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

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Former Director, Hospital Epidemiology, Occupational Health and Safety, UNC Health Care, Chapel Hill, NC (1979-2017)

DISCLOSURES

2020-2021

- **Consultations**
  - Professional Disposables International (PDI)
- **Honoraria**
  - PDI

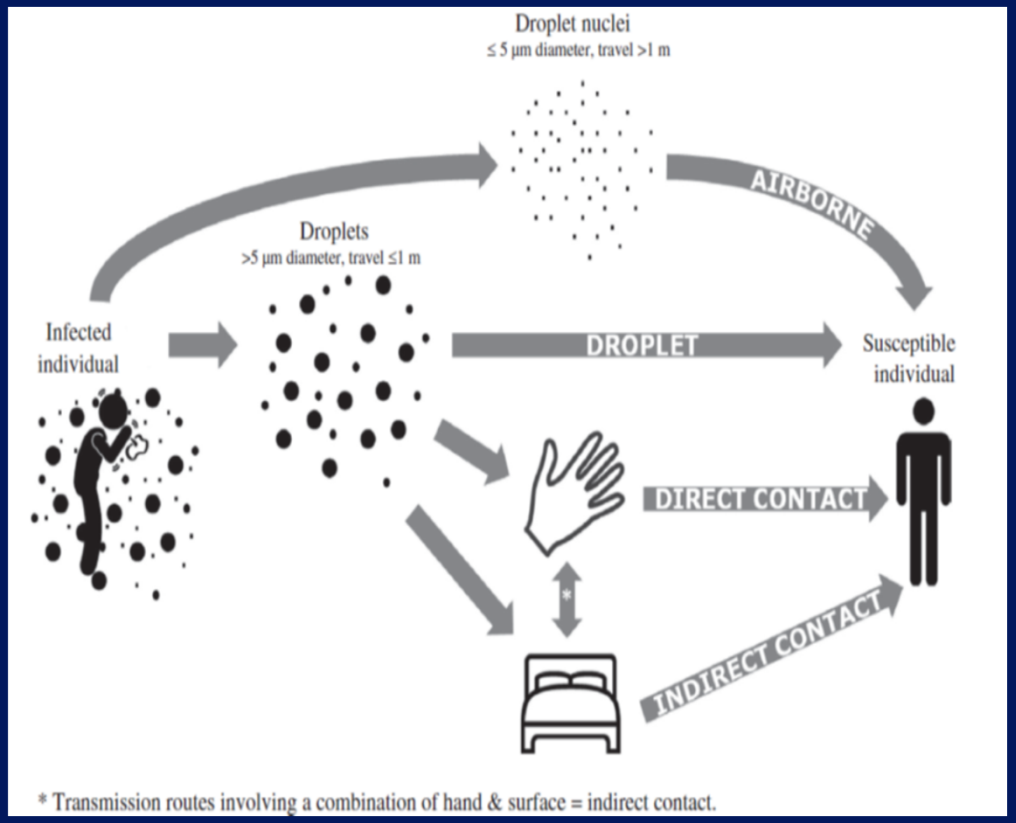
www.disinfectionandsterilization.org

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

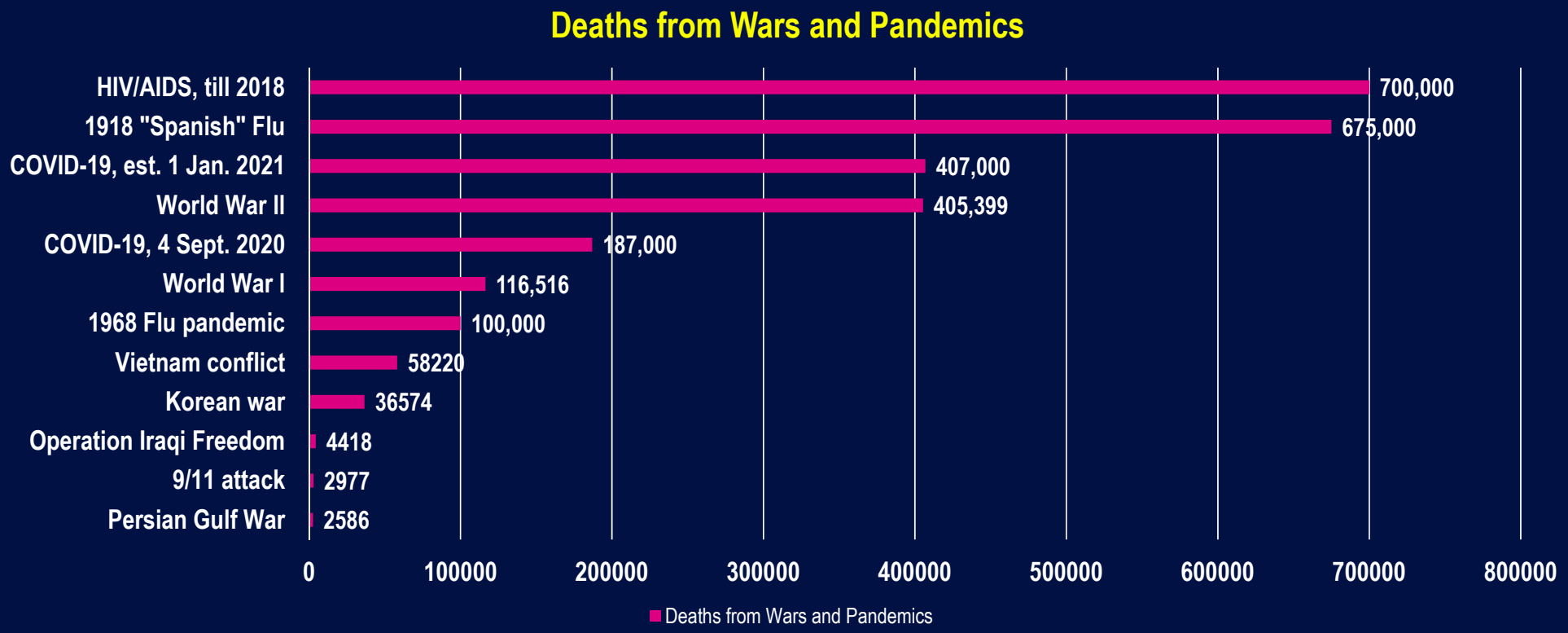
Role of environment in SARS-CoV-2 transmission and environmental disinfection

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



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Role of environment in transmission and environmental disinfection

Environmental Contamination Leads to HAIs

Weber, Kanamori, Rutala. Curr Op Infect Dis 2016:29:424-431

- 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

Weber, Kanamori, Rutala. Curr Op Infect Dis 2016:29:424-431

- 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

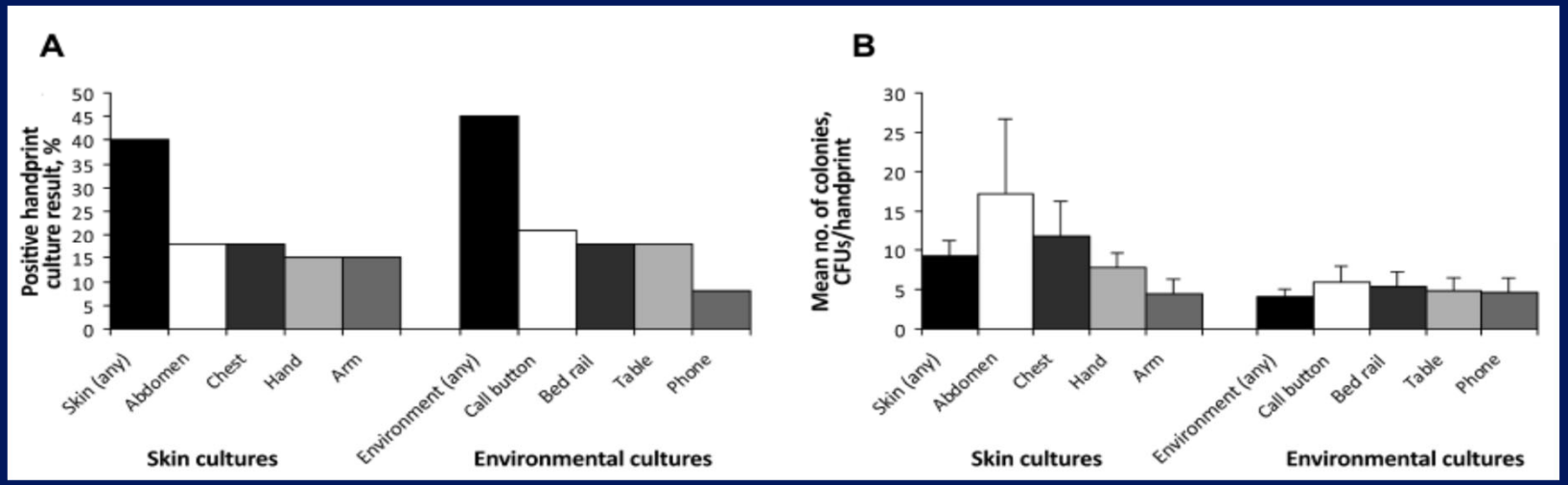
ACQUISITION OF MRSA ON HANDS/GLOVES AFTER CONTACT WITH CONTAMINATED EQUIPMENT

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)



Stiefel U, et al. ICHE 2011;32:185-187

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

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

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 you 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

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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.

