Review of Disease Transmission and Infection Control

In the Era of COVID-19 Pandemic

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Thanks to CDC's Project Firstline and AAP

American Academy of Pediatrics

Disclosures

My husband and I are stockholders:

Abbvie

Becton Dickinson & Co.

Novartis

Gilead Sciences, Inc

Johnson& Johnson

I do not intend to discuss an unapproved/investigative use of a commercial product/device.

Outline

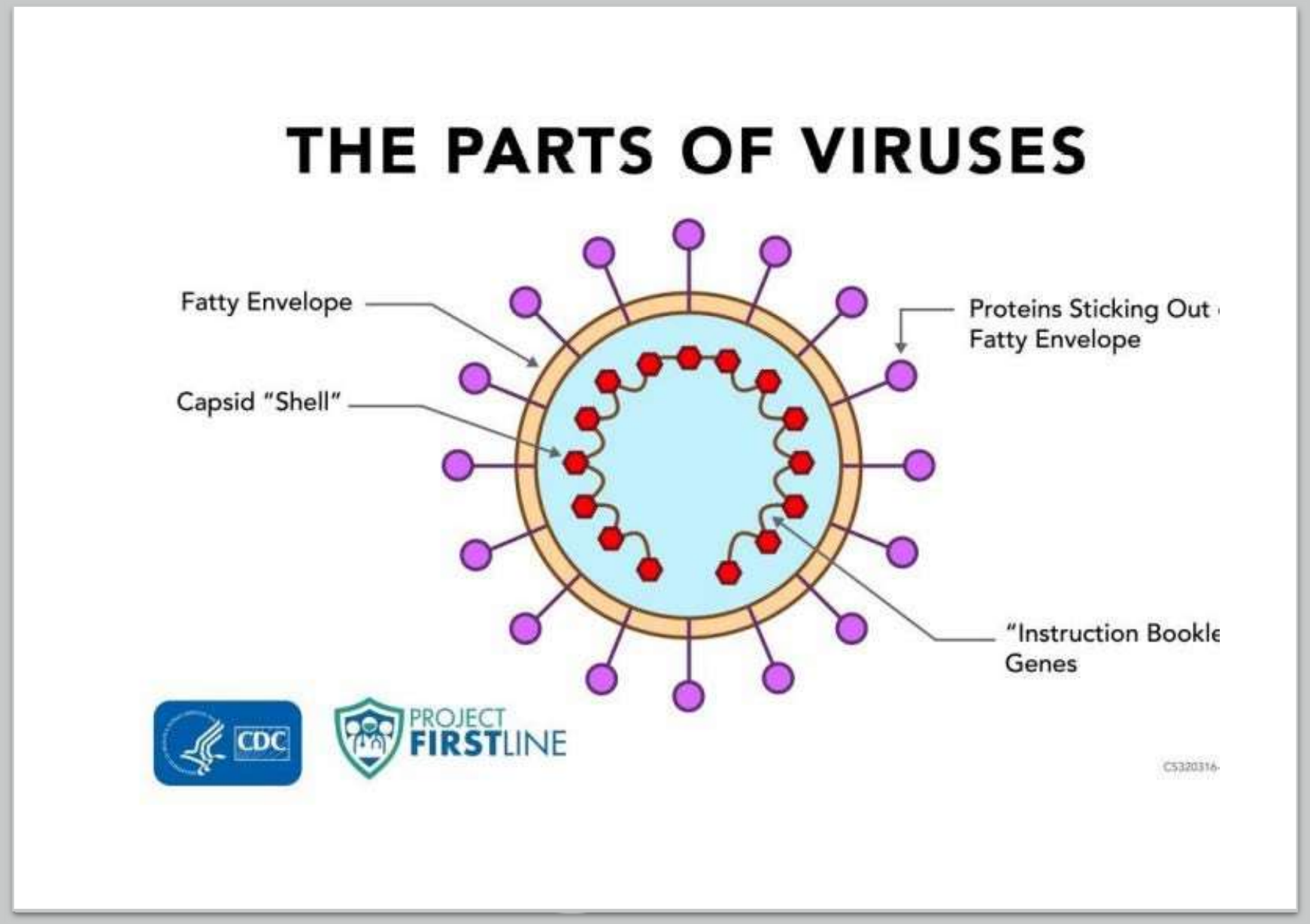
- What have we learned from measles?
- Review basics of disease transmission
- Review current infection control guidelines (CDC, AAP, Project Firstline)
- Reflect on current practice in our offices and hospitals

Objectives

- List methods of transmission of COVID-19
- Understand how environmental factors may affect disease transmission
- List components of infection control
- Know steps of donning and doffing PPE
- Identify components of infection control in a healthcare setting

SARS-CoV-2 is the virus

COVID-19 is the disease



MEASLES:

One of our most contagious diseases

“Transmission of measles virus by respiratory droplets and aerosolized particles. A single infectious individual can infect 9-18 other people on average.”

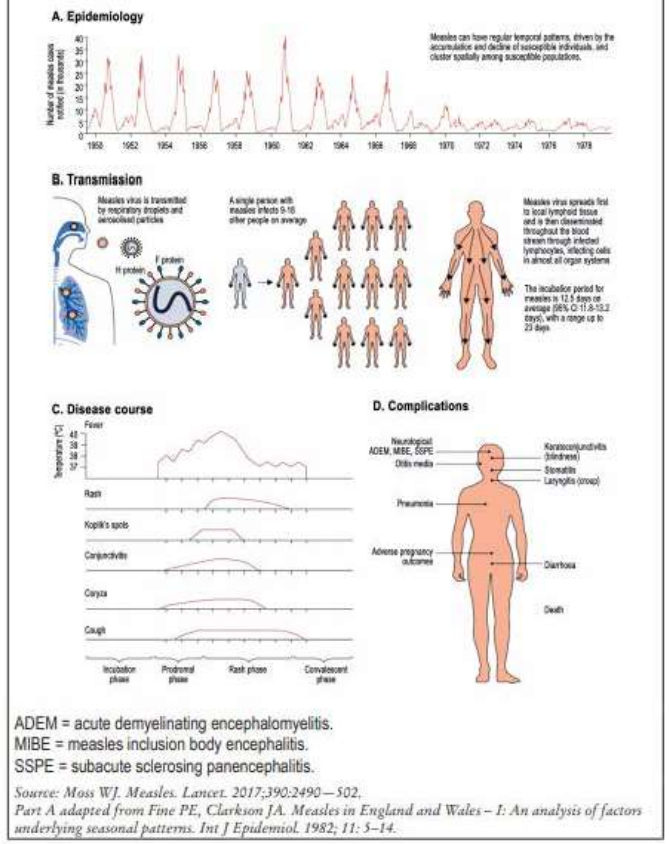
Figure 1. Measles virus transmission, disease course and complications.

A. Epidemiology: Regular temporal pattern of measles driven by accumulation and decline of susceptible individuals.

B. Transmission: Transmission of measles virus by respiratory droplets and aerosolized particles. A single infectious individual can infect 9–18 other people on average. Measles is a systemic infection that spreads throughout the infected host.

