J Clin Pathol 1989;**42**:682–688

Bacteriological sampling of postmortem rooms

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SUMMARY Thirty hospital and coroners' postmortem rooms in the West Midlands were visited over two years. The design, environmental facilities, and hygienic practices were investigated and air exchange rates were measured. Microbiological samples were taken from the environment and from gloves, hands, and protective clothing of staff. Glove punctures were also recorded and a plastic isolator evaluated. Bacterial counts in the air were low and related more to the number of people in the room than to the air exchange rate. There was little evidence of the production of aerosol containing bacteria, although splashing occurred while intestines were being washed out. Surfaces often remained contaminated with Gram negative bacilli after cleaning but numbers were considerably reduced on drying. Decontamination of instruments was satisfactory. A wide range of disinfectants and concentrations was used, but none showed evidence of contamination. Gloves were heavily contaminated after use, and occasionally the hands of the wearer after removal of the gloves. Washing the hands effectively removed residual transient organisms, irrespective of the agent used. The incidence of glove punctures was higher among technicians (38%) than pathologists (12%). The plastic isolator reduced smells and limited environmental contamination but visibility and acceptability were poor.

The results of the study suggest that there is little evidence of risk of infection to staff, providing basic hygienic precautions are taken, but consideration should be given to the prevention of glove punctures.

The risk of infection to staff working in a postmortem room is well established. The main hazards are pulmonary tuberculosis, hepatitis B, and increasingly human immunodeficiency virus (HIV).[1-3] Infection with other organisms is less likely although sepsis of a cut is potentially hazardous and intestinal pathogens can infect staff working in the postmortem room.

The role of the environment in the spread of infection is unknown. Studies have shown the presence of mycobacteria on trays, tables, and in the air during the slicing of a tuberculous lung,[4-6] but no recent evidence is available. Bacteriological sampling for mycobacteria in the air would rarely be possible as the untreated person is often not identified before the postmortem. Total bacterial counts in the air and on surfaces, however, may provide some indication of potential hazard, and some organisms such as Gram negative bacilli are likely to have been disseminated from the cadaver rather than by staff carrying out the postmortem. Newsom *et al* showed that bacterial counts in the air of postmortem rooms were low and mainly disseminated from staff[7]; contact spread is therefore a greater hazard. Hepatitis B and HIV infections are likely to be acquired through cuts or puncture wounds.

In this study air and surface sampling were carried out in hospital and coroners' postmortem rooms in the West Midlands. Hands and clothing were sampled and gloves examined for punctures. A postmortem isolator was also evaluated[8]; this is designed to reduce airborne and contact exposure. Information was collected on staff morbidity, clinical infections, design and support facilities etc; the results of these surveys will be published elsewhere.

Material and methods

Thirty hospital and coroners' postmortem rooms were visited in the West Midlands over two years (1986/87). A record was kept of the design of the unit, the type of equipment used, the ventilation system, the facilities for handwashing, the type of protective clothing worn, and the methods used for disinfection of instruments, work surfaces, and the skin.

To assess the infection risk to pathologists and technicians, samples were taken from the air and

Accepted for publication 2 March 1989

surfaces during postmortem examinations, and from surfaces and instruments after cleaning and disinfection. Further visits were made to some units to assess the risks associated with the use of specific items of equipment or techniques not included in the normal routine such as isolators and bandsaws.

AIR SAMPLING

Air samples were taken using a Casella slit sampler and a Reuter Biotest Centrifugal sampler (RCS). The slit sampler was used to recover bacteria dispersed or aerosolised in successive two minute intervals (1400 litres air per sample) during the necropsy. A longer time interval of five minutes (3500 litres) was occasionally used to recover *Clostridium perfringens* on neomycin-nagler agar.[9] The sampler was operated at cadaver height and within two metres of the postmortem table or dissecting board. The RCS sampler is only capable of sampling 80 litres of air in two minutes but has the advantage that it can be held close to the site of investigation.

Most air samples were taken using nutrient agar (Oxoid No 2) enriched with horse serum and containing phenolphthalein disodium phosphate (PPD) for detection of *Staphylococcus aureus.*[10]

The dispersal of potential pathogens from the skull and long bones during the use of cranial saws and bandsaws was also investigated by use of a tracer organism *Bacillus subtilis var niger* spores (NCTC 10073). A suspension containing 10^6 spores/ml was painted on to the outer surface of the skull and femur before using the saw.

