

Population Health Modeling: Day 4

Check-In



Brief Review

Basic philosophical and ethical principles for public health research and public health modeling

Outbreak Investigations- lots of moving parts in any data collection/analysis process

Brief Overview

Info dump: *Streptococcus pneumoniae*

Info dump: pneumococcal vaccines

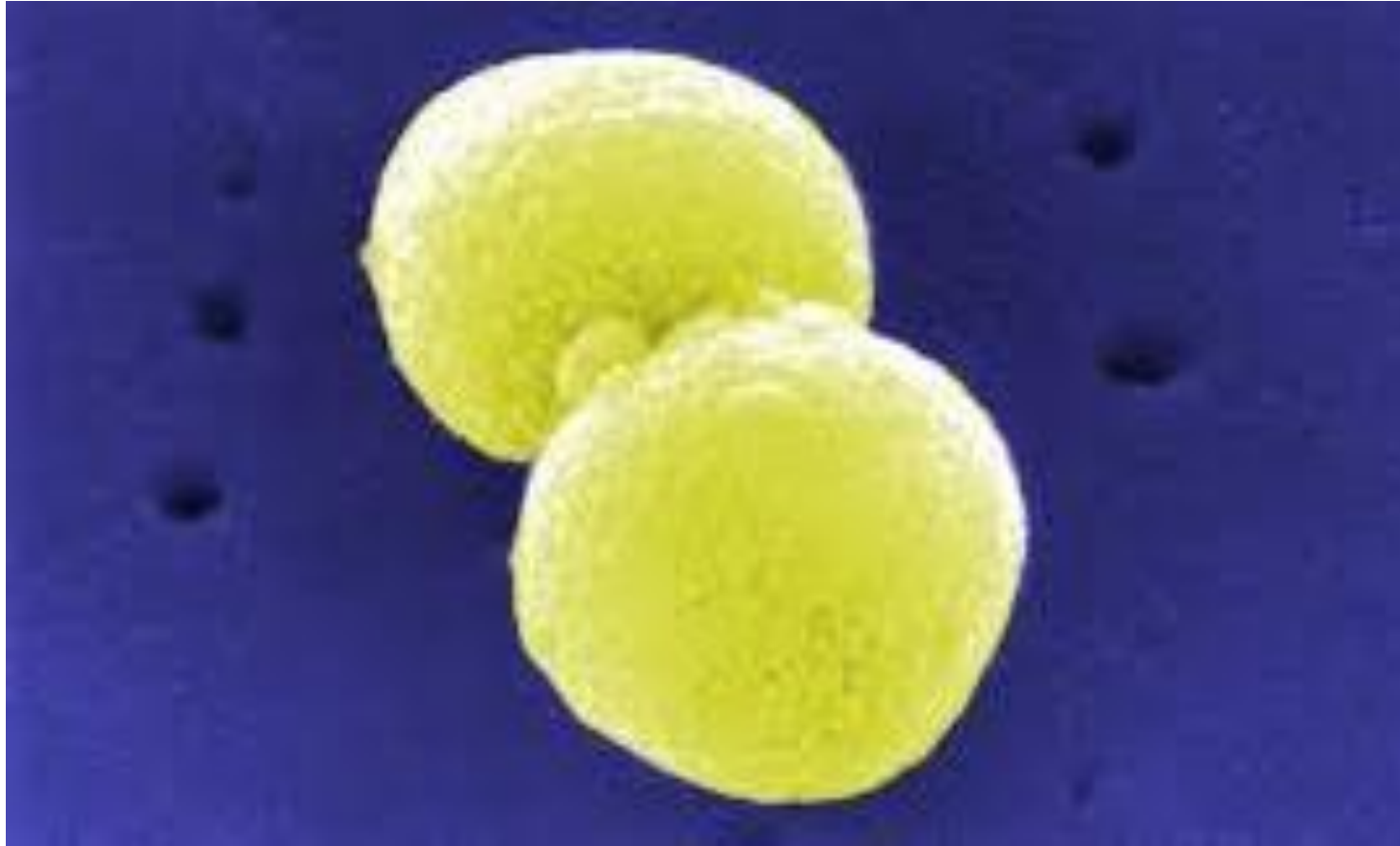
Info smattering: infectious disease surveillance

Small LARP?

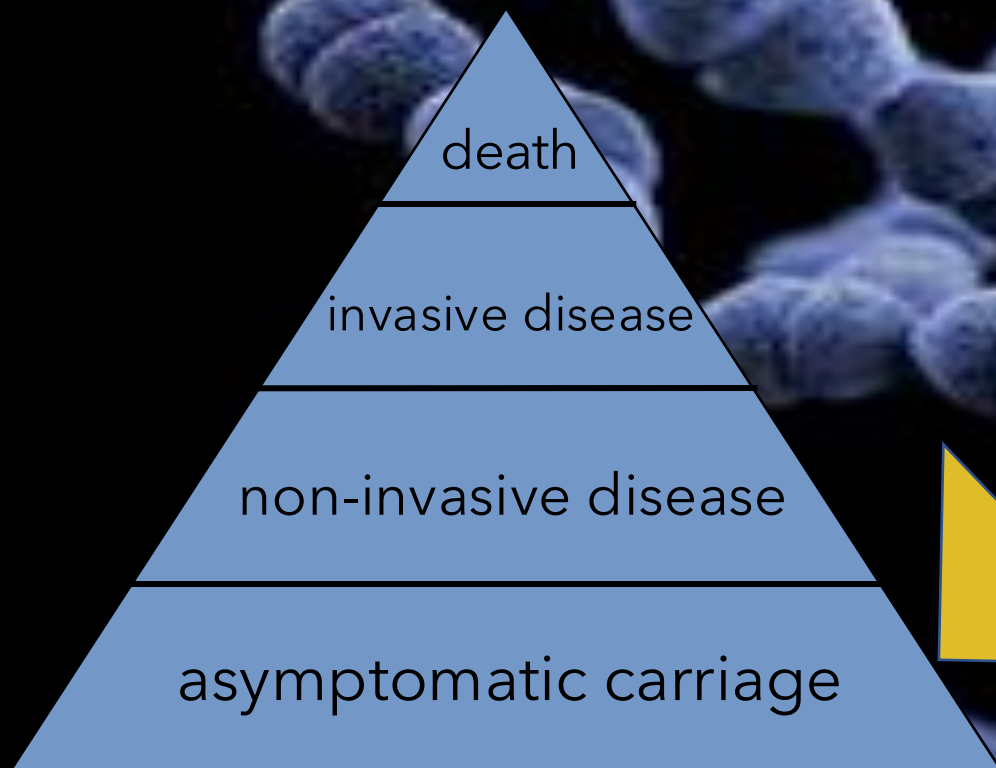
Time series analysis: background and walkthrough

Time series analysis: designing a research question and modifying code

Time series analysis: data viz, prepare presentation and poster materials

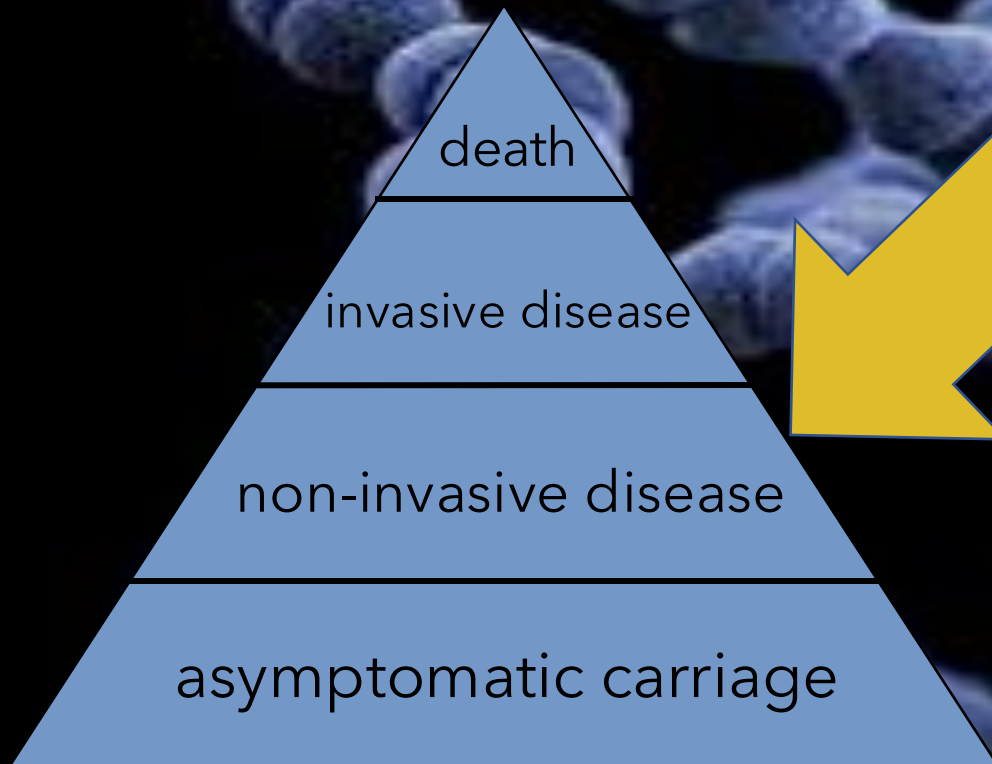


Are you a good witch or a bad witch?



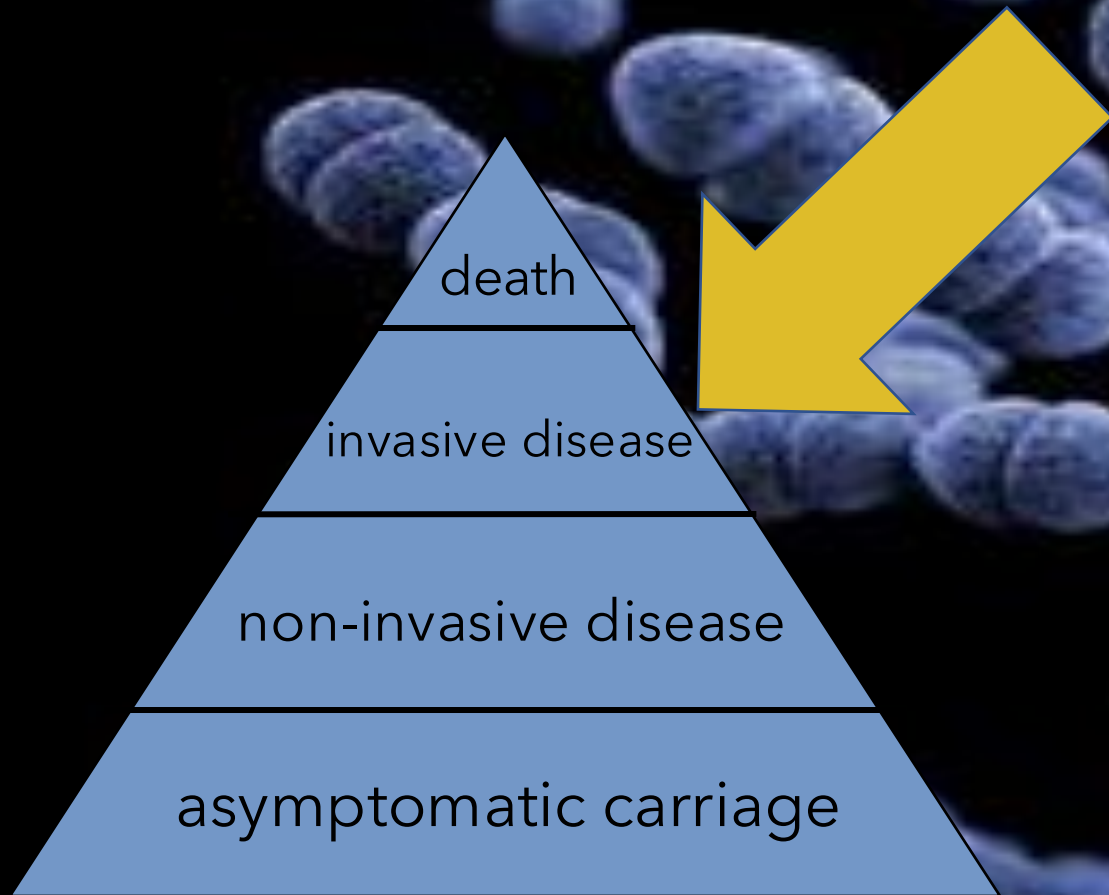
Streptococcus pneumoniae

Source: CDC



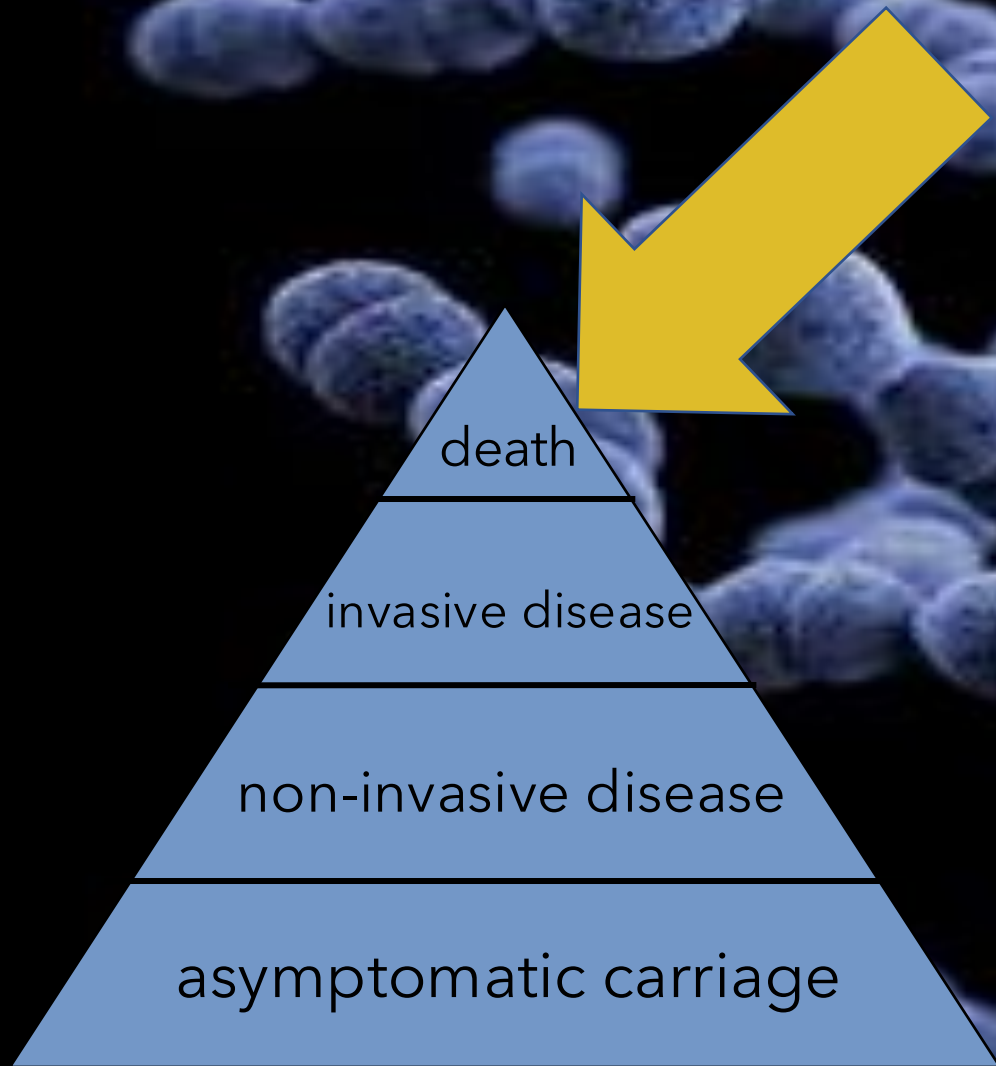
Streptococcus pneumoniae

Source: CDC



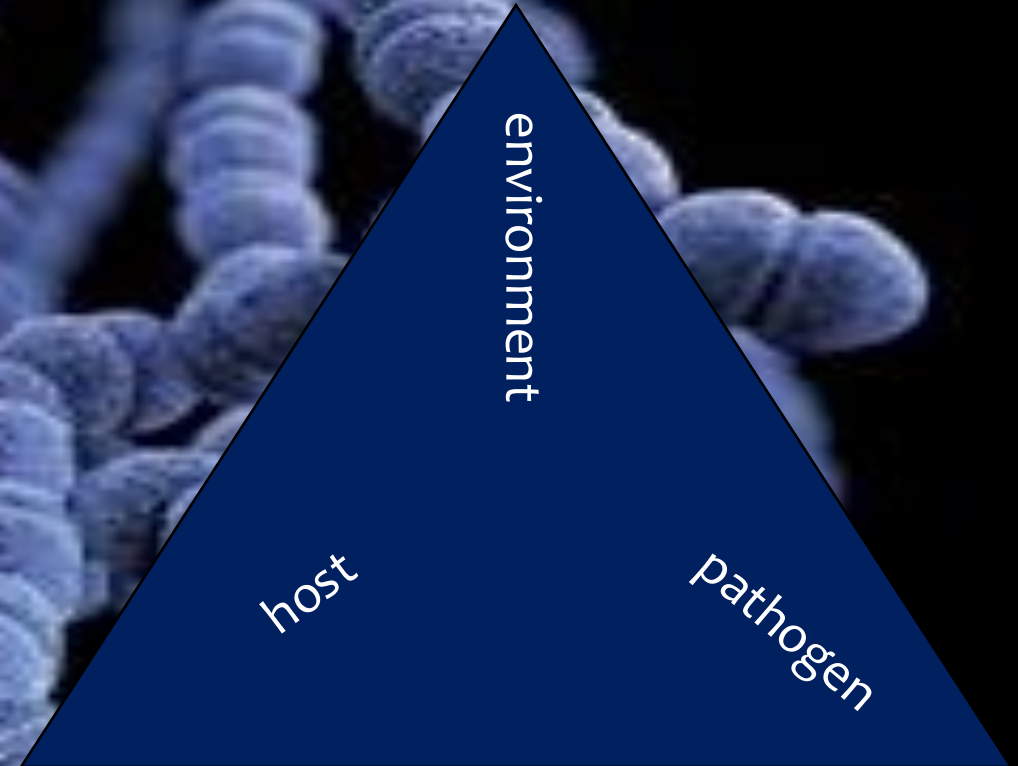
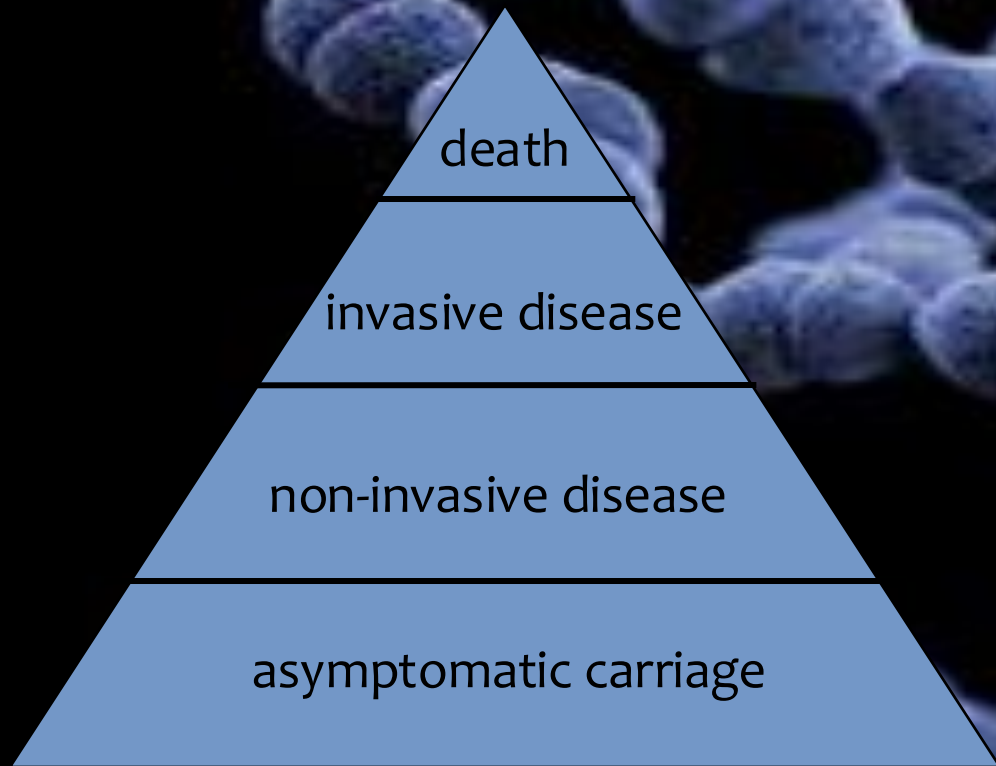
Streptococcus pneumoniae