Type of surface	Virus	Strain / isolate	Inoculum (viral titer)	Temperature	Persistence	Reference
Steel	MERS-CoV	Isolate HCoV-EMC/2012	10^5	20°C 30°C	48 h 8 – 24 h	[21]
	TGEV	Unknown	10^6	4°C 20°C 40°C	≥ 28 d 3 – 28 d 4 – 96 h	[22]
	MHV	Unknown	10^6	4°C 20°C 40°C	≥ 28 d 4 – 28 d 4 – 96 h	[22]
	HCoV	Strain 229E	10^3	21°C	5 d	[23]
Aluminium	HCoV	Strains 229E and OC43	5×10^3	21°C	2 – 8 h	[24]
Metal	SARS-CoV	Strain P9	10^5	RT	5 d	[25]
Wood	SARS-CoV	Strain P9	10^5	RT	4 d	[25]
Paper	SARS-CoV	Strain P9	10^5	RT	4 – 5 d	[25]
	SARS-CoV	Strain GVU6109	10^6 10^5 10^4	RT	24 h 3 h < 5 min	[26]
Glass	SARS-CoV	Strain P9	10^5	RT	4 d	[25]
	HCoV	Strain 229E	10^3	21°C	5 d	[23]
Plastic	SARS-CoV	Strain HKU39849	10^5	22°-25°C	≤ 5 d	[27]
	MERS-CoV	Isolate HCoV-EMC/2012	10^5	20°C 30°C	48 h 8 – 24 h	[21]
	SARS-CoV	Strain P9	10^5	RT	4 d	[25]
	SARS-CoV	Strain FFM1	10^7	RT	6 – 9 d	[28]
	HCoV	Strain 229E	10^7	RT	2 – 6 d	[28]
PVC	HCoV	Strain 229E	10^3	21°C	5 d	[23]
Silicon rubber	HCoV	Strain 229E	10^3	21°C	5 d	[23]
Surgical glove (latex)	HCoV	Strains 229E and OC43	5×10^3	21°C	≤ 8 h	[24]
Disposable gown	SARS-CoV	Strain GVU6109	10^6 10^5	RT	2 d 24 h	[26]

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

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- 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%)

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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%).

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

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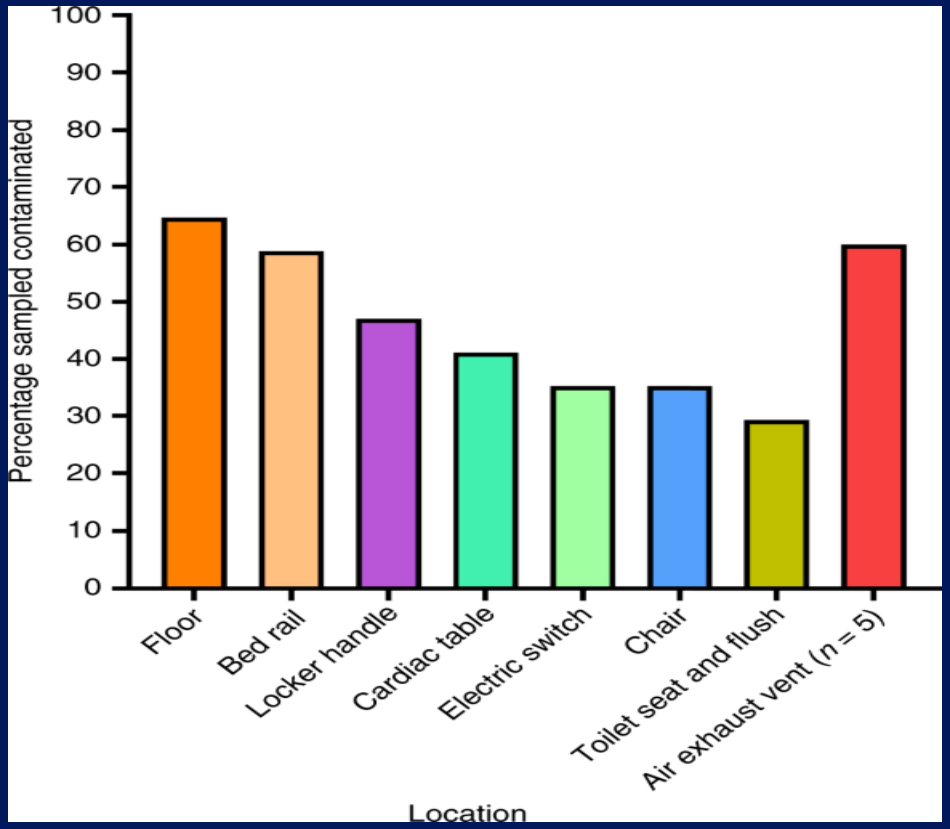
Detection of SARS-CoV-2 RNA does not represent the presence of viable virus. Further, even the detection of viable virus, does not mean an infectious dose of SARS-CoV-2 is present. Infectious dose for SARS-CoV-1 estimated to be 280 viral particles to cause disease in 50% of the population.

Percentage of contaminated swabs from surfaces samples, in rooms with any contamination, SARS-CoV-2

Chia et al. Nature Communication 2020



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Raises concerns that contaminated surfaces leads to contamination of the gloves and hands of HCP and transfer

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

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- 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)

Sites of swabs/air samples and results

Sample location	Grand total	Detected	Not detected
COVID-19 patient's room			
Bed rail	6	4	2
Bedside table	6	3	3
Call bell	4	1	3
Patient chair-arm	4	1	3
Remote for bed	2	2	0
~~Toilet door handle~~	~~4~~	~~0~~	~~4~~
Total	26	11	15
Nurses' station COVID-19 cohort ward			
Desk	10	0	10
Keyboard	10	0	10
Telephone	10	1	9
Total	30	1	29
Patient room post-terminal clean			
Bed rail	5	0	5
Bedside table	5	0	5
Call bell	5	1	4
Patient chair-arm	5	0	5
~~Toilet door handle~~	~~5~~	~~0~~	~~5~~
Total	25	1	24

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

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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

Areas	No. of tests	No. of positive	Positive rate (%)
Medical areas	145	36	24.83
General isolation ward	72	18	25.00
Ward 1	12	6	50.00
Ward 2	12	0	0.00
Ward 3	12	4	33.33
Ward 4	12	3	25.00
Ward 5	12	1	8.33
Ward 6	12	4	33.33
Intensive care units	24	9	37.50
Clinical laboratory	7	0	0.00
Fever clinic	42	9	21.43
Emergency room	12	6	50.00
Observation room	4	1	25.00
Treatment room	4	0	0.00
Infusion room	4	0	0.00
Diagnosis room 1	4	1	25.00
Diagnosis room 2	4	0	0.00
Throat swab sampling room	8	0	0.00
Public area	2	1	50.00
Living quarters	55	2	3.64
Office area	22	2	9.09
Rest room	33	0	0.00
Total	200	38	19.00