VENTILATION

Air flows were measured in ventilated postmortem rooms with a vane anemometer and air exchange rates calculated. As access to ducting was not usually possible, measurement was made at the face of the exit grills.

SURFACE SAMPLING

Samples were taken from dissection boards, necropsy tables, and draining boards using 25 cm^2 PPD nutrient agar contact plates. (Sterilin, No 504). Swabs were taken from instruments and irregular surfaces and cultured on nutrient blood agar. Surfaces were sampled before and after necropsy and after cleaning or disinfection, or both.

DISINFECTANTS

A record was kept of the concentration and type of disinfectant or cleaning agent used in the environment and on the hands of staff. Tests were performed on samples of disinfectant to establish the efficacy at the concentration used—that is, in-use tests.[11] Capacity tests were performed on unfamiliar products[12] and phenol assays using gas liquid chromatography.

STAFF SAMPLING

Hand samples were taken using a finger streak technique.[13] Samples were taken from hands before putting on gloves, from the gloves after necropsy, from the hands after removing the gloves and after washing or disinfection. The type of glove used was recorded and a selection kept and checked for punctures and lacerations.

Samples were taken from protective clothing—for example, aprons and gowns—before and after necropsies using nutrient agar contact plates. Each sample was taken at cadaver height from the outside of the apron and from the gown or clothing worn underneath.

CADAVER SAMPLING

Occasionally contact plate samples were taken from cadaveric skin (thorax, abdomen, and thighs) before and after the postmortem and after sewing up and washing down. Settle plates were placed around the cadaver to monitor splashing or dispersal over small distances.

ISOLATOR STUDY

The isolator used was of the flexible film type described by Trexler and Gilmour.[8]

Table 1 *Influence of mechanical ventilation on total numbers of bacteria recovered from air samples during necropsy*

	No mechanical ventilation			*1–9 air changes an hour*			*10 or more air changes an hour*		
	n	*Median* count*	*Range*	*n*	*Median* count*	*Range*	*n*	*Median* count*	*Range*
Background	6	270	200–1000	7	174	81–717	7	156	55–920
Skull removal	2	121	78–163	6	186	50–271	6	149	29–559
Thoracic organ removal	4	183	144–227	5	68	53–237	7	131	63–272
Bowel removal	5	227	100–1000	4	134	57–232	4	221	83–345
Sewing up	6	196	132–500	3	93	53–102	4	169	54–1500
Washing down	4	178	146–216	5	108	79–261	3	279	112–1500
All procedures	27	200	78–1000	30	127	50–717	31	167	29–1500

*2 minute Casella sample, air volume per sample = 1400 litres.

Table 2 *Influence of the number of persons present during necropsy on bacterial air count*

No of persons present during necropsy	*No of samples*	*Median bacterial count**	*Range*
3–4	48	155	29–1000
5–6	42	216	57–1500
8–9	9	248	208–717

*2 minute Casella sample, total air volume per sample = 1400 litres.

Two examinations were carried out on different days by different pathologists. During the first postmortem, air sampling was carried out with the ventilation system on and during the second postmortem the ventilation was turned off for much of the dissection so that dispersal from the cadaver alone and not organisms in room air could be measured.

BACTERIOLOGY

Nutrient agar and blood plates were incubated aerobically and neomycin-nagler plates anaerobically at 37°C for 18 hours and colonies were counted where possible. Counts of presumptive *S aureus* and Gram negative bacilli were also recorded. Presumptive *S aureus* were confirmed by the deoxyribonuclease test and Gram negative bacilli by Gram stain. Gram negative bacilli were subcultured on to MacConkey agar and a selection identified by Analytical Profile Index (API). Lecithin-producing organisms growing anaerobically in the presence of neomycin were confirmed as *C perfringens* by use of specific antitoxin.

Results

AIR SAMPLING AND VENTILATION

Table 1 shows the total number of colony forming units (cfu) recovered with the Casella slit sampler in two minute samples (1400 litres of air).

The median counts for most procedures were higher in the rooms with no ventilation than in those with a mechanically assisted system. There seems to be little difference, however, between procedures carried out in rooms with very different air change frequency. The background counts were often higher than those during necropsy and were probably due to the amount of activity during preparation. The total counts seem to relate to the number of persons present rather than to the nature of the investigation carried out (table 2). Most organisms isolated were *S epidermidis*, *Micrococcus* spp, and diphtheroids. *S aureus* were occasionally isolated (11% of samples) in small numbers but these did not exceed 0·01 cfu/litre of air sampled.

