precise, the taste/odour threshold for hydrocarbons in drinking water is $10\mu gl^{-1}$ and the toxicity threshold between $300\text{-}900\mu gl^{-1}$. Therefore, the water would at worst have been unpalatable, but unlikely to cause ill-health (TPHCWG, 1997).

The multi-agency response

The addressing of the individual but related components of environmental chemistry, toxicology, environmental distribution, environmental monitoring, public health and clinical implications, together with environmental impact, necessitated a multi-agency and multi-disciplinary response. This formed the basis for local, regional and national collaboration and co-ordination, resulting in an holistic and integrated response, as part of the local, regional and national emergency planning partnership. This partnership also provided the foundation for subsequent community risk communication.

The public health axis of local, regional and national structures worked closely with other agencies and organisations, (including the company involved), the professional clean-up company, the local authority, the Environment Agency, the Health and Safety Executive, Welsh Water, the Food Standards Agency and the Community Council to ensure that environmental aspects of the incident, such as contamination, sampling and clean up, was complimentary to the public health implications and requirements.

Within Wales, such collaborative working between organisations involved in public health is well established as part of integrated emergency planning, preparedness, response and recovery. It has been further strengthened by the establishment of Chemicals in Wales Network, with partners including the local health boards, NPHS, HPA and Food Standards Agency signing an informal contractual agreement ('compact'). The compact provides the basis for the convening of a health advisory group (HAG). The HAG does not convene during the acute phase of the incident, but rather provides a forum for expert integrated debate regarding contentious and difficult issues pertaining to environmental chemicals. It therefore assesses incident management, addressing positive and negative aspects and subsequently disseminates lessons learnt. It also provides a forum for the identification of significant gaps in knowledge in the field, thereby providing a platform for tailored research and development. This in turn may influence policy through scientific innovation. Collectively, the HAG therefore may improve the protection of public health in Wales in relation to chemical events, by adding value to the work of the individual partner organisations (Welsh Assembly Government).

In accordance with the compact arrangements, a HAG was convened for this incident and considered the multi-agency response, provided further guidance on complex issues which had been raised locally and access to further sources of advice including academia. It endorsed the risk assessment approach undertaken, which was consistent with recognised methodology (Department for Business Enterprise and Regulatory Reform (BERR), formerly Department of the Environment, Transport and the Regions) (2000)) and concluded that environmental sampling should continue. However, although it was recognised that undertaking epidemiological studies in small geographical areas is technically feasible (Elliott *et al*., 1997), it was concluded that there were likely to be major limitations associated with studies of small populations and the subsequent meaningful interpretation of results. The limitations of seeking to undertake meaningful studies in relation to environmental hazards associated with small populations has been highlighted by the Committee on the Medical Aspects of Air Pollution (COMEAP), which has advised health bodies investigating the health effects of local industry that *"single site studies of the effects of air pollutants on health are unlikely to have sufficient statistical power to confirm or refute assertions of effects and there is a significant risk that the results of such investigations will be impossible to interpret"* (Department of Health, 1998).

The multi-disciplinary approach used here reinforces the importance of integrated emergency planning and preparedness and subsequent response and recovery, and is consistent with established models of practice in this field. (WHO/IPCS, 1999). The incident further illustrates the complex toxicological properties of common chemicals and the difficulties of risk assessing the likely public health consequences. Such incidents are undoubtedly multi-disciplinary, underlining the necessity for harmonised and integrated communication and collaboration.

Conclusions

- Chemical incidents involving total petroleum hydrocarbons are relatively common and may result in widespread environmental contamination.
- The chemistry of total petroleum hydrocarbons is complex owing to the presence of numerous constituents and additives,
- The potential contamination of air, water, land and crops, coupled with the recognised toxicity of petroleum hydrocarbons may have a significant impact upon community health.
- Public health risk assessment requires an understanding of environmental chemistry and toxicology, environmental persistence, distribution and fete, environmental monitoring as well as clinical toxicology. Therefore, a multi-disciplinary/agency approach is required. This is best addressed through integrated emergency planning and developing robust and clear channels of communication.
- Risk communication is an essential component of the response and should be commenced as soon as possible following declaration of an incident in an open and transparent manner.

