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Risk-based ventilation of patient rooms in hospitals, and its costs –is the ventilation worth the price?

Objectives: Many infection control governmental bodies and international societies have issued recommendations for minimum ventilation in patient rooms in hospitals in the context of covid-19 and before. The recommendations can be summarized to 4-6 air changes per hour (ACH) or 40-60 liters per second and patient. These recommendations may in part be risk-based and in part be issued to reach a comfortable indoor environment. In Sweden the minimal airflow in a standard single patient room is 20 l/s, reaching about 1.5 ACH. We investigated if a modelled risk-based approach together with a cost analysis could be used for a basis for new ventilation rate recommendations. Modeled risk reduction of a higher ventilation rate was analyzed and the costs this would ensue with mechanical ventilation in a Nordic country.
Methods: The airborne risk reduction of different pathogens were calculated with AIRC-tool v3 in a steady state scenario with proposed Quanta emission rates ranging from 0.2 (influenza) to 15 (measles) in a 18 m2 x 2.7 m room with a 60 min exposure time. Results were also compared using "New dose response model" (Aganovic). The costs were calculated using a ventilation installation cost calculation tool used in Sweden (Wiksells©) and additional costs of extra installation space needed. The energy consumption was calculated for an outdoor climate comparable to Stockholm using electricity for fans and district heating and cooling for temperature regulation to reach an indoor temperature of 21-25 ℃. Cost were calculated as the present value, with a 30-year calculation period. No air-recirculation was assumed in the calculations, but heat recovery with 85% efficiency. Only costs directly and indirectly associated with airflow was included.
Results: The airborne transmission risk for Covid-19 (ERq=5.4) were calculated to 14%, 10%, 8% and 7% at 0, 2, 4, 6 ACH, resulting in a risk reduction of 19 % when increasing the ventilation rate from 2 to 4 ACH and another 15% when increasing ventilation from 4 to 6 ACH. With the Influenza (ERq= 0.17) example the risk decreases from 0.2% to 0.15% resulting in a 30% risk reduction comparing 2 and 4 ACH. With measles (ERq=15) the risk is reduced from 24% to 21% resulting in a 12% risk reduction.
The cost of increasing the ventilation rate from 2 to 4 ACH increases almost linear with about 90 €/m2 per each additional ACH and with the example from above from 270 €/m2 at 2 ACH (including 45 €/m2 for energy, 67 €/m2 for spaces and 158 €/m2 for installations) to 450 €/m2 at 4 ACH (including 90 €/m2 for energy, 130 €/m2 for spaces and 230 €/m2 for installations, resulting in a 67% increased cost per m2.
Conclusions: The relative risk reduction of airborne transmission achieved by increasing ventilation rate is calculated to 20% for each additional ACH for the least transmissible pathogens and 5% for each ACH at high transmissibility. But the relative risk reduction achieved decrease with increasing ACH. Costs increases linear up to 6 ACH, after which they tend to increase exponentially). The remaining question is what is the most cost efficient ventilation rate. From these calculations cost effectiveness seems to be best when increasing from a low ventilation rate (1-1.5 ACH) to an intermediate level (3-4 ACH). For higher ventilation rates further relative risk reduction tend to be more expensive, but nevertheless meaningful and perhaps lifesaving. The remaining question is if we can afford to install a better ventilation and if the risk reduction is worth the price –economically and in the context of the climatic footprint.

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