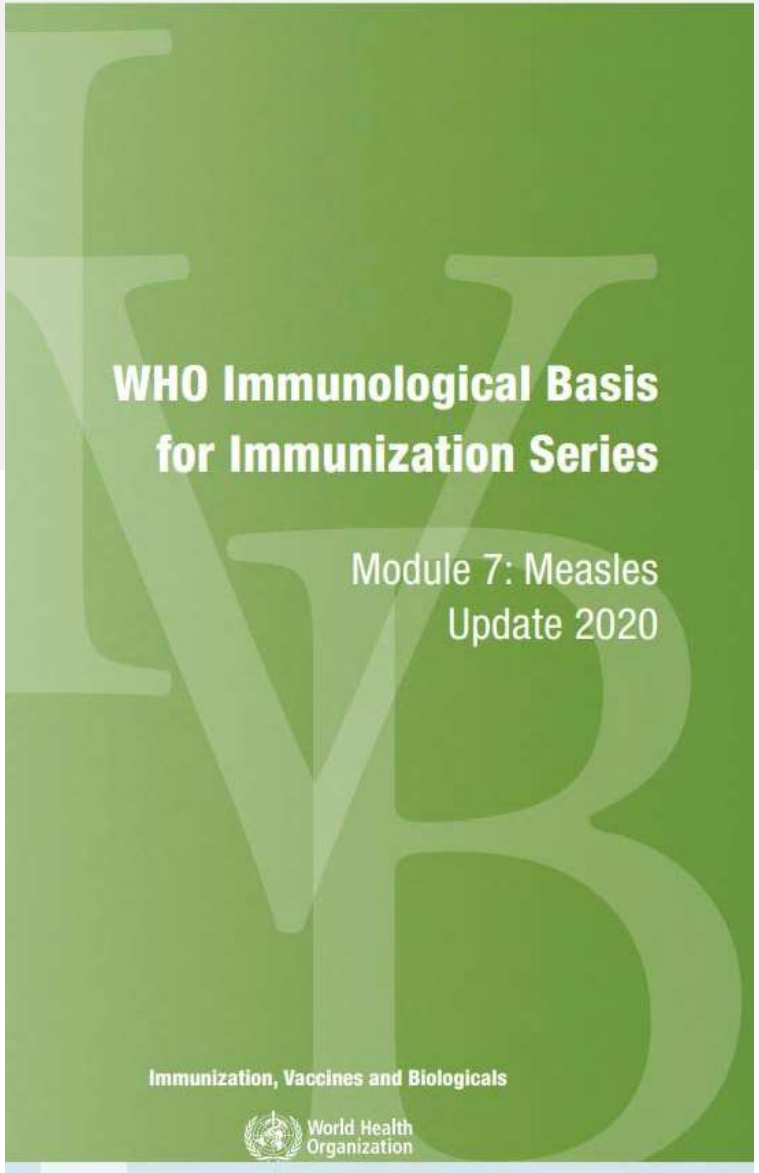
C. Disease course: Clinical disease starts with a prodromal illness of fever, cough, coryza and conjunctivitis, followed by Koplik's spots and the characteristic rash.

D. Complications: Complications of measles occurs in multiple organ systems, including the lungs and nervous system.



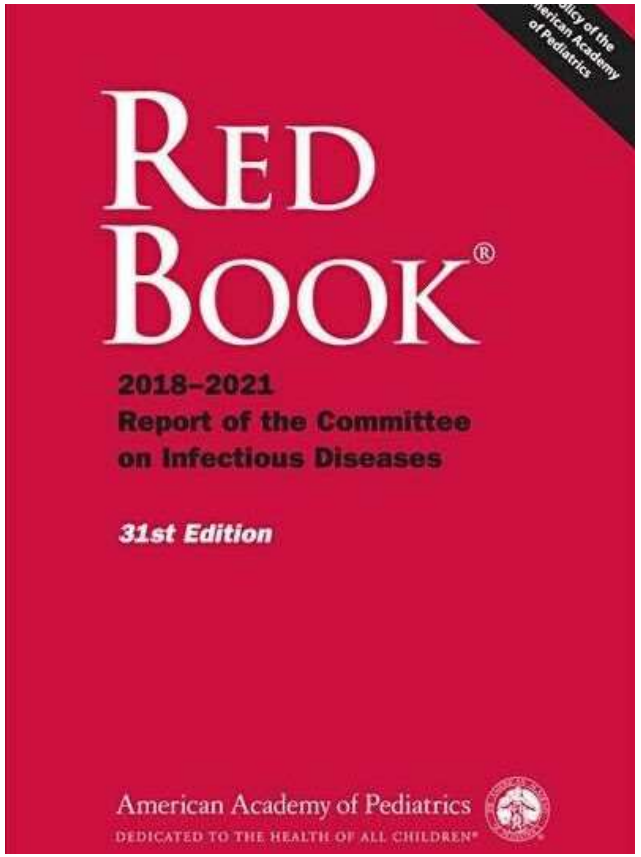
ADEM = acute demyelinating encephalomyelitis.
MIBE = measles inclusion body encephalitis.
SSPE = subacute sclerosing panencephalitis.

Source: Moss WJ. Measles. Lancet. 2017;390:2490—502.
Part A adapted from Fine PE, Clarkson JA. Measles in England and Wales – I: An analysis of factors underlying seasonal patterns. Int J Epidemiol. 1982; 11: 5–14.



Measles

- Page 538
- *“Measles is transmitted by direct contact with infectious droplets or, less commonly, by airborne spread. Measles is one of the most highly communicable of all infectious disease. The attack rate of susceptible individual to measles is 90%.”*



Airborne Spread of Measles in a Suburban Elementary School - 1974

- Index case: 2nd grade girl
- 28 secondary cases in 14 different classrooms
- Virus recirculated by the ventilating system were implicated
- After two subsequent generations, 60 children had been infected

25th, 1974. Twenty-eight secondary cases followed after an incubation period. The remaining 31 cases occurred either in one spread-out generation or, more probably, in two generations of 27 and four cases (figure 1). After a total of 60 cases, the epidemic subsided, well before the end of the school year. Since diagnoses were

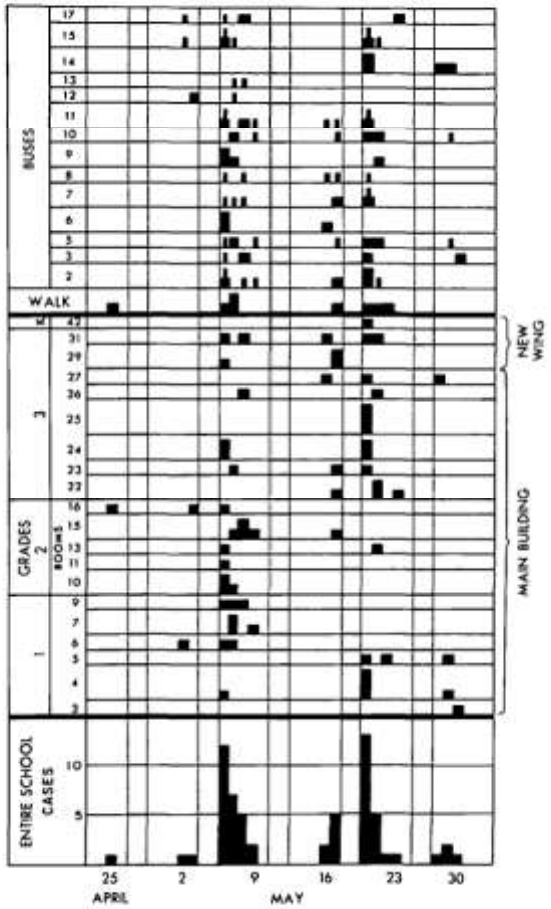


FIGURE 1. Distribution of measles cases in an upstate New York elementary school in spring, 1974, by calendar date of first day of school missed on account of measles. Gray vertical bars identify Saturdays and Sundays. From below up, separated by heavy horizontal lines, cases in entire school; cases by grades and rooms; cases by means of transportation (walk or bus). Cases who traveled one way by bus are shown by narrow vertical bars. On the right the cases with home rooms in the main building and in the new wing are separated because they were supplied by separate ventilating systems.

Riley E.C. et al. American Journal of Epidemiology.

Vol 107. No 5. page 421, 1978.