Table 3 shows the number of air samples from which Gram negative bacilli were recovered during the various procedures. The results are pooled because there was no difference in the counts of Gram negative bacilli from those with or without ventilation systems. The maximum Gram negative bacilli count with the Casella sampler (40 cfu/1400 litres) was obtained during bowel removal. The maximum count with the RCS sampler (500 cfu/80 litres (6·25/litre) held close to the site of investigation was obtained during the washing out of the intestines. The identity of some of the airborne isolates of Gram negative bacilli was as follows; *Acinetobacter, Enterobacter, Proteus, Klebsiella, Citrobacter, Serratia* spp and *Escherichia coli*.

The dispersal of tracer organisms during the use of a cranial saw was investigated on five separate occasions. In spite of the large number of spores applied to the skull few were recovered either during, or immediately after use of the saw. Of 14 samples taken with the RCS sampler held close to the saw, the maximum count per 80 litre sample was 23 (0·29/litre) with a median count of 1 (0·01/litre). Counts obtained with the Casella slit sampler placed two metres from the saw were much lower—that is, a maximum count of 6 cfu and a median count of 1 cfu/1400 litres of air sampled.

Table 3 *Gram negative bacilli recovered during necropsy*

	Casella slit sampler (1400 litres)			*Reuter Centrifugal Sampler (80 litres)*		
	n	*Samples with GNB*	*Range of counts*	*n*	*Samples with GNB*	*Range of counts*
Background	23	2	0–18	21	0	—
Skull removal	16	3	0–7	16	0	—
Dissection of brain	Not done			7	1	0–1
Removal of thoracic organ	19	5	0–13	14	1	0–1
Dissection of thoracic organ	Not done			23	0	—
Dissection of liver or kidney	Not done			17	2	0–2
Removal of bowel	13	2	0–40	10	2	0–4
Examination of bowel	Not done			12	4	0–14
Washing out intestines	Not done			12	12	1–500
Sewing up	14	1	0–3	Not done		
Washing down	14	2	0–4	Not done		
All procedures (%)	99	15 (15·2)	0–40	132	22 (16·7)	0–500

Table 4 *Distribution of Gram negative bacilli on surfaces before and after necropsy and after cleaning and disinfection*

	No (%) of samples			
	cfu per sample	*Before*	*After*	*After cleaning and disinfection*
Instruments* (n = 13)	0	11 (84)	4 (31)	12 (92)
	1–10	1 (8)	2 (15)	1 (8)
	>10	1 (8)	7 (54)	0
Necropsy tables† (n = 20)	0	18 (90)	8 (40)	11 (55)
	1–10	1 (5)	1 (5)	1 (5)
	>10	1 (5)	11 (55)	8 (40)
Dissection boards† (n = 23)	0	21 (91)	4 (17)	12 (52)
	1–10	0	0	4 (17)
	>10	2 (9)	19 (83)	7 (31)
Aprons† (n = 27)	0	26 (96)	15 (56)	
	1–10	1 (4)	4 (15)	Not sampled
	>10	0	8 (29)	
Gowns† (n = 21)	0	20 (95)	20 (95)	
	1–10	1 (5)	0	Not sampled
	>10	0	1 (5)	

*per swab, †per 25 cm^2 contact plate.

Results were similar when long bones were painted with spores and cut on the bandsaw. The maximum count per 80 litre sample with the RCS sampler was 11 cfu (0·14/litre) with a median of 2 cfu (0·025/litre). With the Casella slit sampler, the maximum count was 15 cfu and median count 3 cfu/1400 litres of air sampled.

Small numbers of *C perfringens* were isolated from nine of 14 air samples taken during bowel irrigation and from three of eight samples taken during other necropsy procedures. Counts ranged from 1–7 cfu/3500 litres sampled, with a median of 1.

SURFACE SAMPLING

The results of surface sampling are shown in table 4.