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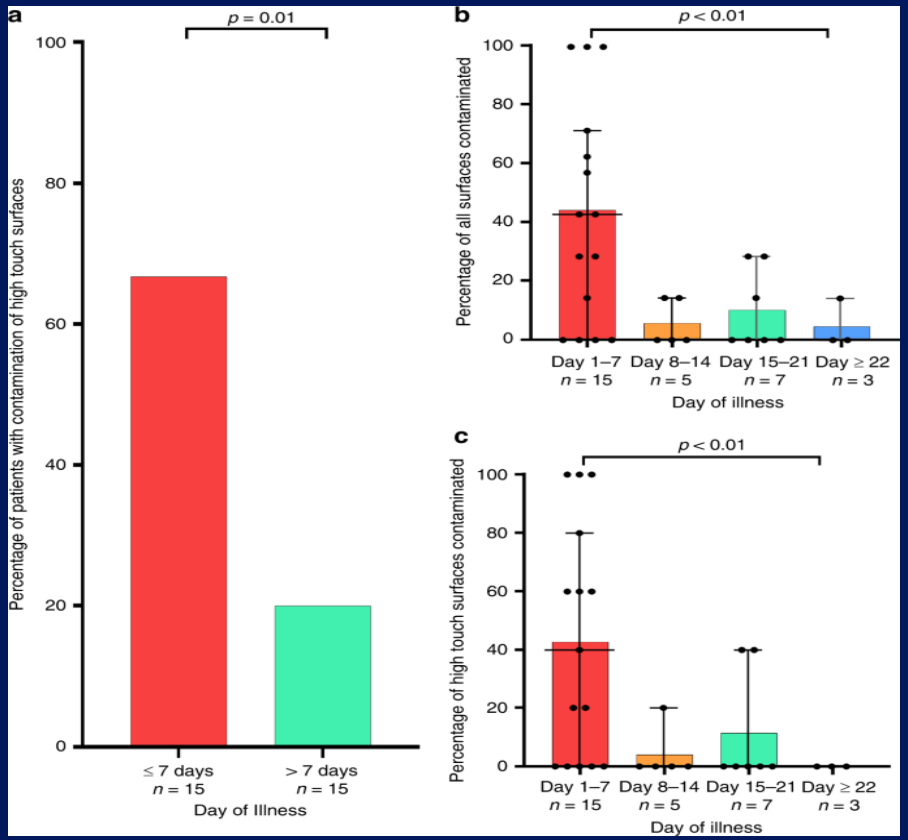
Contamination of surfaces occurred more extensively within the first week of illness and decreased with increasing duration of illness and lower SARS-CoV-2 RNA levels, which supports studies describing the peak viral loads and active viral replication in the upper respiratory tract of COVID-19 patients during the first week

Extent of environmental contamination correlated with day of illness timepoint

Chia el al. Nature Communications 2020



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- 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.

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

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

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

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

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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

(A-more severe patients in ICU; B-less severe in common hospital rooms)

Ryu et al, Am J Infect Control. 2020

Hospital	Patient number	Patient status	Patient data					Room data		
			Clinical syndrome	Respiratory symptom	Mask-wearing behavior	Days from		Site	Ventilation with negative pressure	Hours from the last room disinfection
						Symptom onset	Last (+) RT-PCR			
A	1	Mechanical ventilation with vasopressor	Severe pneumonia	N/A	N/A	12	14*	ICU	Yes	32
	2	Nasal cannula	Severe pneumonia	Dyspnea Cough	Good†	10	1	ICU	Yes	23
	3	HFNC	Severe pneumonia	Dyspnea	Bad†	3	1	Ward	Yes	24
	4	HFNC	Severe pneumonia	Dyspnea Cough	Bad	9	2	Ward	Yes	1
	5	Nasal cannula	Mild pneumonia	No	Good	18	1	Ward	Yes	72
B	6	Room air	N-S	No	Good	14	14	Ward	No	184
	7	Room air	Mild pneumonia	No	Good	17	1			
	8	Room air	N-S	No	Good	16	16			
	9	Room air	N-S	No	Good	13	13			
	10	Room air	N-S	No	Good	38	11	Ward	No	184
	11	Room air	N-S	No	Good	26	13			
	12	Room air	N-S	No	Good	18	1			
	13	Room air	N-S	No	Good	16	13			

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

Hospital	Patient number	Inside the room	Outside the room			Number of real-time RT-PCR-positive samples (collected surface)		
			Anteroom	Corridor	Nursing station	3 of 3 target genes	2 of 3 target genes	1 of 3 target genes
A	1	6/10	0/1*	N/A	N/A	2 Ambu bag Infusion pump	3 Pillow Bed side rail Patient monitor	1 Air exhaust damper
	2	0/10	0/2	N/A	N/A	0	0	0
	3	2/12	0/2	0/1	0/3†	0	1 Fluid stand	1 Upper part of TV
	4	2/13	0/2	0/1		0	1 Head of the bed	1 Patient monitor
	5	0/12	0/1*	0/1		0	0	0
B	6-9	1/11	N/A	0/1	0/5	1 Center of room floor	0	0
	10-13	2/11	N/A	0/1	0/5	1 Seat of toilet	0	1 Side rail of patient 12's bed

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

Ong et al. JAMA 2020;323:1610

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.

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

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- 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

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SARS-CoV-2 RNA				
Bed Rail	Sink	BP monitor	Infusion pump	Keyboard
Bedside table	Floor	ECG monitor	Fluid stand	Phone
Chair	Toilet seat	Oxygen regulator	Hand sanitizer	Computer mouse
Doorknob	Toilet bowl	Oxygen mask	Trash can	Door
Light switches	Stethoscope	CT scanner	Self-service printer	Glass window
Call button	Pulse oximetry	Ventilator	Desktop	PPE storage area
Centrifuge	Biosafety cabinet	Infant bed	Air outlet	Ambu bag
TV remote	Bed sheet	Urinary catheters	TV	Beepers
Elevator buttons	Ventilator tubing	Glove boxes	Touch screen	All surfaces in nurse's station

Environmental Contamination in COVID-19 Rooms with Severe Peumonia

Ahn et al. J Hosp Infect 2020;106:570

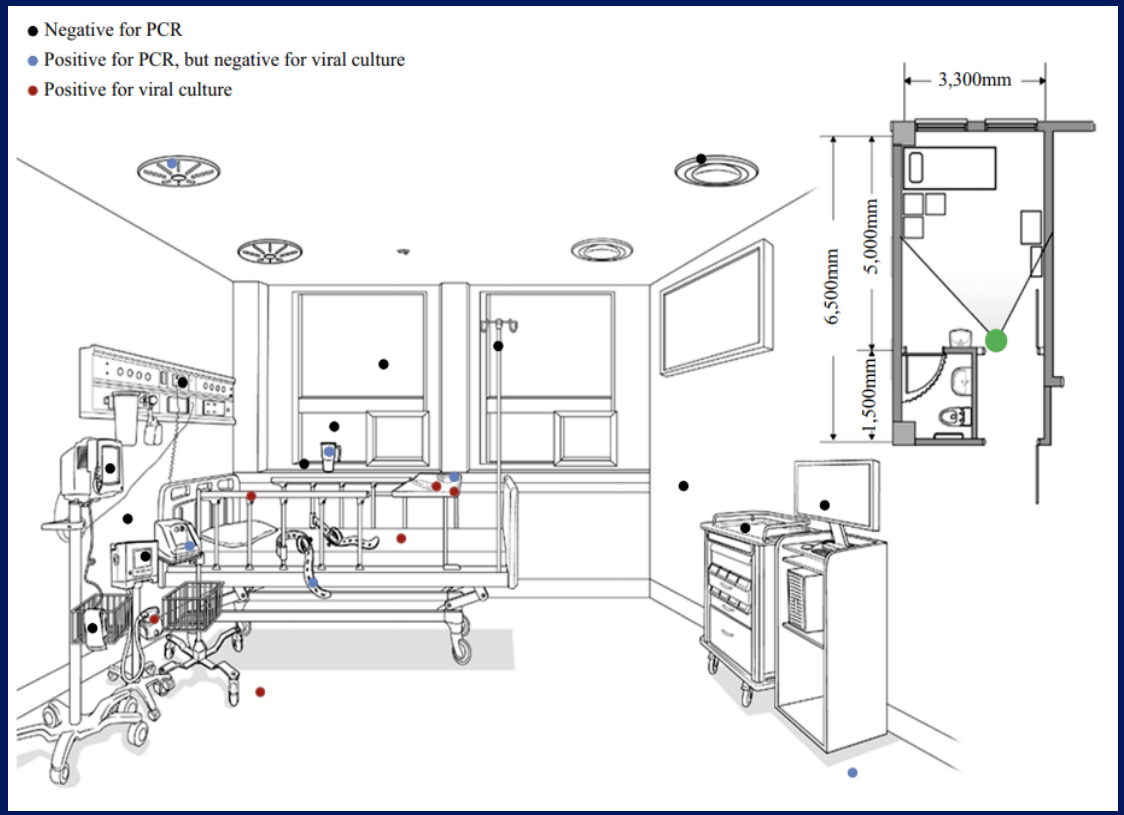
Pt 1 and 2-2/48-4% (closed suction to ventilator) pt 3-13/28-46% (high-flow oxygen therapy via nasal cannula, non-invasive ventilation). Found viable virus (7/28-25%) only on surfaces within droplet distance. All air samples negative.