Acknowlegements

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References

Agency for Toxic Substances and Disease Registry (ATSDR) (1998). Toxicological profiles for jet fuels JP-5 and JP-8. Department of Health and Human Services, Public Health Service (Atlanta, USA). Available on line at: *http://www.atsdr.cdc.gov/substances/jet_fuels-jp5-8/index.html* [accessed 03/02/09].

Campbell D, Cox D, Crum J, Foster K, Christie P and Brewster D (1993). Initial Effects of the grounding of the tanker Braer on health in Shetland, *BMJ* Vol. 307(6914), pp1251-1255.

Campbell D, Cox D, Crum J, Foster K and Riley A (1994). Later effects of grounding of tanker Braer on health in Scotland. *BMJ*, Vol. 309 (6957), pp 773-774.

Department for Business Enterprise and Regulatory Reform (BERR) (formerly Department of the Environment, Transport and the Regions) (2000). 'Guidelines for Environmental Risk Assessment and Management', Available online at: *www.defra.gov.uk/environment/risk/eramguide/03.htm*

Department of Health. Committee on the Medical Affects of Air Pollution (1998). Quantification of the effects of air pollution on health in the United Kingdom. London: The Stationery Office.

Elliott P, Cuzick J, English D and Stern R (1997). Geographical and environmental epidemiology: Methods for small area studies. Oxford University Press (Oxford).

Health Protection Agency (HPA) (2005) 'Health Protection in the 21st Century – Understanding the burden of disease; preparing for the future.' Available online at: *www.hpa.org.uk/webw/HPAweb&HPAweb Standard/HPAweb_C/1203064747564?p=115384667 4362* [accessed 18/02/09]

Health Protection Agency (HPA) (2006a).Compendium of Chemical Hazards – Kerosene key points. Available online at: *www.hpa.org.uk/webw/HPAweb&Page&HPA webAutoListName/Page/1158313434474* [accessed 03/02/09].

Health Protection Agency (2006b). The public health impact of the Buncefield Oil Depot Fire. Available on line at: *www.hpa.org.uk/webw/ HPAweb&HPAwebStandard/HPAweb_C/11970217161 72?p=1153846674362* [accessed 03/02/09].

International Agency for Research on Cancer (IARC) (1989a). Occupational exposures in petroleum refining: Crude oil and major petroleum fuels. *Monographs Eval. Carcinogen. Risk Chem. Hum*., Vol. 45, pp 203–218.

International Agency for Research on Cancer (IARC) (1989b). Monographs on the evaluation of carcinogenic risks to humans. Occupational exposures in petroleum refining, crude oil and major petroleum fuels, Vol 45 World Health Organisation Lyon, France.

Lyons R A, Temple J M, Evans D, Fone D L and Palmer S R (1999). Acute health effects of the Sea Empress oil spill. *Journal of Epidemiology & Community Health*, Vol. 53, pp 306-10.

Ritchie G D, Still K R, Rossi J, Bekkedal M Y-V, Bobb, A J, Arfsten, D P (2003). Biological and health effects of exposure to kerosene-based jet fuels and performance additives. *J. Toxicol and Environ Health* (B): Critical Reviews, Vol 6(4), pp 357–451.

The National Institute for National Safety and Occupational Health (NIOSH) (2005). 'Pocket Guide to Chemical Hazards' (CDC, USA). Available online at: *www.cdc.gov/niosh/npg/* [accessed 18/02/09]

Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) (1997). Volume 4: Development of fraction specific reference doses (Rfds) and reference concentrations (RfCs) for total petroleum hydrocarbons (TPH). Prepared by Edwards D *et al*., Massachusetts, USA: Amherst Scientific

Total Petroleum Hydrocarbon Criteria Working Group Series (TPHCWG) (1998). Analysis of Petroleum Hydrocarbons in Environmental media. Vol.1. Available on line at: *www.aehs.com/publications/catalog/ contents/tph.htm* [accessed 18/02/09]

World Health Organisation (1999). Public Health and Chemical Incidents: Guidance for National and Regional Policy Makers in the Public/Environmental Health Roles. Inter-Organisation Programme for the Sound Management of Chemicals IOMC, WHO.