Very few surfaces were heavily contaminated before the necropsy was begun. Less than three (10%) of samples yielded more than 10 cfu of Gram negative bacilli a swab or contact plate. Post-procedural counts were high, with seven to 19 (54–83%) of the samples yielding more than 10 cfu Gram negative bacilli a sample and 11–19 (54–82%) with total counts in excess of 100 cfu a sample. Some samples after decontamination were also surprisingly high. Necropsy tables and dissection boards often remained heavily contaminated, with seven to eight (31–40%) of the samples showing more than 10 cfu. Instruments were, however, effectively disinfected.

USE OF DISINFECTANTS AND IN-USE TESTS

Of the 30 postmortem rooms visited, 23 (76%) reported that they used a phenolic disinfectant (Stericol, Clearsol, Izal, or Hycolin); 14 (45%), a chlorine releasing agent (bleach, Chloros, or Diversol BX); 11 (38%), glutaraldehyde (Cidex or Totacide) and three (10%), formalin. Seven (23%) used a single disinfectant, usually a phenolic, the others used two or more disinfectants. Twelve "in-use" tests[11] were carried out on phenolic disinfectants and all passed. Five further samples of phenolic were assayed using gas liquid chromatography and concentrations varied between 1·4% and 11·6%. Concentrations recommended by the manufacturers for dirty situations are 2% (Stericol) and 1·2% (Clearsol). Capacity tests were carried out on several products and those which are recommended such as glutaraldehyde and phenolics passed the tests; some unfamiliar products did not.

SAMPLING OF PROTECTIVE CLOTHING

Table 4 also shows the effectiveness of waterproof aprons in preventing cotton gowns and undergarments from becoming contaminated during necropsy. Only one of the 27 aprons sampled before use was found contaminated with Gram negative bacilli, whereas after use 12 (44%) were contaminated, eight (29%) with more than 10 cfu Gram negative bacilli per 25 cm^2. Only one of the 21 gowns sampled after use showed Gram negative bacilli. Contamination with other bacteria followed a similar pattern but it was not possible to distinguish between Gram positive organisms derived from the skin of the cadaver and those from the wearer.

About 18 (60%) of the pathologists used robust, waterproof, reusable aprons, the remainder using the disposable plastic type. Gowns were worn by 50 (80%) of the staff and the remainder used theatre suits or singlets and trousers. Aprons were always worn over protective clothing in the 30 postmortem facilities surveyed.

SAMPLING THE HANDS AND GLOVES OF STAFF

The number of transient Gram negative bacilli recovered from finger streak samples before necropsy, the gloves after necropsy, and the hands after remov-

Table 5 *Gram negative bacilli recovered from hand and glove finger streak samples*

	No (%) of samples					
	Technicians (n = 28)			Pathologists (n = 36)		
	cfu per sample			cfu per sample		
	0	1–10 cfu	> 10 cfu	0	1–10 cfu	> 10 cfu
Hands before necropsy	25 (89)	2 (7)	1 (4)	33 (92)	3 (8)	0
Gloves after necropsy	10 (36)	3 (10)	15 (54)	4 (11)	3 (8)	29 (81)
Hands after removing gloves	24 (86)	3 (10)	1 (4)	23 (64)	3 (8)	10 (28)
Hands after washing	25 (89)	2 (7)	1 (4)	34 (95)	2 (5)	0

ing the gloves and after washing, is shown in table 5. Very few of the samples (six of 64) yielded Gram negative bacilli before necropsy and numbers were low. After necropsy the gloves were heavily contaminated with Gram negative bacilli. Twenty nine (81%) of the pathologists and 15 (54%) of the technicians' gloves yielded 10 or more cfu of Gram negative bacilli a sample. After removing the gloves several of the samples taken from the pathologists' hands showed large numbers of Gram negative bacilli, possibly acquired during glove removal or via holes in the gloves.

Of the 30 postmortem facilities surveyed, 18 used chlorhexidine-detergent (Hibiscrub), two povidone-iodine (Betadine, Videne), one triclosan (Zalclense) and nine used exclusively unmedicated bar or liquid soap. It was not possible with the small sample size to compare the efficacies of the different agents used but all seemed to be reasonably acceptable as the transient flora were easily removed. Only 1·6% of the samples yielded more than 10 cfu of Gram negative bacilli. Most establishments (21, 72%) used disposable towels and the remainder washable hand or roller towels.

GLOVE PUNCTURES

The incidence of glove punctures in relation to the type of glove used is shown in table 6. The incidence of glove punctures among technicians was much higher 34 (38%) than among pathologists eight (12%) but this did not seem to relate to the degree of hand contamination.

