COVID-19: Overview of Contamination of the Healthcare Environment and Effective Surface Disinfection Technologies

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DISCLOSURES
2020-2021

• Consultations
  ■ Professional Disposables International (PDI)

• Honoraria
  ■ PDI
COVID-19: Overview of Contamination of the Healthcare Environment and Effective Surface Disinfection Technologies

The healthcare environment can be contaminated with SARS-CoV-2 and serve as a fomite, leading to possible transmission to personnel and patients.

Role of environment in SARS-CoV-2 transmission and environmental disinfection
Transmission of SARS-CoV-2

- Droplet (< 6 feet)
- Direct-person-to-person via respiratory droplets
- Indirect (via the contaminated environment); not main route
- Asymptomatic (infection transmission demonstrated)
- Pre-symptomatic-highly likely
DEATHS FROM COVID-19 AND OTHER PANDEMICS AND WARS, US

Deaths from Wars and Pandemics

- HIV/AIDS, till 2018: 700,000
- 1918 "Spanish" Flu: 675,000
- COVID-19, est. 1 Jan. 2021: 407,000
- World War II: 405,399
- COVID-19, 4 Sept. 2020: 187,000
- World War I: 116,516
- 1968 Flu pandemic: 100,000
- Vietnam conflict: 58,220
- Korean war: 36,574
- Operation Iraqi Freedom: 4,418
- 9/11 attack: 2,977
- Persian Gulf War: 2,586

Deaths from Wars and Pandemics
COVID-19: Overview of Contamination of the Healthcare Environment and Effective Surface Disinfection Technologies

Role of environment in transmission and environmental disinfection
Environmental Contamination Leads to HAIs

- Evidence environment contributes
- Role-MRSA, VRE, *C. difficile*
- Surfaces are contaminated ~25%
- EIP survive days, weeks, months
- Contact with surfaces results in hand contamination
- Disinfection reduces contamination
- Disinfection (daily) reduces HAIs
- Rooms not adequately cleaned
Admission to Room Previously Occupied by Patient C/I with Epidemiologically Important Pathogen


- Results in the newly admitted patient having an increased risk of acquiring that pathogen by 39-353% 
- For example, increased risk for *C. difficile* is 235% (11.0% vs 4.6%)
Acquisition of EIP on Hands of Healthcare Providers after Contact with Contaminated Environmental Sites and Transfer to Other Patients
ACQUISITION OF MRSA ON HANDS/GLOVES AFTER CONTACT WITH CONTAMINATED EQUIPMENT
Contaminated Gloves to Patient
Acquisition of EIP on Hands of Patient after Contact with Contaminated Environmental Sites and Transfers EIP to Eyes/Nose/Mouth
FREQUENCY OF ACQUISITION OF MRSA ON GLOVED HANDS AFTER CONTACT WITH SKIN AND ENVIRONMENTAL SITES

No significant difference on contamination rates of gloved hands after contact with skin or environmental surfaces (40% vs 45%; p=0.59)

COVID-19: Overview of Contamination of the Healthcare Environment and Effective Surface Disinfection Technologies

Learning Objectives

• Transmission of SARS-CoV-2 through environmental surfaces
• Identify three sites of the healthcare environment positive for SARS-CoV-2
• Describe at least two technologies or new research data that will eliminate the environment as a source of COVID-19
• Discuss one new COVID-19-related recommendation associated with surface disinfection in healthcare facilities
• Identify at least one new COVID-related change/innovation related to disinfection of noncritical surfaces
Learning Objectives

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Centers for Disease Control & Prevention says the virus spreads from person to person mainly through respiratory droplets from coughing, sneezing or talking in close proximity to each other, but the CDC has also said it may be possible for a person to get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose or possibly their eyes. CDC clarified while it is still possible that a person can catch it from touching a contaminated surface, it’s “not thought to be the main way the virus spreads.”
Cleaning and Disinfecting Your Facility
April 5, 2021, CDC

- Risk from touching a surface is low
- Most reliable way to prevent infection from surfaces is regularly wash your hands or use hand sanitizer
- When to clean and when to disinfect (disinfect for all other EIP)
  - Usually once a day is enough
  - Clean more frequently or disinfect: high transmission of COVID-19 in community; low numbers of people wearing masks; infrequent hand hygiene; space occupied by people at increased risk for severe illness from COVID-19
  - If person with COVID-19 within last 24h, clean/disinfect the space
Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