Source: CDC



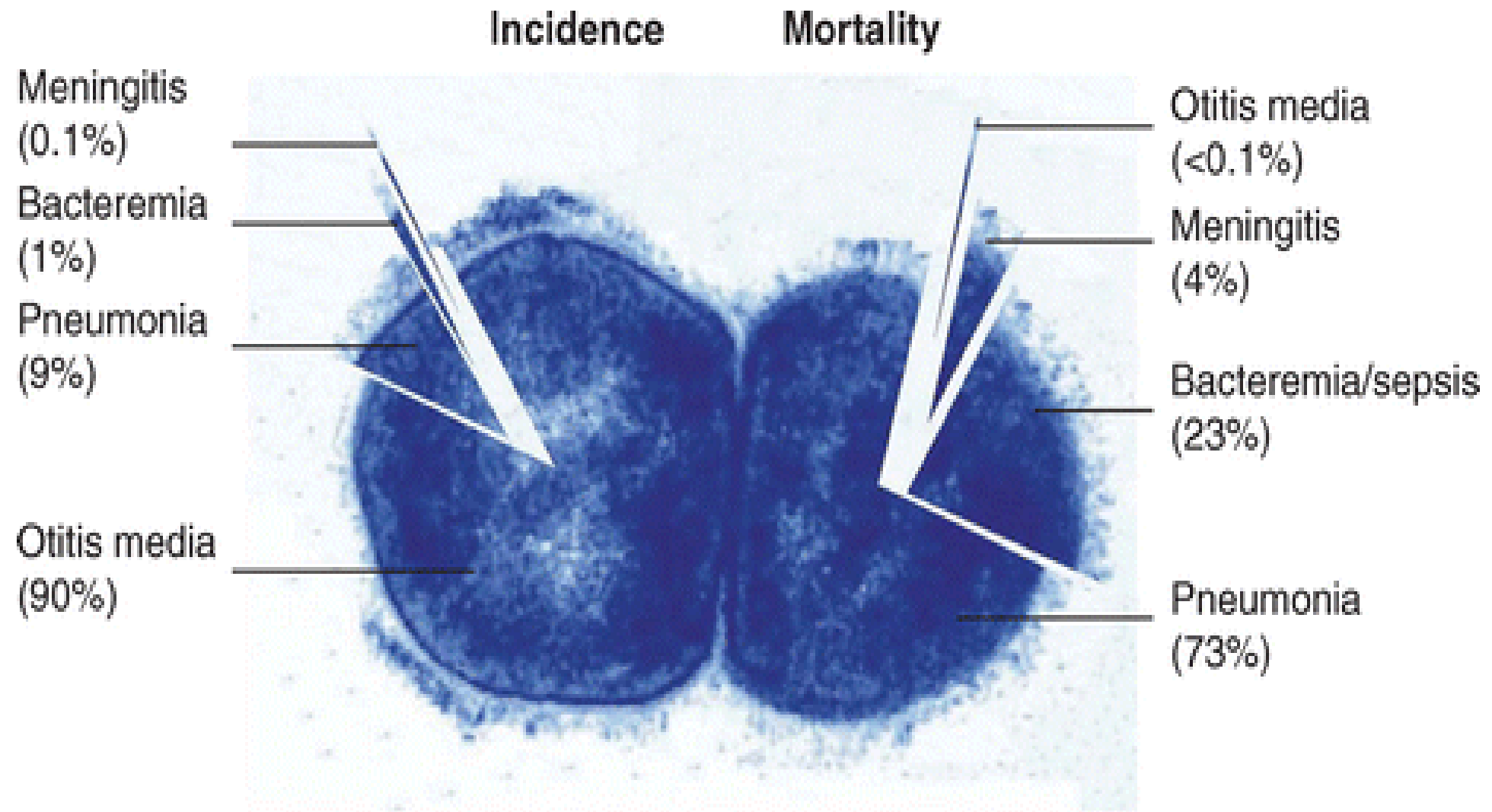
Streptococcus pneumoniae

Source: CDC



Streptococcus pneumoniae

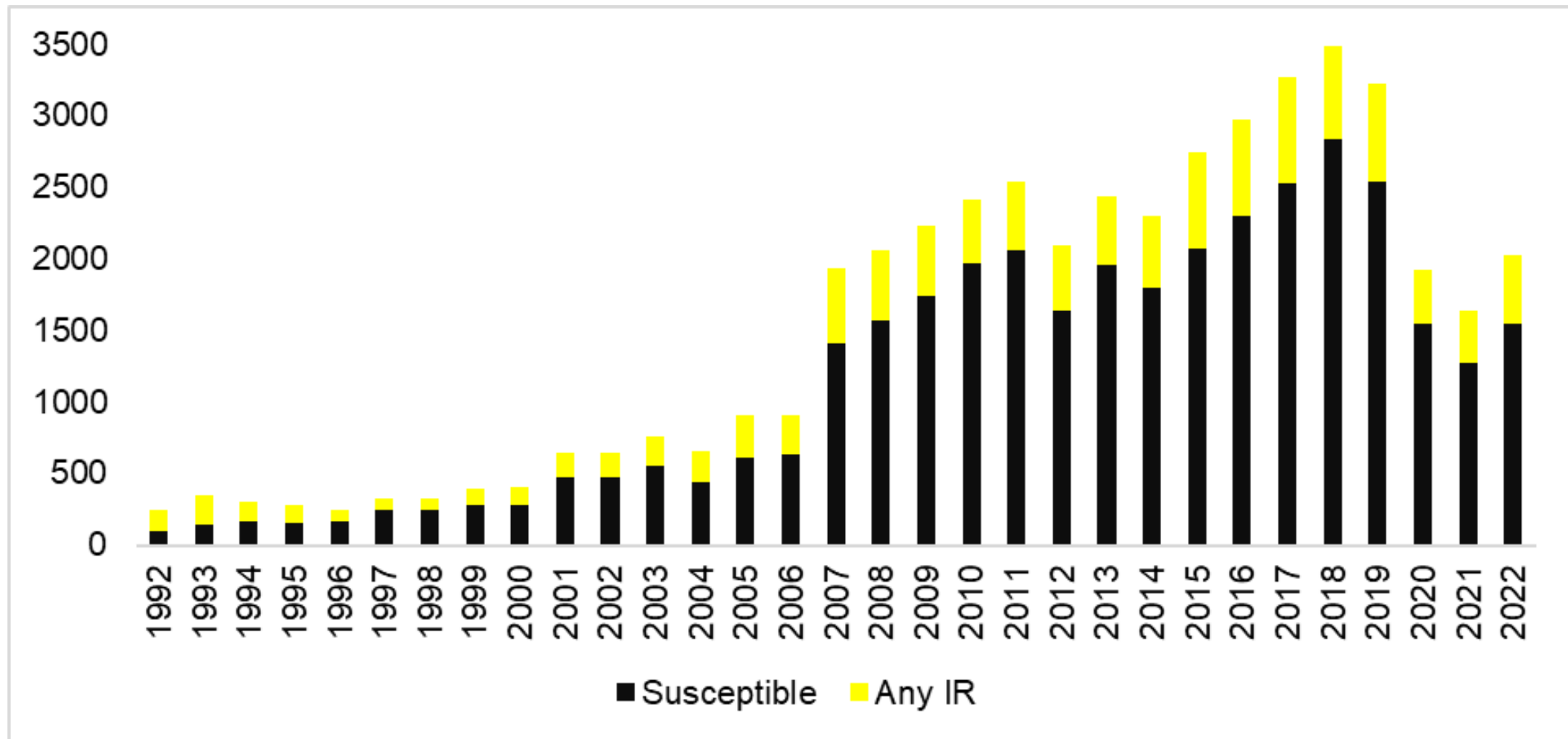
Source: CDC



Antibiotic Therapy



Number of isolates classified as intermediate or resistant to AT LEAST ONE antibiotic class



Streptococcus pneumoniae Basic Fact Sheet

- Gram positive, spherical, paired bacteria that commonly colonizes the nasopharyngeal tract.
- Pneumococcal disease occurs when bacteria in the nasopharyngeal tract move on to other spaces in the body.
- Pneumococcal disease is a major cause of morbidity and mortality worldwide, with 14.5 million cases and 826,000 deaths.
- Burden of disease is highest in the very young and the very old, especially in settings with limited resources.

Pneumococcal Serotypes, Pneumococcal Vaccines,







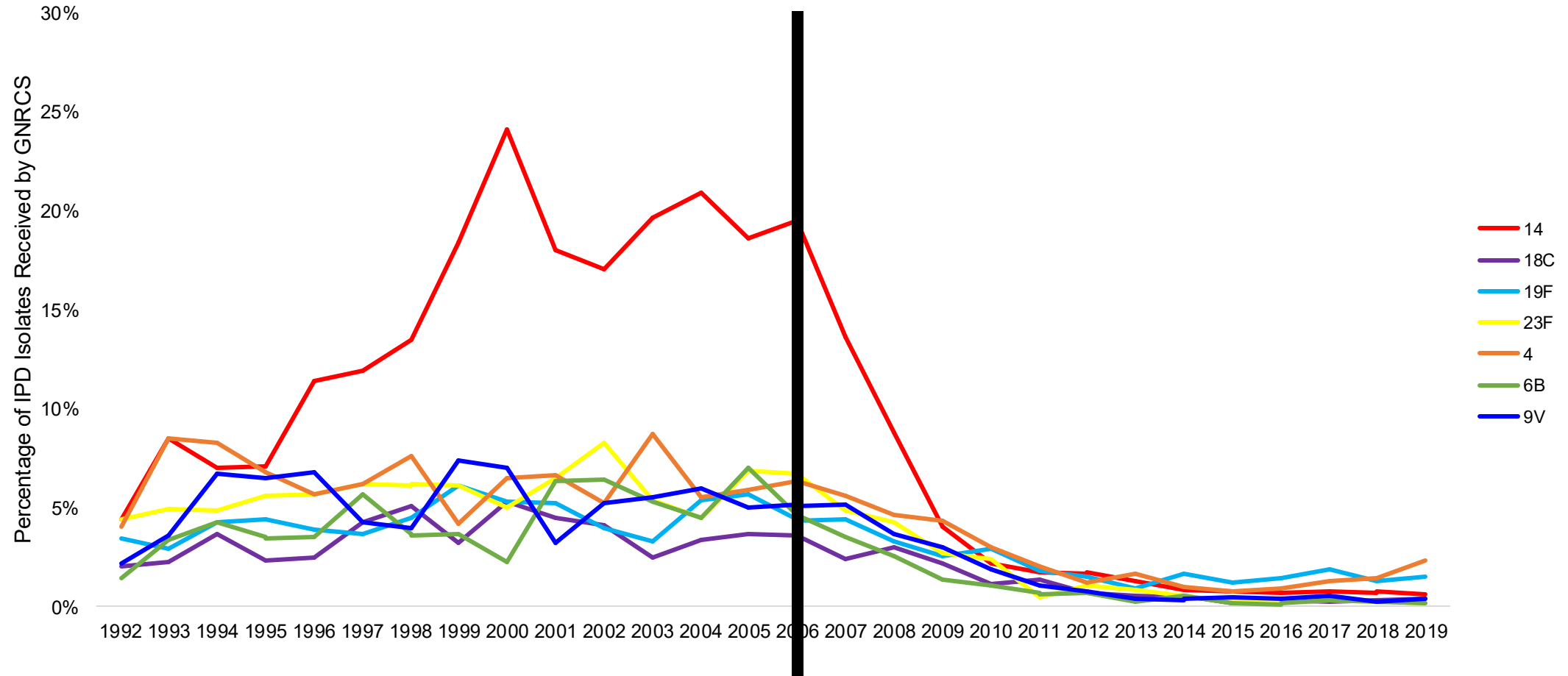


Pneumococcal Conjugate Vaccines



- First in use in the US in 2000
- Given to infants
- Targeting the pneumos most common in severe disease

PCV serotypes in Invasive Pneumococcal Disease in Germany, 1992-2019





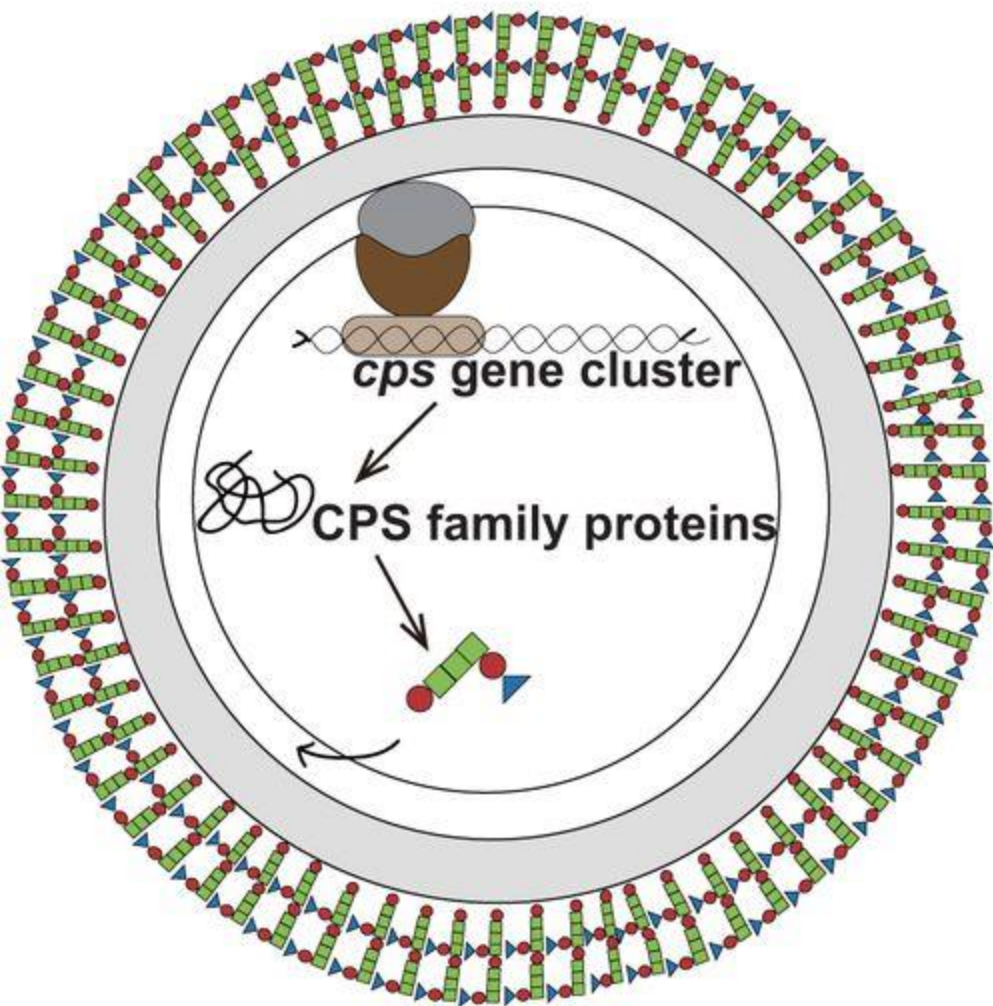
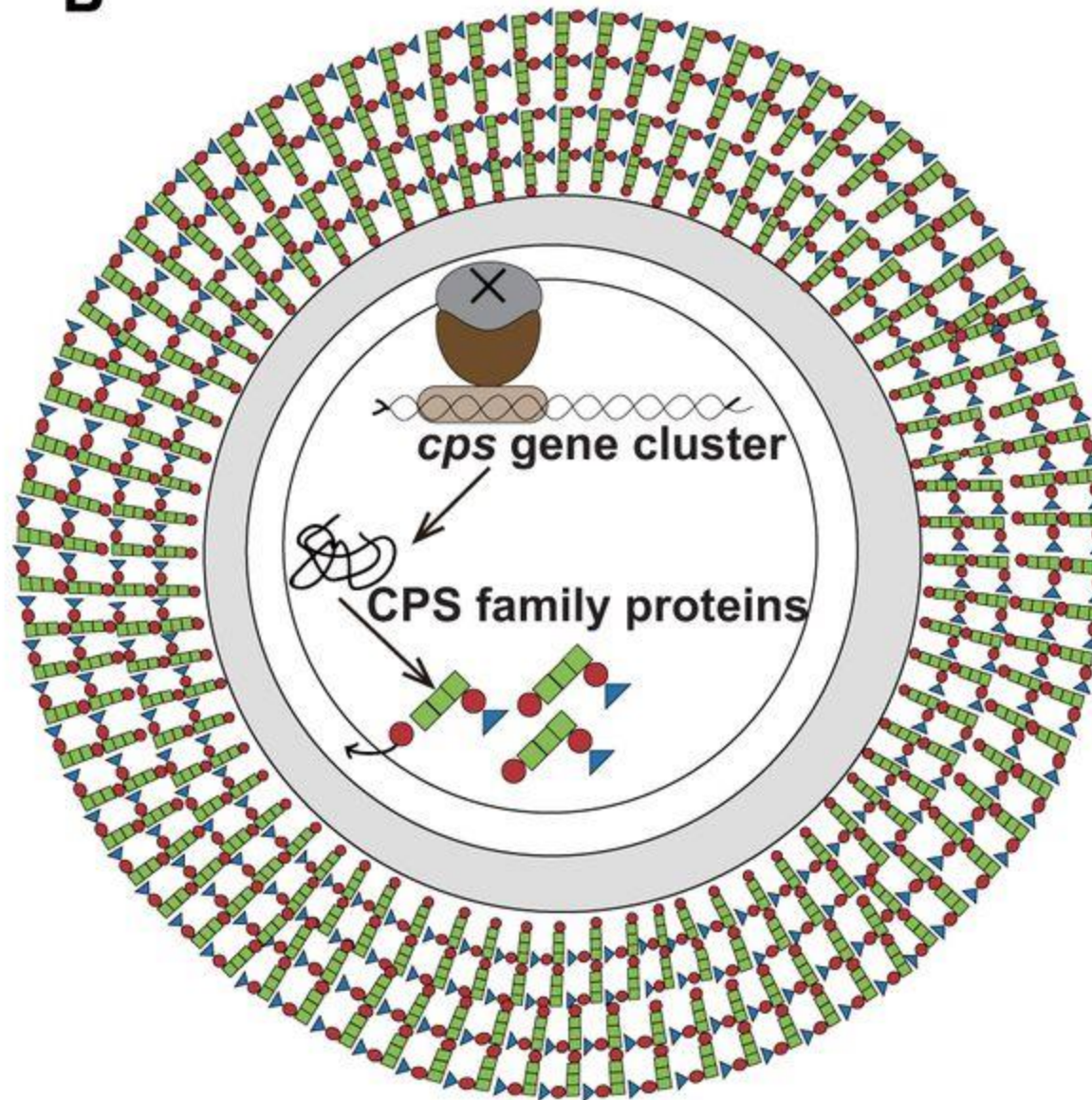










A**D39-WT***Data Science and Data Equity***B****D39 Δ *spd1495***

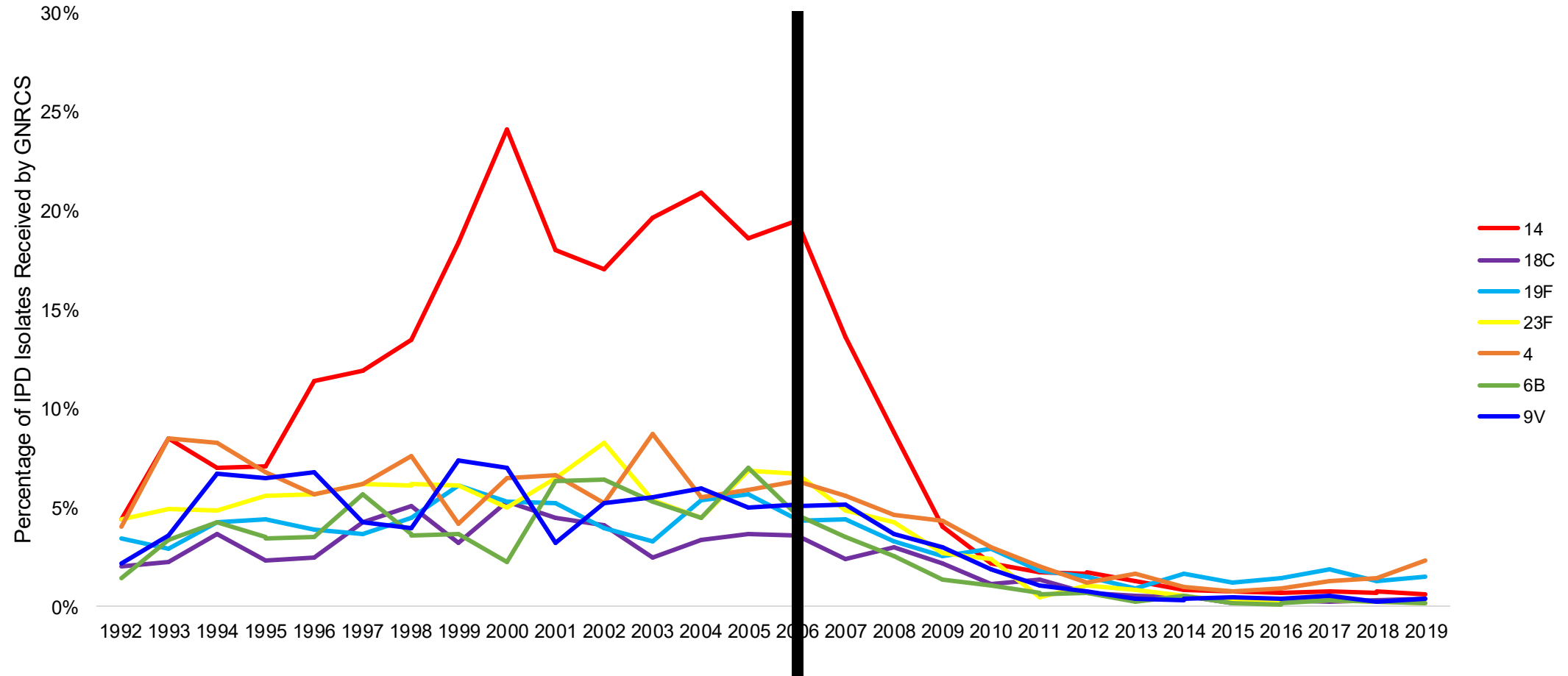
- Glu
- Rha
- ▲ GlcUA
- SPD_1495
- ComE
- Promoter
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Zheng et al. SPD_1495 Contributes to Capsular Polysaccharide Synthesis and Virulence in *Streptococcus pneumoniae*.
 mSystems5:10.1128/msystems.00025-20.



