

World at work: Hospital pharmacy clean-rooms

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An overview of potential hazards and preventive measures

Clean-room technology is a complicated and rapidly growing industry, and although many working processes rely on clean-rooms, this article is solely concerned with clean-room working in UK hospital pharmacies, and the associated regulations. In UK hospitals, drug preparations such as antibiotics and cytotoxics were traditionally prepared at the bedside until the working party on the addition of drugs to intravenous infusion fluids (the Breckenridge Report, 1974) made this type of preparation unfeasible. Since then, intravenous preparations have been prepared centrally under the control of pharmacy departments. The UK COSHH regulations issued in 1989 and the Consumer Protection Act (1987) also affected the way in which pharmaceuticals were prepared in hospitals, considering the health and welfare of the patients, healthcare workers, and pharmacy workers, as well as the products. Commonly prepared products in hospital pharmacy clean-rooms include cytotoxic drugs, total parenteral nutrition (TPN; a food replacement given to patients who are not able to eat), and central intravenous additive service (CIVAS; fluids with antibiotics or pain relief added). Although TPN is not harmful to the pharmacy worker, the product is administered intravenously and must be prepared under the strictest of conditions; with antibiotic preparations, the staff also need to be protected from the product, as well as the product being protected from staff. With the preparation of cytotoxic drugs which can be used in cancer treatment, there is even greater need to minimise the exposure to staff, and as the patients are often immunocompromised because of their treatment, controlled conditions are even more imperative.

TASKS OF THE JOB

To achieve the goals recommended by the guidance mentioned above, the use of clean-rooms has become necessary. The cleanliness of these is achieved and maintained by controlling the environment, workforce, products, and processes in the room. Environmental

controls can include maintaining room temperature and humidity, filtering the air entering the room, easily cleaned fixtures and fittings in the room, solid walls ceiling and floor, flat surfaces, strict room cleaning schedules, and routine testing for microbial contamination. Control of contamination by the workforce is the biggest challenge to maintaining a clean-room, due to bodily microorganisms on hair, hands, and feet, as well as shed skin cells. Clean-room procedures involve covering these body areas to prevent contamination in accordance with a strict process, including the removal of all make-up and jewellery (wedding band excepted), all personal items being left outside, shoe covers, all over coverage by wearing a clean-room suit, and "still" working to avoid disturbing the airflow. Depending on the size of the pharmacy unit and the number of clean-rooms, most rooms can accommodate up to three people, and although two people working independently in a clean-room may be more typical, solitary working is not uncommon in most UK hospital pharmacy clean-rooms. Most pharmacy clean-room workers tend to be female due to the higher prevalence of females working within hospital pharmacies, and as pharmacy is a growing profession, there is a wide range of ages represented.

Modern technology has seen the development of modular, purpose built clean-rooms, which are self contained portable see-through glasshouses. However, within the UK hospital pharmacy system, most clean-rooms are older and have been made by the conversion of existing rooms. There are two main types of converted clean-room: (i) the unidirectional room (laminar flow); and (ii) the non-unidirectional room (conventional turbulent). Unidirectional flow rooms are more expensive to build than non-unidirectional rooms and are not usually chosen for pharmaceutical operations. Laminar airflow in the clean-room can either be an across-flow or a down-flow, while in conventional turbulent rooms, ceiling diffusers are fitted, similar to those found in offices and shops. Clean-room

air differs from the air in such commercial premises in that it is filtered through high efficiency particulate abstractor (HEPA) filters, removing all but the smallest particles from the air before entering the room from the ceiling. The amount of air supplied to a clean-room is much greater than that required solely for ventilation and comfort, with the main purpose being to "sweep" the room with clean air. Typically, 20 room-volumes are desirable for areas where products such as TPN are prepared. Clean-rooms also operate at higher pressures than any surrounding rooms, in order to prevent contamination by air from other rooms.

Trays with the "raw" items required for product preparation are readied in an outside support room, then sprayed with alcohol and placed into a one-way transfer hatch, with materials already removed from outer packaging which may shed particles. Trays are passed through the transfer hatch, and disinfected a second time by spraying/dunking with alcohol to remove the majority of microbiological contamination. Raw material trays are then placed into the laminar flow workspace or isolator cabinet, where products are prepared to specific instructions, using aseptic techniques to ensure sterility. Preparation of batches of products requires prolonged seating at work-spaces or cabinets, with fine motor movements required from both hands, often in continuous extended positions. Finished products are removed from the cabinet/workspace unit through a different outgoing hatch, to then be externally packaged, before being routed to the outer room through the specific outgoing transfer hatch.



Figure 1 Clean-room worker gowning and gloving on the "clean-room" side of the changing room.



Figure 2 Product bags being made inside the isolator cabinet.



Figure 3 Prepared product being removed from isolator about to be sprayed with alcohol.

HAZARDS OF THE JOB

Paradoxically, the greatest threat to workers' wellbeing may be from the unusual working conditions in clean-rooms designed to ensure the quality of products for patients. Although a sanitised and highly controlled environment, clean-rooms contain the potential to be harmful to the workers within, not least in terms of chemical and physical hazards.¹ It is hypothesised from psychological, toxicological, physiological, and ergonomic knowledge that the working conditions within

clean-rooms can possibly lead to problems for clean-room staff. In addition, there may be direct behavioural effects of the environment that have been shown to compromise health in other clean-room workforces; these will be highlighted.