Survival
(hours to days)
# Human Coronavirus: Environmental Survival

Kampf G. J Hosp Infect 2020

## Table I. Persistence of coronaviruses on different types of inanimate surfaces.

<table>
<thead>
<tr>
<th>Type of surface</th>
<th>Virus</th>
<th>Strain / isolate</th>
<th>Inoculum (viral titer)</th>
<th>Temperature</th>
<th>Persistence</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MERS-CoV</td>
<td>Isolate HCoV-EMC/2012</td>
<td>10⁵</td>
<td>20°C</td>
<td>48 h</td>
<td>[21]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30°C</td>
<td>8 – 24 h</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4°C</td>
<td>≥ 28 d</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20°C</td>
<td>3 – 28 d</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40°C</td>
<td>4 – 96 h</td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td>TGEV</td>
<td>Unknown</td>
<td>10⁶</td>
<td>20°C</td>
<td>≥ 28 d</td>
<td>[22]</td>
</tr>
<tr>
<td></td>
<td>MHV</td>
<td>Unknown</td>
<td>10⁶</td>
<td>20°C</td>
<td>4 – 28 d</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td>40°C</td>
<td>4 – 96 h</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>4°C</td>
<td>3 – 28 d</td>
<td></td>
</tr>
<tr>
<td>Aluminium</td>
<td>HCoV</td>
<td>Strain 229E</td>
<td>10³</td>
<td>21°C</td>
<td>5 d</td>
<td>[23]</td>
</tr>
<tr>
<td></td>
<td>HCoV</td>
<td>Strain OC43</td>
<td>5 × 10⁶</td>
<td>21°C</td>
<td>2 – 8 h</td>
<td>[24]</td>
</tr>
<tr>
<td>Metal</td>
<td>SARS-CoV</td>
<td>Strain P9</td>
<td>10⁴</td>
<td>RT</td>
<td>5 d</td>
<td>[25]</td>
</tr>
<tr>
<td>Wood</td>
<td>SARS-CoV</td>
<td>Strain P9</td>
<td>10⁴</td>
<td>RT</td>
<td>4 d</td>
<td>[25]</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV</td>
<td>Strain P9</td>
<td>10⁴</td>
<td>RT</td>
<td>4 – 5 d</td>
<td>[25]</td>
</tr>
<tr>
<td>Paper</td>
<td>SARS-CoV</td>
<td>Strain Gvu6109</td>
<td>10⁴</td>
<td>RT</td>
<td>&lt; 5 min</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RT</td>
<td>3 h</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>RT</td>
<td>24 h</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RT</td>
<td>3 h</td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td>SARS-CoV</td>
<td>Strain P9</td>
<td>10⁴</td>
<td>RT</td>
<td>4 d</td>
<td>[25]</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV</td>
<td>Strain HKU39849</td>
<td>10⁴</td>
<td>22–25°C</td>
<td>≤ 5 d</td>
<td>[27]</td>
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<tr>
<td>Plastic</td>
<td>MERS-CoV</td>
<td>Isolate HCoV-EMC/2012</td>
<td>10⁵</td>
<td>20°C</td>
<td>48 h</td>
<td>[21]</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV</td>
<td>Strain P9</td>
<td>10⁵</td>
<td>30°C</td>
<td>8 – 24 h</td>
<td>[25]</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV</td>
<td>Strain FFM1</td>
<td>10⁷</td>
<td>RT</td>
<td>4 d</td>
<td>[25]</td>
</tr>
<tr>
<td></td>
<td>HCoV</td>
<td>Strain 229E</td>
<td>10⁷</td>
<td>RT</td>
<td>6 – 9 d</td>
<td>[28]</td>
</tr>
<tr>
<td></td>
<td>HCoV</td>
<td>Strain 229E</td>
<td>10⁷</td>
<td>RT</td>
<td>2 – 6 d</td>
<td>[28]</td>
</tr>
<tr>
<td></td>
<td>Silicon rubber</td>
<td>Strain 229E</td>
<td>10⁷</td>
<td>21°C</td>
<td>5 d</td>
<td>[23]</td>
</tr>
<tr>
<td></td>
<td>Surgical glove (latex)</td>
<td>Strain 229E and OC43</td>
<td>5 × 10⁷</td>
<td>21°C</td>
<td>5 – 8 h</td>
<td>[24]</td>
</tr>
<tr>
<td></td>
<td>Disposable gown</td>
<td>SARS-CoV</td>
<td>10⁵</td>
<td>RT</td>
<td>2 d</td>
<td>[26]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24 h</td>
<td></td>
</tr>
</tbody>
</table>
• Survival on environmental surfaces
  - Hours to days (SARS-CoV-2)
  - Depends on experimental conditions such as viral titer ($10^7$ higher than real life) and volume of virus applied to surface, suspending medium, temperature, relative humidity and surface substrates
  - Human coronavirus 229E persist on surface materials at room temperature for at least 5 days
  - SARS-CoV-2 can be viable on surfaces for 3 days (plastic, stainless steel ~2-3 days, cardboard ~24h)
  - Suggest transmission of SARS-CoV-2 may occur
Contamination Rate
SARS-CoV-2 RNA
~20 studies,
0-75% (median 12.1%)
Contamination of SARS-CoV-2 RNA by PCR on environmental surfaces and medical devices have been documented. Rate varies from 0-75% (median 12.1%).
Detection of SARS-CoV-2 RNA does not represent the presence of viable virus. Further, even the detection of viable virus, does not mean an infectious dose of SARS-CoV-2 is present. Infectious dose for SARS-CoV-1 estimated to be 280 viral particles to cause disease in 50% of the population.
Percentage of contaminated swabs from surfaces samples, in rooms with any contamination, SARS-CoV-2
Chia et al. Nature Communication 2020
Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

Raises concerns that contaminated surfaces leads to contamination of the gloves and hands of HCP and transfer
Contamination rate depends on the status of cleaning and disinfection in environmental sampling rather than symptomatic status of COVID-19 patients.

Environmental studies sampled before cleaning/disinfection reported infrequent to frequent contamination, while studies sampled after cleaning/disinfection revealed zero to infrequent contamination.
Do established infection prevention measures prevent spread of SARS-CoV-2 to the hospital environment beyond the patient room?
Jerry et al. J Hosp Infection 2020

Contamination rate: patient room-42% (11/26); nurse’s station-3%; post terminal clean-4% (1/25)
SARS-CoV-2 RNA was detected more frequently on environmental surfaces in medical areas of designated COVID-19 hospitals (24.8%) than in living quarters (3.6%), suggesting the need for dedicated use of medical devices and strict cleaning/disinfection of shared patient care items.
Environmental Contamination by SARS-CoV-2 RNA in Medical Areas (36/145-24.8%) vs Living Quarters (2/55-3.6%)