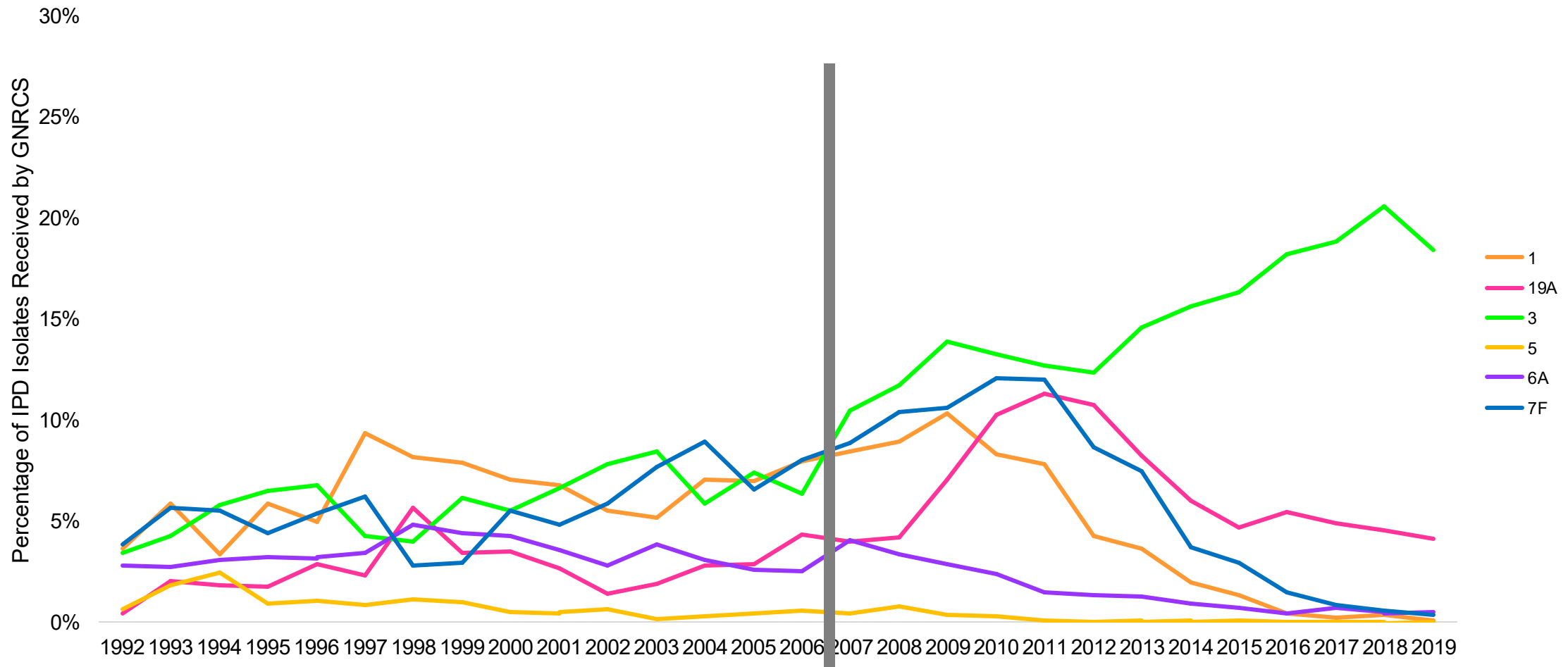


PCV serotypes in Invasive Pneumococcal Disease in Germany, 1992-2019

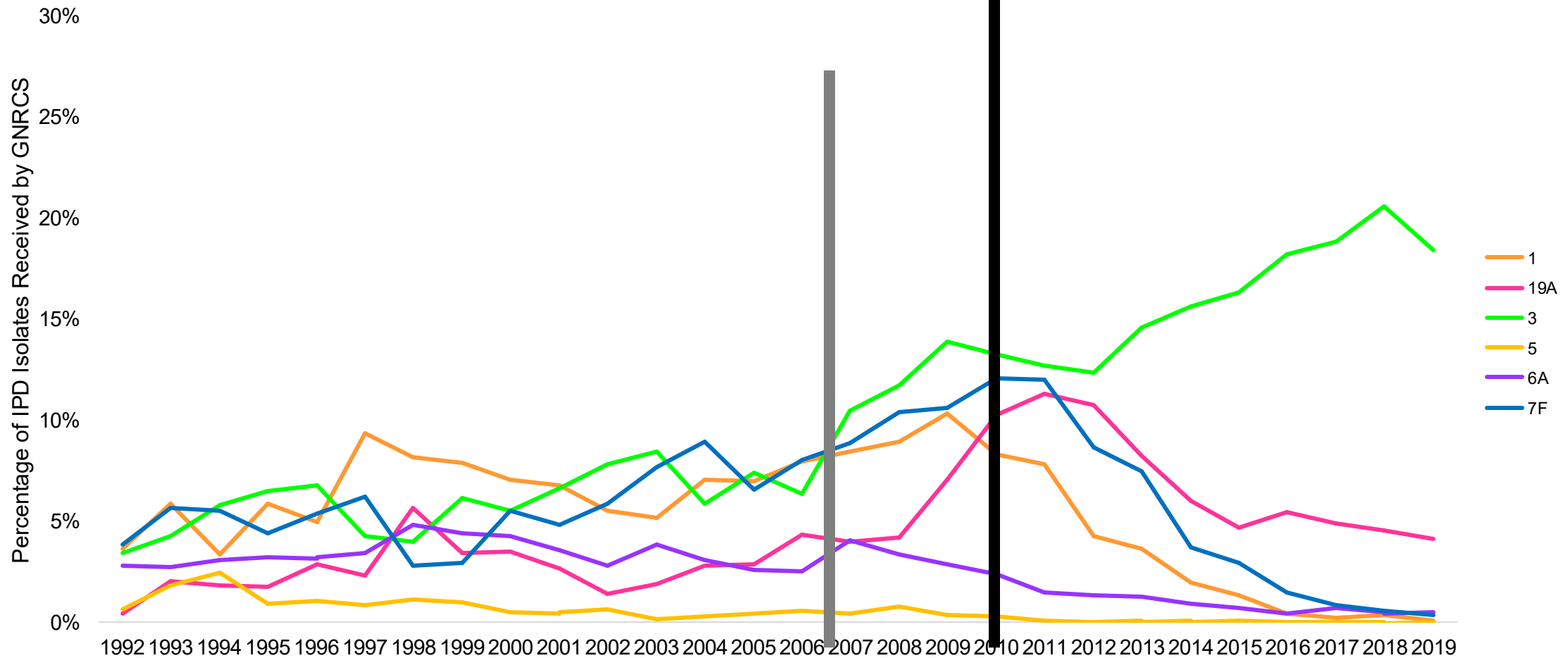




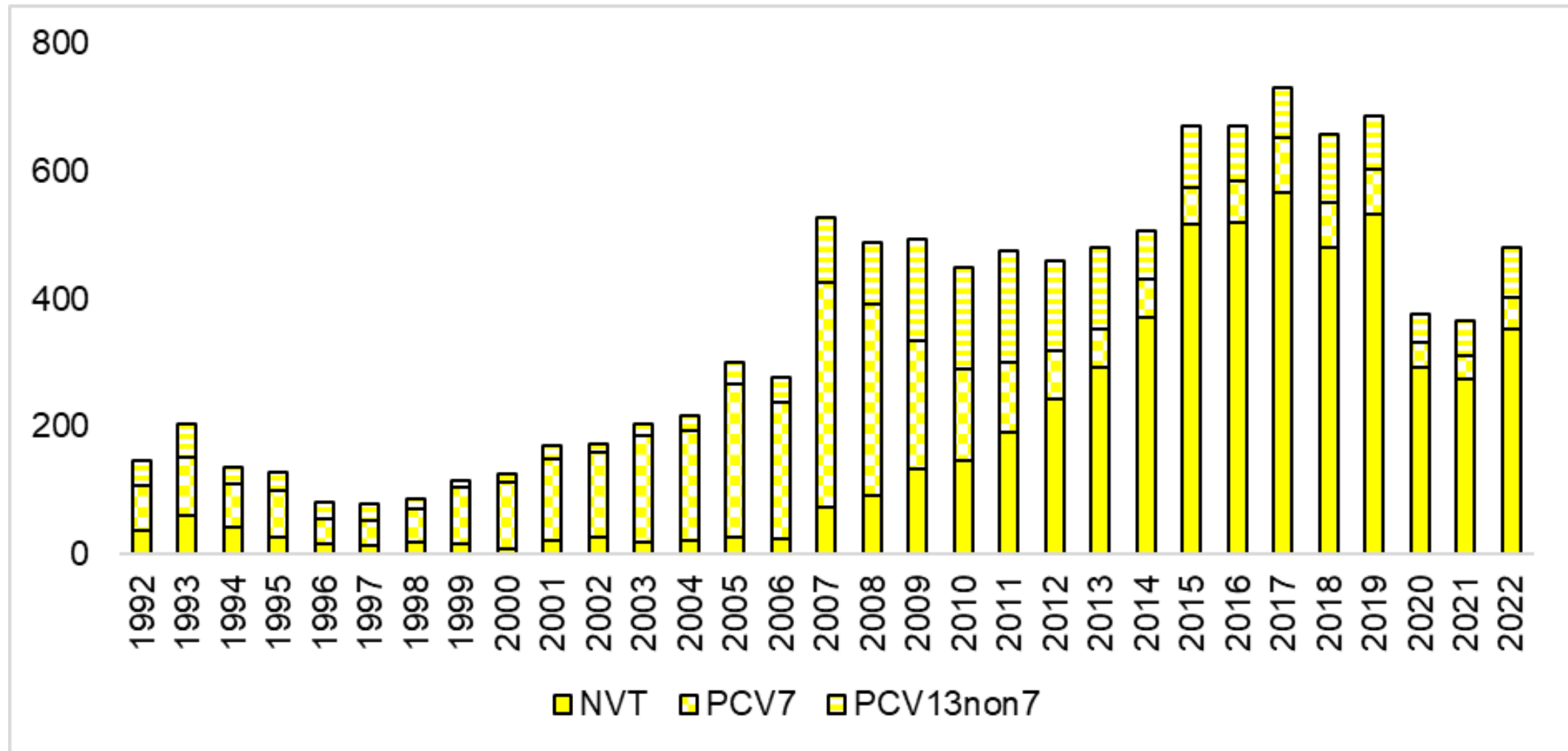
New PCV serotypes in Invasive Pneumococcal Disease, Germany, 1992-2019



New PCV serotypes in Invasive Pneumococcal Disease, Germany, 1992-2019



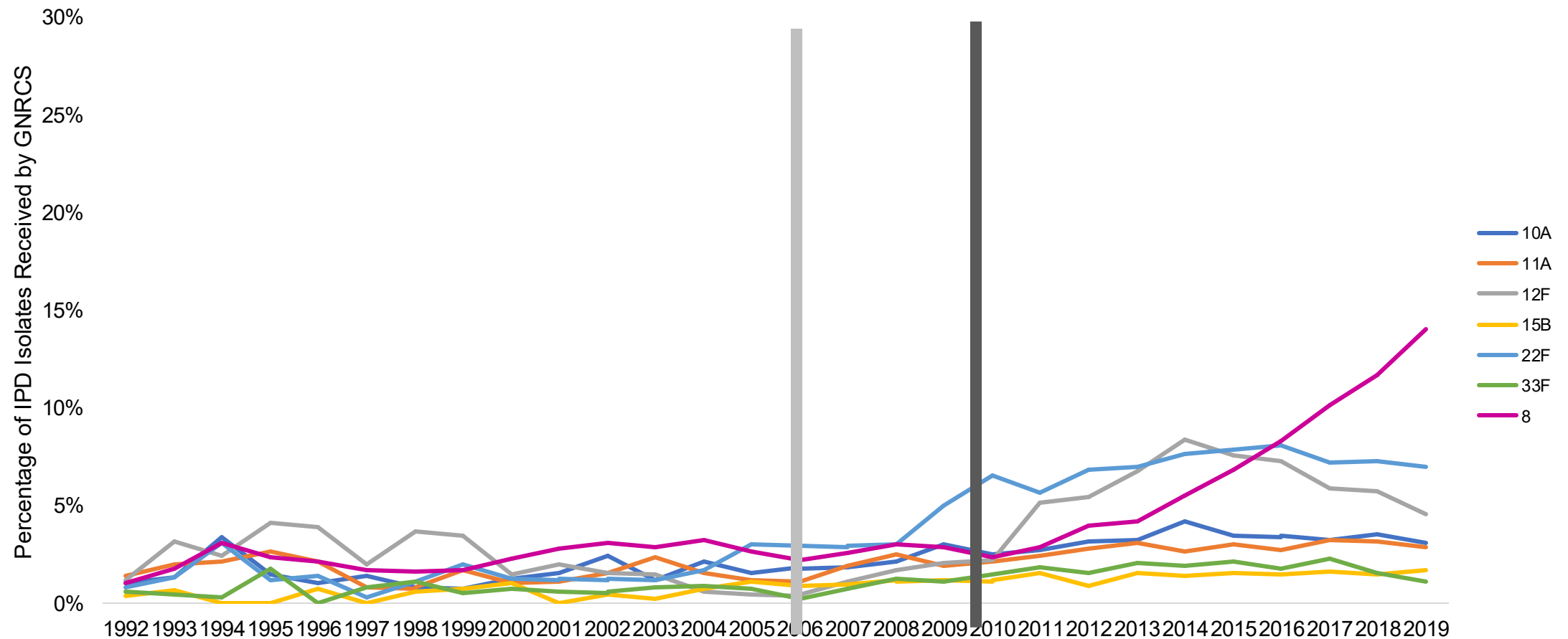
Number of isolates classified as intermediate or resistant to ANY antibiotic class, by vaccine serotype group

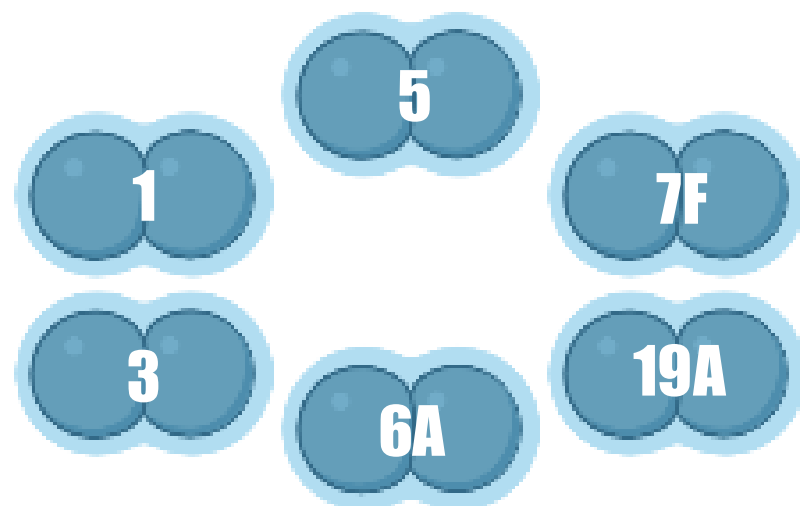
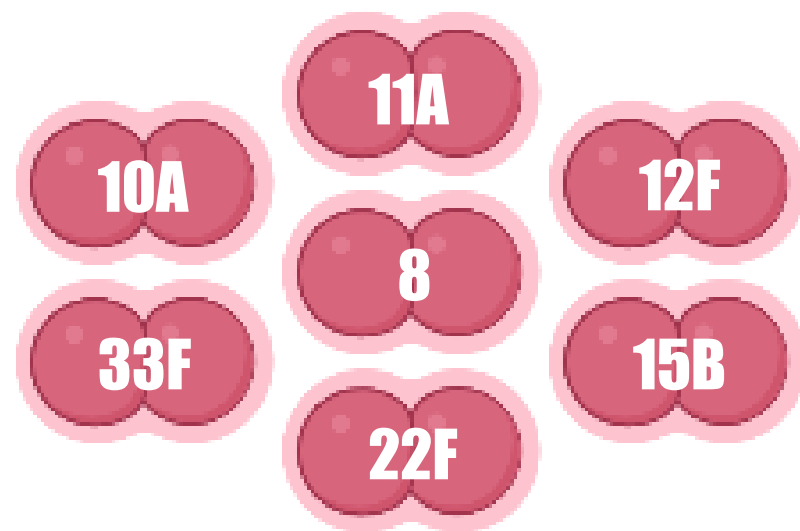
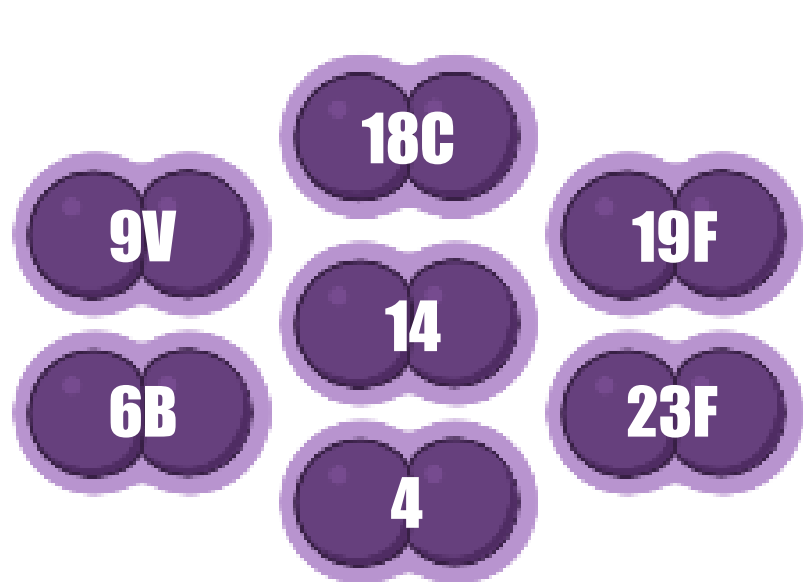




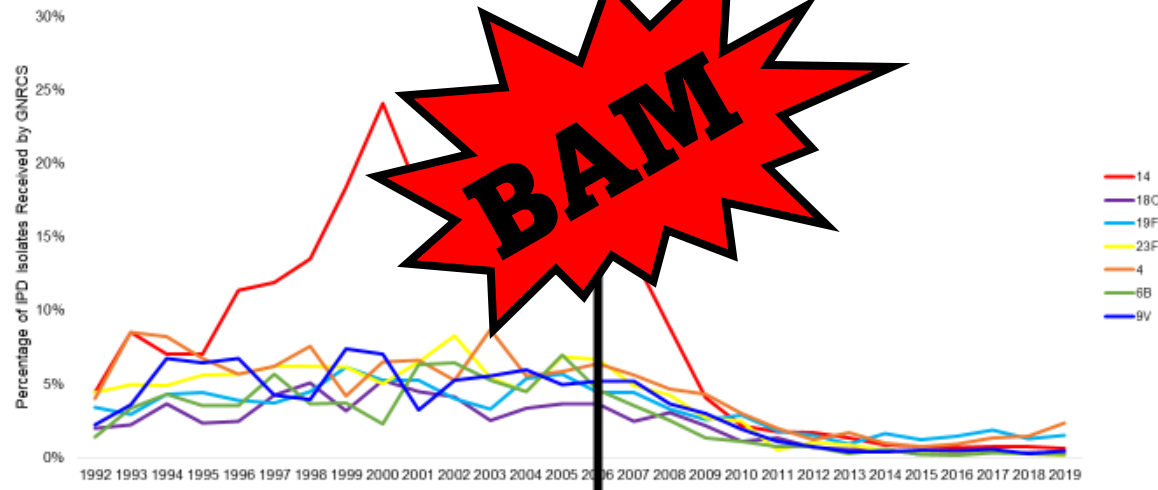


New-New vaccine serotypes in Invasive Pneumococcal Disease in Germany, 1992-2019

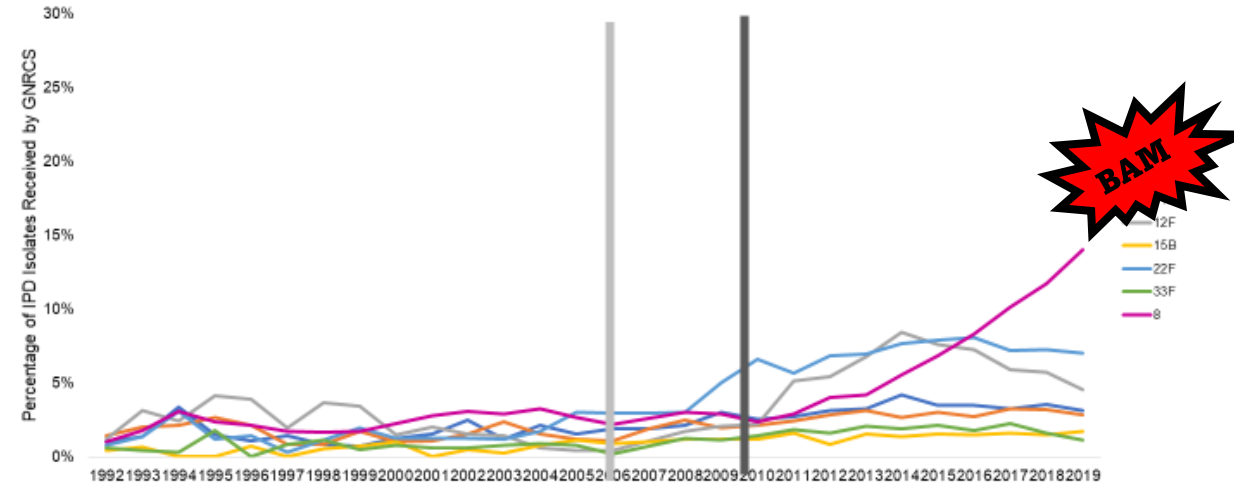




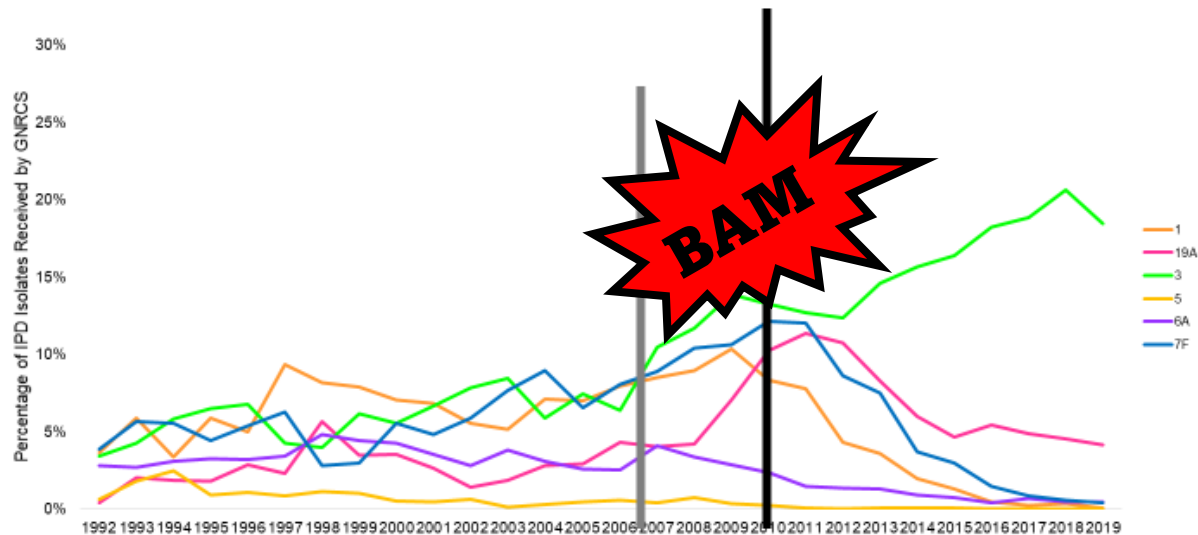
PCV serotypes in Invasive Pneumococcal Disease in Germany, 1992-2019