Toxicological/chemical hazards

Exposure to products and raw materials in clean-rooms is not always optimally controlled, despite isolator cabinets and laminar flow workspaces; measurable amounts of cytotoxic drugs have been

detected on isolator cabinet floors, along with evidence of very low level drug absorption of some cytotoxic drugs. Evidence suggests this may be contamination on drug vials delivered from manufacturers, rather than leakage from the isolators.² Anecdotal reports of exceptionally high levels of ethanol in clean-rooms following the spraying of raw materials brought into the room are not uncommon (this can be seen in the accompanying video clip; see *OEM* website: <http://www.occenvmed.com/supplemental>).

Musculoskeletal hazards

Working at pharmaceutical isolators involves being seated for prolonged periods, engaging in repetitive work while reconstituting, capping, and labelling vials. Minibag+ (a sealed system containing the diluents and antibiotics, that does not require needles) was introduced to help reduce risks while adding to intravenous bags and to help with safe manipulation at the bedside. Clean-room workers can regularly be required to compose up to 200 units of this at a time. Although not heavy, TPN bags and trays used in pharmaceutical preparation are similar in weight and dimension to loads used in studies where muscular strain has been found to be a reality for many seated workers.³ Other studies have also found uplifted and unsupported postures—similar to cabinet working—to be associated with an increased risk of neck and shoulder problems.⁴

Heat stress

Staff in clean-rooms have to wear non-shedding clothing, gloves, masks, and shoe covers, with the skin almost totally covered. Such protective clothing affects the level of heat stress for the wearer,⁵ and if taking everyday clothing as a baseline, commonly worn suits in clean-rooms (such as those made from Tyvek) can add the equivalent of 10.6°C to the heat stress of workers. Even moderate heat stress can decrease arousal and therefore reduce performance; given the added heat effects from clean-room clothing and also the heat from isolator cabinets, heat stress is a serious potential threat to workers in clean-rooms. Some studies have shown that the low humidity used in clean-rooms can also be associated with facial dermatitis problems.⁶

Dehydration and urinary tract infections

Because of the time consuming process of changing clothes when entering and leaving the clean-room facility, many workers tend to drink less water and go to the bathroom less frequently during a

shift. Evidence from industrial clean-rooms shows there to be significantly more urinary tract infections (UTIs) in clean-room workers who drink less water and subsequently void less, and that voiding three times or more during a shift can be a behaviour that protects against UTIs.⁷

Unstimulating environments

As outlined above, staff often do not have access to radios or mobile phones, and clean-room units often do not have windows, and as such constitute an unusually quiet, isolated, and impersonal working environment. Studies of isolated and remote working environments often find negative effects (social isolation and open conflict with others) in workers confined for prolonged periods, although these are often only short term and reversible.⁸ Higher arousal is found in individuals operating in visually complex and colourful environments,⁹ while workers in environments with an absence of natural daylight consistently show negative psychological and physical effects such as visual discomfort, headaches, colds, tiredness, and stress.¹⁰

The potential of such effects occurring in clean-room workers is theoretically large due to the absence of windows and corresponding loss of daylight, and a lack of sounds and external cues from the "outside" world. The effects of bright harsh lighting (essential in clean-rooms) can be varied, but reviews of the literature conclude that bright light tends to improve eagerness and performance, and reduce tension.¹¹ Concerns about the psychological effects of full spectrum fluorescent lighting include depressed mood and behaviour.¹² However, the effects of lighting are not always uniform and it is understood that there can be variation between individuals in their light preferences.¹³ It remains to be discovered what the separate impact of both isolated working and unusual working environments may be, and what the importance may be of any interaction between the two in causing adverse effects in workers.

Shift working

Some studies have found that workers in clean-rooms can be just as susceptible to the adverse effects of shift changes, such as fatigue and weight gain, as other workforces.¹⁴ Although it is likely that such effects are brought about by changes in shift patterns and not the clean-room per se, it is possible that the lack of outside environmental cues and

stimulation may make adaptation to any shift changes in such indoor environments harder for workers.

PREVENTIVE MEASURES

Because pharmacy clean-room working has not been subjected to any biopsychosocial investigation for detrimental effects on workers, there are no special preventive measures in place to assist clean-room workers. However, the hazards highlighted above are certainly indicative that there is a potential for effects on worker wellbeing in clean-rooms, be it on ergonomic, hygienic, psychological, and toxicological planes; established knowledge would suggest that the following preventive measures could improve this unique and unusual working environment.

- Dunking (rather than spraying) raw materials with alcohol to reduce the amount of excess alcohol in the environment
- Ensuring a contamination-free status of products from manufacturers to reduce the potential for cross-contamination
- Allowing personalisation of clean-room environments with respect to decoration, lighting, and soundscapes (e.g. music) to improve alertness
- Selection of the lightest and most comfortable non-shedding suits available to improve comfort and reduce heat stress
- Provision of temperature and humidity controls (adjustable within operational limits) to increase comfort and reduce potential of skin problems
- Provision of skin-care and moisturising products to prevent facial dermatitis
- Encouragement and provision of drinking water to ensure regular voiding and reduction of UTI risk
- Provision of regular breaks to encourage voiding behaviour, improve alertness, and ensure a rest from awkward posture-working
- Provision of laminar flow work-spaces (when viable) to improve worker posture, and use of cabinets with adjustable foot-rests
- Ensuring that communication/intercom systems between clean-room and other areas are working and accessible.

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A video of a workplace visit to a clean-room facility is available on the OEM website (<http://www.occenvmed.com/supplemental>)

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