ISOLATOR STUDY

There was no evidence of aerosol production, although bone dust generated during sawing the skull was found on several air samples taken within the canopy. The bacterial air counts in the postmortem room during use of the isolator were similar to those taken in the absence of the isolator—that is, the median count per 1400 litres of air sampled (Slit sampler) was 150 with a range of 61-235 cfu and, for 80 litres of air (RCS), a median count of 15 with a range of 4–58 cfu per sample. No Gram negative bacilli were recovered from samples taken from the room during the two necropsies.

Inside the isolator dispersal varied with the procedures carried out. The highest counts were achieved during washing down the cadaver, bowel removal, and the use of a cranial saw. Counts were also considerably higher when the exhaust ventilation to the canopy was turned off—that is, with ventilation off, median count of 164, range 27–461 cfu per 80 litres; with the ventilation on, a median count of 17, range 2–33 cfu per sample. Gram negative bacilli were recovered in small numbers (1–14) from eight of the 12 RCS samples inside the isolator.

CADAVER SAMPLING

The organisms present on cadaveric skin before necropsy seemed to be similar to those found on normal healthy skin. Isolates were largely coagulase negative staphylococci, such as *S epidermidis* and diphtheroids. Gram negative bacilli, *S aureus,* and

Table 6 *Glove type and incidence of puncture*

Glove type	Technicians: No sampled	Technicians: No of gloves punctured	Pathologists: No sampled	Pathologists: No of gloves punctured
Household	4	0	0	0
Surgeons (single)	64	24	50	6
Surgeons (double)	2	1	6	0
Linen overgloves with surgeons undergloves	10	4	2	0
Non-sterile	10	5	6	2
Obstetric overgloves (long sleeved)	0	0	2	0
All types	90	34 (38)	66	8 (12)

streptococci were all occasionally isolated, particularly on damaged or moist skin, but during necropsy the number of Gram negative bacilli rapidly increased. Only one of the 66 contact plate samples taken from the skin before necropsy yielded counts of Gram negative bacilli in excess of 100 cfu/25 cm^2; during necropsy 24% yielded Gram negative bacilli and 15% gave counts in excess of 100 cfu/25 cm^2. After sluicing the cadaver the counts of Gram negative bacilli on the moist skin showed little reduction. Gram negative bacilli were splashed on to settle plates placed beside the cadaver during this procedure. The range of Gram negative bacilli identified from cadaveric samples included the following: *Escherichia coli* (36%), *Klebsiella* spp (17%), *Acinetobacter calcoaceticus* (14%), *Proteus* spp (11%), *Enterobacter* spp (10%), *Citrobacter* spp (9%), *Pseudomonas aeruginosa* (2%), *Serratia marcescens* and *Flavobacterium spp* (1%).

Discussion

Spread of infection from cadaver to staff during a postmortem examination may occur by the airborne or contact routes, or particularly from a needle or sharp instrument injury. Assessment of the relative importance of these routes is difficult because the organisms involved are often not readily detected by environmental sampling, and even if this was possible, the infections they cause are unlikely to be present during a study of a limited number of postmortem examinations.

The bacteria in the air of a postmortem room are mainly derived from the skin of staff and counts made before were often higher than during the postmortem examination due to increased activity of staff. Gram negative bacilli are rarely present in the air or dry environment and those present in samples are likely to have arisen from the cadaver, although surfaces could have been contaminated by cleaning equipment.

The total bacterial counts in the air were low, confirming the previous study by Newsom *et al.*[7] The number of bacteria in the air related more to the numbers of people in the room than the air exchange frequency or the procedure being carried out. There was little evidence of aerosol production, but splashing was detected on settle plates adjacent to the cadaver and on the RCS sampler held close by, particularly during washing out of the intestines. Numerous bone particles could be observed on culture plates during the cutting of bone with band or cranial saws, but few bacteria were isolated. Similarly, even when spores were liberally applied to the bone surface, few were recovered in the air.

Surfaces, such as dissection boards and necropsy tables, remained heavily contaminated with Gram negative bacilli after cleaning, but these were often sampled before disinfection and while still moist. From the evidence of counts of samples taken before a postmortem examination contamination of dried surfaces was low. Instruments showed only small numbers of Gram negative bacilli after cleaning, probably because they were immersed in a disinfectant before sampling.

