Do warming blankets increase bacterial counts in the operating field in a laminar-flow theatre?
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Patient warming systems are used routinely to prevent hypothermia under anaesthesia. Airflow from warming blankets may potentially influence bacterial counts either by pumping ‘dirty air’ from floor level to the operating area or by blowing the patients’ skin cells into the operating field from airflow under the blanket. Using slit-air sampling we analysed the air quality within a laminar-flow theatre at a simulated operating site. We assessed the effect of ‘high shedding of skin’ under the blanket using volunteer patients with psoriasis. We also simulated general theatre activity outside the laminar-flow area in order to determine whether the bacterial counts in the operating field were affected.

No colonies were grown in any of the groups tested and our results suggest that the patient warming system does not influence bacterial counts at the operating site in an ultraclean air-ventilated theatre, even with patients who have high shedding of skin cells.

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The benefits of using warming blankets to prevent hypothermia are well documented in the literature on anaesthesia. There is concern that air for the blanket is taken from floor level, outside the laminar flow, and pumped into the operating area. In addition to this potential source of contamination, air blown through holes on the undersurface of the blanket over the patient could theoretically pass colony-forming units (CFUs) to the operating area. Avidan et al.\(^1\) have shown that convection warmers can harbour potentially pathogenic organisms.\(^2\)

Most infections associated with implants are caused by organisms introduced at the time of surgery and direct contamination may theoretically arise from patient warming systems.\(^2\) When ultra-clean ventilation is used with clothing which is designed to minimise the dispersion of bacteria there should be less than 1 CFU per m\(^3\).\(^3,4\) This reduces the incidence of infection of joints by 50% compared with plenum-ventilated theatres.\(^5\) The British Orthopaedic Association recommends that all joint replacements should be carried out in a laminar-flow, ultra-clean-air theatre.\(^6\) Since the consequences of infection, especially in joint replacement surgery, are serious and costly, we have assessed whether warming blankets influence the quality of the air at the operating site.

Patients and Methods

We evaluated the effect of the Warm Touch (Mallinckrodt Medical, USA) warming system on the quality of the air delivered by the Howorth airtech Ex Flow 90 laminar-flow ultra-clean-air-ventilated theatre. The airflow is passed through a high-efficiency particulate air (HEPA) filter. The air for the warming blanket is similarly passed through a HEPA filter before entering the blanket. The quality of the air in the theatre is regularly tested according to standards described in Health Technical Memorandum 2025.\(^3\)

Air samples were taken 30 cm from the simulated operating site using the Sampler Air System according to guidelines described by Whyte et al.\(^4\) The apparatus samples air at 180 l/min directly on to tryptone glucose yeast agar plates. The plates were incubated at 37°C for 48 hours and the number of colonies counted. The sampler can be set from 1 to 15 with each increment representing 20 seconds of sample time or 60 l of air. In the presence of a low level of contamination a large volume of air must be sampled in order to obtain a statistically valid result. With higher levels of contamination a smaller volume is sampled to avoid saturation of the plates, which makes accurate counting of the colonies difficult.

A pilot study to assess baseline contamination revealed low levels of CFU/m\(^3\) in our theatre and the sampler was therefore set to 15 for each plate, sampling 0.9 m\(^3\) per test.

Health Technical Memorandum 2025 states that to ensure minimal contamination of wounds from the air, a concentration of less than 1 CFU/m\(^3\) would be required.
Table I. Details of the groups of people involved in testing the effect of warming blankets on bacterial counts in the operating field in a laminar-flow theatre

<table>
<thead>
<tr>
<th>Group</th>
<th>Details</th>
<th>Variables tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Empty theatre</td>
<td>Baseline counts</td>
</tr>
<tr>
<td>B</td>
<td>People outside laminar flow</td>
<td>Effect of activity outside laminar flow</td>
</tr>
<tr>
<td>C</td>
<td>Warmer switched on, people outside laminar flow</td>
<td>Testing filter in warming unit</td>
</tr>
<tr>
<td>D</td>
<td>Patient A (no skin condition) on table, blanket, not turned on</td>
<td>Groups D to K</td>
</tr>
<tr>
<td>E</td>
<td>Patient A warmer on</td>
<td>Effect of patients with varying levels of skin cell shedding +/- blanket</td>
</tr>
<tr>
<td>F</td>
<td>Patient B (mild psoriasis) warmer off</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Patient B warmer on</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Patient C (moderate psoriasis) warmer off</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Patient C warmer on</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Patient D (severe psoriasis) warmer off</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Patient D warmer on</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>Patient A warmer on, ‘wound’ isolated by impermeable drapes, people</td>
<td>Normal theatre environment without the scrub team</td>
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</tbody>
</table>

Our small pilot study confirmed counts similar to this level. Figure 1 shows the probability of detecting 1 CFU/m$^3$ against the volume of air sampled. If six plates are exposed on a setting of 15, 5.4 m$^3$ of air are sampled. This gives 97% confidence in detecting 1 CFU/m$^3$, and six plates were therefore used for each group.

Table I shows the details of the test groups. Group A was a baseline test of the HEPA filter in the theatre airflow. In groups B, C and L, six people wearing standard cotton theatre clothing walked around the theatre outside the laminar flow to simulate normal activity. In order to eliminate the variations in CFUs, theatre staff were not allowed inside the laminar-flow area. Groups D to K tested whether varying degrees of skin shedding influenced the counts. We recruited volunteers from the dermatology clinic. Group C tested the efficiency of the HEPA filter in the warming unit. In group L, patient A was draped as for a total hip replacement without the skin preparation. This simulated the normal theatre environment without the scrub team. Two plates were used to sample air at floor level just outside the laminar flow, adjacent to the intake of the warming unit. In order to assess visually the influence of blanket airflow on the theatre laminar flow we used a smoke test.

**Results**

No CFUs were grown on any of the plates exposed inside the laminar flow. Of the two samples taken at floor level, one grew 44.4 CFU/m$^3$ and the other was saturated with colonies such that it was impossible to count CFU/m$^3$. The smoke test revealed that the blanket airflow had no significant effect on theatre airflow.

**Discussion**

Our results show no detectable air-borne contamination 30 cm from the simulated operating site in any sample group. The samples at floor level showed a predictably high level of contamination. The HEPA filter in the warming
unit therefore seemed to be fully functional. Activity outside the laminar flow did not influence the counts inside. The theoretical risk of airflow under the blanket passing CFUs from the patient to the operating area was not confirmed by this study even in patients with high shedding of skin cells.

The effect of the blanket in non-laminar-flow theatres was not assessed. Higher background counts in plenum-ventilated theatres means that very large numbers of air samples would be required in order to detect a slight increase in contamination. If a statistically powerful study cannot detect a small increase in contamination in an ultraclean-air theatre, we do not believe that meaningful data could be collected in a non-laminar-flow theatre.

The WarmTouch patient warming system does not increase the number of CFUs at the operating site and activity outside the laminar flow does not influence counts on the table. Since we measured very high bacterial counts at floor level outside the laminar-flow area near the warming systems air-pump inlet, we recommend that the HEPA filter in the warming unit be changed according to the instructions from the manufacturer.

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References