Wu S et al. Am J Infect Control. 2020

<table>
<thead>
<tr>
<th>Areas</th>
<th>No. of tests</th>
<th>No. of positive</th>
<th>Positive rate (%)</th>
</tr>
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<tbody>
<tr>
<td>Medical areas</td>
<td>145</td>
<td>36</td>
<td>24.83</td>
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<tr>
<td>General isolation ward</td>
<td>72</td>
<td>18</td>
<td>25.00</td>
</tr>
<tr>
<td>Ward 1</td>
<td>12</td>
<td>6</td>
<td>50.00</td>
</tr>
<tr>
<td>Ward 2</td>
<td>12</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Ward 3</td>
<td>12</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>Ward 4</td>
<td>12</td>
<td>3</td>
<td>25.00</td>
</tr>
<tr>
<td>Ward 5</td>
<td>12</td>
<td>1</td>
<td>8.33</td>
</tr>
<tr>
<td>Ward 6</td>
<td>12</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>Intensive care units</td>
<td>24</td>
<td>9</td>
<td>37.50</td>
</tr>
<tr>
<td>Clinical laboratory</td>
<td>7</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Fever clinic</td>
<td>42</td>
<td>9</td>
<td>21.43</td>
</tr>
<tr>
<td>Emergency room</td>
<td>12</td>
<td>6</td>
<td>50.00</td>
</tr>
<tr>
<td>Observation room</td>
<td>4</td>
<td>1</td>
<td>25.00</td>
</tr>
<tr>
<td>Treatment room</td>
<td>4</td>
<td>0</td>
<td>0.00</td>
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<tr>
<td>Infusion room</td>
<td>4</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Diagnosis room 1</td>
<td>4</td>
<td>1</td>
<td>25.00</td>
</tr>
<tr>
<td>Diagnosis room 2</td>
<td>4</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Throat swab sampling room</td>
<td>8</td>
<td>0</td>
<td>0.00</td>
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<tr>
<td>Public area</td>
<td>2</td>
<td>1</td>
<td>50.00</td>
</tr>
<tr>
<td><strong>Living quarters</strong></td>
<td><strong>55</strong></td>
<td><strong>2</strong></td>
<td><strong>3.64</strong></td>
</tr>
<tr>
<td>Office area</td>
<td>22</td>
<td>2</td>
<td>9.09</td>
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<tr>
<td>Rest room</td>
<td>33</td>
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<td>0.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>200</strong></td>
<td><strong>38</strong></td>
<td><strong>19.00</strong></td>
</tr>
</tbody>
</table>
Contamination of surfaces occurred more extensively within the first week of illness and decreased with increasing duration of illness and lower SARS-CoV-2 RNA levels, which supports studies describing the peak viral loads and active viral replication in the upper respiratory tract of COVID-19 patients during the first week.
Extent of environmental contamination correlated with day of illness timepoint

Chia el al. Nature Communications 2020
Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

- Other studies have not demonstrated extensive environmental contamination
- Until recently, none of the environmental contamination demonstrated viable SARS-CoV-2 (4 of 21 assayed for virus; 1 virions by EM), suggesting that environmental contamination may be less extensive and infectious than expected in real world conditions when cleaning/disinfection of the healthcare environment is implemented adequately.
SARS-CoV-2 RNA was not detected on environmental surfaces in clean, semi-contaminated, or contaminated areas of isolation wards after routine cleaning/disinfection, which suggests that the routine cleaning/disinfection with List N disinfectants and hand hygiene by HCP is effective.
The environmental surfaces and medical equipment in ICU isolation room occupied by severely ill COVID-19 patients were more contaminated, suggesting that contamination may be affected by viral dispersion through frequent oral or endotracheal suction in the ICU.
# Environmental Contamination of SARS-CoV-2 During the COVID-19 Outbreak in South Korea

(Ryu et al, Am J Infect Control. 2020)

## Table

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Patient number</th>
<th>Patient status</th>
<th>Clinical syndrome</th>
<th>Respiratory symptom</th>
<th>Mask-wearing behavior</th>
<th>Days from symptom onset</th>
<th>Last (+) RT-PCR</th>
<th>Site</th>
<th>Ventilation with negative pressure</th>
<th>Hours from the last room disinfection</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>Mechanical ventilation with vasopressor</td>
<td>Severe pneumonia</td>
<td>N/A</td>
<td>N/A</td>
<td>12</td>
<td>14*</td>
<td>ICU</td>
<td>Yes</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Nasal cannula</td>
<td>Severe pneumonia</td>
<td>Dyspnea</td>
<td>Good</td>
<td>10</td>
<td>1</td>
<td>ICU</td>
<td>Yes</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>HFNC</td>
<td>Severe pneumonia</td>
<td>Dyspnea</td>
<td>Bad</td>
<td>3</td>
<td>1</td>
<td>Ward</td>
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<td>24</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>HFNC</td>
<td>Severe pneumonia</td>
<td>Cough</td>
<td>Bad</td>
<td>9</td>
<td>2</td>
<td>Ward</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>Nasal cannula</td>
<td>Mild pneumonia</td>
<td>No</td>
<td>Good</td>
<td>18</td>
<td>1</td>
<td>Ward</td>
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<td>72</td>
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<td>6</td>
<td>Room air</td>
<td>N-S</td>
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<td>14</td>
<td>14</td>
<td>Ward</td>
<td>No</td>
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<td>7</td>
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<td>8</td>
<td>Room air</td>
<td>N-S</td>
<td>No</td>
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<td>16</td>
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<td>N-S</td>
<td>No</td>
<td>Good</td>
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<td>N-S</td>
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<td>N-S</td>
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<td>Ward</td>
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<td>N-S</td>
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<td>16</td>
<td>13</td>
<td>Ward</td>
<td>No</td>
<td>184</td>
</tr>
</tbody>
</table>

**Abbreviations:** HFNC, high-flow nasal cannula; ICU, intensive care unit; N/A, not available; N-S, nonspecific.
Environmental Contamination of SARS-CoV-2 During the COVID-19 Outbreak in South Korea (A-more severe patients in ICU [6/20-30%]; B-less severe in common hospital rooms [3/22-13.6%])

Ryu et al, Am J Infect Control. 2020

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Patient number</th>
<th>Inside the room</th>
<th>Outside the room</th>
<th>Number of real-time RT-PCR-positive samples (collected surface)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td>3 of 3 target genes</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
<td>6/10</td>
<td>0/1*</td>
<td>2</td>
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<td></td>
<td>2</td>
<td>0/10</td>
<td>0/2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2/12</td>
<td>0/2</td>
<td>0</td>
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<tr>
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<td>4</td>
<td>2/13</td>
<td>0/1</td>
<td>0</td>
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<td>5</td>
<td>0/12</td>
<td>0/1</td>
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<td>1/11</td>
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<td>10-13</td>
<td>2/11</td>
<td>N/A</td>
<td>1</td>
</tr>
</tbody>
</table>

Ambu bag
Infusion pump
Pillow
Bed side rail
Patient monitor
Air exhaust damper
Fluid stand
Upper part of TV
Head of the bed
Patient monitor
Center of room floor
Seat of toilet
Side rail of patient 12’s bed
Environmental surfaces in a room occupied by a COVID-19 patient with mild upper respiratory track (URT) symptoms were extensively contaminated SARS-CoV-2 RNA (17/28, 61%) but surfaces were negative in two COVID-19 patient rooms with moderate URT symptoms after CD.
MERS-CoV and SARS-CoV potential HA transmission

- Environmental surfaces contaminated with SARS-CoV and MERS-CoV can lead to contamination of HCP hands or medical equipment, then indirect contact transmission via contact with nose, eyes, or mouth or transfer from contaminated hands to patients.