Sample	Patient 1				Patient 2				Patient 3			
	PCR	C_T value		Culture	PCR	C_T value		Culture	PCR	C_T value		Culture
		E gene	RdRp			E gene	RdRp			E gene	RdRp	
Air	−			ND	−			ND	−			ND
Air outlet fan	−			ND	−			ND	+	33.93	34.99	−
Air inlet fan	−			ND	−			ND	−			ND
Nasal prong/endotracheal tube	+	30.95	31.36	+	+	32.33	33.02	−	+	31.78	34.28	+
Intravenous pole	−			ND	−			ND	−			ND
Computer	−			ND	−			ND	−			ND
Medication cart	−			ND	−			ND	−			ND
Window	−			ND	−			ND	U	U	U	−
Window frame	−			ND	−			ND	−	34.23	36.04	−
Blind curtain	−			ND	−			ND	−			ND
Wall 1	−			ND	−			ND	−			ND
Wall 2	−			ND	−			ND	−			ND
Floor near the patient[a]	−			ND	−			ND	+	30.38	33.07	+
Floor far from the patient[b]	−			ND	−			ND	+	31.97	34.28	−
Bed rails	−			ND	−			ND	+	30.22	30.13	+
Bedsheet	−			ND	−			ND	+	31.54	31.99	+
Pillows	−			ND	−			ND	ND			ND
Faucet handle	−			ND	−			ND	ND			ND
Door knob	−			ND	−			ND	−			ND
Call button	−			ND	−			ND	−			ND
Restraint	−			ND	−			ND	+	34.08	35.18	−
Blood pressure cuff	−			ND	−			ND	−			ND
Ambu mask/NIV mask	−			ND	−			ND	+	28.85	28.94	+
Ventilator	−			ND	−			ND	−			ND
Patient monitor	−			ND	−			ND	−			ND
Bedside table	ND			ND	ND			ND	U	33.09	U	+
High-flow oxygen generator	ND			ND	ND			ND	+	30.56	33.12	−
Telephone	ND			ND	ND			ND	+	31.39	33.42	−
Remote controller	ND			ND	ND			ND	+	29.48	29.66	+
Thermometer	ND			ND	ND			ND	+	31.56	32.13	−
Cup	ND			ND	ND			ND	+	32.32	33.55	−

Environmental Contamination in COVID-19 Rooms with Severe Peumonia

Ahn et al. J Hosp Infect 2020;106:570

Found viable virus only on surface within droplet distance.



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- 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.

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- 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

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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

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

- 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.

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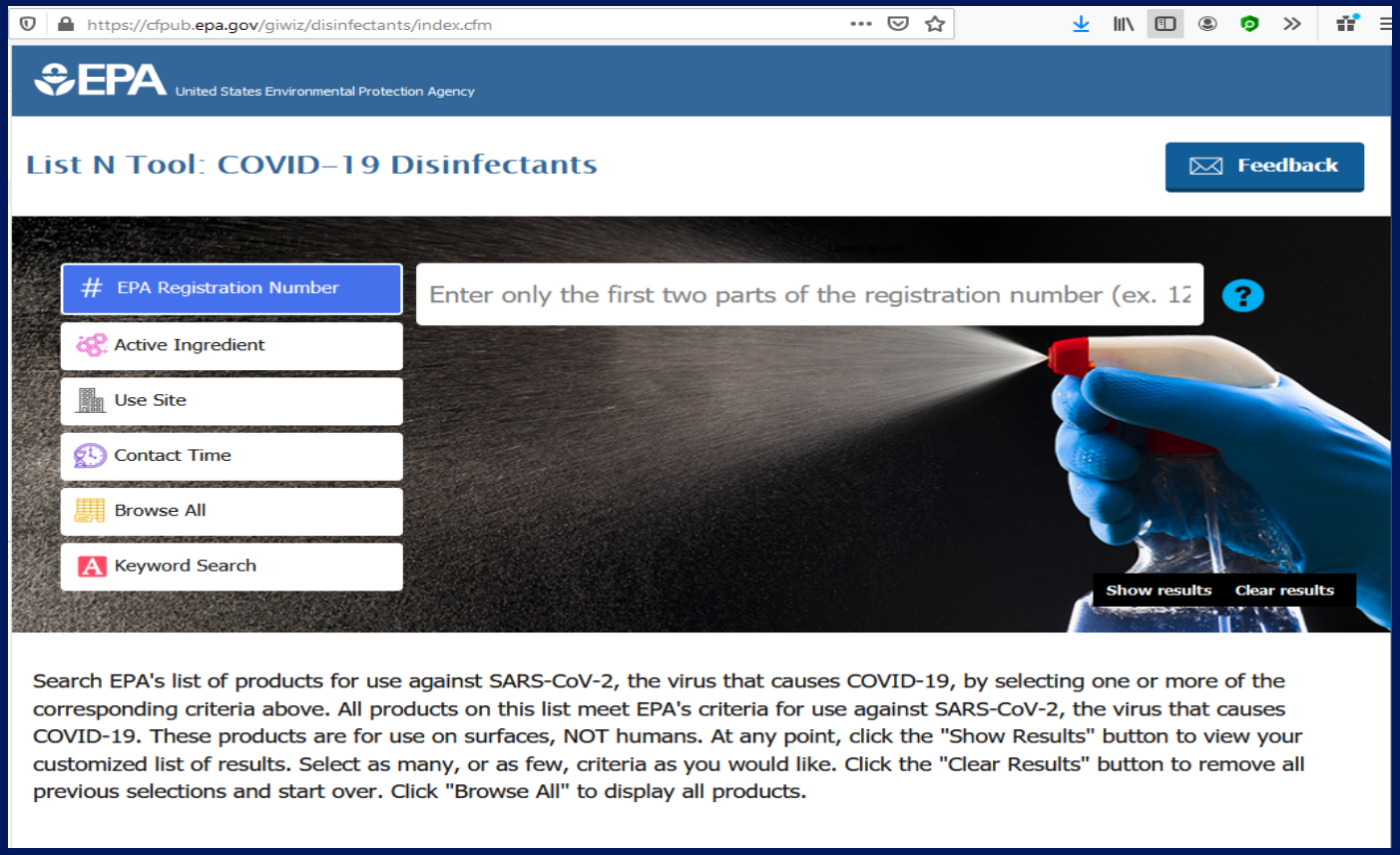
- CDC recommends that an EPA-registered disinfectant on the EPA's List N that has qualified under the emerging pathogen program for use against SARS-CoV-2 be chosen for the COVID-19 patient care.
- List N has >500 entries and >30 different active ingredients

List N Tool: COVID-19 Disinfectants

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



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

Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865; Rutala, Weber. AJIC 2019;47:A3-A9