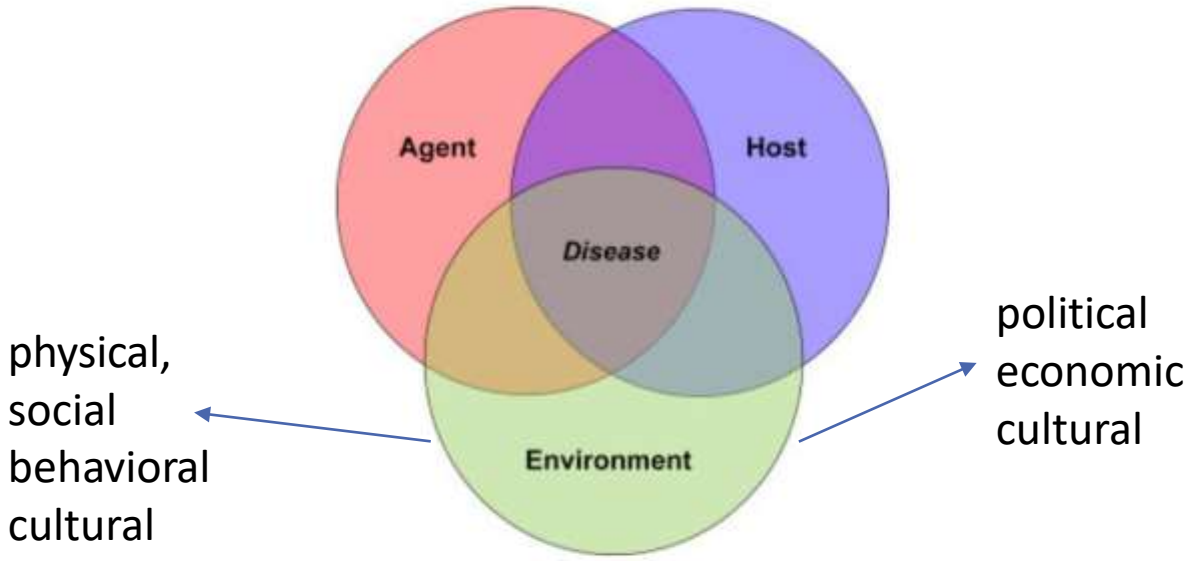
Measles: What is the primary mode of transmission?

James Cherry
4th Ed Feigin and Cherry Textbook of Pediatric Infectious Disease

- Mainly by aerosolized droplets of respiratory secretions
- Acquisition in new host by nose and possible conjunctivae
- Infection can occur by:
  - small-droplet nuclei that stay suspended –or-
  - direct hits of large droplets at close range
- It also seems possible that spread involves close person-to-person contact in children with large virus-containing droplets of nasal secretions picked up on hands of the future host and applied to the nose

Disease Transmission – The Big Picture

Figure 1



The epidemiological triad model of infectious disease causation. The triad consists of an agent (pathogen), a susceptible host, and an environment (physical, social, behavioral, cultural, political, and economic factors) that brings the agent and host together, causing infection and disease to occur in the host.

Van Seventer J, Hochberg N. International Encyclopedia of Public Health, 2nd edition, Volume 6
http://dx.doi.org/10.1016/B978-0-12-803678-5.00516-6

Modes of Transmission from Reservoir to Host

Direct

1. Direct Contact
2. Direct spread of droplets
3. Direct spread in environment
4. Bite
5. Transplacental/perinatal

Indirect

1. Biological
   - Biological vector
   - Intermediate host
2. Mechanical
   - Mechanical vector
   - Vehicle
3. Airborne

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http://dx.doi.org/10.1016/B978-0-12-803678-5.00516-6

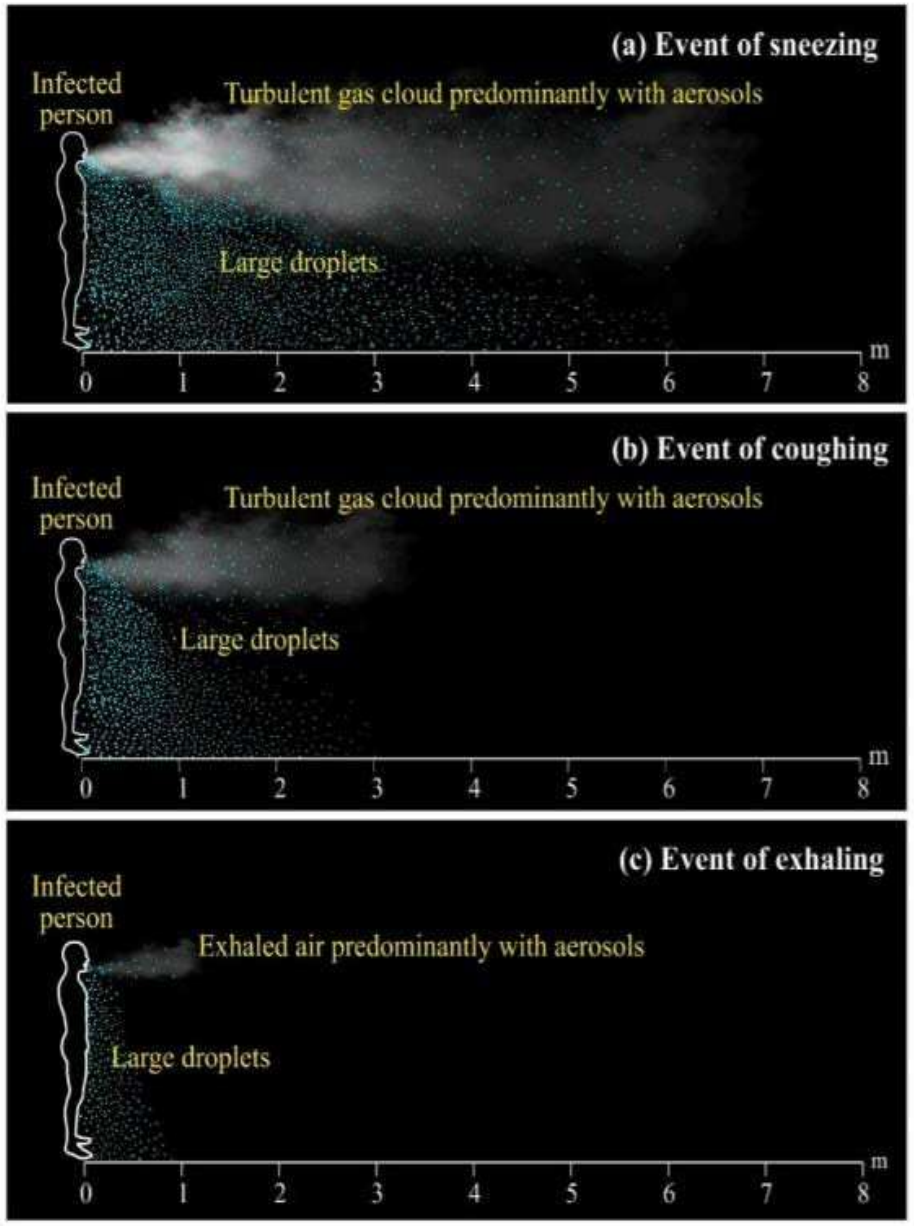


Fig. 2. Trajectories of droplets and aerosols from an infected patient (a) event of sneezing with droplets travelled for 6 m at a speed of 50 m/s within 0.12 s (b) event of coughing with droplets travelled for 2 m at a speed of 10 m/s within 0.2 s (c) event of exhaling with droplets travelled for 1 m at a speed of 1 m/s within 1 s.

Transmission COVID-19 virus by droplets & aerosols:

Critical review on unresolved dichotomy

Droplet > 10 µm ?
Aerosols < 10 µm ?