- Investigators described potential HA transmission of MERS-CoV and SARS-CoV was led by persistent contamination of environmental surfaces and medical equipment and recommended enhanced HH and CD.
COVID-19: Overview of Contamination of the Healthcare Environment and Effective Surface Disinfection Technologies

Learning Objectives

• Transmission of SARS-CoV-2 through environmental surfaces
• Identify three sites of the healthcare environment positive for SARS-CoV-2
• Describe at least two technologies or new research data that will eliminate the environment as a source of COVID-19
• Discuss one new COVID-19-related recommendation associated with surface disinfection in healthcare facilities
• Identify at least one new COVID-related change/innovation related to disinfection of noncritical surfaces
## Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

Kanamori, Weber, Rutala, Clin Infect Dis, [https://doi.org/10.1093/cid/ciaa1467](https://doi.org/10.1093/cid/ciaa1467), 28 September 2020

<table>
<thead>
<tr>
<th>SARS-CoV-2 RNA</th>
<th>Sink</th>
<th>BP monitor</th>
<th>Infusion pump</th>
<th>Keyboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed Rail</td>
<td>Floor</td>
<td>ECG monitor</td>
<td>Fluid stand</td>
<td>Phone</td>
</tr>
<tr>
<td>Bedside table</td>
<td>Toilet seat</td>
<td>Oxygen regulator</td>
<td>Hand sanitizer</td>
<td>Computer mouse</td>
</tr>
<tr>
<td>Chair</td>
<td>Toilet bowl</td>
<td>Oxygen mask</td>
<td>Trash can</td>
<td>Door</td>
</tr>
<tr>
<td>Doorknob</td>
<td>Stethoscope</td>
<td>CT scanner</td>
<td>Self-service printer</td>
<td>Glass window</td>
</tr>
<tr>
<td>Light switches</td>
<td>Pulse oximetry</td>
<td>Ventilator</td>
<td>Desktop</td>
<td>PPE storage area</td>
</tr>
<tr>
<td>Call button</td>
<td>Biosafety cabinet</td>
<td>Infant bed</td>
<td>Air outlet</td>
<td>Ambu bag</td>
</tr>
<tr>
<td>Centrifuge</td>
<td>Bed sheet</td>
<td>Urinary catheters</td>
<td>TV</td>
<td>Beepers</td>
</tr>
<tr>
<td>TV remote</td>
<td>Ventilator tubing</td>
<td>Glove boxes</td>
<td>Touch screen</td>
<td>All surfaces in nurse’s station</td>
</tr>
<tr>
<td>Elevator buttons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Environmental Contamination in COVID-19 Rooms with Severe Pneumonia
Ahn et al. J Hosp Infect 2020;106:570

Pt 1 and 2-2/48-4% (closed suction to ventilator) pt 3-13/28-46% (high-flow oxygen therapy via nasal cannula, non-invasive ventilation). Found viable virus (7/28-25%) only on surfaces within droplet distance. All air samples negative.
Environmental Contamination in COVID-19 Rooms with Severe Pneumonia
Ahn et al. J Hosp Infect 2020;106:570

Found viable virus only on surface within droplet distance.
Evidence suggests:

- The healthcare environment contaminated with SARS-CoV-2 may play a role in transmission of SARS-CoV-2.
- Medical devices commonly used in daily practice also can be contaminated.
- Environmental surfaces in rooms occupied by patients with SARS-CoV-2 RNA and shared patient care items should be regularly and rigorously cleaned/disinfected by well-trained healthcare providers using appropriate disinfectant with an emerging viral pathogen claim.
Learning Objectives

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Role of Healthcare Surface Environment in SARS-CoV-2 Transmission


• Describe at least two technologies or new research data that will eliminate the environment as a source of COVID-19
  - List N Disinfectants (>500 disinfectants, >30 chemicals)
  - “No touch” room decontamination - given cleaning/disinfection often inadequate, supplemental use of no-touch should be considered when patients with coronavirus infection are discharged
    - 5 log_{10} reduction of MHV-59, mouse analog of MERs and SARs in 10m (Bedel et al. ICHE 2016)
  - Electrostatic sprays - new research
Surface disinfection effective provided thorough cleaning/disinfection and effective product used as recommended
Effective Surface Decontamination

Product and Practice = Perfection
Effective Surface Decontamination

Product and Practice = Perfection
Recommendations for Cleaning and Disinfecting of Noncritical Surfaces and Medical Devices in COVID-19 Patient Care

• Use an EPA-registered disinfectant on the List N that has qualified under emerging viral pathogens program for use against SARS-CoV-2.

• All noncritical touchable surfaces and medical devices should be cleaned/disinfected at least once daily and when visibly soiled.

• Assess cleaning thoroughness with a validation method (e.g., fluorescent dye markers). Provide regular feedback to environmental services personnel on the thoroughness of cleaning.
CDC recommends that an EPA-registered disinfectant on the EPA’s List N that has qualified under the emerging pathogen program for use against SARS-CoV-2 be chosen for the COVID-19 patient care.

List N has >500 entries and >30 different active ingredients.
List N Tool: COVID-19 Disinfectants

https://cfpub.epa.gov/giwiz/disinfectants/index.cfm

Search EPA’s list of products for use against SARS-CoV-2, the virus that causes COVID-19, by selecting one or more of the corresponding criteria above. All products on this list meet EPA’s criteria for use against SARS-CoV-2, the virus that causes COVID-19. These products are for use on surfaces, NOT humans. At any point, click the “Show Results” button to view your customized list of results. Select as many, or as few, criteria as you would like. Click the “Clear Results” button to remove all previous selections and start over. Click “Browse All” to display all products.
List N Tool: COVID-19 Disinfectants
32 Active Ingredients

- Ethyl alcohol
- Hydrogen peroxide
- Hypochlorous acid
- Isopropyl alcohol
- Peracetic acid
- Phenolic
- Quaternary ammonium
## LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES


<table>
<thead>
<tr>
<th>Germicide</th>
<th>Use Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl or isopropyl alcohol</td>
<td>70-90%</td>
</tr>
<tr>
<td>Chlorine</td>
<td>100ppm (1:500 dilution)</td>
</tr>
<tr>
<td>Phenolic</td>
<td>UD</td>
</tr>
<tr>
<td>Iodophor</td>
<td>UD</td>
</tr>
<tr>
<td>Quaternary ammonium (QUAT)</td>
<td>UD</td>
</tr>
<tr>
<td>QUAT with alcohol</td>
<td>RTU</td>
</tr>
<tr>
<td>Improved hydrogen peroxide (HP)</td>
<td>0.5%, 1.4%</td>
</tr>
<tr>
<td>PA with HP, 4% HP, chlorine (<em>C. difficile</em>)</td>
<td>UD</td>
</tr>
</tbody>
</table>

UD=Manufacturer’s recommended use dilution; others in development/testing-electrolyzed water; polymeric guanidine; cold-air atmospheric pressure plasma (Boyce Antimicrob Res IC 2016. 5:10)
Microbiological Disinfectant Hierarchy

Rutala WA, Weber DJ, HICPAC. www.cdc.gov

Most Resistant

Spores (*C. difficile*)

Mycobacteria (*M. tuberculosis*)

Non-Enveloped Viruses (norovirus, HAV, polio)

Fungi (*Candida, Trichophyton*)

Bacteria (*MRSA, VRE, Acinetobacter*)

Enveloped Viruses (HIV, HSV, Flu, SARS-CoV-2)

Most Susceptible

LLD
# Inactivation of Coronavirus

Kampf G. J Hosp Infect 2020

<table>
<thead>
<tr>
<th>Biocidal agent</th>
<th>Concentration</th>
<th>Virus</th>
<th>Strain / isolate</th>
<th>Exposure time</th>
<th>Reduction of viral infectivity (log₁₀)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ethanol</strong></td>
<td>95%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 5.5</td>
<td>[29]</td>
</tr>
<tr>
<td></td>
<td>85%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 5.5</td>
<td>[29]</td>
</tr>
<tr>
<td></td>
<td>80%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 4.3</td>
<td>[29]</td>
</tr>
<tr>
<td></td>
<td>80%</td>
<td>MERS-CoV</td>
<td>Strain EMC</td>
<td>30 s</td>
<td>&gt; 4.0</td>
<td>[14]</td>
</tr>
<tr>
<td></td>
<td>78%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 5.0</td>
<td>[28]</td>
</tr>
<tr>
<td></td>
<td>70%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>&gt; 3.9</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>70%</td>
<td>CCV</td>
<td>Strain F-71</td>
<td>10 min</td>
<td>&gt; 3.3</td>
<td>[29]</td>
</tr>
<tr>
<td><strong>2-Propanol</strong></td>
<td>75%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 3.3</td>
<td>[14]</td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td>MERS-CoV</td>
<td>Strain EMC</td>
<td>30 s</td>
<td>≥ 4.0</td>
<td>[14]</td>
</tr>
<tr>
<td></td>
<td>70%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 3.3</td>
<td>[28]</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>&gt; 3.7</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>CCV</td>
<td>Strain F-71</td>
<td>10 min</td>
<td>&gt; 3.7</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>45% and 30%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 2.8</td>
<td>[28]</td>
</tr>
<tr>
<td><strong>Benzalkonium chloride</strong></td>
<td>0.2%</td>
<td>HCoV</td>
<td>ATCC VR-759 (strain OC43)</td>
<td>10 min</td>
<td>0.0</td>
<td>[31]</td>
</tr>
<tr>
<td></td>
<td>0.05%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>&gt; 3.7</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>0.00175%</td>
<td>CCV</td>
<td>Strain S378</td>
<td>3 d</td>
<td>&gt; 4.0</td>
<td>[32]</td>
</tr>
<tr>
<td><strong>Ammonium chloride</strong></td>
<td>0.0025%</td>
<td>CCV</td>
<td>Strain S378</td>
<td>3 d</td>
<td>&gt; 4.0</td>
<td>[32]</td>
</tr>
<tr>
<td><strong>Chlorhexidine</strong></td>
<td>0.02%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>0.7 – 0.8</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>0.02%</td>
<td>CCV</td>
<td>Strain I-71</td>
<td>10 min</td>
<td>0.3</td>
<td>[30]</td>
</tr>
<tr>
<td><strong>Digluconate</strong></td>
<td>0.21%</td>
<td>MHV</td>
<td>Strain MHV-1</td>
<td>30 s</td>
<td>≥ 4.0</td>
<td>[33]</td>
</tr>
<tr>
<td></td>
<td>0.01%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>2.3 – 2.8</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>0.001%</td>
<td>CCV</td>
<td>Strain I-71</td>
<td>10 min</td>
<td>1.1</td>
<td>[30]</td>
</tr>
<tr>
<td><strong>Sodium hypochlorite</strong></td>
<td>0.001%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>0.3 – 0.6</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>0.001%</td>
<td>CCV</td>
<td>Strain I-71</td>
<td>10 min</td>
<td>0.9</td>
<td>[30]</td>
</tr>
<tr>
<td><strong>Hydrogen peroxide</strong></td>
<td>0.5%</td>
<td>HCoV</td>
<td>Strain 229E</td>
<td>1 min</td>
<td>&gt; 4.0</td>
<td>[34]</td>
</tr>
<tr>
<td><strong>Formaldehyde</strong></td>
<td>1%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>2 min</td>
<td>&gt; 3.0</td>
<td>[28]</td>
</tr>
</tbody>
</table>
Recommendations for Cleaning and Disinfecting of Noncritical Surfaces and Medical Devices in COVID-19 Patient Care

- Comply with the manufacturer’s treatment time/contact time/kill time for wipes and liquid disinfectants.
- Consider no-touch methods (e.g., UV devices) when available as an adjunct to chemical disinfection for terminal disinfection as data demonstrate reduction of microbial contamination and colonization/infection due to epidemiologically-important pathogens despite less scientific and clinical evidence on inactivation of SARS-CoV-2
- No recommendation for using a method of continuous room disinfection as there is insufficient evidence of effectiveness
EFFECTIVENESS OF DISINFECTANTS AGAINST MRSA AND VRE