New-New vaccine serotypes in Invasive Pneumococcal Disease in Germany, 1992-2019



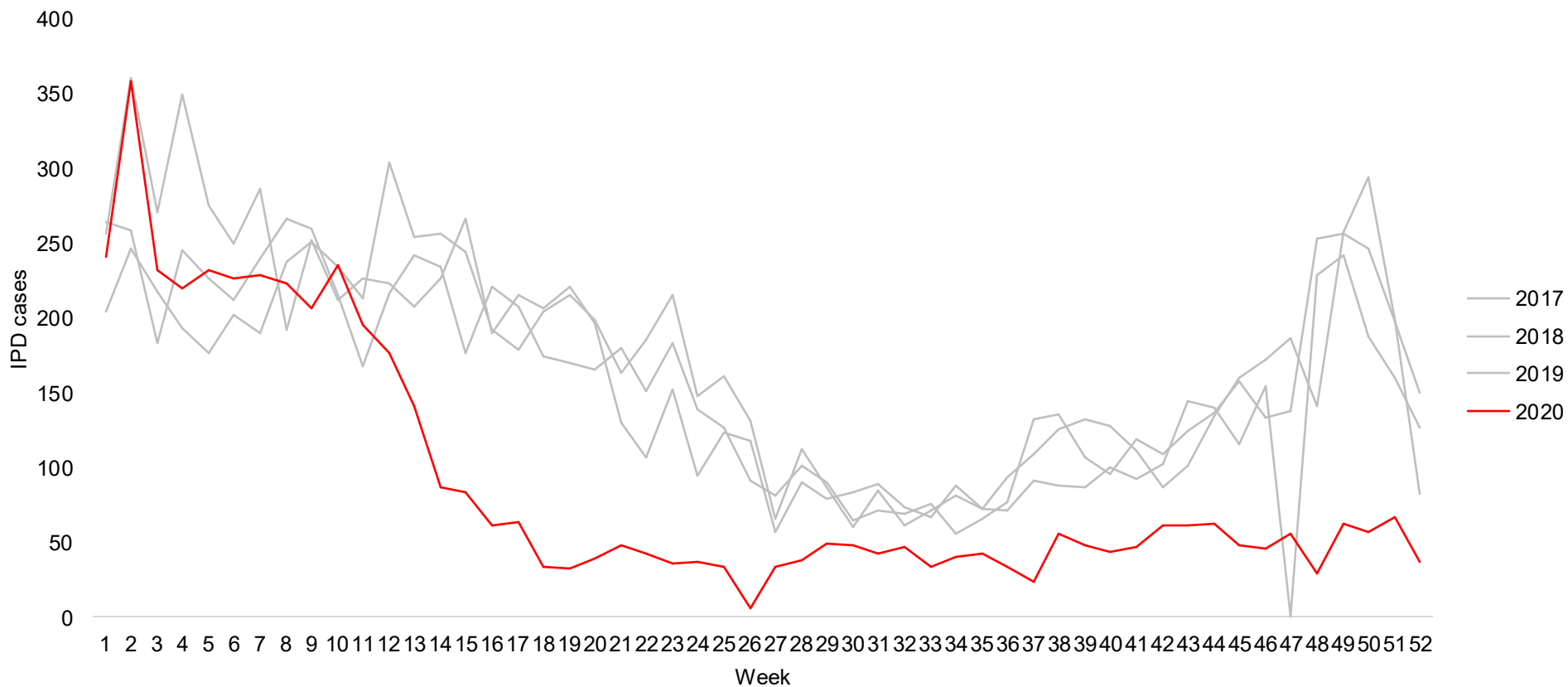
New PCV serotypes in Invasive Pneumococcal Disease, Germany, 1992-2019



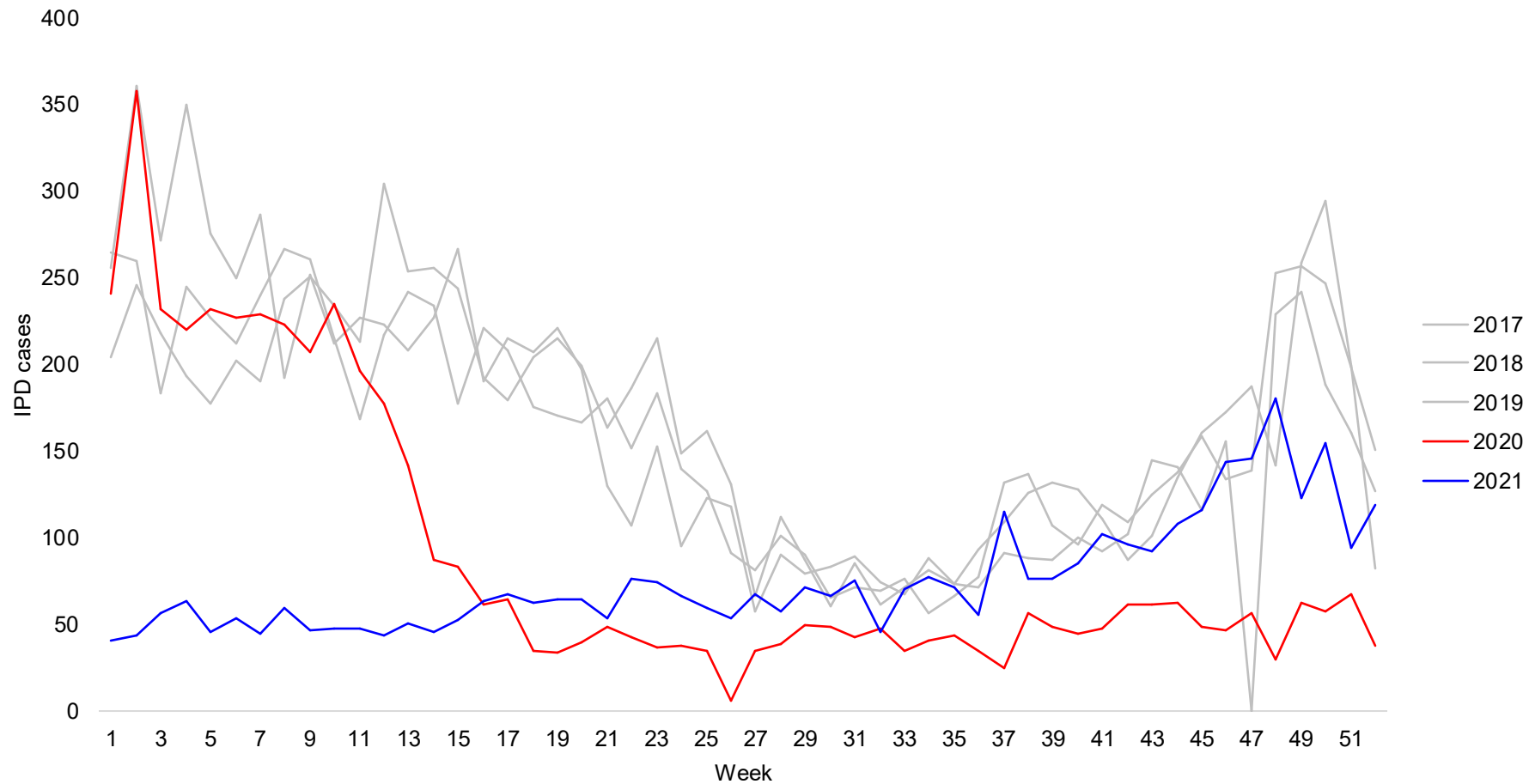
Viruses and Pneumococci

- Flu
- RSV
- SARS-CoV-2

What happened to IPD in 2020?



What happened to IPD in 2021?



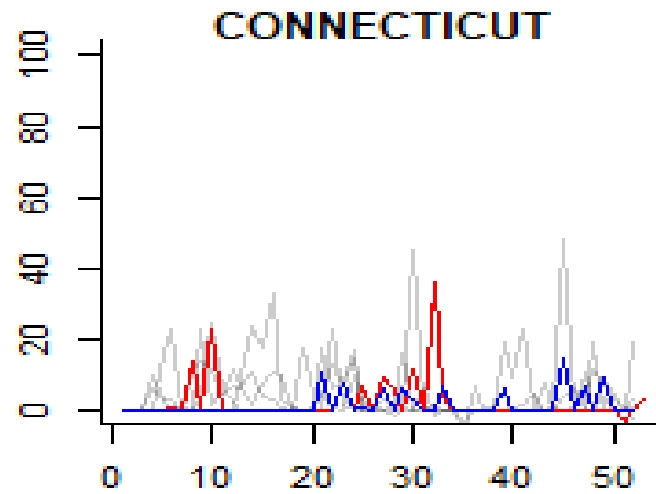
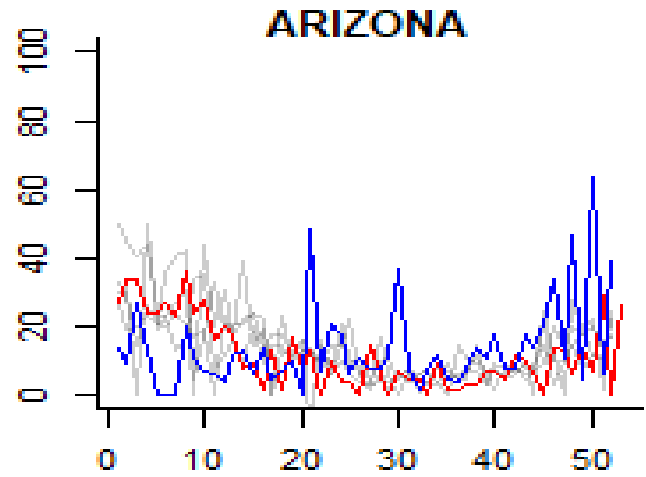
But Why?

- Artefactual
 - Clinical System Overtaxed
 - Surveillance System Overtaxed
- Actual
 - Changing Dynamics of Respiratory Pathogens
 - Nonpharmaceutical interventions

Artefactual

- Clinical Systems
 - Point of Care
 - Medical Laboratories
- Surveillance Systems
 - Health Departments
 - Federal Agencies

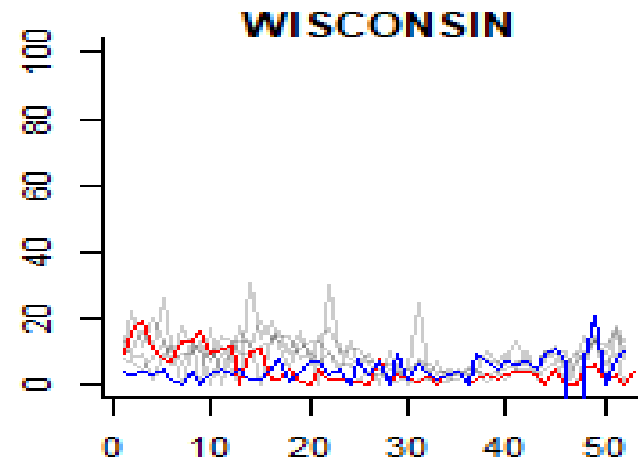
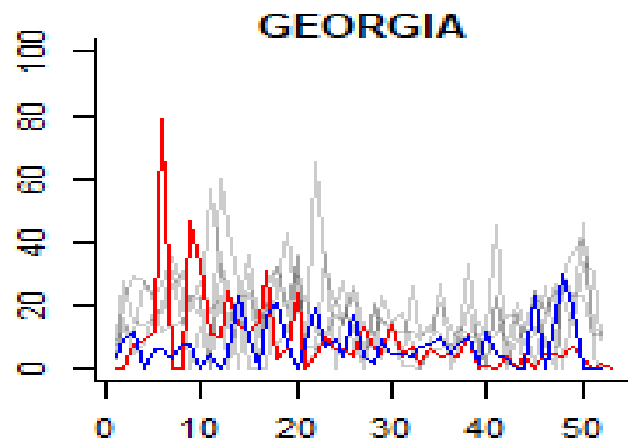
NNDSS IPD, 2016-2021



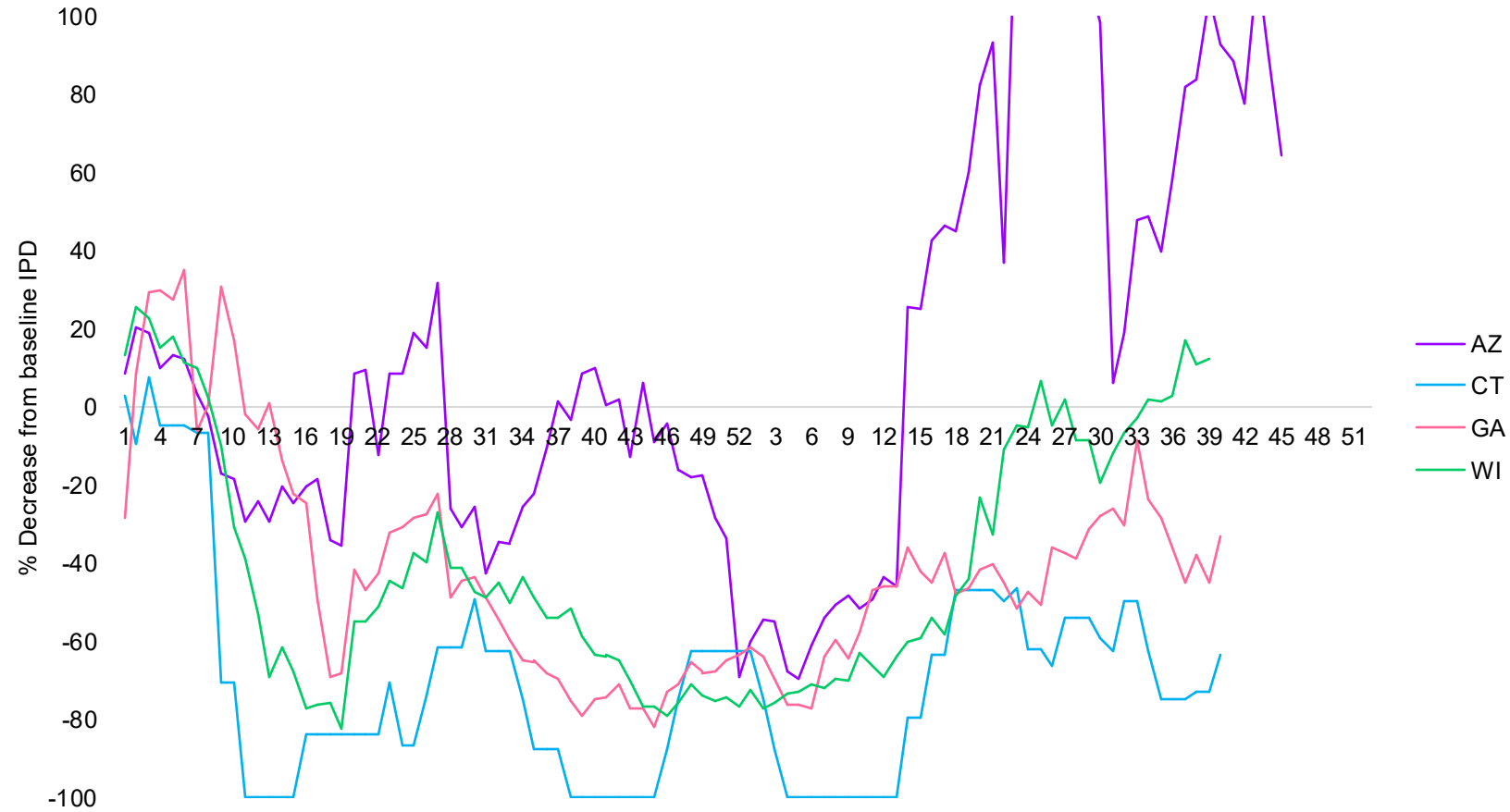
2016-2019

2020

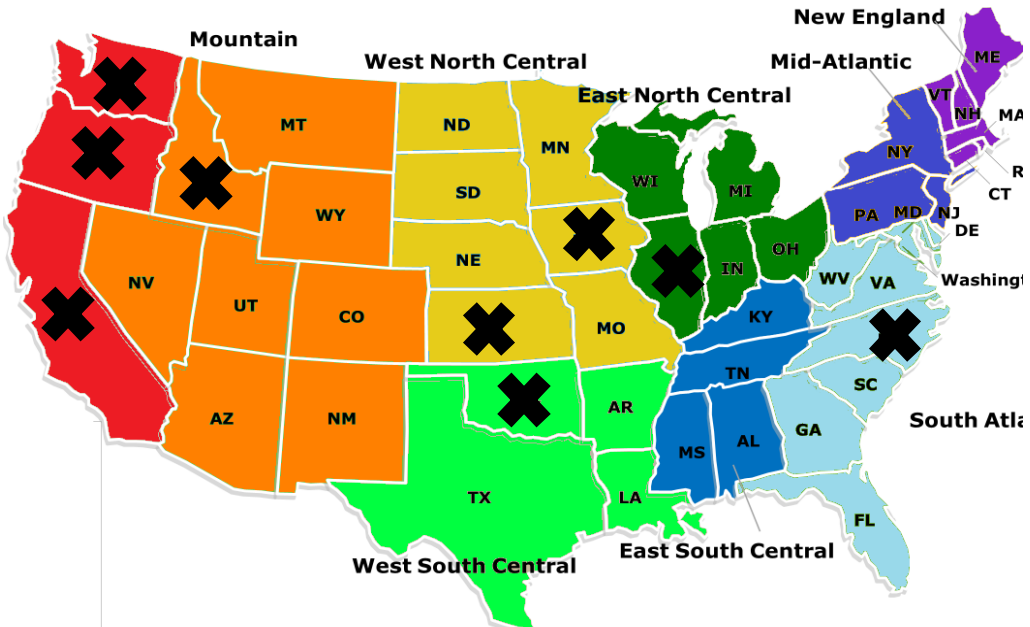
2021



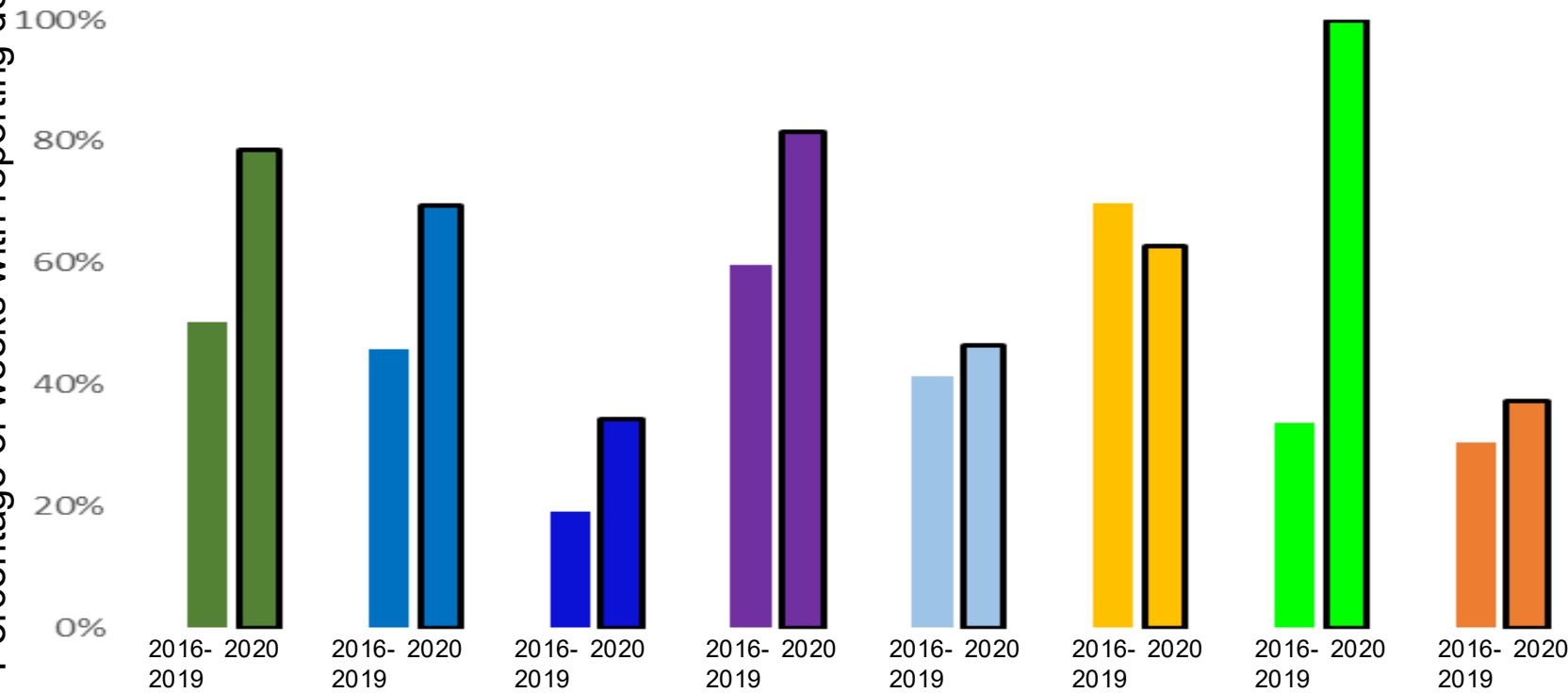
NNDSS IPD, change from baseline



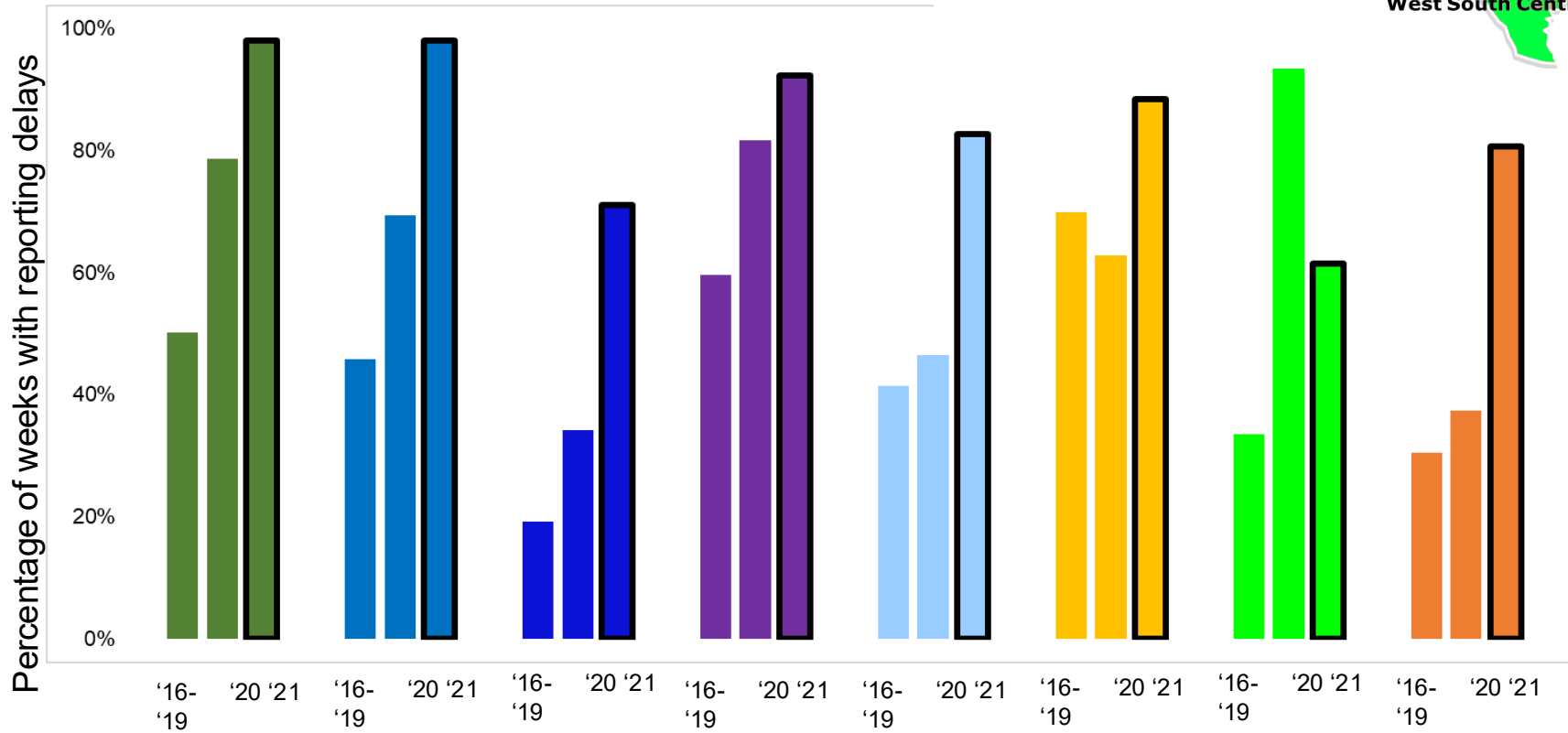
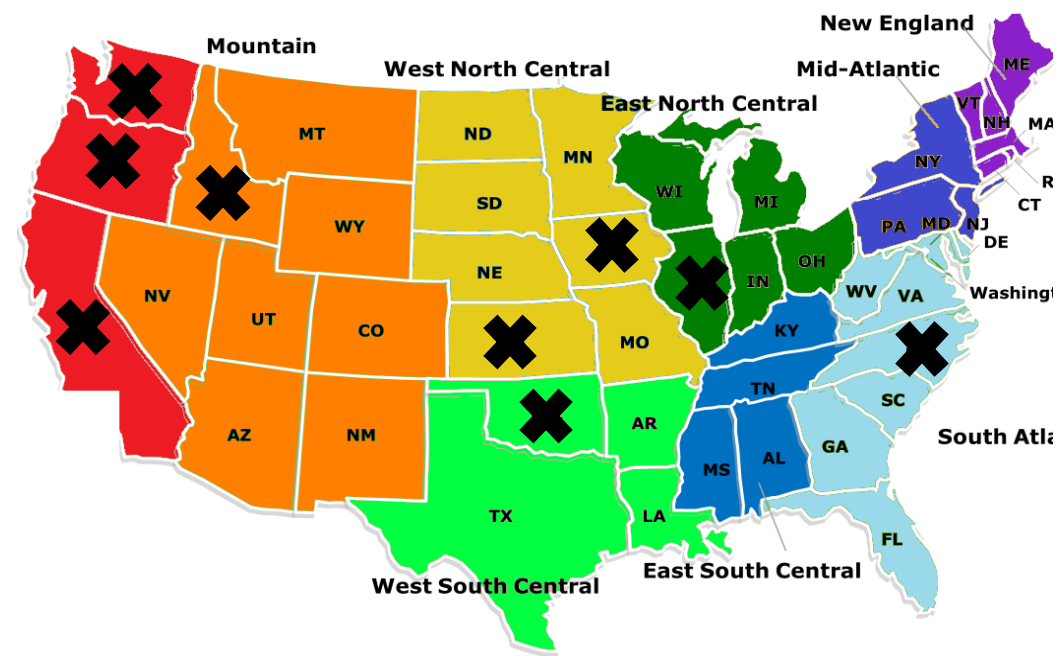
Reporting Delays, 2020