Some droplets covert to aerosols particles through evaporation and then become airborne (bioaerosols)

Factors that affect spread: Humidity, temperature, radiation (sunlight), airflow (ventilation).

SARS-CoV-2: viable in aerosols for 3 h

Droplets on surfaces: viable for 4 hours to 3 1/2days

Https://doi.org/10.1016/J.envres2020.109819

Environmental Factors

Climate / weather

Natural disaster

Infrastructure

Change in land use

Technology

Travel

Politics

Economics

War and conflict

Social

Less humidity and heat (cooler temps) promote formation of aerosols

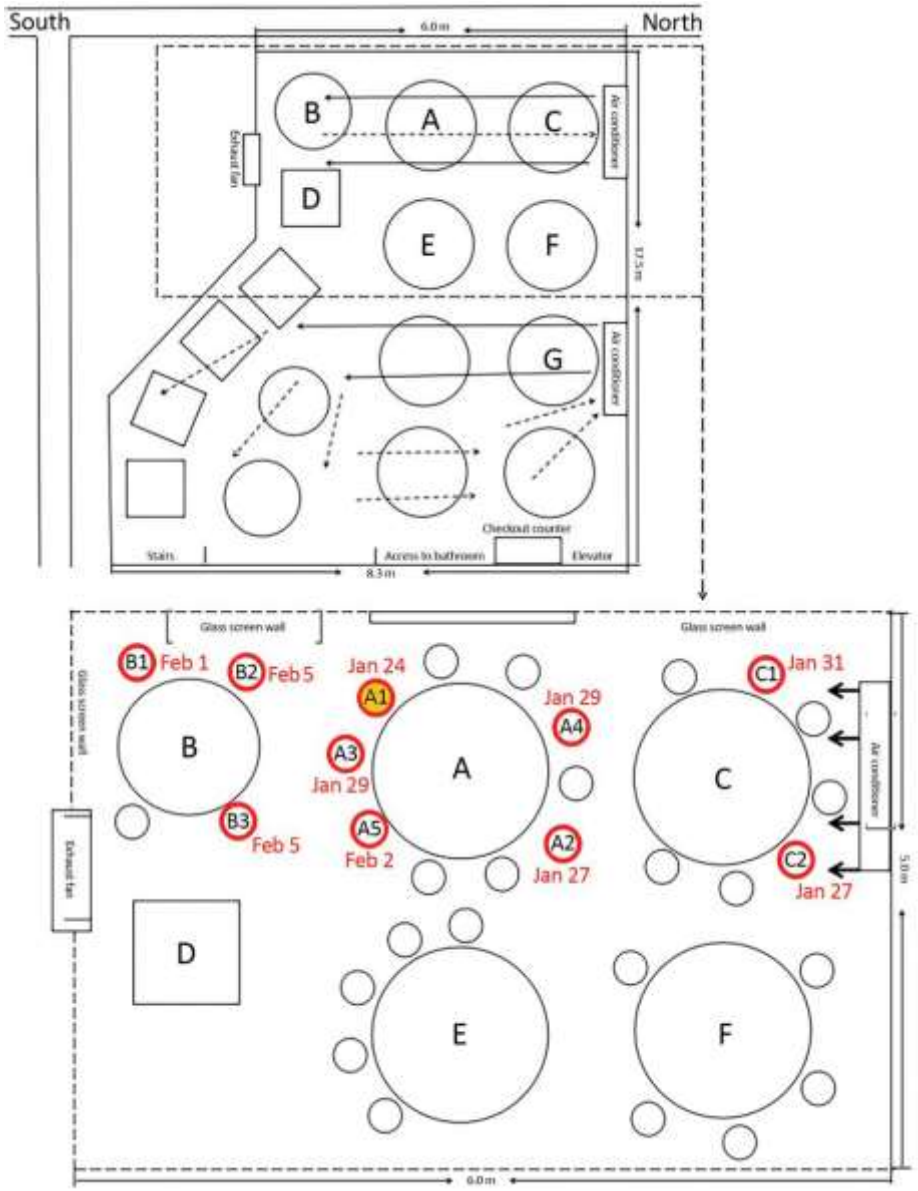
SARS-COV-2 does less well with exposure to UV light

Construction producing dust may release botulism spores

Ventilation systems

Van Seventer J, Hochberg N. International Encyclopedia of Public Health, 2nd edition, Volume 6
http://dx.doi.org/10.1016/B978-0-12-803678-5.00516-6

COVID -19 Outbreak in Restaurant



Members of three families became ill with COVID – 19 after eating lunch in close proximity to an asymptomatic individual who recently returned from Wuhan

Individuals in path of same air conditioner became ill

Authors concluded transmission by droplets over aerosolized droplets

Recommend increasing space between tables

Figure. Sketch showing arrangement of restaurant tables and air conditioning airflow at site of outbreak of 2019 novel coronavirus disease, Guangzhou, China, 2020. Red circles indicate seating of future case-patients; yellow-filled red circle indicates index case-patient

Lu J, et al. www.cdc.gov/eid.vol 26, No. 7. July 2020.

Portals of Entry / Exit

- **Respiratory**
  - Inhalation
  - Exhalation, cough sneeze
- **Gastrointestinal**
  - Ingestion
  - Diarrhea
- **Mucosal**
  - Conjunctiva
- **Skin**

2003 SARS Airborne transmission from sewage disposal system

- Housing complex in Hong Kong
- 187 cases
- Likely infected with rising plume of contaminated warm air
- Traps in floor drains were dry and connection was open to drainage pipe
- Exhaust fan in bathroom likely drew fine droplets or aerosols into bathroom through unsealed floor drains

Yu ITS, et al. Evidence of Airborne Transmission of the Severe Acute Respiratory Syndrome Virus. *N Engl J Med 2004:350;17. 1731-1739.*

Transmission in the Healthcare Setting

Infection Transmission

- **Transmission** is the way pathogens are moved to the susceptible person.
- Pathogens depend on **people, the environment, and/or medical equipment** to move in healthcare settings.
- Pathogens travel in healthcare settings through:
  - Contact (ie, touching),
  - Sprays and splashes,
  - Inhalation, and
  - Sharp injuries (ie, when someone is accidentally stuck with a used needle or sharp instrument).

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Infection Source

- A source is any place **where infectious agents/pathogens live.**
  - Can be found in many places within a health care setting.
- People:
  - Patients,
  - Healthcare workers, and
  - Visitors.
- Environmental:
  - Dry surfaces in patient care areas (eg, bed rails, medical equipment, countertops and tables),
  - Wet surfaces, moist environments, and biofilms (eg, cooling towers, faucets and sinks and equipment such as ventilators),
  - Indwelling medical devices (eg, catheters and IV lines), and
  - Dust or decaying debris (eg, construction dust or wet materials from water leaks).

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CDC Scientific Brief (October 2020): SARS-CoV-2 and Potential Airborne Transmission

Aerosol: in the healthcare setting, the term is used with respect to "aerosol-generating procedures." In the community, the term is used to describe the sewage system-generated cloud of small droplets

Airborne transmission: any size particle capable of travel through the air. Some experts reserve this for those infections transmitted via small droplets and particles suspended in the air over long distances and that persist in the air for long times.