<table>
<thead>
<tr>
<th>Product</th>
<th>VSE 0.5 min</th>
<th>VSE 5 min</th>
<th>VRE 0.5 min</th>
<th>VRE 5 min</th>
<th>MSSA 0.5 min</th>
<th>MSSA 5 min</th>
<th>MRSA 0.5 min</th>
<th>MRSA 5 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesphene Ilse</td>
<td>&gt;4.3</td>
<td>&gt;4.3</td>
<td>&gt;4.8</td>
<td>&gt;4.8</td>
<td>&gt;5.1</td>
<td>&gt;5.1</td>
<td>&gt;4.6</td>
<td>&gt;4.6</td>
</tr>
<tr>
<td>Clorox</td>
<td>&gt;5.4</td>
<td>&gt;5.4</td>
<td>&gt;4.9</td>
<td>&gt;4.9</td>
<td>&gt;5.0</td>
<td>&gt;5.0</td>
<td>&gt;4.6</td>
<td>&gt;4.6</td>
</tr>
<tr>
<td>Lysol Disinfectant</td>
<td>&gt;4.3</td>
<td>&gt;4.3</td>
<td>&gt;4.8</td>
<td>&gt;4.8</td>
<td>&gt;5.1</td>
<td>&gt;5.1</td>
<td>&gt;4.6</td>
<td>&gt;4.6</td>
</tr>
<tr>
<td>Lysol Antibacterial</td>
<td>&gt;5.5</td>
<td>&gt;5.5</td>
<td>&gt;5.5</td>
<td>&gt;5.5</td>
<td>&gt;5.1</td>
<td>&gt;5.1</td>
<td>&gt;4.6</td>
<td>&gt;4.6</td>
</tr>
<tr>
<td>Vinegar</td>
<td>0.1</td>
<td>5.3</td>
<td>1.0</td>
<td>3.7</td>
<td>+1.1</td>
<td>+0.9</td>
<td>+0.6</td>
<td>2.3</td>
</tr>
</tbody>
</table>

**Log₁₀ Reductions**

**TABLE 2**

**Disinfectant Activity Against Antibiotic-Susceptible and Antibiotic-Resistant Bacteria**

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *S aureus*; VRE, vancomycin-resistant *Enterococcus*; VSE, vancomycin-susceptible *Enterococcus*.

Data represent mean of two trials (n=2). Values preceded by “+” represent the limit of detection of the assay. Assays were conducted at a temperature of 20ºC and a relative humidity of 45%. Results were calculated as the log of Nd/No, where Nd is the titer of bacteria surviving after exposure and No is the titer of the control.
Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

• Describe at least two technologies or new research data that will eliminate the environment as a source of COVID-19
  ■ List N Disinfectants (>500 disinfectants, >30 chemicals)
  ■ “No touch” room decontamination—given cleaning/disinfection often inadequate, supplemental use of no-touch should be considered when patients with coronavirus infection are discharged
    ◆ 5 log₁₀ reduction of MHV-59, mouse analog of MERs and SARs in 10m (Bedel et al. ICHE 2016)
  ■ Electrostatic sprays—new research
Susceptibility of SARS-CoV-2 to UV Irradiation
Heilingloh CS et al. AJIC 2020

- Virus is highly susceptible to ultraviolet light
- High infectious titer of $5 \times 10^6$ was completely inactivated by UVC irradiation after 9 m of exposure
- UVC dose required for complete inactivation was 1048 mJ/cm²
- UVC reliable disinfection method
Efficacy of Disinfectant Spray in Reducing Pathogen Contamination
Cadnum et al. AJIC 2020

Picture of electrostatic sprayer
(0.25% sodium hypochlorite)

Efficacy of disinfectant spray
(waiting room chairs)

![Graph showing the efficacy of disinfectant spray before and after spraying.
Legend: Blue bars represent before spraying, red bars represent after spraying.]

- Any pathogen
- Clostridioides difficile
- Gram-negative bacilli
- Enterococci
- MRSA
• Use an EPA-registered disinfectant on the List N that has qualified under emerging viral pathogens program for use against SARS-CoV-2.

• All noncritical touchable surfaces and medical devices should be cleaned/disinfected at least once daily and when visibly soiled.

• Assess cleaning thoroughness with a validation method (e.g., fluorescent dye markers). Provide regular feedback to environmental services personnel on the thoroughness of cleaning.
Effective Surface Decontamination

Product and Practice = Perfection
HA infections and outbreaks via contamination of environmental surfaces with MDRO have occurred and associated with practice failure to thoroughly CD surfaces/medical devices rather than defective disinfectants.
• Use an EPA-registered disinfectant on the List N that has qualified under emerging viral pathogens program for use against SARS-CoV-2.

• All noncritical touchable surfaces and medical devices should be cleaned/disinfected at least once daily and when visibly soiled.

• Assess cleaning thoroughness with a validation method (e.g., fluorescent dye markers). Provide regular feedback to environmental services personnel on the thoroughness of cleaning.
Clean/disinfect at least daily with List N
Portable Equipment
(decontaminate after each patient use)
Environmental Services Fighting COVID-19
ES worked heroically to fight transmission-Lompoc Valley
Strategies to Support EVS Workers
Tyan, Cohen. Annals Internal Med. May 2020

• **Culture**-acknowledge and elevate role of EVS worker on care team; **build** culture of respect and recognize EVS staff essential to patient safety

• **Investment**-invest in EVS workforce as core strategy to improve patient outcomes; avoid understaffing; **retain workers with increased wages that reflect importance of work**

• **Effectiveness**-enhance EVS efforts through training, research, and innovation; **evidence-based practices and checklist to guide cleaning/disinfection**; automated cleaning technology (“no touch” room decontamination)

• **Safety**-increase worker safety through signage for PPE, health insurance
• Cleaning/disinfection performed using proper PPE
  ■ Correct donning and doffing of PPE
  ■ Following PPE items suggested
    ◆ Filtering facepiece respirator (N95)
    ◆ Goggles or face shield
    ◆ Disposable long-sleeved water-resistant gown
    ◆ Disposable gloves
Surface disinfection effective provided thorough cleaning/disinfection and effective product used as recommended.
• Use an EPA-registered disinfectant on the List N that has qualified under emerging viral pathogens program for use against SARS-CoV-2.

• All noncritical touchable surfaces and medical devices should be cleaned/disinfected at least once daily and when visibly soiled.