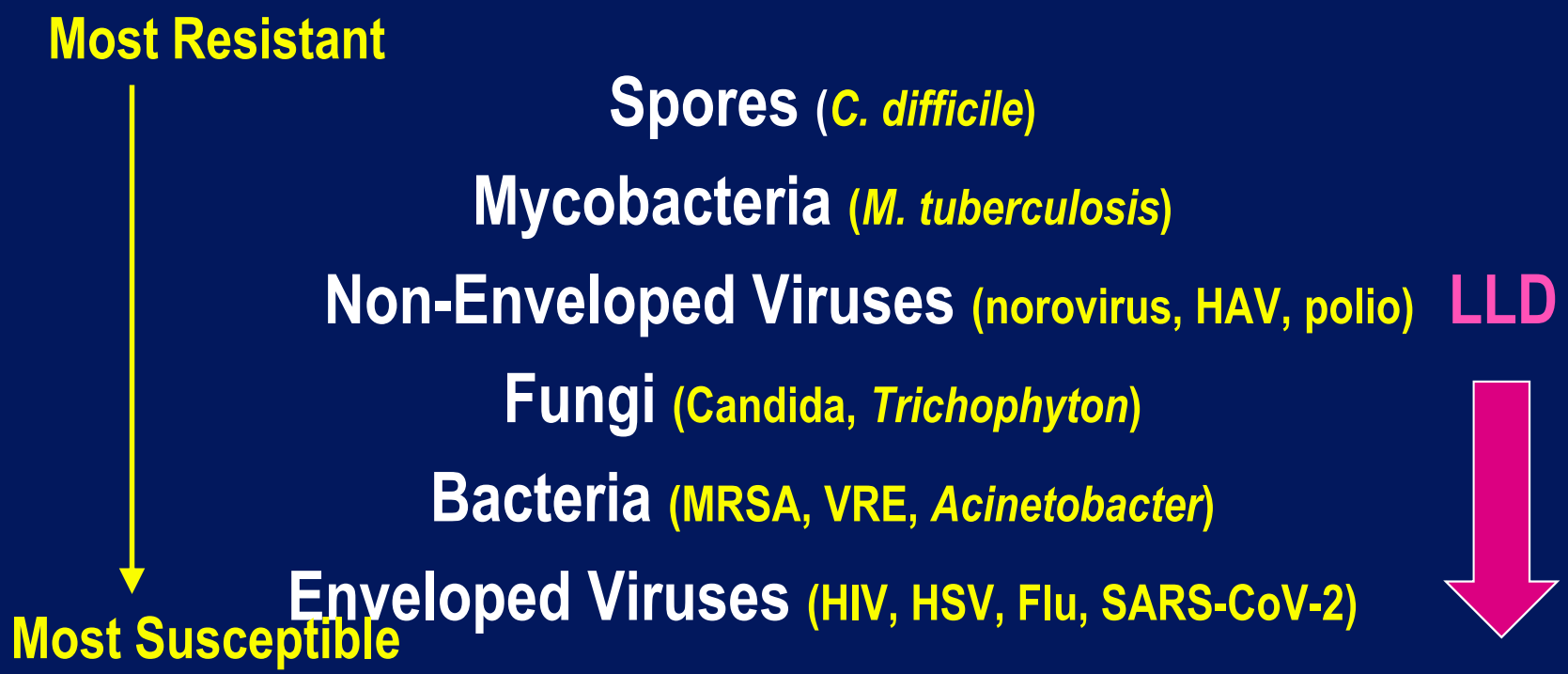
Exposure time ≥ 1 min

Germicide	Use Concentration
Ethyl or isopropyl alcohol	70-90%
Chlorine	100ppm (1:500 dilution)
Phenolic	UD
Iodophor	UD
Quaternary ammonium (QUAT)	UD
QUAT with alcohol	RTU
Improved hydrogen peroxide (HP)	0.5%, 1.4%
PA with HP, 4% HP, chlorine (*C. difficile*)	UD

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



Inactivation of Coronavirus

Kampf G. J Hosp Infect 2020

Table II. Inactivation of coronaviruses by different types of biocidal agents in suspension tests.

Biocidal agent	Concentration	Virus	Strain / isolate	Exposure time	Reduction of viral infectivity (log_{10})	Reference
Ethanol	95%	SARS-CoV	Isolate FFM-1	30 s	≥ 5.5	[29]
	85%	SARS-CoV	Isolate FFM-1	30 s	≥ 5.5	[29]
	80%	SARS-CoV	Isolate FFM-1	30 s	≥ 4.3	[29]
	80%	MERS-CoV	Strain EMC	30 s	> 4.0	[14]
	78%	SARS-CoV	Isolate FFM-1	30 s	≥ 5.0	[28]
	70%	MHV	Strains MHV-2 and MHV-N	10 min	> 3.9	[30]
	70%	CCV	Strain I-71	10 min	> 3.3	[30]
2-Propanol	100%	SARS-CoV	Isolate FFM-1	30 s	≥ 3.3	[28]
	75%	SARS-CoV	Isolate FFM-1	30 s	≥ 4.0	[14]
	75%	MERS-CoV	Strain EMC	30 s	≥ 4.0	[14]
	70%	SARS-CoV	Isolate FFM-1	30 s	≥ 3.3	[28]
	50%	MHV	Strains MHV-2 and MHV-N	10 min	> 3.7	[30]
	50%	CCV	Strain I-71	10 min	> 3.7	[30]
2-Propanol and 1-propanol	45% and 30%	SARS-CoV	Isolate FFM-1	30 s	≥ 4.3	[29]
		SARS-CoV	Isolate FFM-1	30 s	≥ 2.8	[28]
Benzalkonium chloride	0.2%	HCoV	ATCC VR-759 (strain OC43)	10 min	0.0	[31]
	0.05%	MHV	Strains MHV-2 and MHV-N	10 min	> 3.7	[30]
	0.05%	CCV	Strain I-71	10 min	> 3.7	[30]
	0.00175%	CCV	Strain S378	3 d	3.0	[32]
Didecyldimethyl ammonium chloride	0.0025%	CCV	Strain S378	3 d	> 4.0	[32]
Chlorhexidine digluconate	0.02%	MHV	Strains MHV-2 and MHV-N	10 min	0.7 – 0.8	[30]
	0.02%	CCV	Strain I-71	10 min	0.3	[30]
Sodium hypochlorite	0.21%	MHV	Strain MHV-1	30 s	≥ 4.0	[33]
	0.01%	MHV	Strains MHV-2 and MHV-N	10 min	2.3 – 2.8	[30]
	0.01%	CCV	Strain I-71	10 min	1.1	[30]
	0.001%	MHV	Strains MHV-2 and MHV-N	10 min	0.3 – 0.6	[30]
	0.001%	CCV	Strain I-71	10 min	0.9	[30]
Hydrogen peroxide	0.5%	HCoV	Strain 229E	1 min	> 4.0	[34]
Formaldehyde	1%	SARS-CoV	Isolate FFM-1	2 min	> 3.0	[28]

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

- 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

Rutala WA, et al. Infect Control Hosp Epidemiol 2000;21:33-38

TABLE 2

DISINFECTANT ACTIVITY AGAINST ANTIBIOTIC-SUSCEPTIBLE AND ANTIBIOTIC-RESISTANT BACTERIA

	Log_{10} Reductions							
	VSE		VRE		MSSA		MRSA	
Product	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min
Vesphene IIse	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.6	>4.6
Clorox	>5.4	>5.4	>4.9	>4.9	>5.0	>5.0	>4.6	>4.6
Lysol Disinfectant	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.6	>4.6
Lysol Antibacterial	>5.5	>5.5	>5.5	>5.5	>5.1	>5.1	>4.6	>4.6
Vinegar	0.1	5.3	1.0	3.7	+1.1	+0.9	+0.6	2.3

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 20°C 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

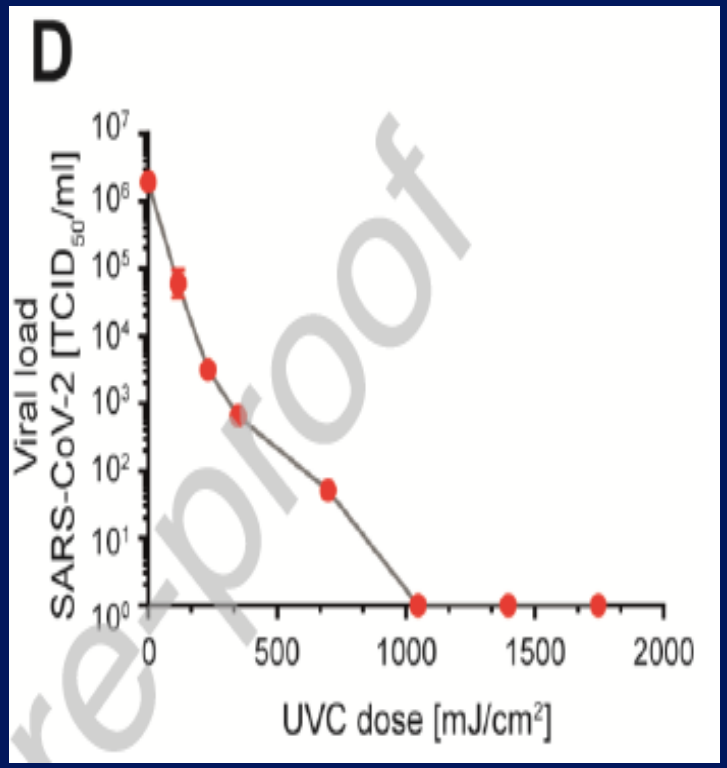
Kanamori, Weber, Rutala, Clin Infect Dis, https://doi.org/10.1093/cid/ciaa1467, 28 September 2020