Percentage of weeks with reporting delays



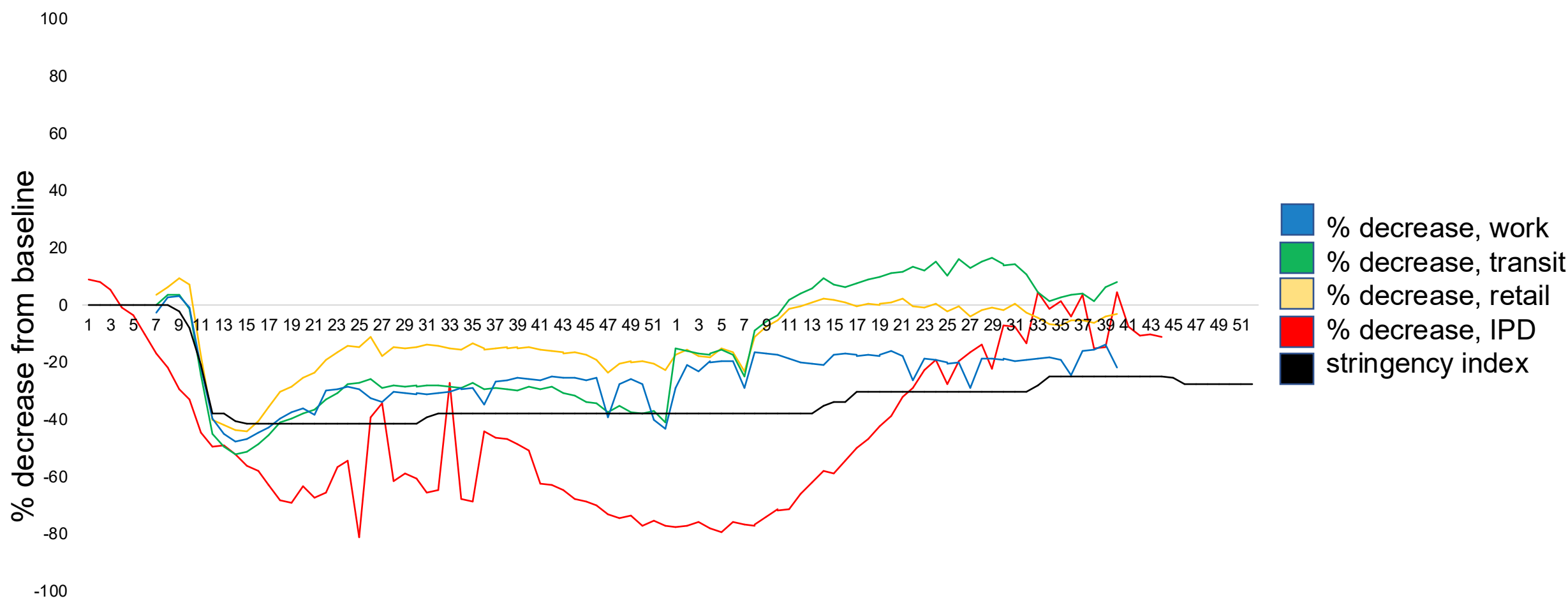
Reporting Delays, 2021



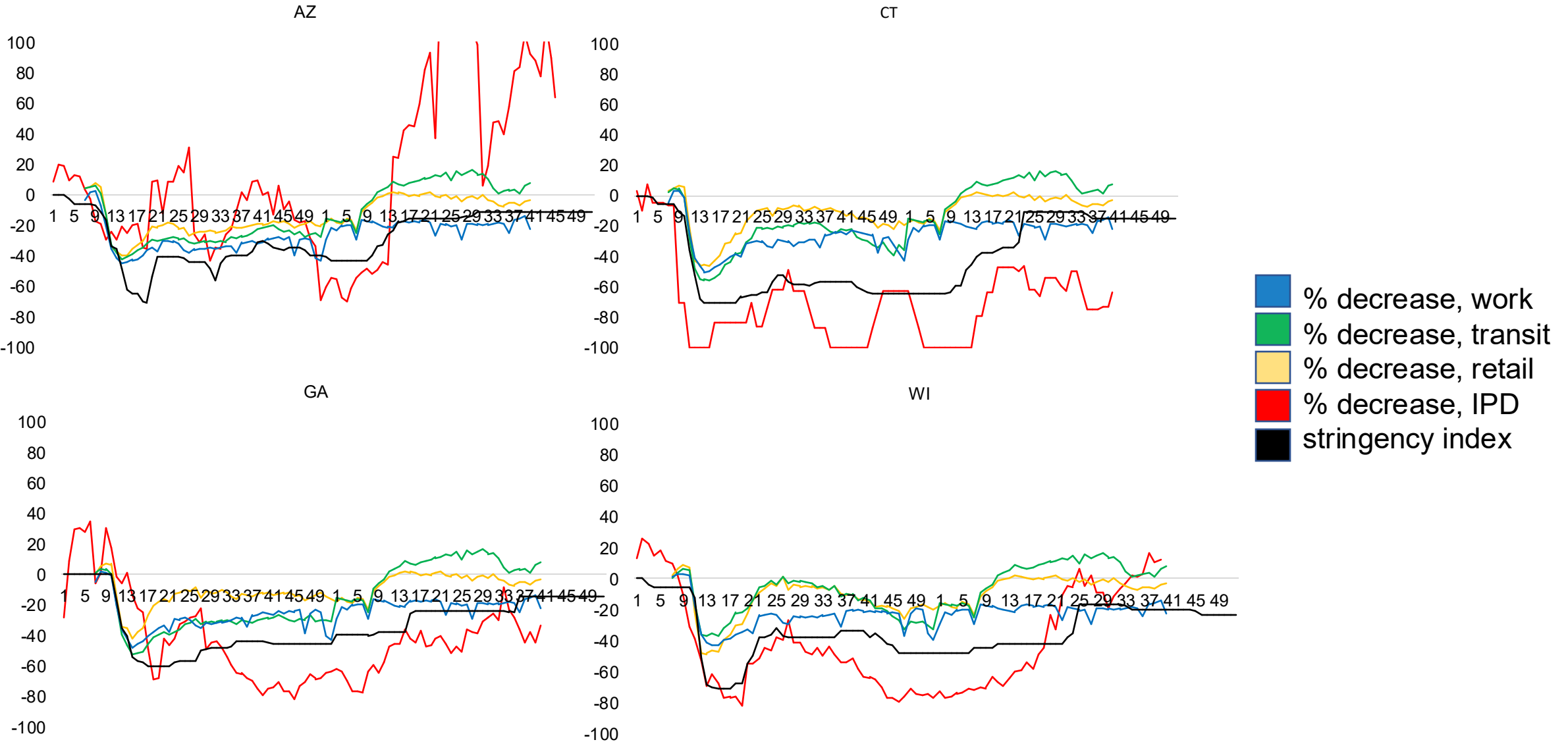
Actual

- Changing dynamics of respiratory pathogens
- Nonpharmaceutical interventions

United States Mobility, Overall



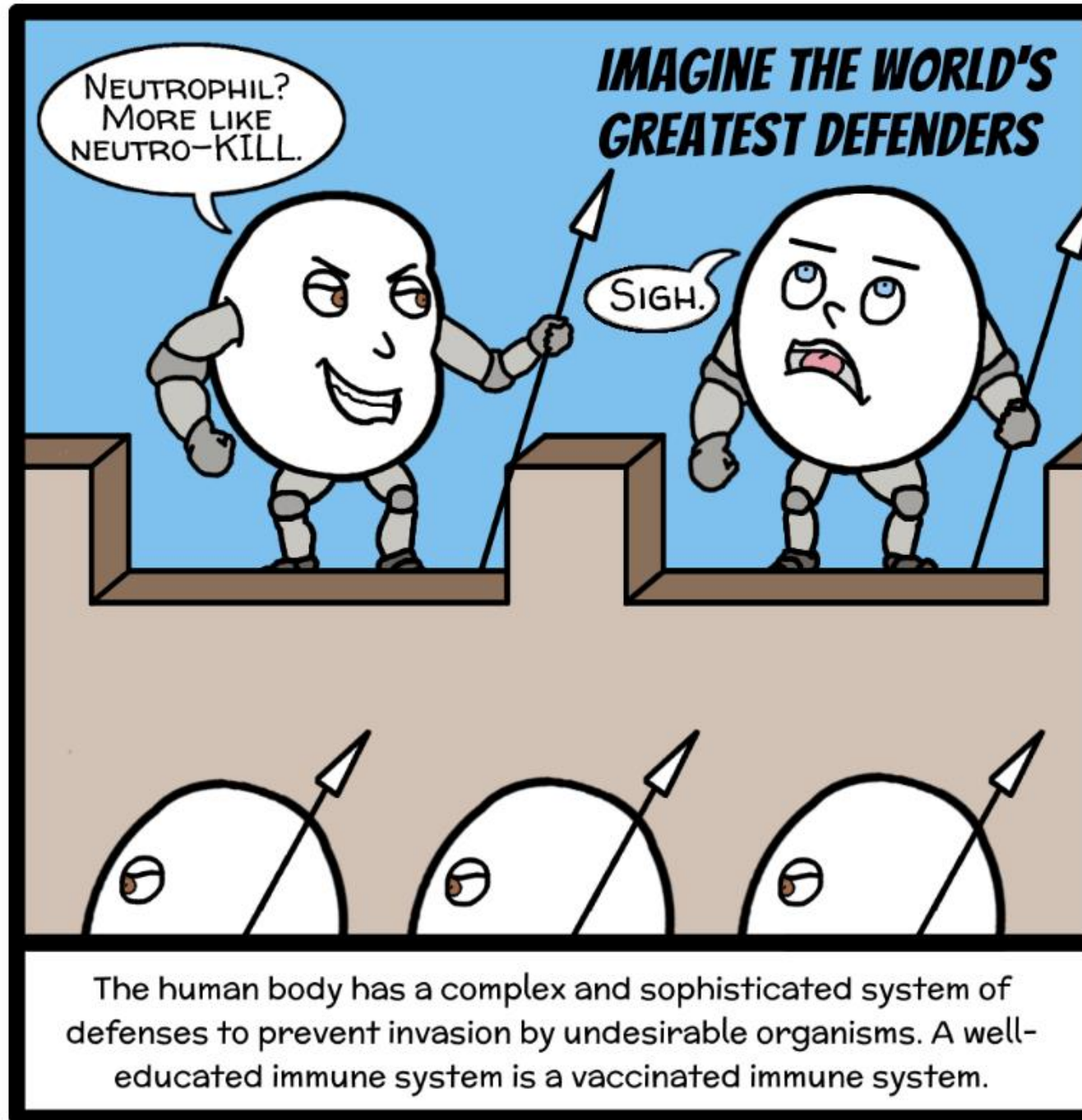
US Mobility, State Level

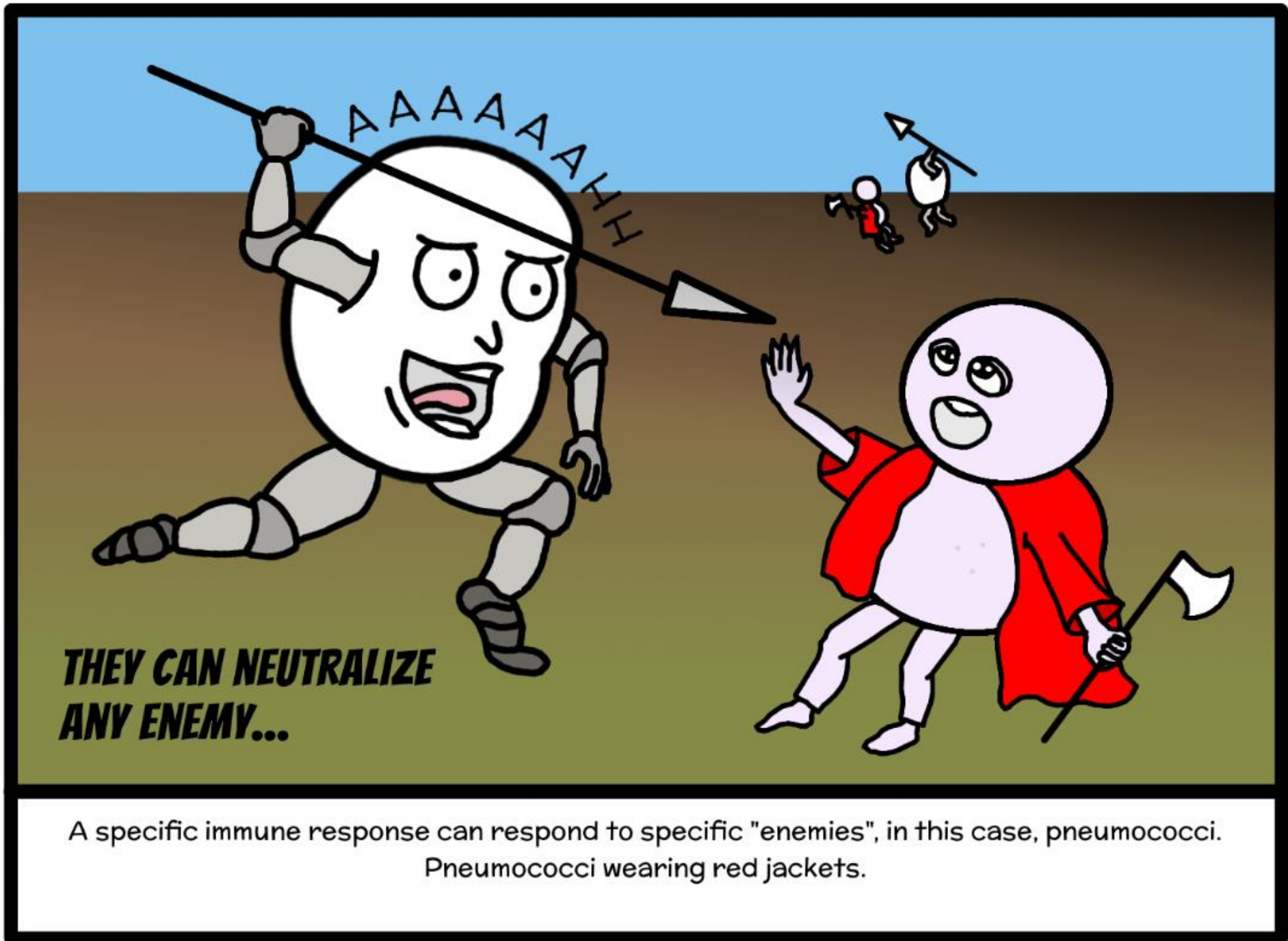


But Why?

- Artefactual
 - Clinical System Overtaxed
 - Surveillance System Overtaxed
- Actual
 - Changing Dynamics of Respiratory Pathogens
 - Nonpharmaceutical interventions

