Operating Room Ventilation

- In general there are 4 sources of infection in the operating room: direct contact with the surgical team, instruments, the patient and airborne contamination.
  - Ventilation systems address the latter most.
  - Airborne contamination accounts for 95% of wound infections, as humans shed 3000-50000 micro-organisms per minute
  - 90% of shed bacteria are from the neck level down – rest is from talking / coughing

- Air is usually drawn in from roof layer and pass via a high-efficiency particulate air (HEPA) filter, to reduce filter particles of 0.5 microns in size (99.97% efficient)

- Plenum systems:
  - Air drawn in from ceiling or wall vents and let out at floor level
  - Positive pressure with 15-25 air changes per hour
  - < 180 CFU (colony forming units) bacteria per m³

- Laminar flow:
  - Entire body of air within a designated space moving with uniform velocity along parallel flow lines
  - Minimum eddies and definition of ultra-clean laminar flow theatres is with <20 CFU/m³ at periphery and <10 CFU/m³ at centre
  - Requires nearly 100% coverage of ceiling with HEPA filters

- Horizontal laminar flow:
  - Not used in theatres as more susceptible to eddy currents by obstacles or theatre personnel and shown to actually increase TKR joint infections (Salvati 1982)

- Vertical laminar flow (rate of 0.3 m/s)
  - Usually restricted to the centre of the operating theatre (room-in-a-room principle)
  - Susceptible to entrainment of particles into field, but objects/personnel standing at periphery of laminar flow area
  - This is avoided by full enclosure
  - Reduces joint deep infection from 7% to 0.5% when combined with body exhaust suits (Charnley, 1972)
  - Ultra-clean air reduced joint sepsis by a factor of 2.6 (Lidwell, MRC 1982)

- Ex-flow System (exponential flow / Howorth enclosure)
  - Flow lines pass vertically down and outward (inverted trumpet)
  - Avoids peripheral entrainment
  - Only requires partial vertical panels to enclose the area
  - Achieves up to 500 air changes per hour and allows for barns-theatre design – open space with multiple operating areas

(www.howarthgroup.com)
**prophylactic measure** | **deep joint sepsis reduction factor**
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antibiotic loaded cement | x 11
systemic antibiotics | x 4.8
ultra-clean air (vs. +ve pressure) | x 2.6
plastic isolators | x 2.2
body exhaust suits | x 2.2
**ultra-clean air + body exhaust suits + prophylactic antibiotics** | x 14

Table 1 prophylactic measures identified by the MRC trial (Lidwell OM 1982, BMJ, 285; 10-14). Multi-centre RCT with 2.5 years follow-up with three randomised arms: positive pressure theatre (n=4133), ultra-clean (n=1789) theatre, and ultra-clean with body-exhaust suits (n=2133).