- 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

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 x 10^6 was completely inactivated by UVC irradiation after 9 m of exposure
- UVC dose required for complete inactivation was 1048 mJ/cm^2
- UVC reliable disinfection method

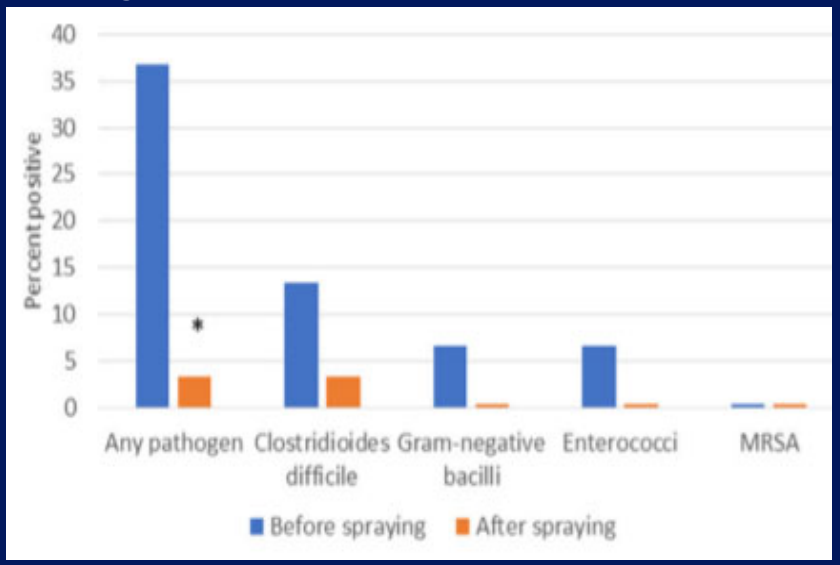


Efficacy of Disinfectant Spray in Reducing Pathogen Contamination

Cadnum et al. AJIC 2020

Picture of electrostatic sprayer
(0.25% sodium hypochlorite)

Efficacy of disinfectant spray
(waiting room chairs)



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

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- 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

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

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

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

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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

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

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

- 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

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

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

Surface disinfection effective provided thorough cleaning/disinfection and effective product used as recommended

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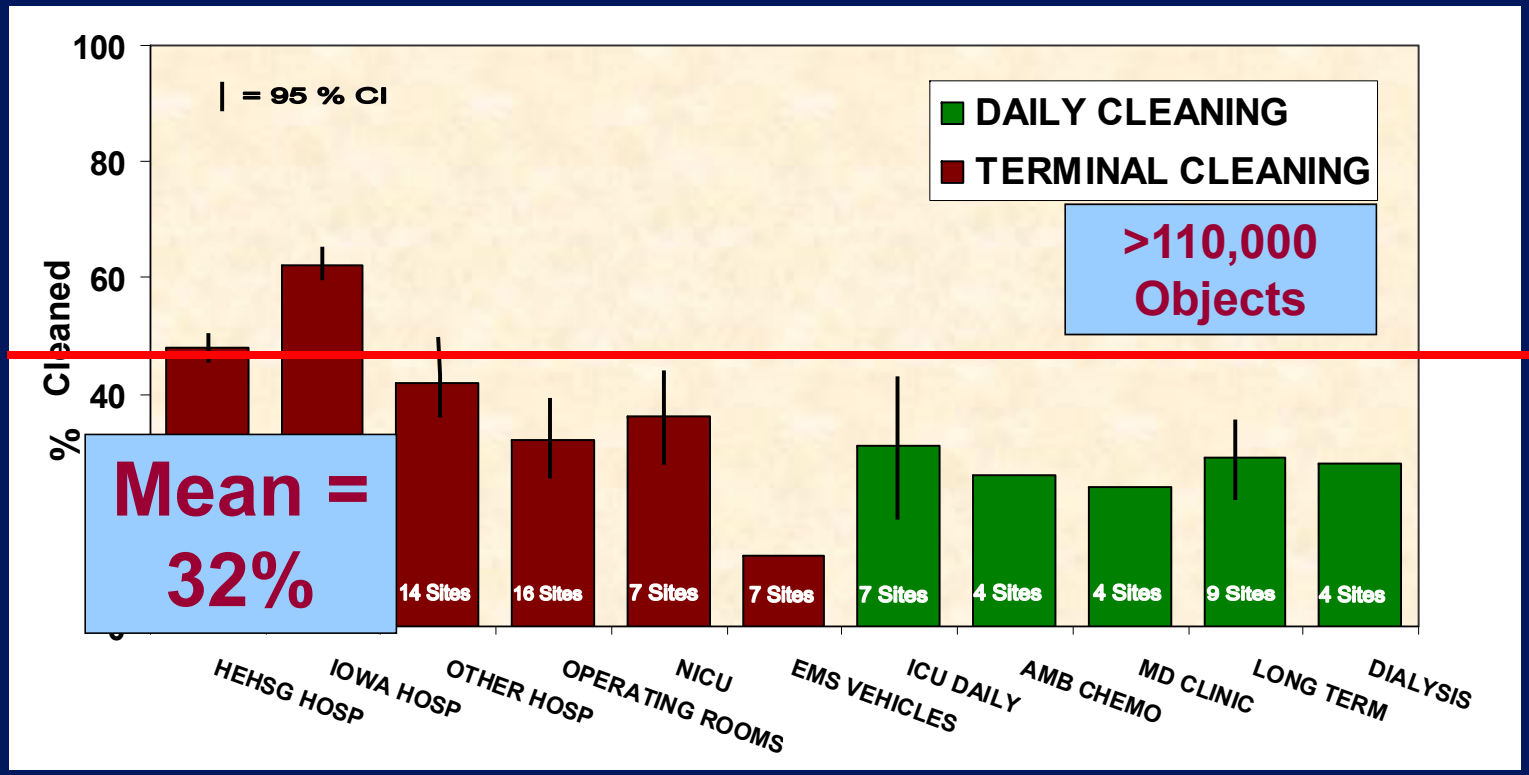
Thoroughness of Environmental Cleaning

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



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/cm^2-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)

Thoroughness of Environmental Cleaning

Carling and Herwaldt. Infect Control Hosp Epidemiol 2017;38:960–965

Hospitals can improve their thoroughness of terminal room disinfection through fluorescent monitoring and feedback/education

