Occupational hazards in hospitals: risk of infection

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ABSTRACT: In this review of the risk of infection to hospital staff, attention is drawn to the continuing risk presented by hepatitis B and pulmonary tuberculosis, which are more common than diseases such as typhoid fever, brucellosis, histoplasmosis, whooping cough, infectious gastroenteritis, measles, and parotiditis. Other items considered include the susceptibility of female hospital staff to rubella and the importance of their undergoing screening and vaccination; the risks currently presented by epidemic keratoconjunctivitis and by herpes viruses (herpes simplex, varicella zoster, and cytomegalovirus); and the risk of contracting the new infectious diseases (Legionnaires' disease, Marburg disease, Lassa fever, and the acquired immune deficiency syndrome).

The social pressures that first led to legislation regarding protection against occupational hazards resulted from the efforts of many health workers in occupational pathology. Paradoxically, however, health workers often display relatively little concern about the occupational hazards to which they themselves and their colleagues are exposed, though certain dangers were pointed out as early as 1700 in chapter XIX of Ramazzini's *De Morbis Artificum Diatriba*.¹ Despite the many serious dangers present in hospitals and medical research centres, health and safety regulations are frequently ignored. Indeed, hospital staff at times act as though their medical knowledge and their being surrounded by fellow professionals make protective measures unnecessary. Alternatively, certain hazards, notably the risk of infection (whose many victims include such figures as Louis Thillier, Otto Obermeir, Lazear, John E Dutton, Kolletscka, Allan Macfadyen, Ricketts, and Von Prowasek), are considered as an unavoidable part of medical practice and research.² Finally, the desire to make use of novel techniques in the fight against disease before their possible pathogenic effects have been investigated has not infrequently led to both the doctor and his family being placed at risk. Well known examples of this last phenomenon are the early use of ionising radiation, cytostatics, and anaesthetic gases, the latter having been blamed for the chronic nephritis that led to the premature death at the age of 45 of John Snow.

Although hazards exist wherever health care is practised, the greatest risks are undoubtedly run by the staff of hospitals and research centres. The

economic consequences of occupational disease and injury in hospitals may be measured in terms of the number of working days lost due to temporary sickness and the cost of the lost days together with the cost of medical attention, compensation, and pensions. From the moral point of view, the consequences go further than the economic, physical, and psychological damage to the worker and his family (including the increased frequency of abortions, congenital malformations, premature births, underweight babies, and perinatal deaths), and together constitute a possible threat from an increase in the mutation rate. Awareness of the gravity of the problem has led the World Health Organisation to set up a working group on occupational hazards in hospitals, whose recommendations³ are summarised in table 1.

Exposed population and the classification of hazards

In the United States the health sector is a "growth industry"; in the United Kingdom one in 20 workers is employed by the National Health Service and in France there were an estimated 350 000 employees in public hospitals in 1977. In Spain and other countries the hospital is the chief employer of labour in many cities. Furthermore, the fact that nearly two thirds of hospital staff are women whose professional life lasts only about five years on average means that the number of people exposed at some time to occupational hazards in hospitals is considerably larger than the number of workers at any given moment. Hospital personnel may be divided into two categories: health workers proper—that is, medical

Table 1 *Recommendations of the WHO working party on occupational hazards in hospitals (The Hague, 20–22 October 1981)*

Accumulation of data:	
Morbidity	Hospital infections
Mortality	Accidents and injuries
Pregnancies	Stress, frustration, and wellbeing
Absenteeism	New surveillance techniques
Environmental monitoring:	
Ethylene oxide	Noise
Formol	Radiation
Anaesthetic gases	Waste
Solvents	
Surveillance of the health of staff:	
Periodical check ups	
Surveillance of ergonomics	
Organisation of working methods	
Health advice and education	
Legislative regulation of working conditions	

Table 2 *Distribution of hospital personnel*

Category	France**	Hospital General de Galicia ⁵
Health workers proper	68.7%	71.4%
Auxiliary staff:		
Technical and general	23.3%	20.6%
Administrative	8.0%	7.7%

*Based on a review of 170 000 hospital employees.

and paramedical staff directly attending the patient or collaborating in the diagnosis of disease—and auxiliary staff (cooks, butchers, bakers, gardeners, bricklayers, labourers, painters, plumbers, boilermen, electricians, laundrywomen, sempstresses, porters, messengers and administrative staff). The latter, who generally make up about 30% of the total hospital workforce (table 2) are exposed to both the hazards intrinsic to their own trades and to those faced by the health workers proper, albeit less intensely. Thus the administrative staff dealing with admissions, orderlies, meals distributors, and cleaners all enter into contact with patients, whereas electricians and mechanics may be exposed, for example, to ionising radiation.