• Assess cleaning thoroughness with a validation method (e.g., fluorescent dye markers). Provide regular feedback to environmental services personnel on the thoroughness of cleaning.
Thoroughness of Environmental Cleaning

Carling et al. ECCMID, Milan, Italy, May 2011

[Graph showing percentages of cleaned objects in different environments, with a mean of 32% and >110,000 objects cleaned.]
MONITORING THE EFFECTIVENESS OF CLEANING
Cooper et al. AJIC 2007;35:338

- Visual assessment-not a reliable indicator of surface cleanliness
- ATP bioluminescence-measures organic debris (each unit has own reading scale, <250-500 RLU)
- Microbiological methods-<2.5 CFUs/cm²-pass; can be costly and pathogen specific
- Fluorescent marker-transparent, easily cleaned, environmentally stable marking solution that fluoresces when exposed to an ultraviolet light (applied by IP unbeknown to EVS, after EVS cleaning, markings are reassessed)
Hospitals can improve their thoroughness of terminal room disinfection through fluorescent monitoring and feedback/education.
Fluorescent marker is a useful tool in determining how thoroughly a surface is wiped and mimics the microbiological data better than ATP.
There was no statistical correlation between ATP levels and standard aerobic plate counts.
These interventions (effective surface disinfection, thoroughness indicators) not enough to achieve consistent and high rates of cleaning/disinfection

No Touch

(supplements but do not replace surface cleaning/disinfection)
“NO TOUCH” APPROACHES TO ROOM DECONTAMINATION
(UV/VHP~20 microbicidal studies, ~12 HAI reduction studies; will not discuss technology with limited data)
Recommendations for Cleaning and Disinfecting of Noncritical Surfaces and Medical Devices in COVID-19 Patient Care

• Comply with the manufacturer’s treatment time/contact time/kill time for wipes and liquid disinfectants.

• Consider no-touch methods (e.g., UV devices) when available as an adjunct to chemical disinfection for terminal disinfection as data demonstrate reduction of microbial contamination and colonization/infection due to epidemiologically-important pathogens despite less scientific and clinical evidence on inactivation of SARS-CoV-2.

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- UVC dose required for complete inactivation was 1048 mJ/cm$^2$
- UVC reliable disinfection method
Evidence suggests:

- Healthcare environment frequently contaminated with SARS-CoV-2 RNA in most environmental studies but no evidence of viable virus
- Healthcare environment can possibly result in transmission of SARS-CoV-2 as described with SARS and MERS
- To reduce the risk of HA transmission of SARS-CoV-2 via the environment, essential to improve the thoroughness of cleaning/disinfection practices and select/employ adequate disinfectants
Recommendations for Cleaning and Disinfecting of Noncritical Surfaces and Medical Devices in COVID-19 Patient Care
Kanamori, Weber, Rutala, Clin Infect Dis, [https://doi.org/10.1093/cid/ciaa1467], 28 September 2020

- Standardize cleaning/disinfection of environmental surfaces and medical devices in rooms occupied by COVID-19 patients.
- Follow CDC recommendation for letting room remain empty (or wearing PPE required for COVID-19 patient care) after discharge for the specified time period.
- Provide education and training for cleaning/disinfecting staff on proper donning and doffing of PPE as recommended by CDC.
Disinfection of Noncritical Surfaces Bundle
NL Havill AJIC 2013;41:S26-30; Rutala, Weber AJIC 2019;47:A96-A105

- Develop policies and procedures (e.g. daily disinfection)
- Select cleaning and disinfecting products
- Educate staff—environmental services and nursing
- Monitor compliance (thoroughness of cleaning, product use) and feedback
- Implement “no touch” room decontamination technology and monitor compliance
Disinfection of Noncritical Surfaces Bundle
Rutala, Weber AJIC 2019;47:A96-A105

- Develop policies and procedures
  - Standardize C/D patient rooms and pieces of equipment throughout the hospital
  - All touchable hand contact surfaces wiped with disinfection daily, when spills occur and when the surfaces are visibly soiled.
  - All noncritical medical devices should be disinfected daily and when soiled
  - Clean and disinfectant sink and toilet
  - Damp mop floor with disinfectant-detergent
  - If disinfectant prepared on-site, document correct concentration
  - Address treatment time/contact time for wipes and liquid disinfectants (e.g., treatment time for wipes is the kill time and includes a wet time via wiping as well as the undisturbed time).
COVID-19: Overview of Contamination of the Healthcare Environment and Effective Surface Disinfection Technologies

Learning Objective

- Transmission of SARS-CoV-2 through environmental surfaces
- Identify three sites of the healthcare environment positive for SARS-CoV-2
- Describe at least two technologies or new research data that will eliminate the environment as a source of COVID-19
- Discuss one new COVID-19-related recommendation associated with surface disinfection in healthcare facilities
- Identify at least one new COVID-related change/innovation related to disinfection of noncritical surfaces
After discharge, terminal cleaning can be performed by EVS personnel. They should delay entry into the room until time has elapsed for enough air changes to remove potentially infectious particles. After this time has elapsed, EVS personnel can enter the room and should wear a facemask (for source control) along with a gown and gloves when performing terminal cleaning. Eye protection should be added if splashes or sprays during cleaning and disinfection activities are anticipated or otherwise required based on the selected cleaning products. Shoe covers are not recommended at this time for personnel caring for patients with SARS-CoV-2 infection.
<table>
<thead>
<tr>
<th>ACH § ¶</th>
<th>Time (mins.) required for removal 99% efficiency</th>
<th>Time (mins.) required for removal 99.9% efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>138</td>
<td>207</td>
</tr>
<tr>
<td>4</td>
<td>69</td>
<td>104</td>
</tr>
<tr>
<td>6⁺</td>
<td>46</td>
<td>69</td>
</tr>
<tr>
<td>8</td>
<td>35</td>
<td>52</td>
</tr>
<tr>
<td>10⁺</td>
<td>28</td>
<td>41</td>
</tr>
<tr>
<td>12⁺</td>
<td>23</td>
<td>35</td>
</tr>
<tr>
<td>15⁺</td>
<td>18</td>
<td>28</td>
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<tr>
<td>20</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>
• Standardize cleaning/disinfection of environmental surfaces and medical devices in rooms occupied by COVID-19 patients.