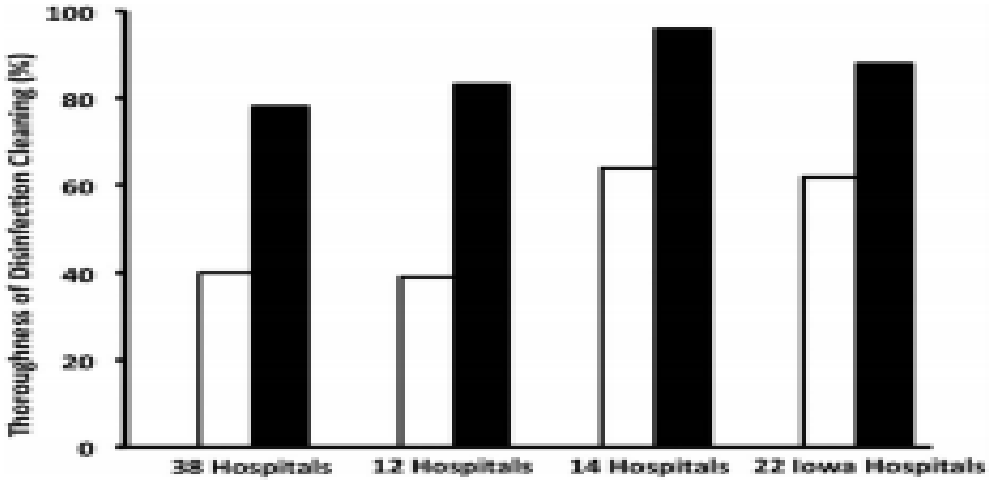
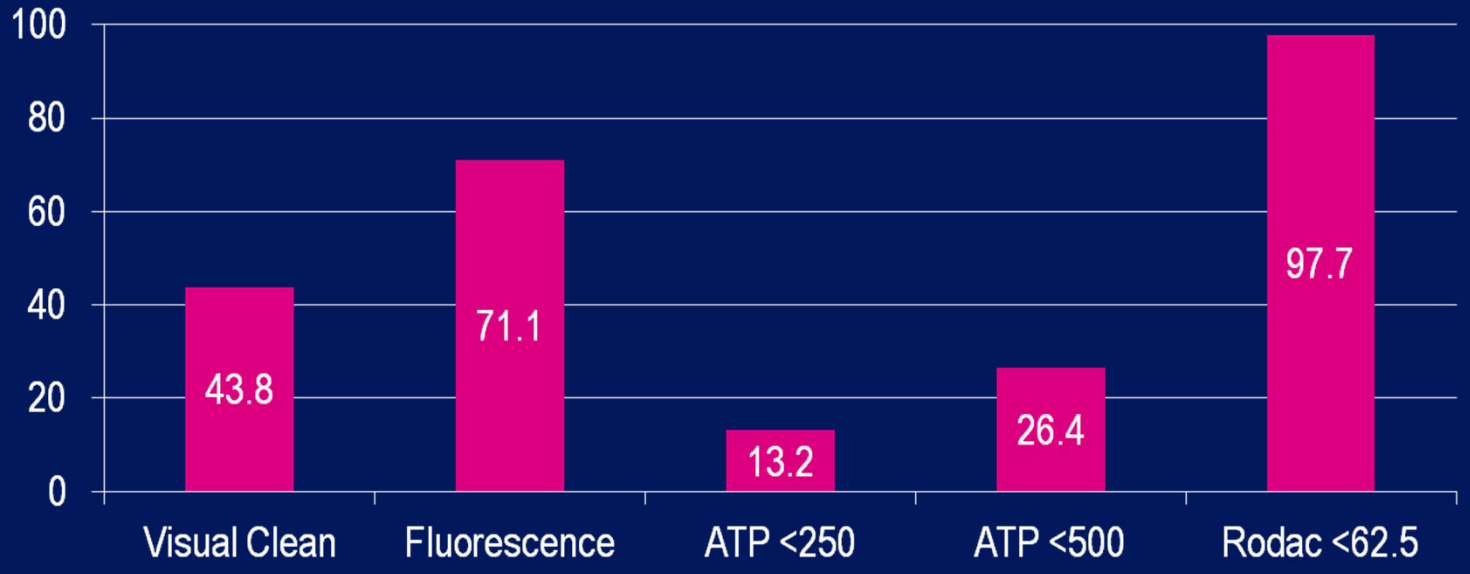


FIGURE 4. A comparison of the results of the 3 previously published multisite studies compared with results from the Iowa project. White bars represent the average baseline TDCs and black bars represent the average final TDCs for sites that completed each study.

Percentage of Surfaces Clean by Different Measurement Methods

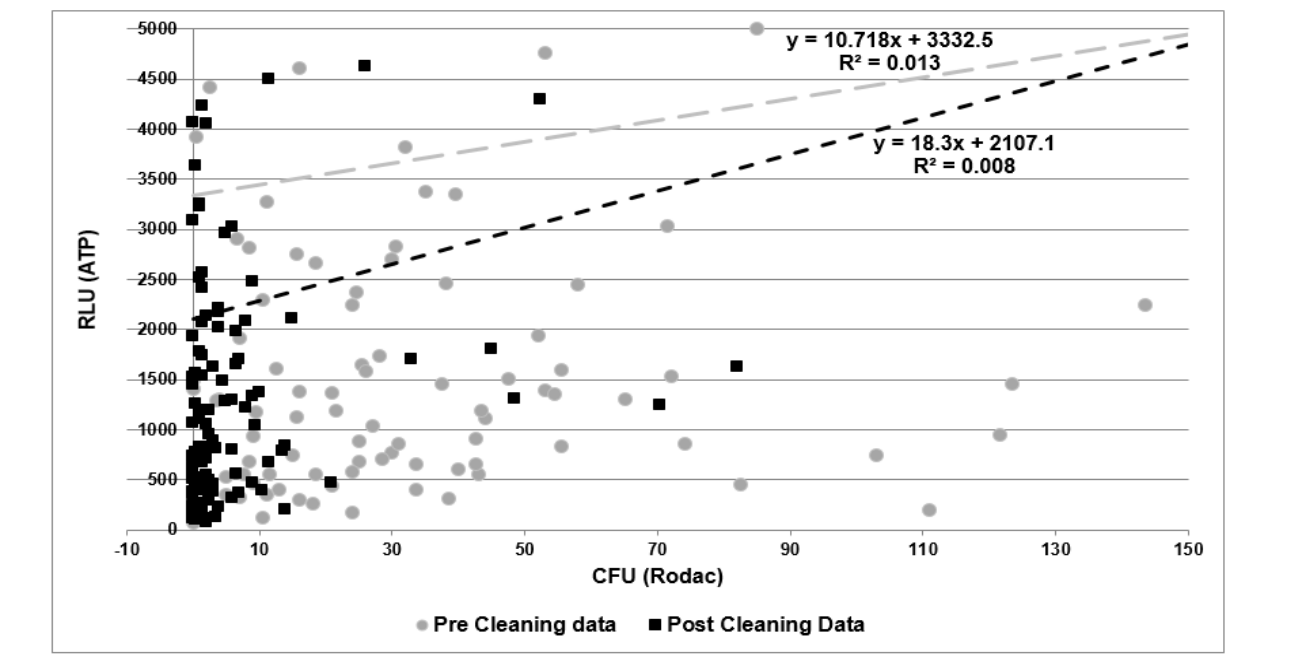
Rutala, Kanamori, Gergen, Sickbert-Bennett, Huslage, Weber. APIC 2017.

Fluorescent marker is a useful tool in determining how thoroughly a surface is wiped and mimics the microbiological data better than ATP



Scatterplot of ATP Levels (less than 5000 RLUs) and Standard Aerobic Counts (CFU/Rodac)

Rutala, Kanamori, Gergen, Sickbert-Bennett, Huslage, Weber. APIC 2017.