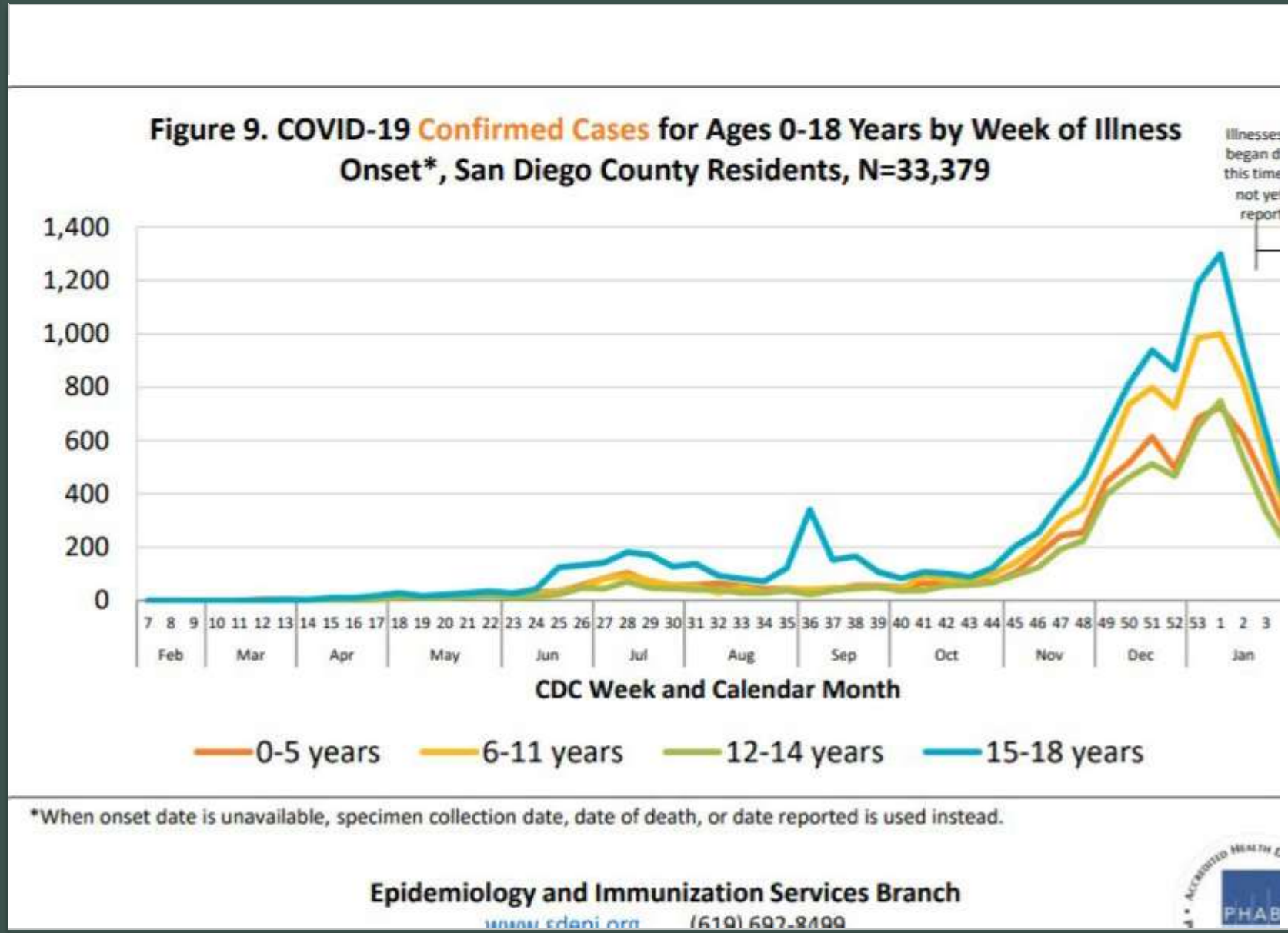
Epidemiology SARS-CoV-2: spread mostly through close contact and not airborne transmission; primarily spread through respiratory droplets within a short range (6 feet)

Airborne transmission can occur: under special circumstances such as enclosed spaces, prolonged exposure with respiratory particles generated from expiratory exertion, and inadequate ventilation

Infection Control

1) Continue Routine Infection Control Practices

2) Additional Measures during CoV-2 Pandemic



Pediatric COVID-19 Cases (San Diego County)

Infection Control Components

Each component builds on the next and should be used together all the time.

- Source Control/ Visitor Exclusion
- Screening and Triage practices
- Environmental and Hand Hygiene
- Personal Protective Equipment

Adapted from AAP/Firstline slide set

Source Control/ Visitor Exclusion

- Source Control should be practiced by everyone in the healthcare facility.
- Wear a mask to cover your nose and mouth any time you might be near other people. – even when you're not in patient care areas, eg, break rooms.
- Cloth masks should be worn by patients and visitors.
- Healthcare personnel should wear surgical masks while at work, and switch to respirators (eg, N95) when caring for known or suspected COVID-19 patients.
- One visitor / child except for newborns (?)

Adapted from AAP/Firstline slide set

Adapted from AAP/Firstline slide set

Screening and triage practices

- **Screening protocol** for persons calling with concern for COVID-19
- **Where ill persons** with likelihood of COVID-19 should be seen (? ED)
- **Sick visits late afternoon**
- **Reschedule well or follow up appointments** if they are diagnosed with or develop symptoms of COVID-19 in the 10 days prior to appointment, or have exposure to someone suspected of COVID-19 infection in the preceding 14 days of the scheduled appointment
- **Screening all for symptoms** on arrival (HC providers, visitor, parents, patients)
- **Visual alerts** for handwashing and masking
- **Provide masks and hand sanitizers**

Adapted from AAP/Firstline slide set

Environmental and Hand Hygiene

- Environmental engineers- check HVAC and airflow (CDC website)
- Hospital- negative pressure rooms
- Physical barriers- Plexiglass screens
- Clean all non-disposable equipment and hard surfaces between patients
- Wash or use hand sanitizer before and after every patient encounter

Adapted from AAP/Firstline slide set

Personal Protective Equipment (PPE)

Barriers provide protection of eye, nose, and mouth (mucous membranes): for ALL PATIENT ENCOUNTERS

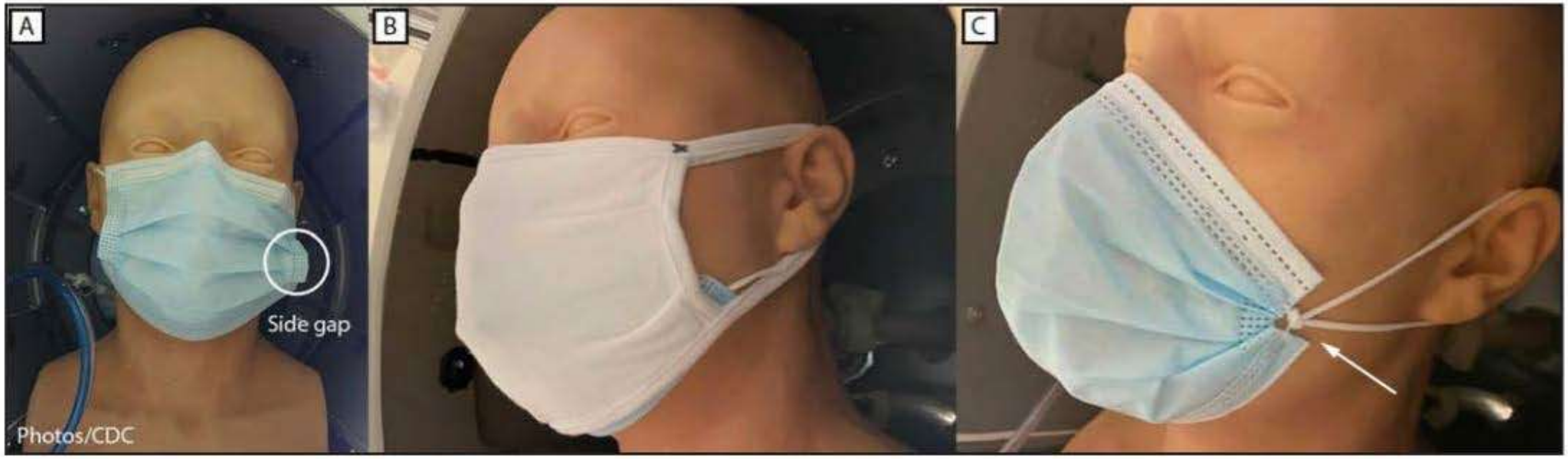
Filtering respirators to prevent inhalation: for all patients or if patient has or suspected of COVID-19