• Follow CDC recommendation for letting room remain empty after discharge for the specified time period.

• Provide education and training for cleaning/disinfecting staff on proper donning and doffing of PPE as recommended by CDC.
Environmental Services Fighting COVID-19
ES worked heroically to fight transmission-Lompoc Valley
• World Health Organization
  ■ Cleaning practices and cleanliness should be routinely monitored
  ■ Number of cleaning staff should be planned to optimize cleaning practices
  ■ In general, WHO recommends cleaning/disinfection environmental surfaces in inpatient areas (plus screening/triage area) with suspected or confirmed COVID-19 patients at least twice daily
COVID:19: Overview of Contamination of the Healthcare Environment and Effective Surface Disinfection Technologies

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Continuous Room Decontamination Technologies for Disinfection of the Healthcare Environment
Weber, Rutala et al. AJIC. 2019;47:A72

- Visible light disinfection through LEDs
- Dry/dilute hydrogen peroxide
- Self-disinfecting surfaces (e.g., copper)
- Far UV 222 nm
- Bipolar ionization
- Multijet cold air plasma
- Continuously active disinfectant (CAD) or persistent disinfectant that provides continuous disinfection action
  - Allows continued disinfection (may eliminate the problem of recontamination)
  - Patients, staff and visitors can remain in the room
### Continuous Room Decontamination

**Continuously Active Disinfectants**


<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allows continued disinfection (may eliminate the problem of recontamination)</td>
<td>Room decontamination/biocidal activity is slow</td>
</tr>
<tr>
<td>Patients, staff and visitors can remain in the room</td>
<td>Capital equipment costs are substantial</td>
</tr>
<tr>
<td>Does not require an ongoing behavior change or education of personnel</td>
<td>Does not remove dust, dirt, stains that are important to patients and visitors</td>
</tr>
<tr>
<td>Self-sustaining once in place</td>
<td>Studies have not shown whether the use will decrease HAIs</td>
</tr>
<tr>
<td>Once purchased might have low maintenance cost</td>
<td></td>
</tr>
<tr>
<td>Technology does not give rise to health or safety concerns</td>
<td></td>
</tr>
<tr>
<td>No (limited) consumable products</td>
<td></td>
</tr>
</tbody>
</table>
Long-Term Efficacy of a Self-Disinfecting Coating in an ICU
Tamimi, Carlino, Gerba. AJIC 2014. 42:1178-81

• Assess the effectiveness of a QUAT organosilane compound that binds to surfaces and produces residual disinfecting activity
• Coating applied with electrostatic spray applicator of all surfaces in the ICU
• During the course of the study, staff maintained normal daily cleaning schedule, which involved disinfecting with reusable cloths containing bleach and/or disposable QUAT wipes
Bacterial numbers were 99.9% less at 4 weeks after the treatment, 99% after 8 weeks, and almost 99% after 15 weeks. Must reapply every 3-4 months to ensure effective reduction.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of samples</td>
<td>95</td>
<td>81</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>45</td>
</tr>
<tr>
<td>Average number of bacteria</td>
<td>233,064</td>
<td>98</td>
<td>80</td>
<td>43</td>
<td>2,247</td>
<td>3,320</td>
</tr>
<tr>
<td>Range</td>
<td>10–7,000,000</td>
<td>10–2,500</td>
<td>10–8,400</td>
<td>10–2,500</td>
<td>10–44,000</td>
<td>10–57,000</td>
</tr>
<tr>
<td>% reduction</td>
<td>NA</td>
<td>99.96</td>
<td>99.97</td>
<td>99.98</td>
<td>99.04</td>
<td>98.58</td>
</tr>
</tbody>
</table>

*NA, not applicable.  
*Before treatment.
Evaluation of a Continuously Active Disinfectant
“EPA Protocol for Residual Self-Sanitizing Activity of Dried Chemical Residuals on Hard, Non-Porous Surfaces”
Rutala et al. Unpublished Results, 2020

- Test surface inoculated (10^5), treated with test disinfectant, allowed to dry.
- Surface will undergo “wears” (abraded under alternating wet and dry conditions [24 passes, 12 cycles]) and 6 re-inoculations (10^{3-7.5}, 30min dry) over 48hr
- At the end of the study and at least 48 hours later, the ability of the test surface to kill microbes (99.9%) within 1 min is measured using the last inoculation (10^6)
A novel disinfectant studied using an EPA protocol (wears/re-inoculations) demonstrated continuous antiviral activity (i.e., $>4.5 \log_{10}$ reduction) in 1 minute after 48 hours for a human coronavirus, 229E.

<table>
<thead>
<tr>
<th>Carrier Treatment with Wears and Re-inoculations</th>
<th>Contact Time</th>
<th>Mean Viral Recovery Titer per Carrier ($\log_{10}$)</th>
<th>Log$_{10}$ Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (sterile water, n=3)</td>
<td>1 minute</td>
<td>$6.00 \pm 0.25$</td>
<td>N.A.</td>
</tr>
<tr>
<td>Test disinfectant (n=3)</td>
<td>1 minute</td>
<td>$\leq 1.50 \pm 0.00$</td>
<td>$&gt;4.50$</td>
</tr>
</tbody>
</table>
• Comply with the manufacturer’s treatment time/contact time/kill time for wipes and liquid disinfectants.

• Consider no-touch methods (e.g., UV devices) when available as an adjunct to chemical disinfection for terminal disinfection as data demonstrate reduction of microbial contamination and colonization/infection due to epidemiologically-important pathogens despite less scientific and clinical evidence on inactivation of SARS-CoV-2

• No recommendation for using a method of continuous room disinfection as there is insufficient evidence of effectiveness
COVID-19: Overview of Contamination of the Healthcare Environment and Effective Surface Disinfection Technologies

Summary

- Standardize cleaning/disinfection
- Follow CDC recommendations for letting room remain empty
- Provide education/training for cleaning/disinfection staff on proper PPE
- Use EPA-registered disinfectant on List N
- All noncritical touchable surfaces and medical devices cleaning/disinfection daily
- Assess cleaning/disinfection thoroughness with a validation method
- Comply with manufacturer’s contact time for disinfectants
- Consider “no touch” methods as adjunct to cleaning/disinfection for terminal disinfection
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THANK YOU!

www.disinfectionandsterilization.org