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

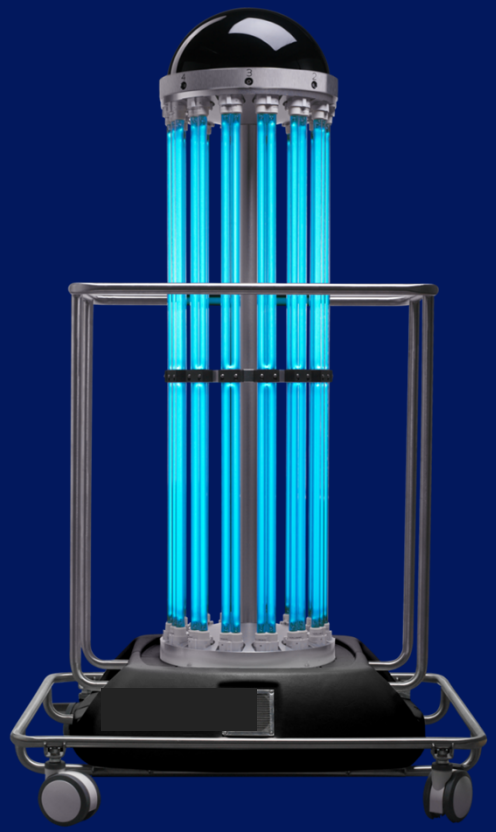
No Touch

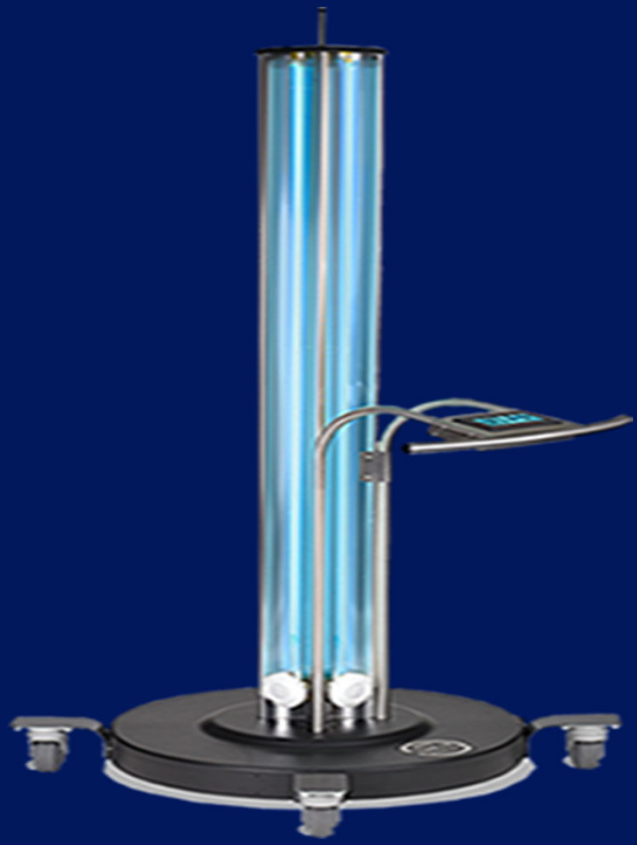
(supplements but do not replace surface cleaning/disinfection)

“NO TOUCH” APPROACHES TO ROOM DECONTAMINATION

(UV/VHP~20 microbicidal studies, ~12 HAI reduction studies; will not discuss technology with limited data)

Weber, Kanamori, Rutala. Curr Op Infect Dis 2016;29:424-431; Weber, Rutala et al. AJIC; 2016:44: e77-e84; Anderson et al. Lancet 2017;389:805-14; Anderson et al. Lancet Infect Dis 2018;June 2018.





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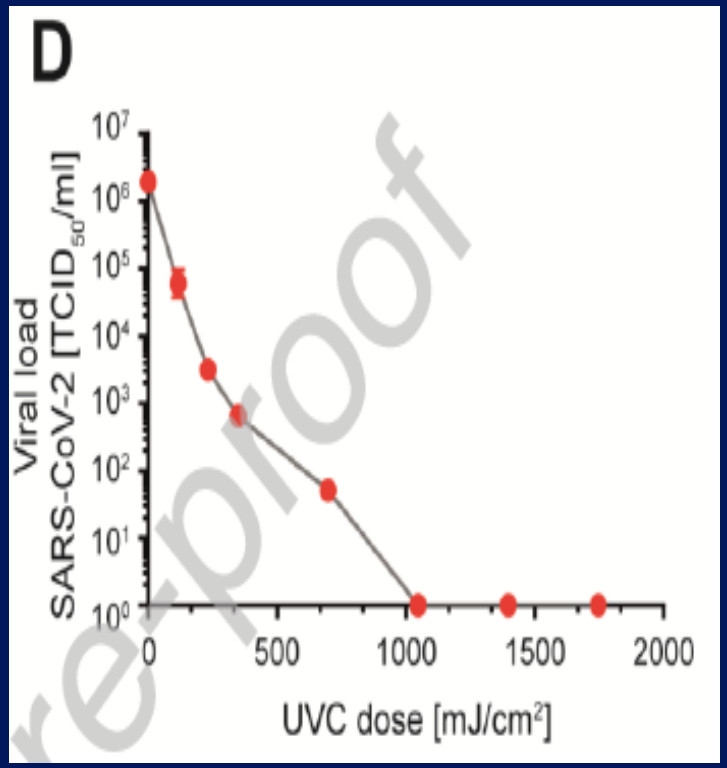

Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

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

- 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

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

CDC, FAQ for COVID-19

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 B.1. Air changes/hour (ACH) and time required for airborne-contaminant removal by efficiency *

Air changes/hour (ACH) and time required for airborne-contaminant removal by efficiency *

ACH § ¶	Time (mins.) required for removal 99% efficiency	Time (mins.) required for removal 99.9% efficiency
2	138	207
4	69	104
6+	46	69
8	35	52
10+	28	41
12+	23	35
15+	18	28
20	14	21
50	6	8

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Environmental Services Fighting COVID-19

ES worked heroically to fight transmission-Lompoc Valley

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

World Health Organization, May 2020

- 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

Learning Objectives

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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

Weber, Rutala, et al. AJIC 2019;47:A72-A78

Advantages

- Allows continued disinfection (may eliminate the problem of recontamination)
- Patients, staff and visitors can remain in the room
- Does not require an ongoing behavior change or education of personnel
- Self-sustaining once in place
- Once purchased might have low maintenance cost
- Technology does not give rise to health or safety concerns
- No (limited) consumable products

Disadvantages

- Room decontamination/biocidal activity is slow
- Capital equipment costs are substantial
- Does not remove dust, dirt, stains that are important to patients and visitors
- Studies have not shown whether the use will decrease HAIs

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

Long-Term Efficacy of a Self-Disinfecting Coating in an ICU

Tamimi, Carlino, Gerba. AJIC 2014. 42:1178-81

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 2
Average (arithmetic mean) total bacterial numbers (cfu) isolated on 100 cm^2 from fomites and percent reduction after treatment

		Weeks after treatment				
Variable	Baseline*	1	2	4	8	15
Number of samples	95	81	64	64	64	45
Average number of bacteria	233,064	98	80	43	2,247	3,320
Range	10-7,000,000	10-2,500	10-840	10-2,500	10-44,000	10-57,000
% reduction	NA	99.96	99.97	99.98	99.04	98.58

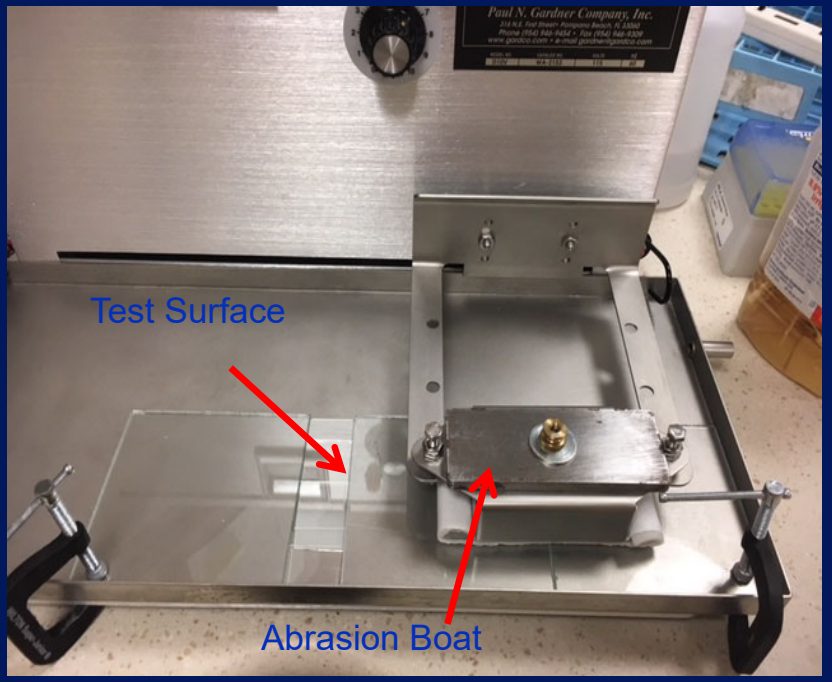
NA, not applicable.
*Before treatment.

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 ($10^{\geq 3.75}$, 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)



Efficacy of a Continuously Active Disinfectant Against a Human Coronavirus, 229E, Evaluated after 48 hours

Rutala WA et al. Unpublished data, September 2020

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

Carrier Treatment with Wears and Re-inoculations	Contact Time	Mean Viral Recovery Titer per Carrier (log_{10})	Log_{10} Reduction
Control (sterile water, n=3)	1 minute	6.00 ± 0.25	N.A.
Test disinfectant (n=3)	1 minute	≤ 1.50 ± 0.00	>4.50

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

- 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

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

THANK YOU!

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