Gloves: for all patients or if patient has or suspected of COVID-19

Gowns: if patient has or suspected of COVID-19

Correct use is important

CDC tested different mask configurations



- MMWR / February 10, 2021 / Vol. 70

Double masking is superior to other methods

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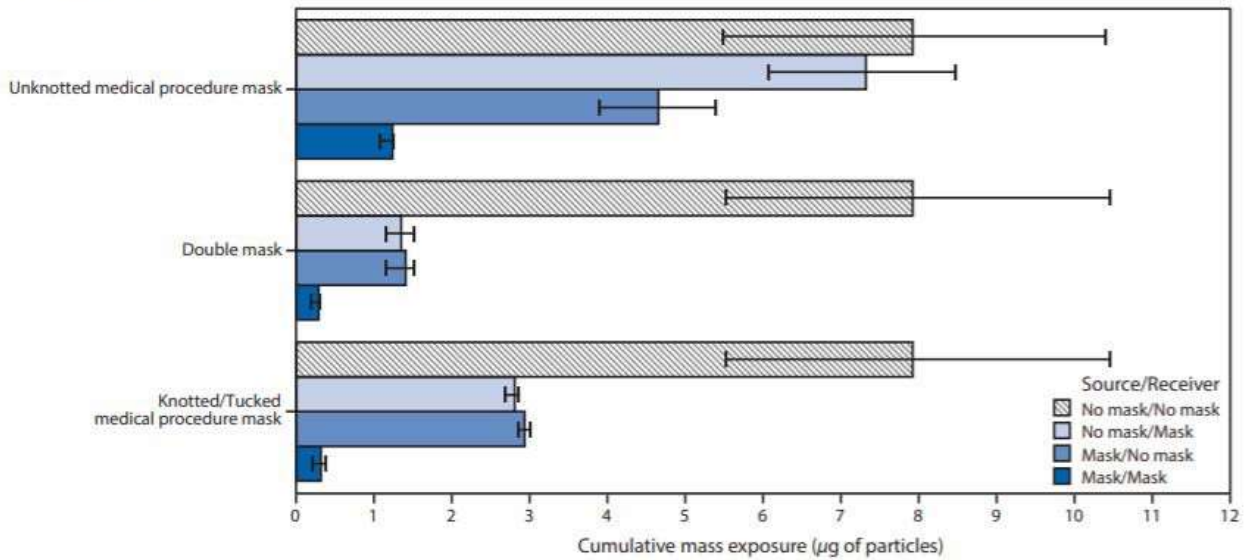
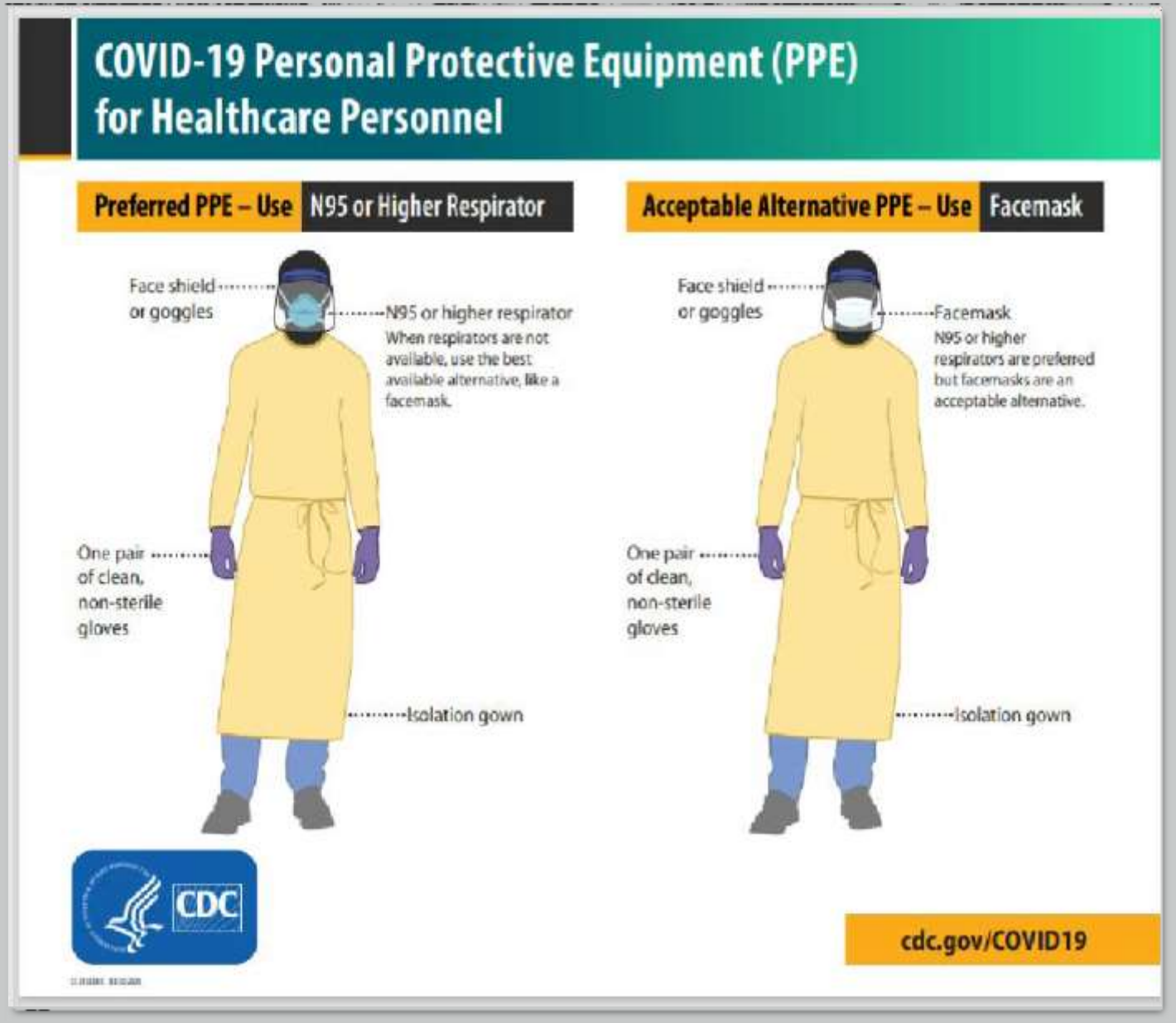
FIGURE 2. Mean cumulative exposure* for various combinations of no mask, double masks, and unknotted and knotted/tucked medical procedure masks†