The main hazards to which health workers proper are exposed may be classified as follows: (1) infection, (2) accident, (3) radiation, (4) exposure to noxious chemicals, (5) drug addiction and psychological problems, and (6) assault.

In the remainder of this paper we shall examine the first category, the risk of infection; the other classes of hazard will be discussed elsewhere.

Risk of infection

The risk of infection, historically the first to be recog-

nised, is testified by the many health workers who over the years have lost their lives in the fight against disease, to the point that society as a whole to some extent accepts such losses as an inevitable consequence of medical research or practice. Though present in all medical environments, the greatest risks arise in hospital and germ research centres, especially in areas such as laboratories, infectious disease wards, and paediatric departments, or during procedures such as bronchoscopy, and it is the class of health workers proper that is the most frequently affected. Though occupational disease may be produced by any type of pathogenic micro-organism to which the health worker is exposed, we shall necessarily restrict our attention to a discussion of the most common or most threatening.

Among the infectious occupational diseases to which the health worker is prone, that which offers the most serious threat overall is undoubtedly hepatitis B. Much has been written recently on the subject of hepatitis B in health workers, and I shall limit myself here to outlining the general problem. The risk of contracting the disease is particularly great during the first few years of medical practice and in those departments in which there is frequent contact with blood (haemodialysis units, operating theatres and anaesthetic rooms, blood banks, and laboratories). The fact that many patients entering hospital³ for other reasons are hepatitis B carriers makes the risk presented by this disease greater than it would be otherwise, and justifies strict safety procedures for the manipulation of all blood samples or suspect body fluids, especially when the patient belongs to high prevalence groups such as drug addicts, homosexuals, haemophiliacs, patients undergoing haemodialysis, or residents in high prevalence areas. The available means of preventing infection nowadays include not only physical and chemical barriers (the use of gloves and disposable syringes and needles and disinfection with 0.5% sodium hypochlorite) but also biological barriers (hyperimmune gammaglobulin and vaccines). Vaccination is the least expensive preventive measure and should be offered to all health workers or at least those working in high risk areas. Though the cost of present day vaccines is still too high to allow their widespread use (the Spanish government, for example, has had to limit their prescription), second generation vaccines produced by cloning genetically modified yeasts or by laboratory synthesis of surface antigen proteins should soon allow cheap mass produced vaccines to be used on a large scale in countries with high rates of hepatitis B and hepatocellular carcinoma.

Of the bacterial diseases likely to be contracted by health workers as a result of their professional activity, the danger presented by pulmonary tuberculosis

is still the most noteworthy. The first quantitative estimate of the risk of catching this disease was made in 1957 by Reid,⁶ who, in a prospective study of 345 English laboratories between 1940 and 1953, found that the risk of contracting tuberculosis was several times higher among pathologists than among a comparable sample of postmen. These results were confirmed 20 years later by Harrington.⁷⁻¹¹ Nowadays, the greatest hazard is not presented by patients under treatment for tuberculosis but by patients not suspected of suffering from the disease who are admitted to hospital for other reasons. Both these patients themselves and their pathological products may act as sources of contagion: Claver *et al* obtained positive diagnoses of tuberculosis for 0.91% of samples from biopsies and postmortem examinations¹²; and among 39 835 biopsies and extirpated tissues examined in Cordoban hospitals between 1978 and 1982 by Garcia Barbero *et al* positive diagnoses were obtained in 115 cases (0.29%), in 59 (51.3%) of which tuberculosis had not been suspected.¹³ In the United Kingdom 38 cases of pulmonary tuberculosis were diagnosed by positive cultures among health workers in the year 1981-2, 18 of the patients being nurses or doctors.

Most types of food borne infectious gastroenteritis occurring in the community also crop up in hospitals, the best documented cases having been outbreaks of salmonellosis.¹⁴⁻²⁶ Whooping cough has low infection and morbidity rates among adults and is generally limited to a slight respiratory illness, the risk of acquiring it being too small to justify systematic vaccination even in paediatric departments, whose staff are the most exposed.²⁷ The fact that typhoid fever, brucellosis, and histoplasmosis have occasionally been picked up by laboratory staff or students as a consequence of strains of these micro-organisms having been used for quality control or with educational intent^{11 28-30} poses the question of whether it is correct for pathogens to be used for such purposes.

