Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

**Airborne transmission from room to room**

Even if buildings have well-functioning ventilation systems, which is the case in most Nordic countries, it does not mean that airborne infectious disease transmission from room to room could be avoided.
Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

The spread of airborne pollutants depends on air movement or airflow.

Two prerequisites must be fulfilled for airflow from one room to another: a pressure difference and a leakage path.

Pressure differences in buildings can be created through wind forces, temperature differences and mechanical ventilation.

There must be a careful design of a mechanical ventilation system to accomplish directed airflow in a building, whereas the pressure differences created by wind and temperature are considered disturbances.

Depending on the balance between the supplied and exhausted airflows, a mechanical ventilation system can create a pressure difference between the room and adjoining spaces, both outside and between adjacent rooms.

The pressure difference depends on the airtightness of the building envelope and the interior walls and airflow balance.
**Ventilation system design and the risk areas for spreading airborne contaminants in office buildings**

Most of the new office buildings in Nordic countries are equipped with balanced mechanical ventilation systems.

The most common solutions in the office buildings are variable-air-volume (VAV) systems.

The ventilation systems should be able to precisely control the indoor climate or otherwise the target values of indoor temperature or CO₂ concentration may not be fulfilled.

![Photo: Lindab, Denmark](image)

---

**Ventilation system design and the risk areas for spreading airborne contaminants in office buildings**

**Typical Design of Swedish Office Buildings**

Transferred air is often used in Swedish offices.

The air is supplied to the office rooms and transferred into the adjoining corridor where it is exhausted.

Special air terminal devices are used to accomplish this, allowing air to pass from the room to the corridor. These devices constitute a known opening, a controlled leakage path for the air.
Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

Typical Design of Danish Office Buildings

Supply and exhaust air is installed in every room. Equal volumes of air are brought into and exhausted out of the building. However, in a room, the supplied air volume is not equal to the exhausted air volume when the supply air volume varies in a variable air volume system.

Thus, a common exhaust is used, and the exhaust airflow rate from each room is an average airflow rate from several given rooms.

Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

Typical Design of Norwegian Office Buildings

In Norway, the most common ventilation system in new office buildings is the balanced-room ventilation system.

In such systems, the supply and exhaust sections usually depend on each other; thus, the variation is often equal for the supply and exhaust air. This dependence cannot cause over or under pressure in the rooms.
All three zones have the same volume (27 m$^3$), but different supply ventilation rates.

The zones were modelled assuming complete mixing of air.

Bi-directional airflow between offices and the corridor was modelled using a door model with a leakage area of 0.02 m$^2$ when the door is closed.

Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

Simulation study

Source of contaminant

Typical increase of PM10 in relation to CO$_2$, comparing breathing and talking, is shown in the figure, strong correlation.
Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

Simulation study

Table shows supply and exhaust ventilation rates for each ventilation system, together with the airflow passing through the doors.

<table>
<thead>
<tr>
<th></th>
<th>Supply ventilation rate [l/s]</th>
<th>Exhaust ventilation rate [l/s]</th>
<th>Airflow through doors [l/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Office 1</td>
<td>Office 2</td>
<td>Corridor</td>
</tr>
<tr>
<td>Denmark</td>
<td>60</td>
<td>30</td>
<td>17</td>
</tr>
<tr>
<td>Sweden</td>
<td>60</td>
<td>30</td>
<td>17</td>
</tr>
<tr>
<td>Norway</td>
<td>60</td>
<td>30</td>
<td>17</td>
</tr>
</tbody>
</table>

Tabel Pressure differences [Pa] across doors

<table>
<thead>
<tr>
<th></th>
<th>Doors open</th>
<th>Doors closed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Office 1 – Corridor</td>
<td>Office 2- Corridor</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.001</td>
<td>-0.001</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.003</td>
<td>0.001</td>
</tr>
<tr>
<td>Norway</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

### Denmark

<table>
<thead>
<tr>
<th></th>
<th>Supply ventilation rate [l/s]</th>
<th>Exhaust ventilation rate [l/s]</th>
<th>Airflow through doors [l/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office 1</td>
<td>60</td>
<td>17</td>
<td>45</td>
</tr>
<tr>
<td>Office 2</td>
<td>30</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Corridor</td>
<td>17</td>
<td>17</td>
<td>Door 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Door 2</td>
</tr>
</tbody>
</table>

### Sweden

<table>
<thead>
<tr>
<th></th>
<th>Supply ventilation rate [l/s]</th>
<th>Exhaust ventilation rate [l/s]</th>
<th>Airflow through doors [l/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office 1</td>
<td>60</td>
<td>0</td>
<td>107</td>
</tr>
<tr>
<td>Office 2</td>
<td>30</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>Corridor</td>
<td>17</td>
<td>0</td>
<td>30</td>
</tr>
</tbody>
</table>
Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

Conclusions

The existing ventilation systems of Swedish office rooms can contribute to spreading airborne contaminants from office rooms to corridors but not to adjacent rooms.

Airflows should be supplied and exhausted from each room and from each corridor to avoid spreading airborne contamination to corridors.
Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

Conclusions

The existing ventilation systems of Danish office rooms can contribute to spreading airborne contaminants from room to room when the room demands are different.

The extracted airflows must be equal to the supplied airflows of each room to achieve the correct pressurization.

Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

Conclusions

The existing ventilation systems of Norwegian office rooms do not spread airborne contaminants from room to room or from room to corridor, even if the room demands are different.
Ventilation system design and the risk areas for spreading airborne contaminants in office buildings

HYPOTHESIS AND THEORY ARTICLE

Ventilation System Design and the Coronavirus (COVID-19) Provisionally accepted The final, formatted version of the article will be published soon. Notify me

Ali Reza Afshari*, Göran Hultmark1 and Peter V. Nielsen1
1Aalborg University, Denmark

Thank you for your attention