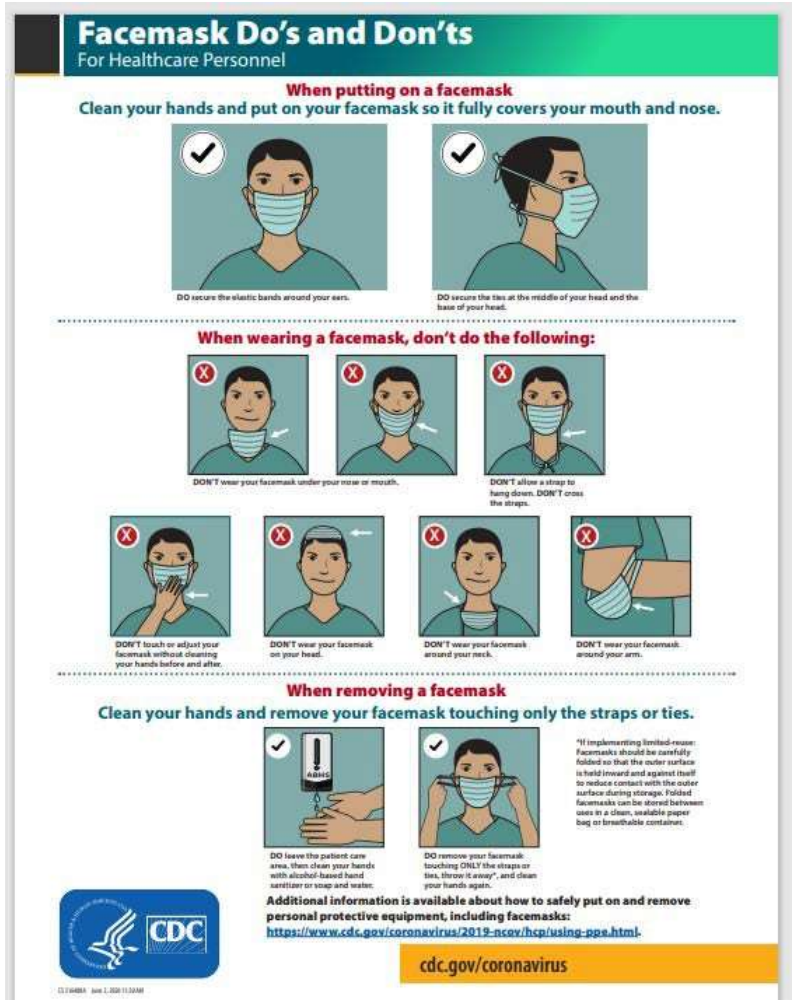
* To an aerosol of 0.1–7 μm potassium chloride particles (with 95% confidence intervals indicated by error bars) measured at mouthpiece of receiver headform configured face to face 6 ft from a source headform, with no ventilation and replicated 3 times. Mean improvements in cumulative exposures compared with no mask/no mask (i.e., no mask wearing, or 100% exposure) were as follows: *unknotted medical procedure mask*: no mask/mask = 7.5%, mask/no mask = 41.3%, mask/mask = 84.3%; *double mask*: no mask/mask = 83.0%, mask/no mask = 82.2%, mask/mask = 96.4%; *knotted/tucked medical procedure mask*: no mask/mask = 64.5%, mask/no mask = 62.9%, mask/mask = 95.9%.

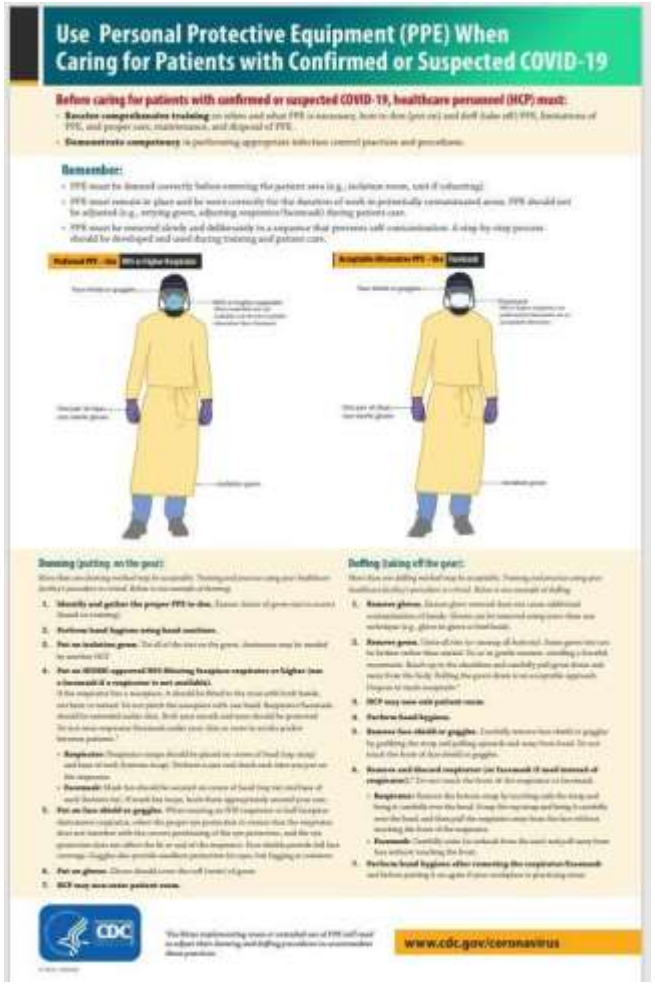
† Double mask refers to a three-ply medical procedure mask covered by a three-ply cloth cotton mask. A knotted and tucked medical procedure mask is created by bringing together the corners and ear loops on each side, knotting the ears loops together where they attach to the mask, and then tucking in and flattening the resulting extra mask material to minimize the side gaps.



Recommended when caring for patients with known or suspected COVID-19 include:

- Barriers that protect eye, nose, and mouth
- Filtering respirator to prevent inhalation
- Gloves and gown to make it easy to remove infectious secretions





Proper Donning and Doffing of PPE

https://www.cdc.gov/coronavirus/2019-ncov/hcp/using-ppe.html

https://www.youtube.com/watch?v=PQxOc13DxvQ&feature=emb_rel_end

Steps in donning

1. **Identify and gather the proper PPE to don.** Ensure choice of gown size is correct (based on training).
2. **Perform hand hygiene using hand sanitizer.**
3. **Put on isolation gown.** Tie all of the ties on the gown. Assistance may be needed by other healthcare personnel.
4. **Put on NIOSH-approved N95 filtering facepiece respirator or higher (use a facemask if a respirator is not available).** If the respirator has a nosepiece, it should be fitted to the nose with both hands, not bent or tented. Do not pinch the nosepiece with one hand. Respirator/facemask should be extended under chin. Both your mouth and nose should be protected. Do not wear respirator/facemask under your chin or store in scrubs pocket between patients.
    1. **Respirator:** Respirator straps should be placed on crown of head (top strap) and base of neck (bottom strap). Perform a user seal check each time you put on the respirator.
    2. **Facemask:** Mask ties should be secured on crown of head (top tie) and base of neck (bottom tie). If mask has loops, hook them appropriately around your ears.
5. **Put on face shield or goggles.** When wearing an N95 respirator or half facepiece elastomeric respirator, select the proper eye protection to ensure that the respirator does not interfere with the correct positioning of the eye protection, and the eye protection does not affect the fit or seal of the respirator. Face shields provide full face coverage. Goggles also provide excellent protection for eyes, but fogging is common.
6. **Put on gloves.** Gloves should cover the cuff (wrist) of gown.
7. **Healthcare personnel may now enter patient room.**

Steps for doffing

1. **Remove gloves.**
2. **Remove gown.** Untie all ties (or unsnap all buttons). Some gown ties can be broken rather than untied. Do so in gentle manner, avoiding a forceful movement. Reach up to the shoulders and carefully pull gown down and away from the body. Rolling the gown down is an acceptable approach. Dispose in trash receptacle.*
3. **Healthcare personnel may now exit patient room.**
4. **Perform hand hygiene.**
5. **Remove face shield or goggles.** Carefully remove face shield or goggles by grabbing the strap and pulling upwards and away from head. Do not touch the front of face shield or goggles.
6. **Remove and discard respirator (or facemask if used instead of respirator).** Do not touch the front of the respirator or facemask.
    1. **Respirator:** Remove the bottom strap by touching only the strap and bring it carefully over the head. Grasp the top strap and bring it carefully over the head, and then pull the respirator away from the face without touching the front of the respirator.
    2. **Facemask:** Carefully untie (or unhook from the ears) and pull away from face without touching the front.
7. **Perform hand hygiene after removing the respirator/facemask and before putting it on again if your workplace is practicing reuse.**

Strategies for Optimizing the Supply of PPE

- Consider these options and **implement them sequentially**.
- Understand current PPE inventory, supply chain, and utilization rate.
- Train health care personnel on PPE use and have them demonstrate competency with donning and doffing any PPE ensemble that is used to perform job responsibilities.