Because Gram negative bacilli die on drying, air samples included an examination for spores of *C perfringens* which are normally present in the intestinal tract and survive well. These were only isolated in small numbers, even during procedures involving the intestinal tract.

A wide range of disinfectants was used, but most were effective for the purpose for which they were chosen. In-use concentrations were variable and rarely complied with the manufacturers' instructions or hospital policy, but there was no evidence of in-use contamination. The type of disinfectant was not always appropriate. Glutaraldehyde is expensive and its continued use is associated with skin hypersensitivity in staff.[14] It does not damage metals, however, and is the most appropriate agent for decontamination of instruments likely to be contaminated with viruses. Hypochlorites are useful general disinfectants but should not be used on metal surfaces. Phenolic disinfectants are suitable for routine use but may not be effective against viruses.

As expected, gloves were heavily contaminated after use and in some instances the hands of the wearer were also contaminated after removal of the gloves. The hand contamination may have been due to faulty technique in removal of gloves or due to glove puncture. Washing the hands after glove removal was effective, irrespective of the washing agent.

The most disturbing finding was the high glove puncture rate, particularly with technicians, presumably because they are more likely than the pathologist to carry out procedures which may puncture gloves—for example, removal of sternum, sewing up after the postmortem examination. Surgical gloves were commonly worn, but other types were too infrequently used for a comparison to be made between types of glove.

Plastic aprons were often heavily contaminated during the necropsies but seemed to provide adequate protection to underlying clothing. Aprons were usually disposable but reusable aprons seemed to be satisfactorily decontaminated after use and should present no hazard to the wearer.

The skin of cadavers was frequently contaminated with Gram negative bacilli during necropsies and numbers were not appreciably reduced after cleaning. This finding suggests that cadavers should be handled with gloves and protective clothing should be worn at all times.

Overall comments from the pathologist and technicians were that there were few advantages in using isolators of the type described. Visibility and accessibility were poor and consequently procedures were more cumbersome and less precise. Removal of the principal organs would normally take 20 minutes but took 50 minutes in the isolator. Although there were no accidents with sharp instruments, pathologists considered that the risk would be greater than carrying out the necropsy without the isolator. Cleaning, disinfecting, and drying the isolator all proved difficult. In spite of these operational dificulties the isolator did reduce unpleasant smells and contain environmental contamination.

This study suggests that carrying out a postmortem examination provides little risk of infection to staff, provided basic hygienic precautions are taken and glove punctures can be avoided. Careful technique is necessary to avoid puncture wounds or cuts such as avoiding slicing organs in the hands. Consideration should be given to new techniques being developed in surgery, such as avoiding the use of needles, greater use of non-touch techniques, not passing instruments from one person to another, and possibly the use of reinforced gloves. Blood contaminated with hepatitis B virus is more infectious than that infected with HIV and immunisation of postmortem staff against the virus is advised. The recommendation of 10 changes an hour[15] seems to be reasonable for the provision of good working conditions and reducing unpleasant smells, but is probably not essential for prevention of spread of infection. A ventilated postmortem table is unnecessary. Arrangements are required, possibly by additional air extraction—by a local exhaust system—to reduce the hazards, not necessarily of infection, but of inhalation of bone particles and of potentially toxic chemicals, such as glutaraldehyde and formaldehyde. The use of vizors when sawing bone would seem to be a useful precaution as well as techniques to reduce aerosol production.

Thorough cleaning and drying of surfaces is important. Disinfection is probably unnecessary but is a rational procedure for heavily contaminated surfaces such as dissecting boards and postmortem examination surfaces. Thorough cleaning should be adequate for floors.

Disinfectants should be used at the correct concentration and for appropriate purposes as already discussed. Routine use of antiseptic hand-washing agents is not required, but an alcoholic hand rub should be available for use after washing if the hands are either heavily contaminated or are in contact with an infectious agent.[16]

We thank Jean Davies (Hospital Infection Research Laboratory) for help with sampling, professor JM Harrington for instigating the research, and Fiona Reid (Institute of Occupational Health) for processing data. We also thank the consultant pathologists and anatomical technicians of the West Midlands for their cooperation during sampling visits, especially the pathologists and technicians in Queen Elizabeth Hospital for assistance in evaluating the plastic isolator. This research was supported by a grant from the Department of Health and Social Security.

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