On various occasions hospitals and health centres have been affected by Legionnaires' disease.³¹⁻³³ In July 1968, for instance, 95% of the personnel working in a building of the Oakland County Health Department in Pontiac (Michigan) caught the illness then christened "Pontiac fever."³⁴⁻³⁶ Another important outbreak among the patients and staff of the Wadsworth Medical Center in Los Angeles between May 1977 and July 1978 produced 49 cases, 15 of whom died.³⁷ The probable sources of infection in at least some of these outbreaks were aerosols produced from recycled or stagnant water contaminated with *Legionnaire pneumophila* in air conditioning cooling towers and by sprinklers in showers and taps. The dangers ever present in pathology laboratories are nevertheless exemplified by the case of Dr Sheila

Katz of the Atlanta Center for Disease Control, who in 1976 was accidentally contaminated when handling infected lungs from patients who had died of atypical pneumonia.

Rubella is continually being introduced inadvertently into hospitals, the areas of highest risk being obstetric and paediatric departments and serological and microbiological laboratories. Its importance lies in the high risk of it causing congenital malformation or absorption if contracted by pregnant women during the first few months of gestation. About 6.1% of pregnant women within the area of influence of the Hospital General de Galicia³⁸ and 5.69% of its female staff³⁹ are susceptible to rubella and similar percentages have been reported by the Hospital Clínico de Sevilla.⁴⁰ The most appropriate preventive measures consist in the serological screening of all female staff of child bearing age and the vaccination of those found to be susceptible. Vaccination of susceptible men has also been recommended. Measles is a much less serious threat than rubella because only a small proportion of adults are susceptible. The risk of contracting parotiditis is also small,^{41 42} though it might be worth while offering Jeryl-Linn vaccine⁴³ to paediatric staff, who are the most exposed. Paediatric workers are likewise frequently affected by respiratory syncytial virus.⁴⁴⁻⁴⁷

Two adenovirus diseases affecting health workers are pharyngoconjunctival fever^{48 49} and, much more commonly, epidemic keratoconjunctivitis,^{50 51} which is transmitted by fingers⁵² and ophthalmological instruments or fluids^{53-56 57} which have been contaminated by patients' ocular secretions. Outbreaks of keratoconjunctivitis are relatively common at first aid posts treating eye injuries and in ophthalmological consulting rooms.⁵⁸⁻⁶² Between February and May 1984, for example, 145 cases originated in an ophthalmological department in Madrid (seven of them among the staff)⁶³ and a similar outbreak occurred the same year in the province of Pontevedra.

Of the herpes viruses,⁶⁴ herpes simplex produces whitlows and herpetic paronychia, especially among the doctors and nurses of intensive care units, odontological departments, and the anaesthetic service, who are the most exposed to patients with infected oral secretions.⁶⁵⁻⁶⁹ These complaints may be painful and ugly but there is no evidence of their being actually dangerous for otherwise healthy individuals. Fetuses, however, are at risk, especially during the first three months of gestation when there is most danger of congenital defects.

There is little risk of health workers becoming infected with varicella zoster because few adults are susceptible (figures of 3.2%⁷⁰ and 2.6%⁷¹ have been published), but in those cases that do arise the illness presents with more complications than in children.

Infection during pregnancy may, occasionally, have teratogenic effects on the fetus during the first three months and transplacental infection may occur in the final weeks of gestation.

Infection by varicella zoster may be prevented by physical and chemical barriers and by biological barriers in the form of specific immunoglobulin (which should be administered as soon as possible after exposure, and in any case before 96 hours have passed⁷²) and the attenuated live vaccines KM_cC⁷³ and OKA.⁷⁴⁻⁷⁹

There is less evidence that cytomegalovirus⁸⁰⁻⁸¹ has the same capacity as rubella to produce outbreaks in hospital but it is the commonest cause of congenital infections (0.4-2.0% of all live newborn babies).⁸² Classic cytomegalic inclusion disease is rare (1 case per 3000-5000 births) but congenital infection by cytomegalovirus (the clinical signs of which are similar to those of congenital infection by toxoplasma, rubella, or herpes simplex) occurs in about 1% of births, with serious sequelae in 10% of the affected infants.⁸³⁻⁸⁴ Little is known concerning the risk of cytomegalovirus being transmitted to adults caring for these children (it would be particularly desirable to know the risks to women of child bearing age in hospitals, nurseries, schools, and other institutions) but it is probably small and no greater for paediatric workers than for the general population.⁸⁵⁻⁸⁷ Sero-epidemiological studies indicate that infection commonly occurs in infancy, though the observed increase in seroconversion rates at puberty suggests transmission through sexual intercourse and kissing. Annual seroconversion rates among adults with high occupational risk range from 0 to 7.7%,⁸⁶⁻⁸⁸⁻⁸⁹ as compared with the 10.3% seroconversion rate among children and the 53% attack rate within families. These figures suggest that transmission requires prolonged close contact and that the occupational hazard, if any, is slight. There nevertheless remains the theoretical possibility of a susceptible pregnant woman catching the disease from a child excreting viruses in urine or through the upper respiratory tract, and prudence recommends certain precautions being taken.⁶⁴