Centers for Disease Control and Prevention. Summary for Healthcare Facilities: Strategies for Optimizing the Supply of PPE during Shortages. Accessed December 9, 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/strategies-optimize-ppe-shortages.html

PPE Reuse

- Practices for extended use (more than 1 patient encounter) and reuse of PPE should be defined in the facility's IPC policy and will be driven by the patient(s) for whom care is provided and the procedures performed:

  When caring for an asymptomatic patient with unknown status: Masks, eye protection, and gowns may be used all day if not soiled or contaminated. If some or all of these items are reusable, these items might be able to be sanitized at the end of the day and reused. If used, gloves should be changed between patients.

  When caring for a patient with a COVID-19-compatible illness: Gloves and gown should be removed and disposed of between patients. Eye protection (goggles and/ or face shields) should be sanitized between patients. Masks should be changed between patients unless covered by a face shield or another mask.

  When performing an aerosol-generating procedure **(AGP):** When performing AGPs, the highest available level of PPE should be used. PPE reuse should follow policies for the care of patients **with** a COVID-19-compatible illness.

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Discontinuationof Transmission-BasedPrecautions for COVID-19

- **Symptom-Based Strategy for Discontinu ing Transmission -Based Precautions**

  Pat ients with mild to moderate illness who are not severely immunocompromised:

  - At least 10 days have passed *since symptoms first oppeored* **and**
  - At least 24 hour s ha ve passed *since lost* fever without the use of fever-reducing medications **and**
  - Symptoms **(eg,** coug,h shortness of breath) have improved

  Pat ients with severe to critical illness or who areseverely immu nocomp romised:

  - At least 10 days and up to 20 days have passed *since symptoms first oppeored* **and**
  - At least 24 hours have passed *since lost* fever without the use of fever-reducing medications **and**
  - Symptoms **(eg,** cough, shortness of breath) have improved
  - Consider consultation withinfection control experts

- A test-based strategy is no longer recommended because in the m ajority of cases, it results in prolonged isolation of patients who continue to shed detect able SARS–CoV-2 RNA but are no longer infectious.

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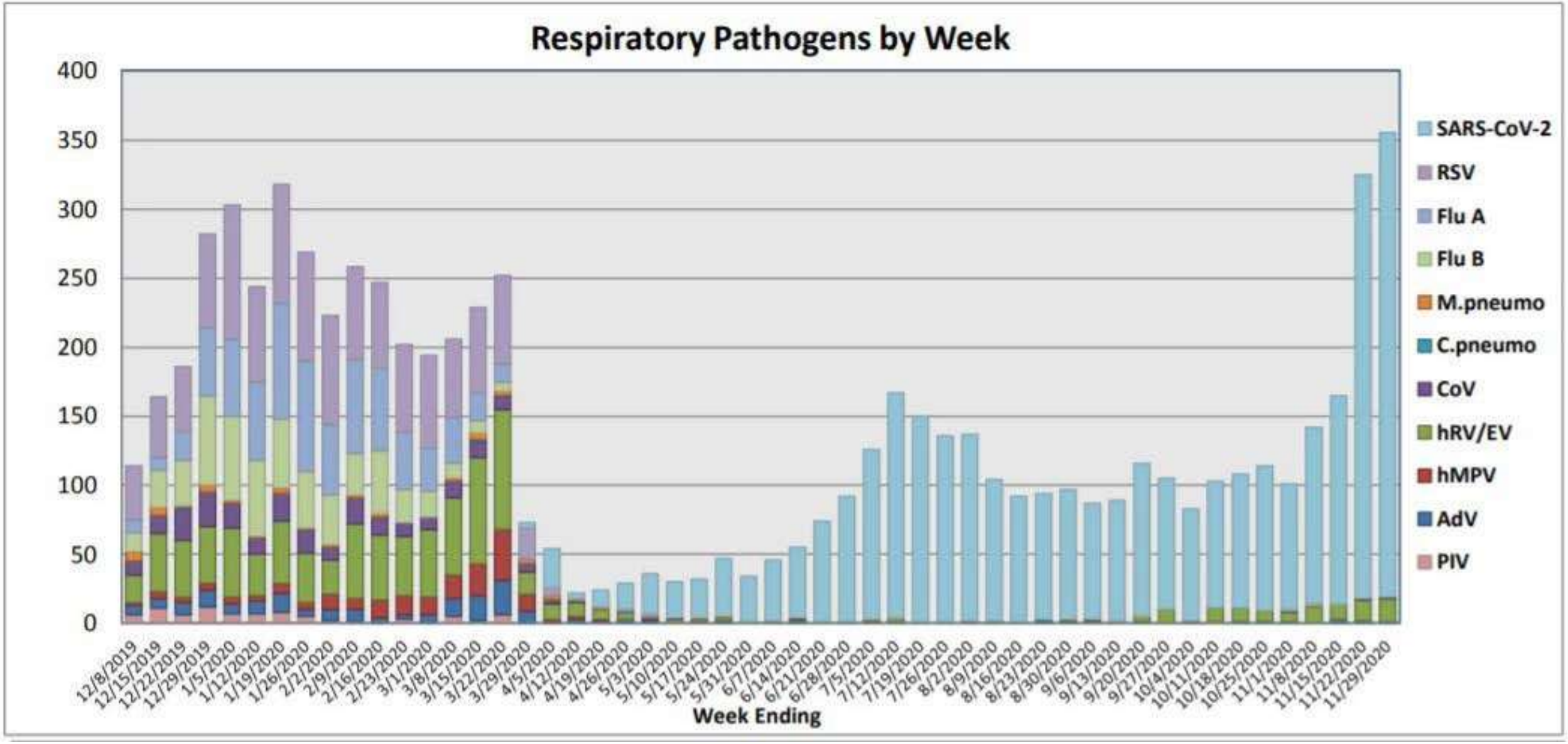
Summary & Reflections

- Guidelines change
- Cooperation is needed at all levels
- COVID fatigue is real
- Pediatric providers likely to see more children with disease in the next weeks
- Cannot let our guard down
- Lingering Questions

1. Should patients and parents waiting in rooms be expected to keep their masks on the entire time?
2. Which children are at risk of having COVID-19, i.e. those with sniffles? Do I wear gown and gloves when seeing them?
3. How long can I really wear my mask?

RADY CHILDREN'S HOSPITAL



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- Yu ITS, et al. Evidence of Airborne Transmission of the Severe Acute Respiratory Syndrome Virus. *N Engl J Med 2004:350;17. 1731-1739.*

Resources

- American Academy of Pediatrics COVID-19 Guidance and Resources
  - Guidance on the use of PPE for Pediatric Care in Ambulatory Care Settings During the SARS-CoV-2 Pandemic
  - Masks or Cloth Face Coverings for Children During COVID-19
  - COVID Town Halls
  - Practice Management Tips
  - Preparing for Flu Season
  - Discounts on PPE and COVID-19 Supplies
- Centers for Disease Control and Prevention
  - Using Personal Protective Equipment (PPE)
  - Strategies to Optimize the Supply of PPE and Equipment
  - Use Personal Protective Equipment (PPE) correctly for COVID-19 **(video)**
  - Personal Protective Equipment: Questions and Answers
  - PPE Burn Rate Calculator
- Project Firstline

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THANK YOU

Special thanks to
Dr. Helen Wang
Meredith Kennedy
Kirstie Pfeifer