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The CIEH sets aside a budget each year to support environmental health research. If you would like further information and/or to apply for support for a research project please contact John Guild at j.guild@cieh.org or on 0207 827 5842. The maximum grant available is £3,000.

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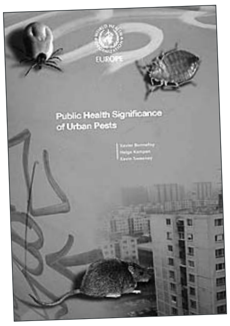

Public Health Significance of Urban Pests

Xavier Bonnefoy, Helge Kampen, Kevin Sweeney
Published by World Health Organization (WHO) Regional Office for Europe.
ISBN 978-92-890-7188-8. March 2008. 569pages.

The historical interaction of humankind and urban pests is a long and complicated relationship, where, on balance, the pests have more than held their own. It is remarkable that at this stage of human development, our urban pests have repeatedly demonstrated their ability to compete with us for food, shelter, and water. In too many cases we continue to aid them in this by failing to acknowledge and change our own behaviours, or to learn by our past mistakes. This landmark publication by the World Health Organization clearly demonstrates that we do not have the luxury of consigning pest management to the history books, but rather we face a new generation of challenges.

One of these challenges is undoubtedly the influence of climate change. The authors show that our growing awareness of this challenge has changed the nature of the discourse. By way of example, simulated climate change models predict a potential increase in fly populations of 244% by 2080, compared with current levels. Climate change will also influence the nature of pest management in terms of changes in flooding patterns and land use. Some of the outcomes concerning the increase in pest-related diseases are already upon us. The growing problem of Lyme disease in Europe and North America is proof enough that the time for action is now.

Public Health Significance of Urban Pests succeeds as an integrated body of work on several levels. On one level it is a peerless reference book for practitioners, with input from the very best in field on the full range of urban pests – cockroaches, house dust mites, bedbugs, fleas, pharaoh ants and fire ants, flies, birds, human body lice, ticks, mosquitoes, commensal rodents, non-commensal rodents and lagomorphs.

On another level, it stays true to its stated purpose by determinedly putting public health at the centre of pest management. This approach is demonstrated from the outset by bringing together an impressive body of research on allergic asthma and the various contributions of urban pests to this major burden of disease in our societies.

One recurring theme throughout the book addresses the issue of costs in terms of pest management, as well as societal and health-related costs. While these are all extremely difficult to quantify, where solid information exists, this is presented. Where there are still uncertainties, (and there are many) these are also discussed and contextualised. In this respect, this book will be an important ally for those who must make the economic arguments and business case for delivering and improving pest management services. The authors advocate that the most effective way forward is through integrated pest management (IPM) or as they describe it " the common-sense approach to pest management". As is often the case, pest control programmes that are not integrated often focus on killing pests instead of focussing on why pests are present.

It is fitting in the context of this review to acknowledge the emphasis placed by the authors on the need for resources to be invested in research in pest related disease and pest management. While the biology and behavior of pests has been well studied, the epidemiology of the diseases they transmit, particularly in the case of newly emerging diseases, are poorly understood.

In the current economic circumstances, prudence in reducing our personal and corporate spending is essential for all. For those involved in the pest management field, if you purchase one book this year on the subject, make it this one.

Martin Fitzpatrick
Associate Editor, JEHR

The full text of the book is available online at: *www.euro.who.int/InformationSources/Publications/Catalogue/20080617_9* [accessed 06/02/09]

Notes for authors

Notes for authors

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Communication from the editors will normally be by email only.

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