Although there is no statistical evidence to suggest that health workers are more likely to contract Creutzfeld-Jakob disease than others, it is worth mentioning a possible case reported by Traub *et al*⁹⁰ and Gajdusek *et al*.⁹¹ In 1974 the brain of a neurosurgeon who had died from an illness unrelated to Creutzfeld-Jakob disease was found to exhibit the pathological alterations characteristic of this disease, which was furthermore transmitted to a primate. It is not known whether the surgeon in question had ever operated on a patient suffering from transmissible dementia, but the possibility clearly exists. No cases of infection

have been reported among laboratory personnel after 10 years of handling the Creutzfeld-Jakob virus⁹² or after 20 years of working with the kuru virus.⁹³ The same type of preventive measures as are used against hepatitis B should nevertheless be observed. The possibility of contracting smallpox in the laboratory and the consequent risk of its propagation among hospital staff and inmates will persist so long as variola viruses are preserved in collections. A year after the last case of endemic smallpox, which was recorded in Merca (Somalia) on 25 October 1977, came the outbreak at the East Birmingham Hospital on 24 August 1978.¹¹³ Nor should the threat of smallpox being used as military weapon be forgotten. Vaccination is nevertheless only justified at present among research staff working with orthopoxvirus or personnel engaged in the production of antismallpox vaccine.

At the same time as some of the infectious diseases traditionally affecting man have been dealt with and contained others have taken their place. Legionnaires' disease has already been mentioned; other new infectious diseases include viral haemorrhagic fever, such as Marburg disease, which caused seven deaths among the 31 cases registered in Germany and Yugoslavia in 1976. This epidemic originated among laboratory staff who had handled the blood and tissues of green monkeys (*Cercopithecus aethiops*) imported from Uganda, subsequent cases arising among patients with whom these workers had had contact.⁹⁴⁻⁹⁵ Other viral infections that have appeared in recent years include the Ebola virus, which is highly contagious by contact and has a high mortality rate; Lassa fever,⁹⁶⁻⁹⁷ caused by an adenovirus that is likewise extremely pathogenic for man under hospital and laboratory conditions⁹⁸⁻¹⁰¹; haemorrhagic Crimea-Congo fever, reported to have been contracted by hospital personnel after contact with patients' blood¹⁰²; and haemorrhagic fever with renal syndrome reported in laboratory staff who had handled rats spontaneously infected with Hantaan virus.¹⁰³⁻¹⁰⁵ In all such cases special safety measures must be used both in the care of patients and in carrying out laboratory tasks.

The infectious disease currently giving rise to most anxiety among both hospital workers and the general population is perhaps the acquired immune deficiency syndrome (AIDS). Hospital staff have not been reported as being more at risk than others,¹⁰⁶ and although their undoubted concern about AIDS has been increased by the discovery of asymptomatic carriers and by the virus having been isolated from saliva,¹⁰⁷ tears,¹⁰⁸ and contact lenses,¹⁰⁹ there is nevertheless little risk of the AIDS virus being transmitted by these routes.¹¹⁰⁻¹¹¹ It is rare for the virus to be present in the saliva of those infected,¹¹²⁻¹¹³ and if present the quantities are small and

Occupational hazards in hospitals: risk of infection

non-infectious. Saviteer *et al.*, for example, have reported that two nurses who took part in mouth to mouth resuscitation of a patient with AIDS neither fell sick nor suffered seroconversion¹¹⁴; and there have been no reports of AIDS having been passed on by a patient with AIDS to housemates exposed to saliva and tears but with whom there has been no sexual intercourse.¹¹⁵⁻¹¹⁷ It may therefore be concluded that AIDS is transmitted chiefly by sexual contact, injection of contaminated blood, or from mother to fetus, other mechanisms being extremely rare.¹¹⁸