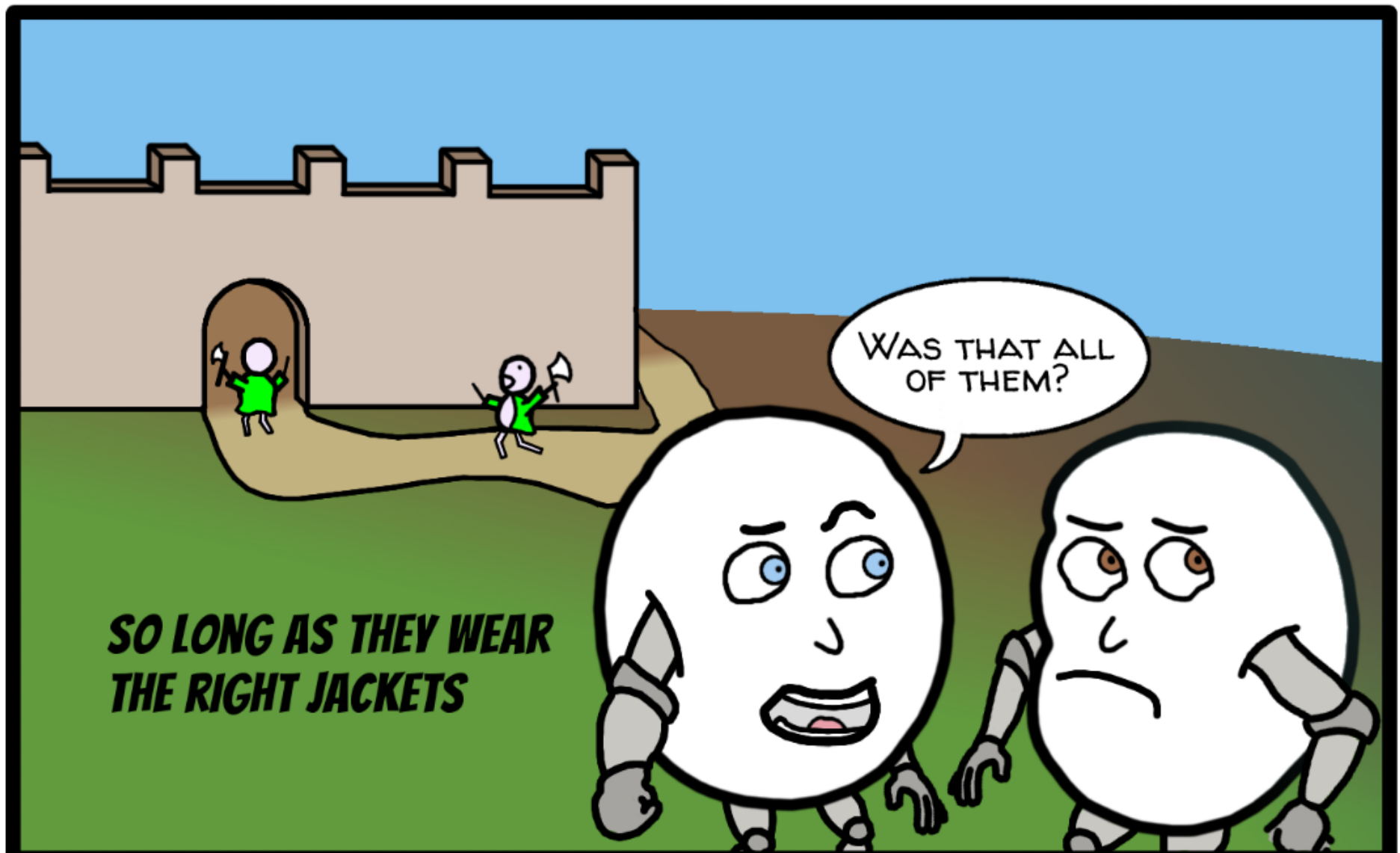
Pneumococcal Serotype Replacement



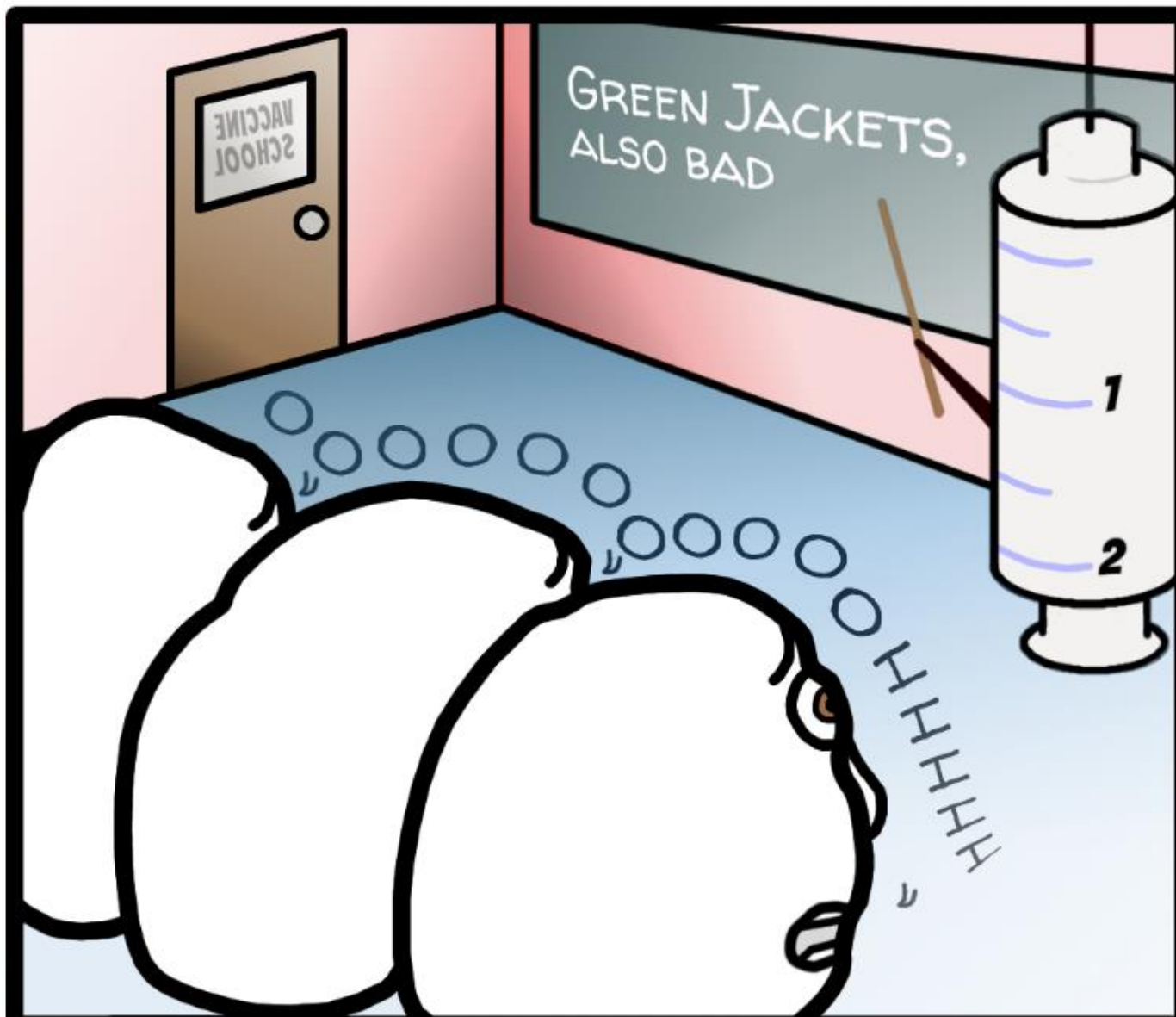


**THEY CAN NEUTRALIZE
ANY ENEMY...**

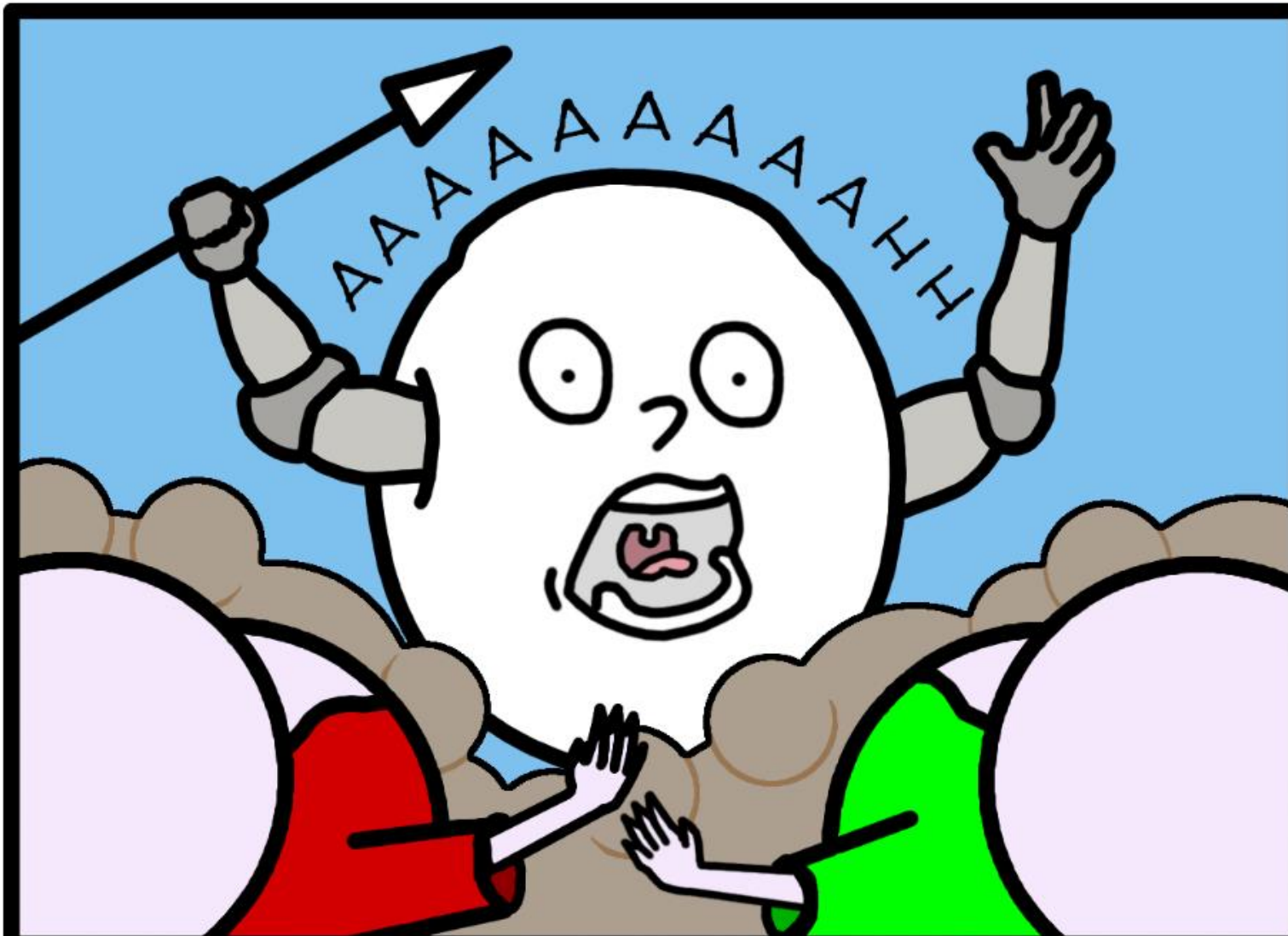
A specific immune response can respond to specific "enemies", in this case, pneumococci.
Pneumococci wearing red jackets.



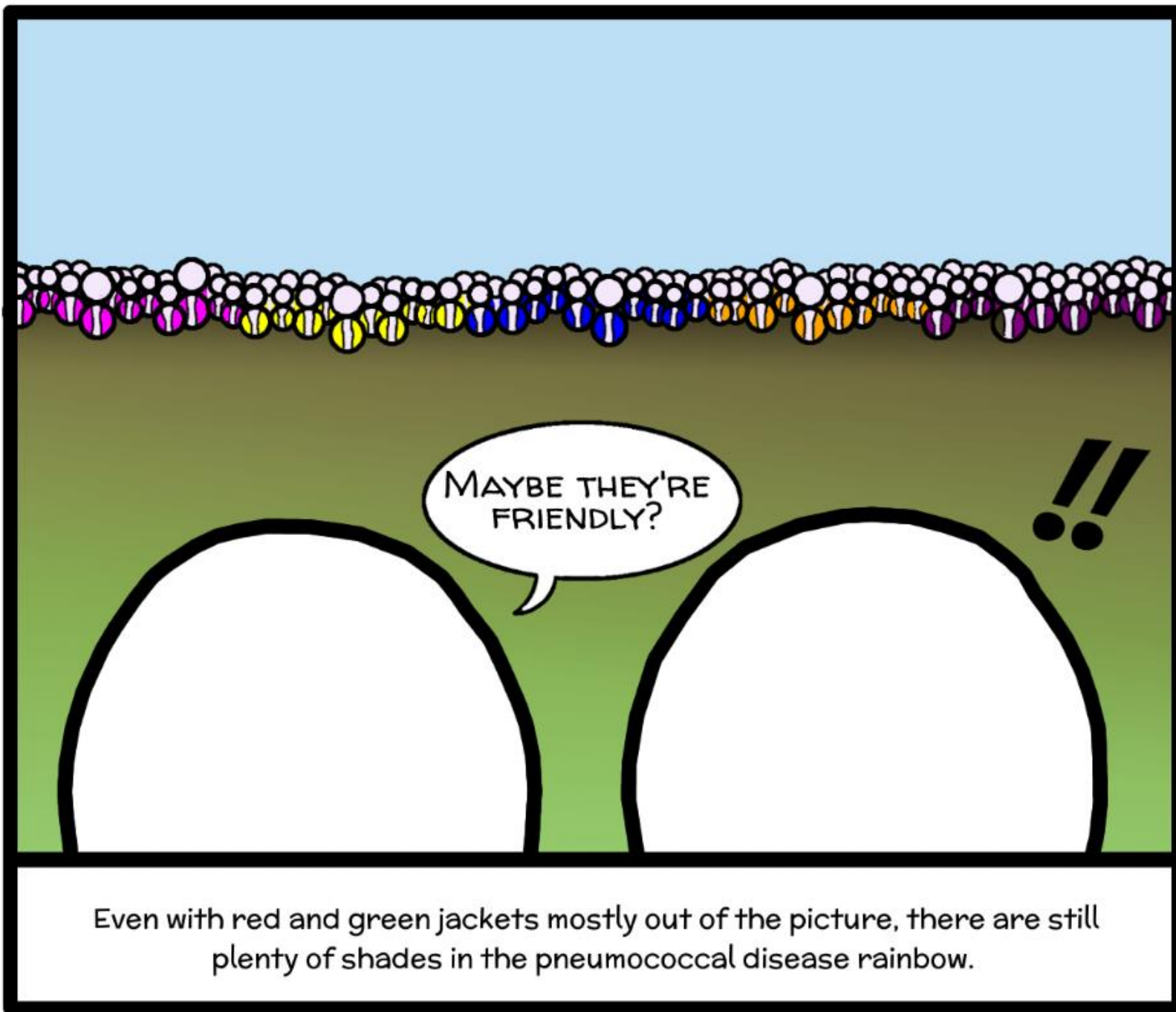
Jackets represent the polysaccharide capsule of the pneumococci, one of the things that help the bacteria live inside the human body. Red jackets represent a group of seven types of pneumococci, which were included in the first-generation vaccine for children.



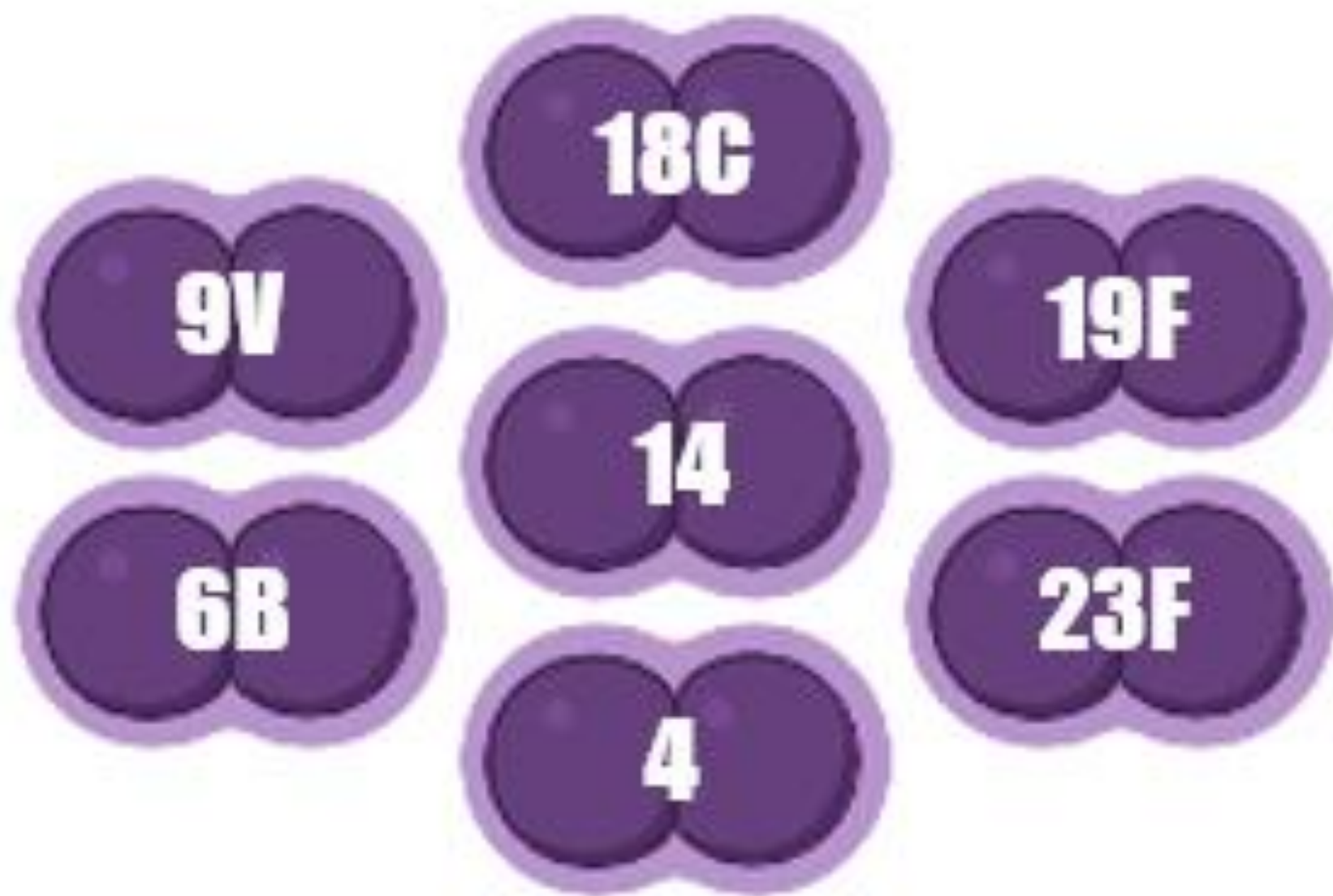
The immune system can be further educated (by new vaccines) to recognize additional types of pneumococci, for example, those wearing green jackets.

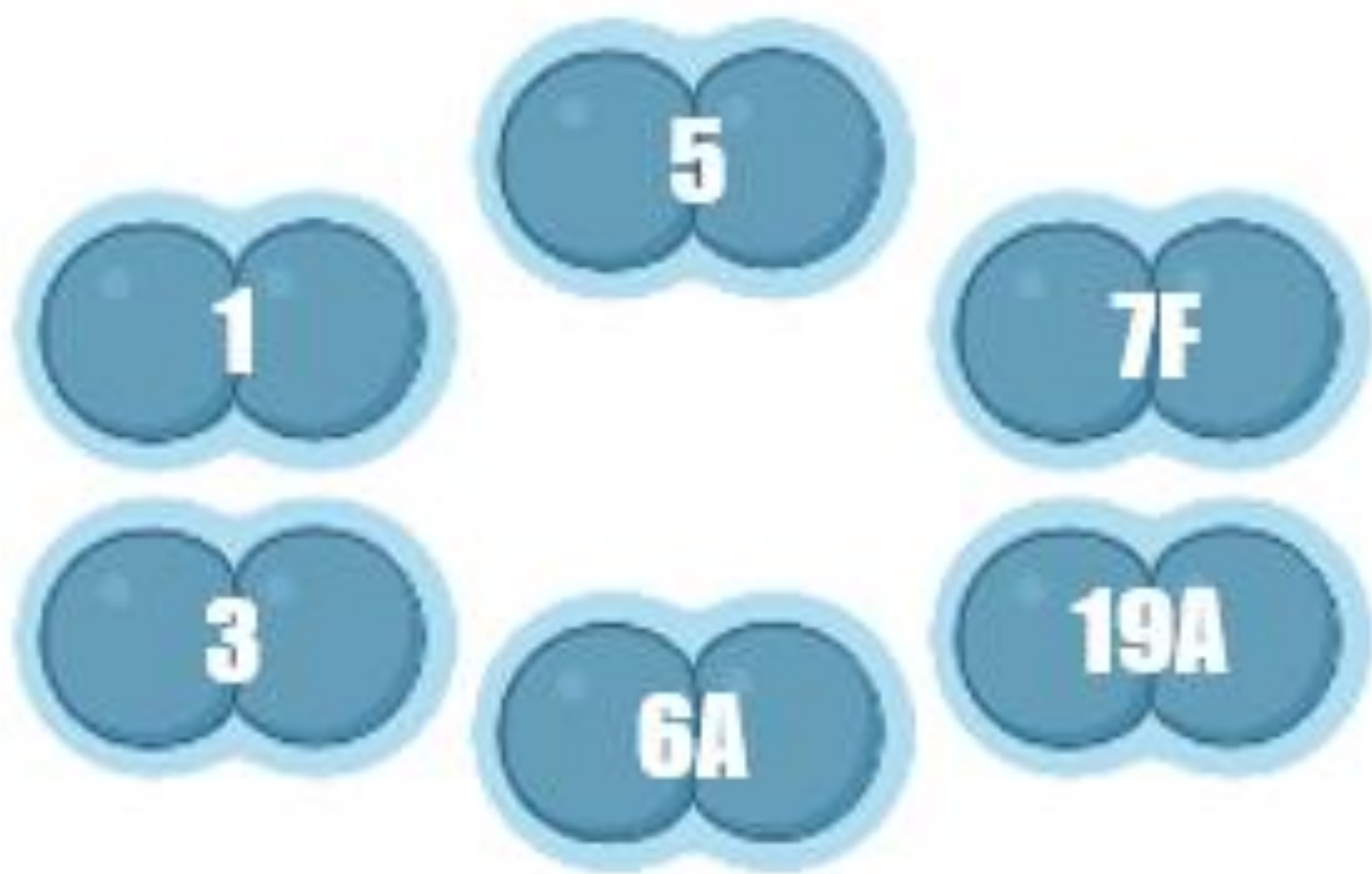


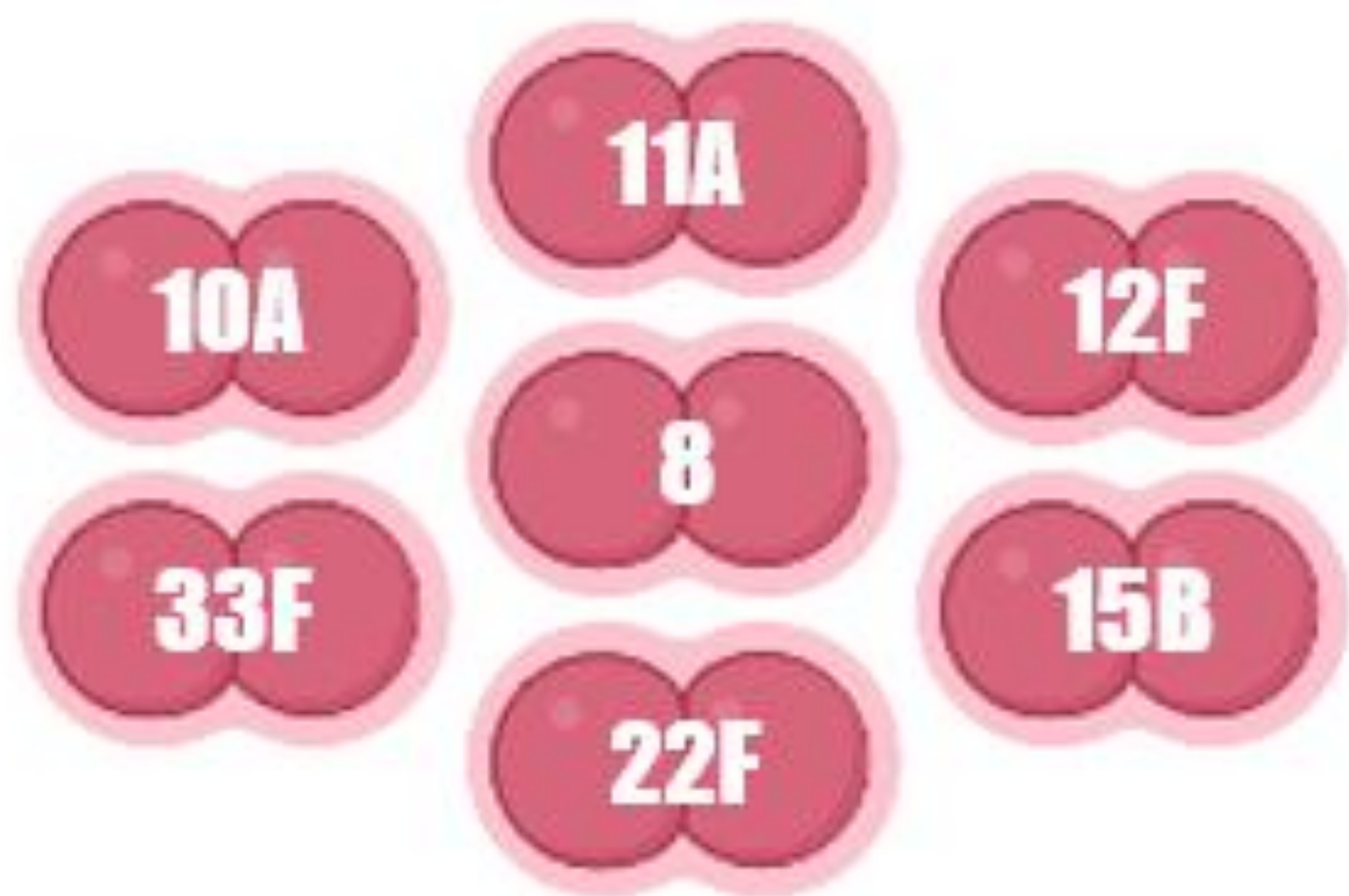
This broader, but still specific, immune response can respond to both red-jacketed and green-jacketed pneumococci now.



Even with red and green jackets mostly out of the picture, there are still plenty of shades in the pneumococcal disease rainbow.



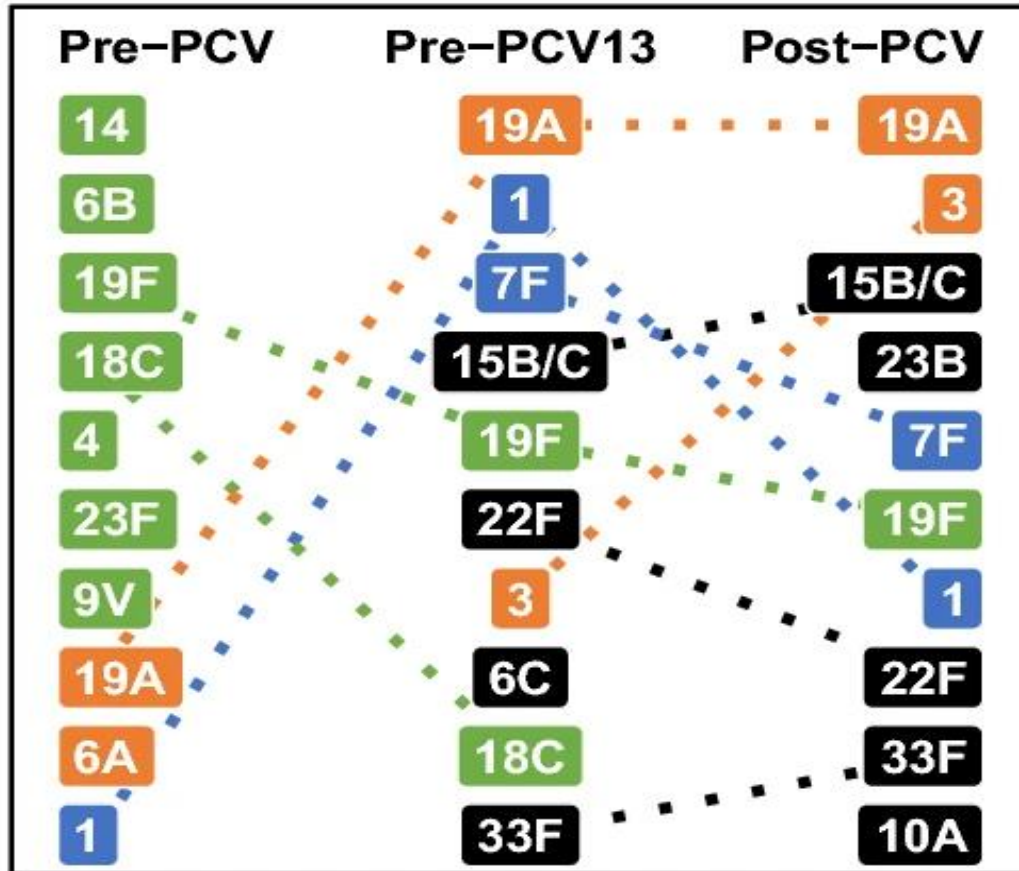




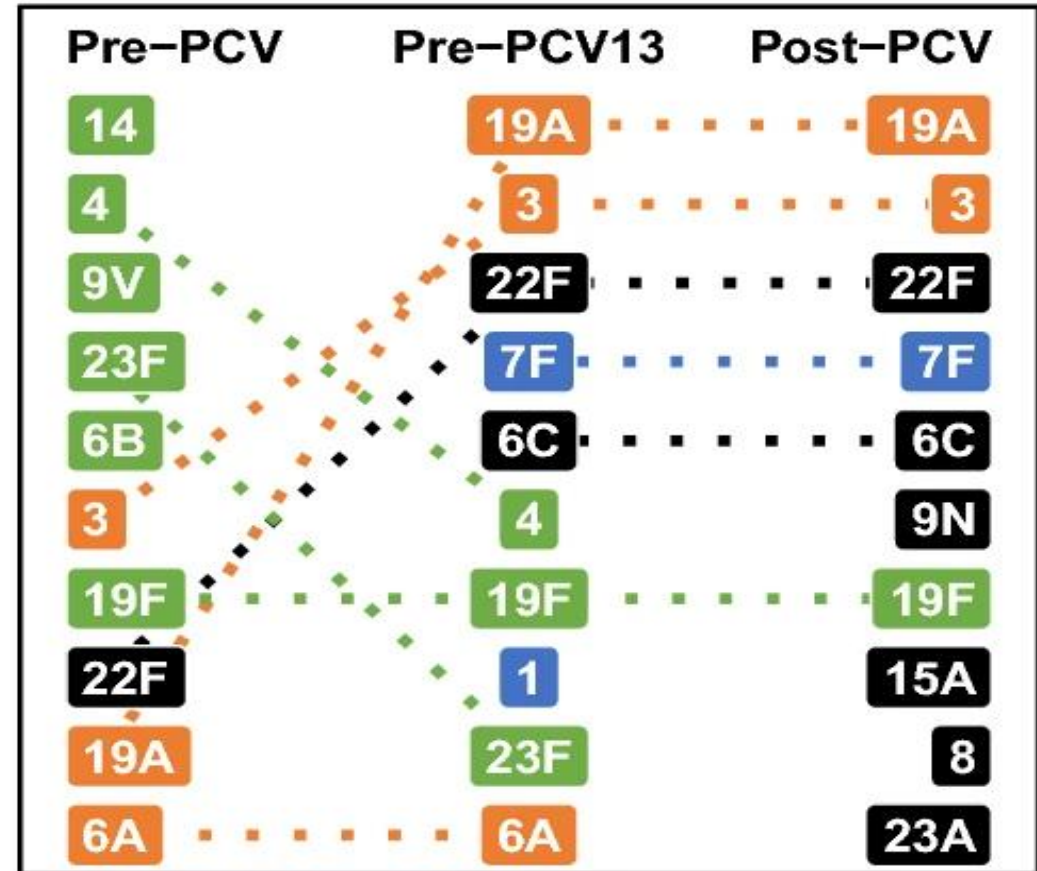
Serotype Replacement Differences by Age

A

Australia < 18 yrs



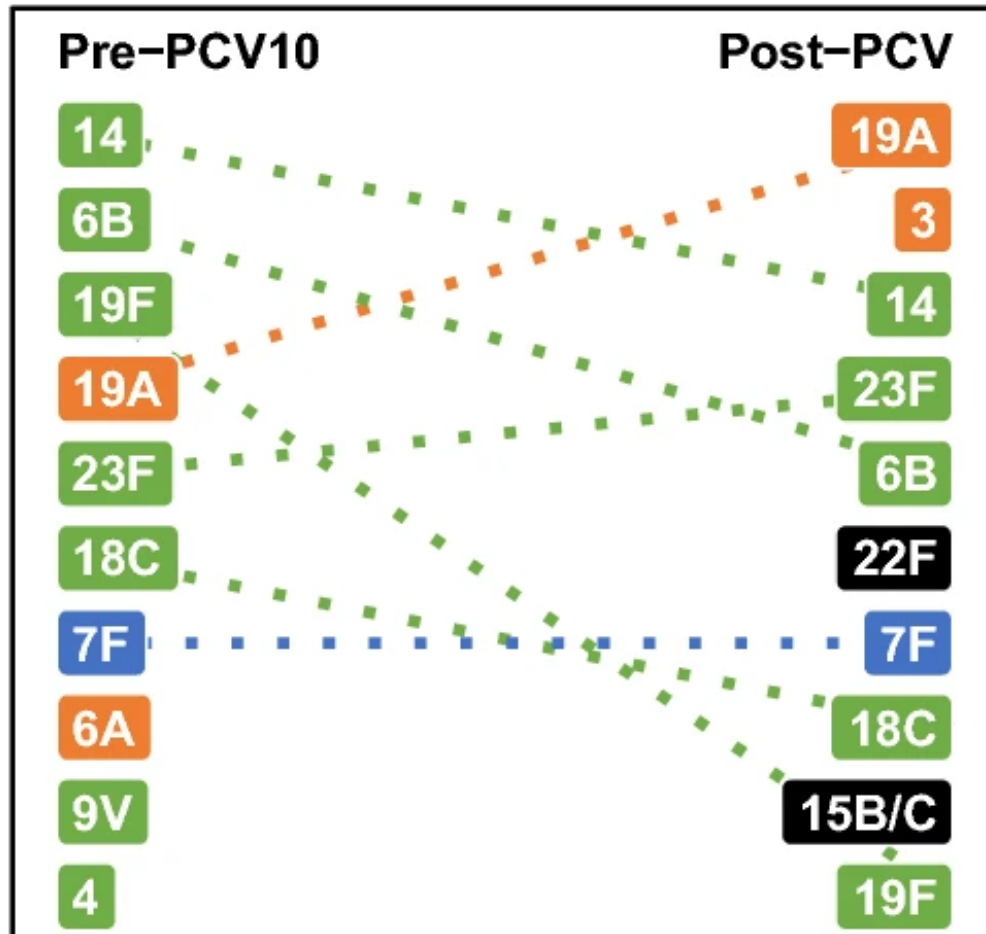
Australia > 18 yrs



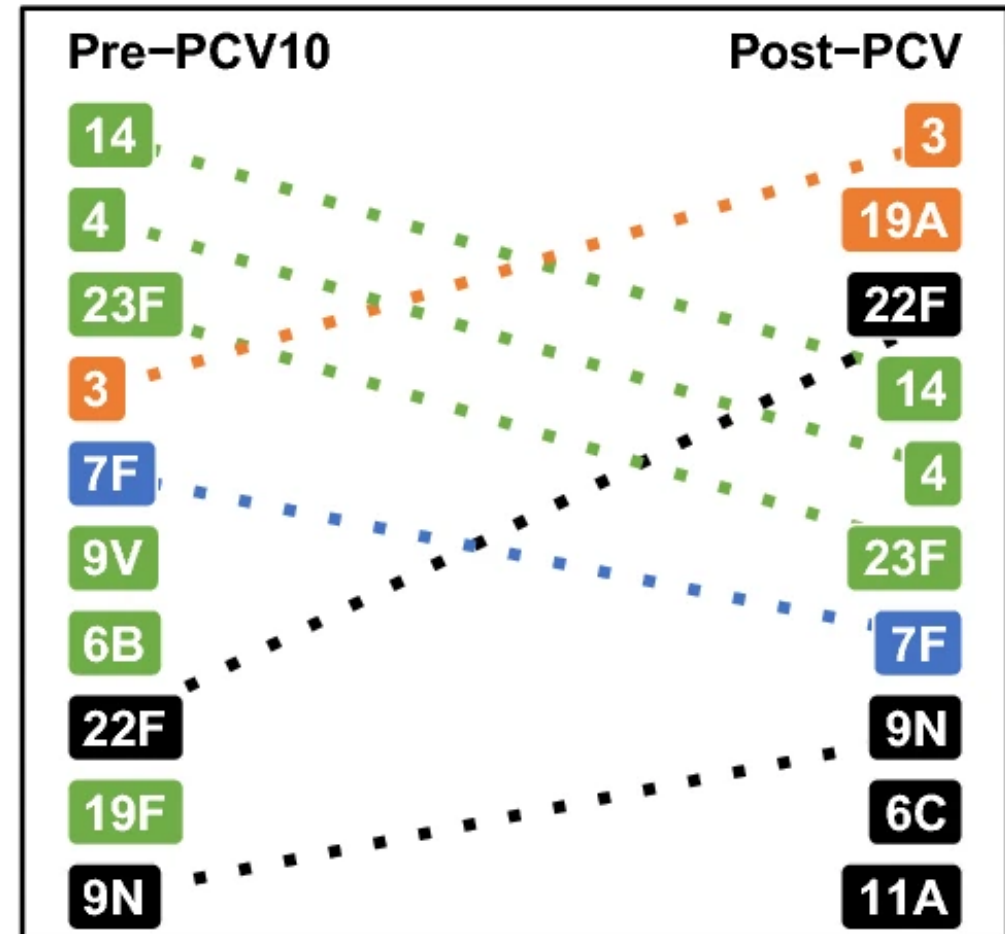
Serotype Replacement Differences by Age

B

Finland < 18 yrs



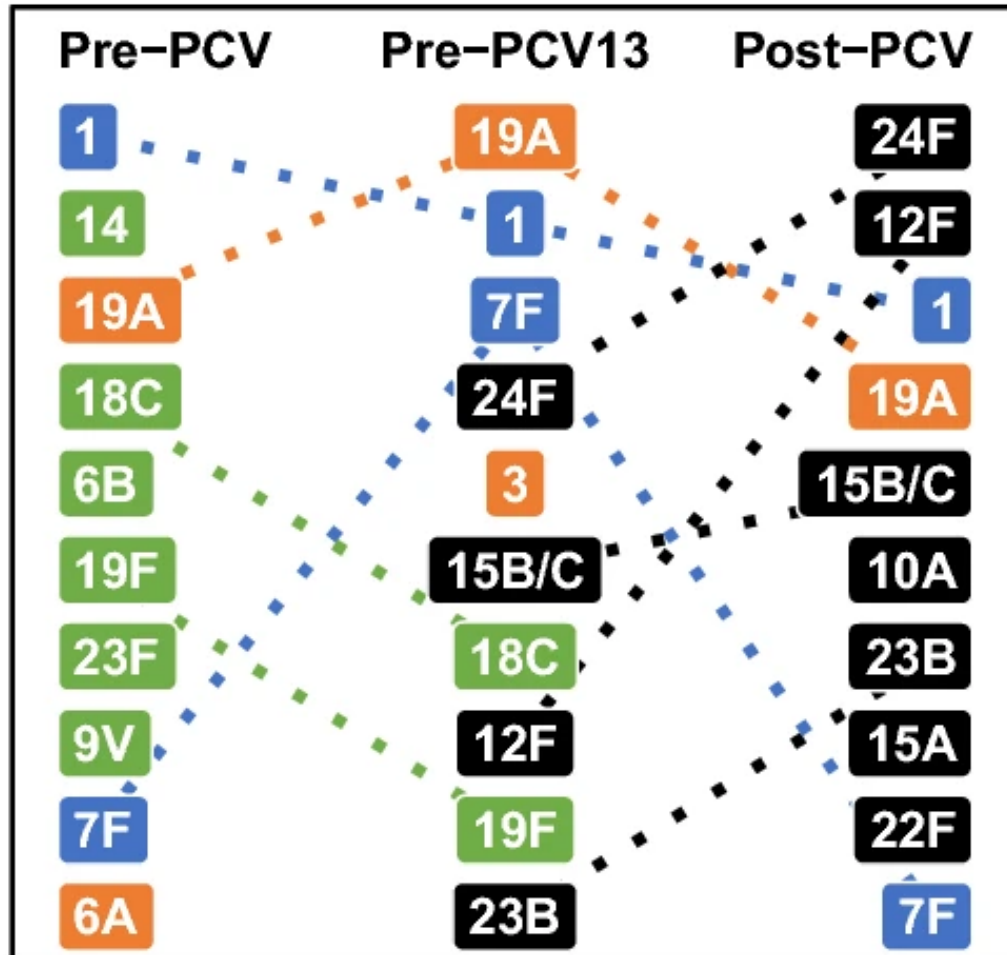
Finland > 18 yrs



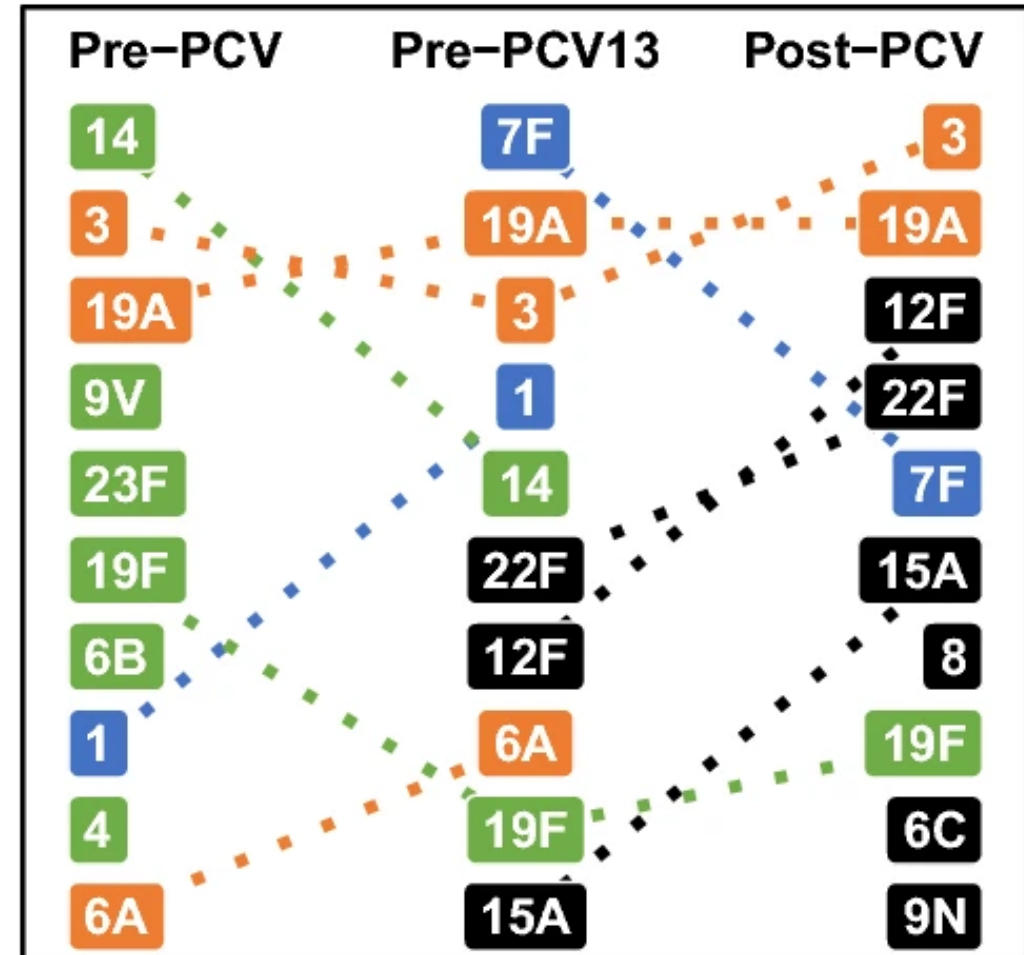
Serotype Replacement Differences by Age

C

France <16 yrs



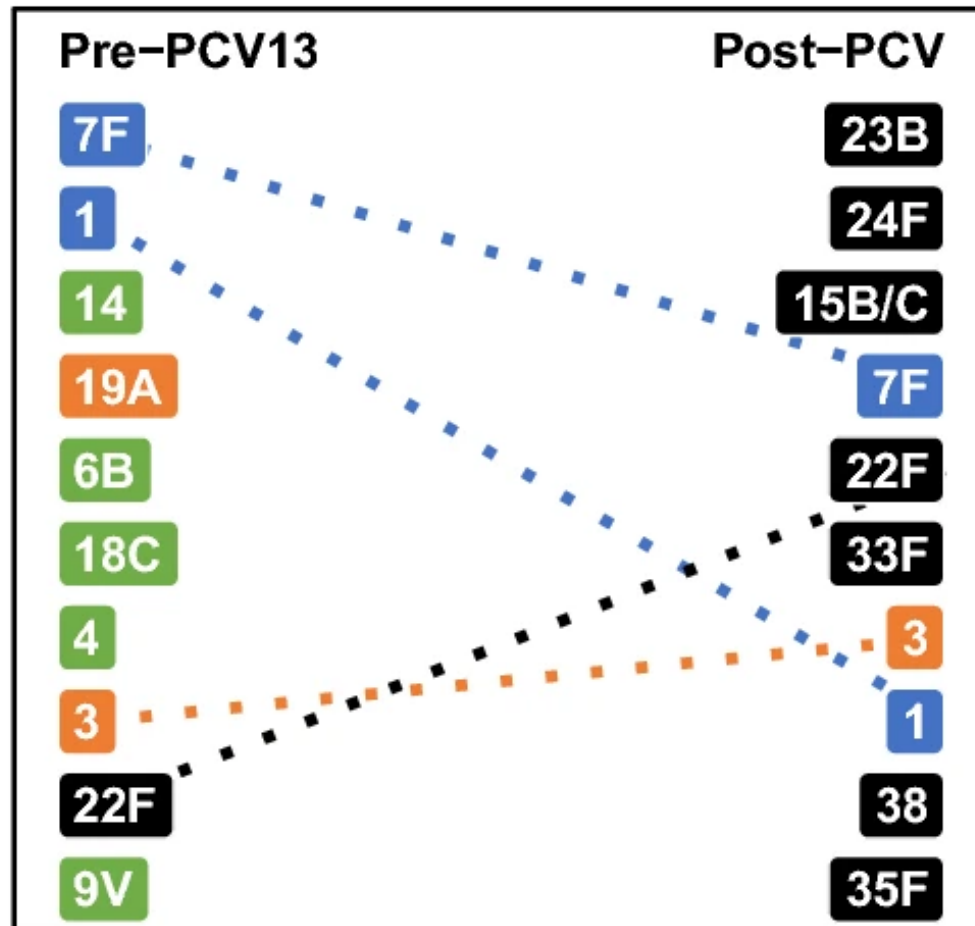
France >16 yrs



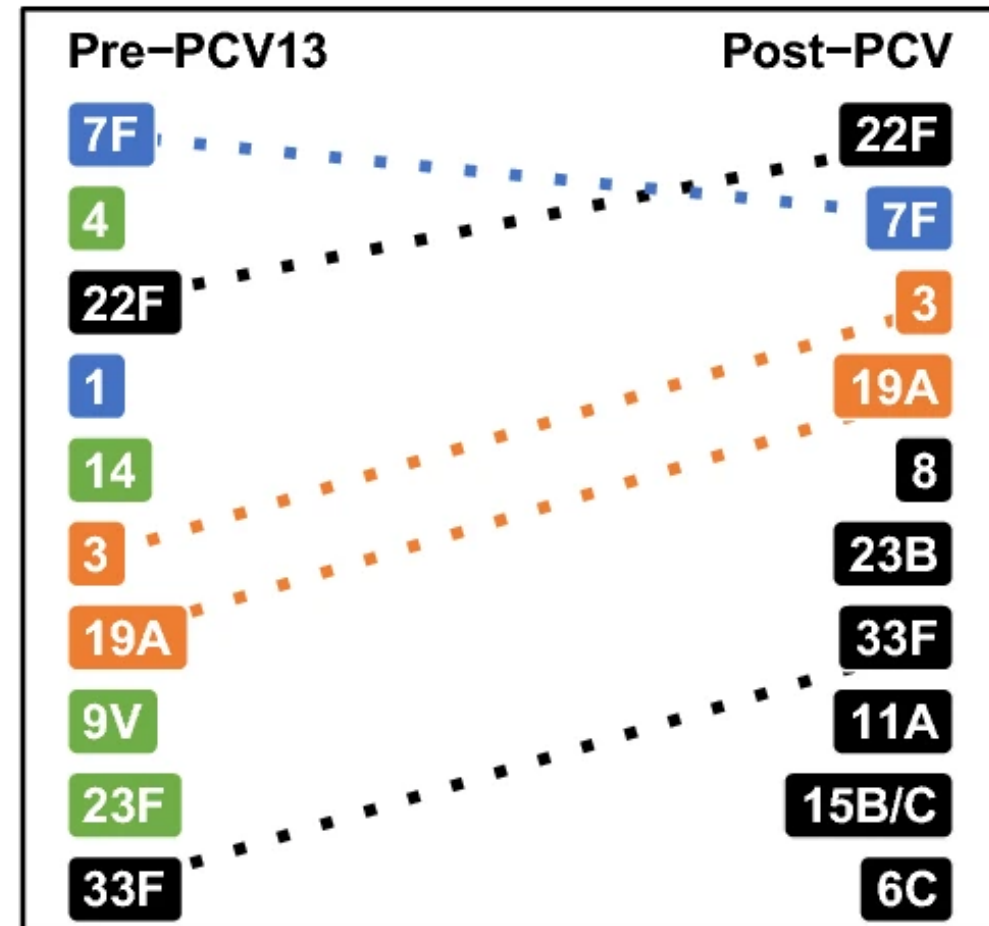
Serotype Replacement Differences by Age

D

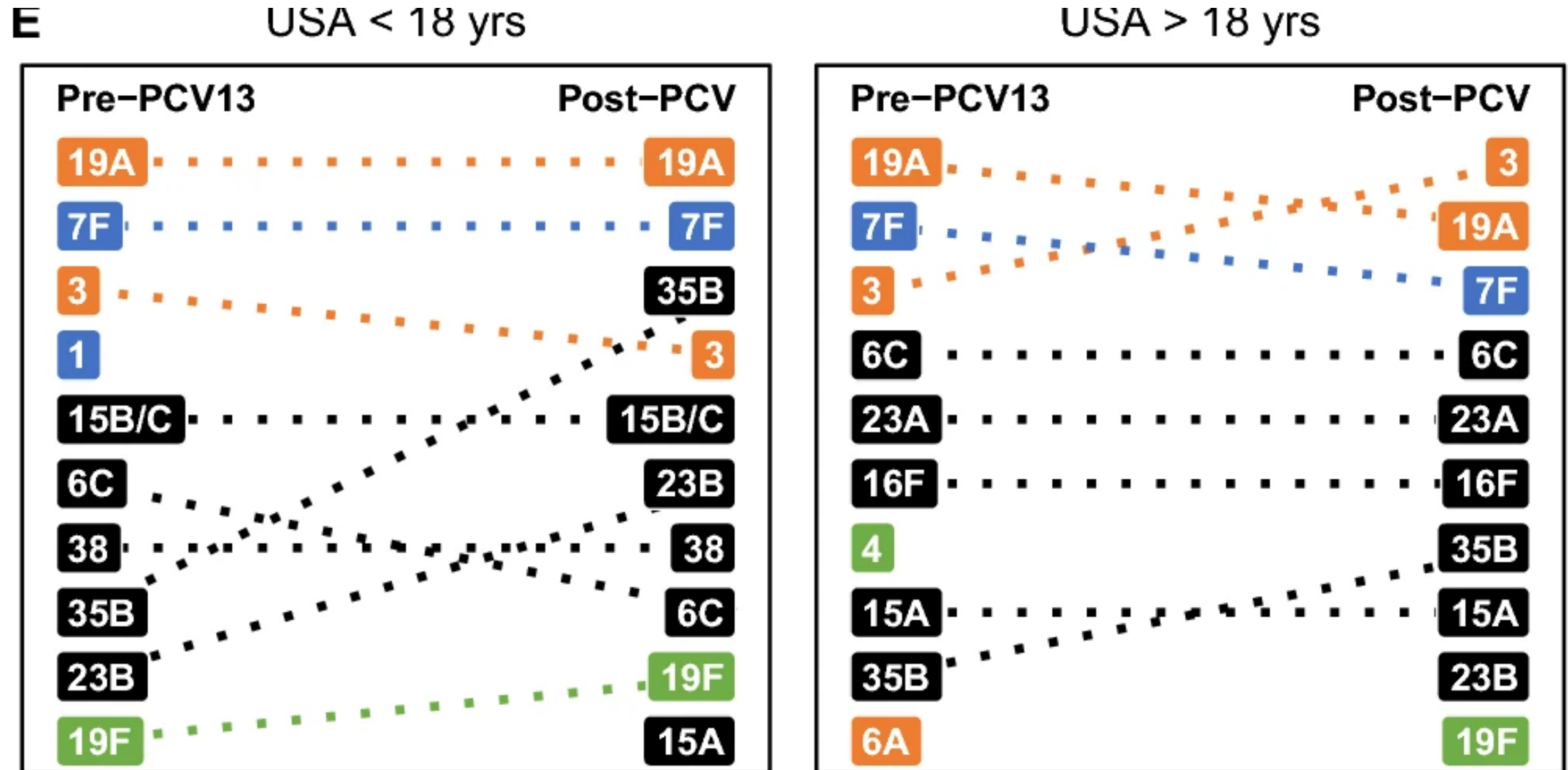
Norway < 18 yrs



Norway > 18 yrs



Serotype Replacement Differences by Age



Example: Surveillance of non-Invasive Pneumococcal Pneumonia (SnIPP)

Why pneumococcal pneumonia?

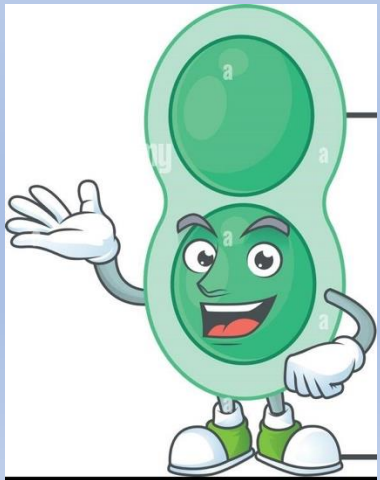
- #

- \$

Death

Invasive
Pneumococcal
Disease

Non-invasive Disease



Clinical Presentations: IPD

- **Invasive** Pneumococcal Disease
 - bacteria isolated from a normally sterile site within the body
 - blood
 - cerebrospinal fluid
 - synovial fluid
- Severe, high mortality illnesses
 - meningitis
 - sepsis
 - bacteremic pneumonia

Surveillance of IPD

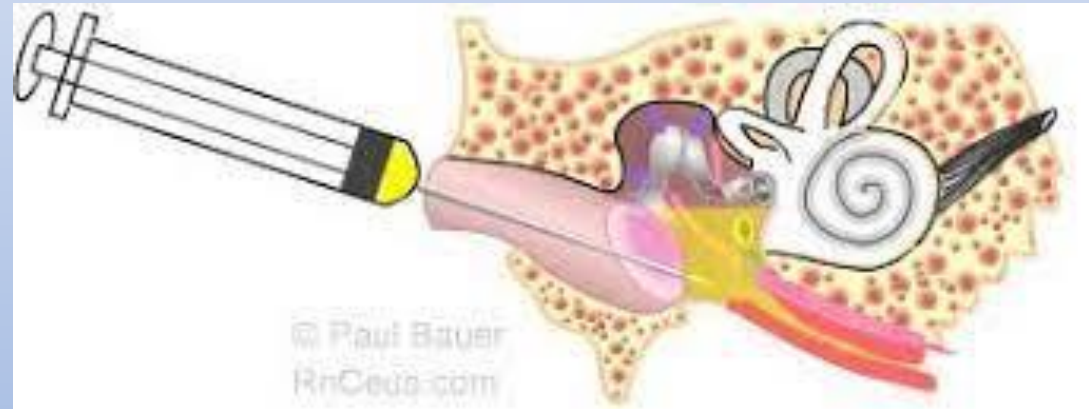
- 109 countries have an IPD surveillance system
- IPD is hard to miss, but not impossible

Clinical Presentation: NIPD

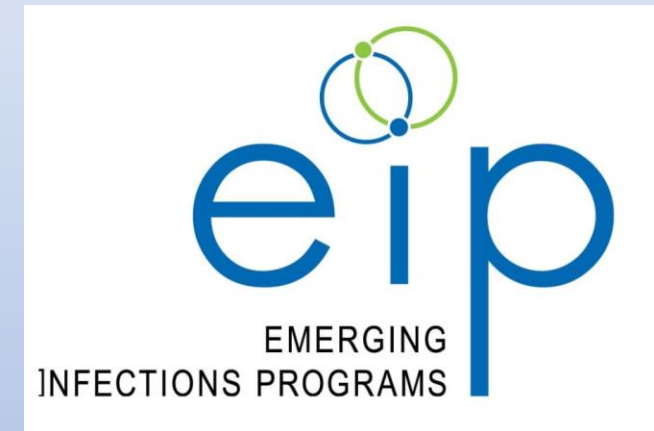
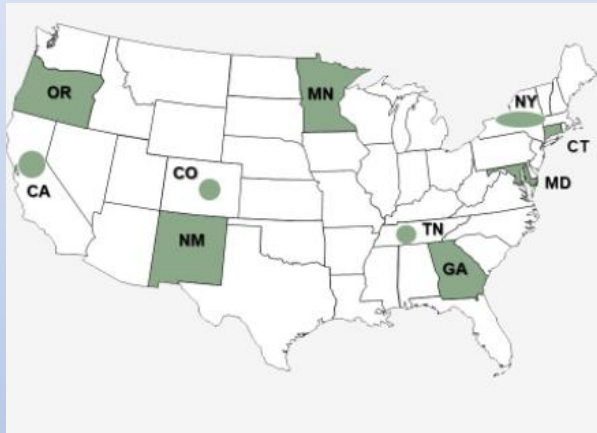
- **Non-invasive** Pneumococcal Disease
 - bacteria overgrow and infect tissue, causing disease
 - Middle ear fluid
 - Sputum
 - Urine
- Less severe, but can be clinically serious and can lead to IPD and death
- HUGE burden of disease
 - Hospitalizations
 - Primary care visits
 - Antibiotic use

Surveillance of Non-invasive Disease

- Patchy, syndromic
- Etiology of NIPDs not often ascertained
 - Treat empirically
 - Sample collection issues
- NIPDs are easy to miss
 - But if missed
 - underestimated burden of disease
 - underestimate cost-effectiveness of vaccines



Surveillance System Participants



Surveillance System Participants

- Physician/APRN- clinical suspicion of pneumonia, trust in PUAT
- Clin Micro Lab- timely result, sufficient sample volume
- CT DPH staff- receive faxes of Case Report Forms
- Yale EIP personnel- verify cases and submit them to CDC
- CDC- use compiled case data for analyses and to inform recommendations for pneumococcal vaccine policy

Surveillance System Technology



So Why Bother?

Why pneumococcal pneumonia?

- #

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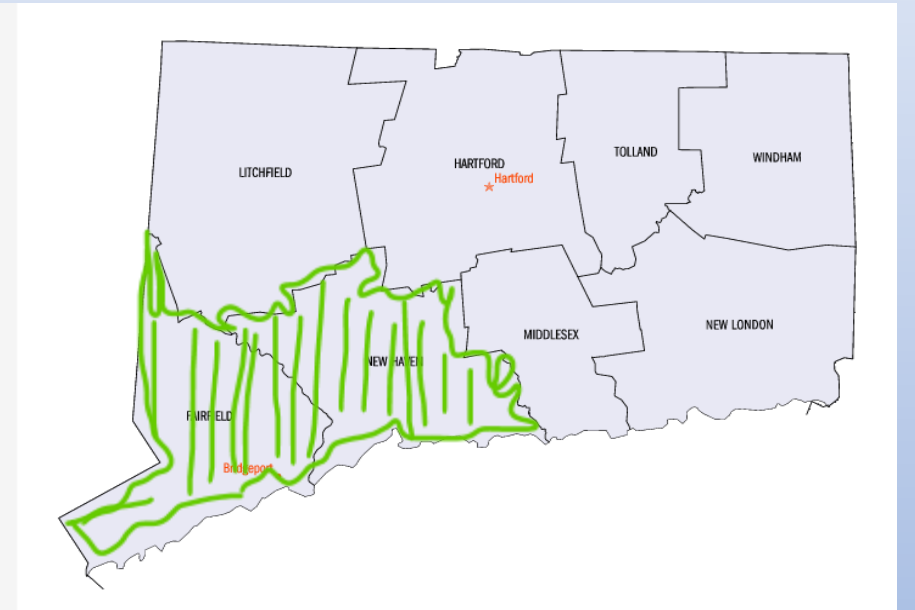
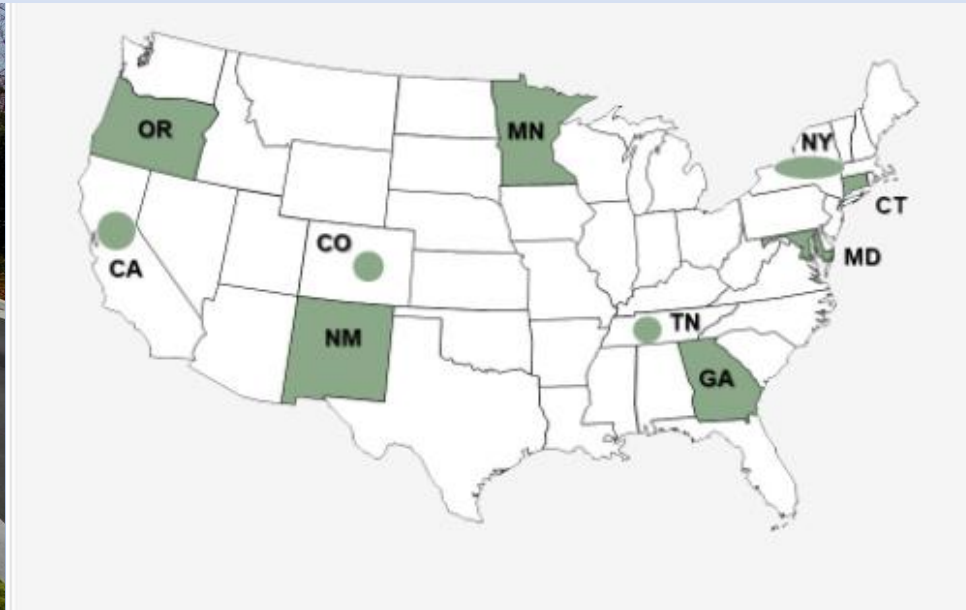
Pneumococcal Vaccines

- Costs of IPD + NIPD warrant costs of vaccines
 - Costs of vaccines are high
- Pneumococcal vaccines were in use in 145 countries (as of 2020)
- Vaccines are highly effective at protecting against included serotypes
 - Other serotypes rise in prevalence and replace vaccine serotypes

CT SNiPP goals

- Contribute to national analyses of non-invasive pneumococcal pneumonia trends
- Inform adult vaccine recommendations
- Save money, improve clinical management, reduce antibiotic use, etc.

CDC → ABC → CT SNIIPP



SNiPP

Surveillance of **Non-invasive** Pneumococcal Pneumonia

How to count SNiPP cases?

- Does a case get identified?
- Does a case reported?
- Does a case get verified?

SNiPP

Surveillance of **Non-invasive** Pneumococcal Pneumonia

Does a case get identified?

- Decision point hub 0: Patients
 - Access to care
 - PCP vs ED

SNiPP

Surveillance of **Non-invasive** Pneumococcal Pneumonia

Does a case get identified?

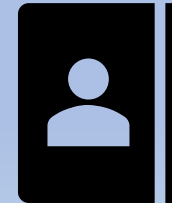
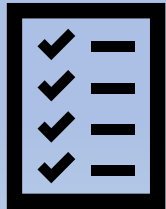
- Decision point hub 1: Point of care
 - Clinical suspicion (EMR)
 - PUAT
 - CXR or CT

SNiPP

Surveillance of **Non-invasive** Pneumococcal Pneumonia

Does a case get reported?

- Decision point hub 2: Lab to Lab
 - Clinical microbiology
 - Administrative staff
 - System compatibility



SNiPP

Surveillance of **Non-invasive** Pneumococcal Pneumonia

Does a case get verified?

- Decision Point hub 3: Data Quality
 - System compatibility
 - Inclusion/exclusion criteria

SNiPP

Surveillance of **Non-invasive** Pneumococcal Pneumonia

Inclusion/Exclusion Criteria

- Has pneumococcal pneumonia
 - Positive UAT
 - Clinically confirmed inpatient pneumonia
- Is ≥ 18 years old
- Resident of New Haven County or Resident of Fairfield County
- Non-invasive disease
- No prior hospitalization for pneumococcal pneumonia within 30 days

SNiPP

Surveillance of Non-invasive Pneumococcal Pneumonia

DATE: 02/09/21 @ 0738
USER: [REDACTED]

Stamford Hospital LAB *LIVE*
LIS SPECIMEN MARKER REPORT
ACTIVITY DATES: 10/01/20 - 01/31/21
MARKERS: S

STAMFORD HOSPITAL (HP0243)
REPORTABLE DISEASES

MODULE: LAB