None of the health workers subjected to prospective surveillance by the Atlanta Center for Disease Control since August 1983 has developed signs or symptoms suggestive of AIDS, and although 278 of the 8218 cases of AIDS notified to the CDC up to 11 February 1985 were health workers (3%), all except 24 (9%) belonged to known high risk groups, and of the 24 exceptions, six of the 17 cases investigated were probably due to non-occupational exposure (in the remaining 11 cases no infective risk factors were identified, though specific occupational exposure to patients with AIDS or suspects may not have been recorded).¹¹⁹ These negative findings are corroborated by those of McGray *et al.*,¹²⁰ who likewise failed to discover AIDS among hospital workers attending patients with AIDS in the United States. No reported case of AIDS among hospital staff has been preceded by the patients attending another patient with AIDS professionally.¹²⁰⁻¹²² The only confirmed case of the AIDS virus being acquired by a hospital worker as the result of her work was a British nurse in whom seroconversion was detected 49 days after she was accidentally injected with traces of the blood of a patient with AIDS.¹²³ In 1984 Belani *et al.* also reported the case of a 33 year old black male hospital cleaner who belonged to none of the known high risk groups and apparently had no contact with any patient with AIDS known in the hospital but who began to exhibit signs of AIDS 14 months after prophylactic gammaglobulin had been administered after his accidentally pricking himself with a needle¹²⁴; however, there have been many cases of AIDS in which it has been impossible to identify any known risk factor^{120 125} and the mere fact of the accidental prick having preceded the onset of AIDS is insufficient for this case to be attributed to occupational hazard. In the United States two other cases of hospital workers being pricked by blood-stained needles before acquiring the virus have been reported^{126 127} but in these cases too it was impossible to prove conclusively that these accidents were in fact the means of transmission; and several clinical, immunological, and serological studies of groups of hospital workers who were either in frequent contact with patients with AIDS or their biological products

or who had been pricked or soiled with blood from patients with confirmed AIDS have failed to discover any cases of AIDS or seroconversion among the subjects studied.^{124 128-134} Gerberding *et al.* have reported the case of a bronchioscopist who, on pricking himself with a needle contaminated by lung tissue from a patient with AIDS acquired hepatitis B, which showed itself 15 weeks later (no prophylactic measures had been taken) but in whom no immune response to HTVL-III virus could be detected even after 15 months.¹³⁵

Perhaps the low incidence of transmission of AIDS by needle pricks (one case of seroconversion in over 650 accidents¹³⁶ as against an acquisition rate of 20-30% in the case of hepatitis B) may be due to the low concentration of infectious particles in the blood (10^4 viral particles per millimetre as against 10^{13} in the case of hepatitis B).¹³⁷ Medical and paramedical staff in contact with patients with AIDS or their biological products should nevertheless scrupulously observe the hygienic recommendations of the University of California, the Atlanta Center for Disease Control, the Hospital Infection Society Working Party on AIDS,¹³⁷⁻¹⁴⁵ and others,¹⁴⁶⁻¹⁴⁸ which are basically identical to those laid down for hepatitis B. It should also be remembered that, as Das *et al.* have pointed out, the risk of AIDS being contracted by hospital staff during the course of their duties derives not only from contact with samples from infected patients but also from the use of commercial products prepared by pooling the sera of many individuals.¹⁴⁹

RISK OF INFECTION IN THE LABORATORY

The laboratory is for many reasons an area of particularly high risk. Procedures such as centrifugation, the opening of culture vessels, or the seeding of agar plates favour the formation of aerosols that may be inhaled¹⁵⁰⁻¹⁵²; the use of oral pipettes and the habits of smoking, eating, or drinking in the laboratory involve the risk of ingesting pathogens; and the use of needles and the unwary handling of animals brings with it the risk of cutaneous inoculation. Observance of correct microbiological procedures and the use of safety equipment nevertheless greatly reduce the risk of infection in the laboratory. Most laboratories in developed countries have codes of good practice in the form of either voluntary recommendations or legal requirements,¹⁵³ and as part of its special programme on safety measures in microbiology the WHO has recently published a biological safety manual for laboratories.¹⁵⁴

Measures for the prevention of infection among health workers may thus be summed up as follows.

(1) Susceptible members of the staff should be identified by means of periodic check-ups.

(2) Subjects susceptible to diphtheria, tetanus, hepatitis B, and rubella should be immunised and possibly those susceptible to influenza, parotiditis, and measles also.

(3) All personnel should be taught and trained in safety measures.

(4) Codes of practice should be adopted.

(5) The architectural design of laboratories should be suited to their function.

(6) Appropriate isolation and disinfection measures should be applied both to the material handled and the environment in which it is handled.

(7) An epidemiological system for the surveillance of infection among hospital workers should be set up.

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