Pt Addr: [REDACTED] 41/F <DIS IN 01/09> [REDACTED] 626C-01 60NC [REDACTED]
0104:S00510R COMP, Coll: 01/04/21-1350 Recd: 01/04/21-1715
Subm Dr: [REDACTED] MD - EMP, STAMFORD, CT 06904
Ordered: LEGIONELLA AG, S PNEUMO UR AG
Markers: S

Test	Result	Flag	Reference
LEGIONELLA AG	NEGATIVE		NEGATIVE
STREP PNEUMO AG	POSITIVE	*	NEGATIVE

@ Results called to [REDACTED] RN/
@ by [REDACTED] at 1047 on 01/05/21

Reportable Laboratory Findings
Diseases Relating to Public Health - Form OL-15C
For information or to order forms call (860) 509-7994. (rev. 01/01/2021)

Connecticut Department of Public Health
410 Capitol Avenue, MS #11FDS
P.O. Box 340308
Hartford, CT 06134-0308

Patient Last Name: [REDACTED] First: [REDACTED] D.O.B: [REDACTED] 1955 Age: 65
Street Address: [REDACTED] City: BRIDGEPORT State/Zip Code: CT [REDACTED]
Patient Phone: (203) [REDACTED] Gender: ☐ Male ☒ Female ☐ Other specify: ☐ Yes ☐ No ☐ Unk.
Race: ☐ White ☐ Black/African Amer. ☐ Asian ☐ Amer. Indian/Alaska Nat. ☐ Nat. Hawaiian/Other Pacific Islander
☐ Other specify: ☐ Unknown If patient resides in a LTC facility please check: ☐ Yes
Occupation: ☐ Name and address of workplace: ☐
Attending Physician Last Name: Wolff, Armand John, MD First: [REDACTED] Phone: (203) 384-5009

Dr. [REDACTED]
Bridgeport Hospital
Pathology Dept. Microbiology Lab
267 Grant Street
Bridgeport CT 06610
203-384-3068

Specimen collection date: 01/30/2021
Date laboratory finding reported to physician: 01/30/2021
Date OL-15C completed: 01/30/2021
Hospital Chart No: [REDACTED] Lab Specimen No: 73866946
Source/Type specimen: Urine
Submitted to state lab (see reverse) ☐ Yes ☒ No

☐ Babesia ☐ IFA ☐ IgM (Ifer) ☐ IgG (Ifer) ☐ PCR
☐ Blood smear ☐ PCR ☐ Other: ☐
☐ microfil ☐ divergens ☐ duncani ☐ Unspediated
☐ Bordetella pertussis (Ifer)
☐ Culture ☐ Non-pertussis Bordetella (specify) ☐
☐ DFA PCR
☐ Borrelia burgdorferi ^{1,2}
☐ Borrelia miyamotoi
☐ California group virus ¹ spp. ☐ Culture ☐ PCR ☐ EIA
☐ Campylobacter ¹ spp. ☐ Culture ☐ PCR ☐ EIA
☐ Candida auris (report samples from all sites) ¹
☐ Candida spp. (blood isolates only): ☐
☐ Carbapenem-resistant Acinetobacter baumannii (CRAB) ^{1,4}
☐ Carbapenem-resistant Enterobacteriaceae (CRE) ^{1,4}
☐ Genus spp. ☐
☐ Carboxyhemoglobin $\geq 5\%$ ² ☐ % COHb
☐ Chikungunya virus
☐ Chlamydia trachomatis (test type) ☐
☐ Clostridium difficile ⁵
☐ Corynebacterium diphtheriae ¹
☐ Cryptosporidium spp ² ☐ PCR ☐ DFA ☐ EIA
☐ Microscopy ☐ Other: ☐
☐ Cyclospora spp ¹
☐ PCR ☐ Microscopy ☐ Other: ☐
☐ Dengue virus
☐ Eastern equine encephalitis virus

☐ Legionella spp ¹
☐ Culture ☐ DFA ☐ Ag positive ☐ PCR
☐ Four-fold serologic change (Ifer)
☐ Listeria monocytogenes ¹ ☐ Culture ☐ PCR
☐ Mercury poisoning
☐ Urine ≥ 35 μ g/g creatinine ☐ μ g/g
☐ Blood ≥ 15 μ g/L ☐ μ g/L ☐ PCR
☐ Mumps virus ^{1,4} (Ifer) ☐ PCR
☐ Mycobacterium leprae
☐ Mycobacterium tuberculosis Related Testing ¹
☐ AFB Smear ☐ Positive ☐ Negative
☐ If positive ☐ Rare ☐ Few ☐ Numerous
☐ NAAT ☐ Positive ☐ Negative ☐ Indeterminate
☐ Culture ☐ Mycobacterium tuberculosis
☐ Non-TB mycobacterium (specify M) ☐
☐ Neisseria gonorrhoeae (test type) ☐
☐ Neisseria meningitidis, invasive ^{1,4}
☐ Culture ☐ Other: ☐
☐ Neonatal bacterial sepsis ^{1,13} spp. ☐
☐ Plasmodium ^{1,2} spp. ☐
☐ Poliovirus
☐ Poxvirus
☐ Rabies virus
☐ Rickettsia rickettsii ☐ PCR ☐ IgG $\geq 1:128$ only ☐ Culture
☐ Respiratory syncytial virus ²
☐ Rubella virus ^{1,4} (Ifer) ☐ PCR
☐ Rubella virus (Measles) ^{1,4} (Ifer) ☐ PCR
☐ St. Louis encephalitis virus
☐ Salmonella ^{1,3} (serogroup & type) ☐ Culture ☐ PCR

YALE-NEW HAVEN HOSPITAL
Clinical Microbiology Laboratory
20 York Street - PS 656, New Haven, CT 06504
Telephone (203) 688-2460
Laboratory Manager: Jacqueline Nadeau

To: Connecticut Department of Public Health
410 Capitol Avenue, MS #11FDS
P.O. Box 340308
Hartford, CT 06134-0308

LABORATORY REPORT OF SIGNIFICANT FINDINGS

Disease Description: Streptococcus Pneumoniae Antigens

Patient Name: [REDACTED] DOB: [REDACTED] 1974 Sex: F
Street Address: [REDACTED] City: West Haven State/Zip Code: CT [REDACTED]
Patient Telephone: (475) [REDACTED] Hispanic? Unk Race: Black
Attending Physician Name: [REDACTED] Telephone: (203) [REDACTED]
Address: YNH, 20 York Street, New Haven, CT 06510

Specimen Collection Date: 1/19/2021
Date Reported to Physician: 1/20/2021
Date Report Completed: 1/19/2021
Hospital Chart Number: [REDACTED]
Hospital Lab Number: 21Y-019IMU453

SPFILT_20220106_3cf21736-b06d-48bd-a58f-bbe43a7b5692 - Notepad

PatientLastName	PatientFirstName	PatientMiddleName	PatientGender	PatientDOB	PatientAddress1	PatientAddress2	PatientCity	PatientState	PatientPostalCode	PatientPhone
[REDACTED]	[REDACTED]	[REDACTED]	Male	1942-01-01	[REDACTED]	[REDACTED]	White Non Hispanic	1002038889	[REDACTED]	[REDACTED]
PRESNG										
Presumptive Negative										
F	Positive for pneumococcal pneumonia A	24027-5	S pneum Ag Ur Ql	10828004	Positive	SPFILT	CWE	URINE	Urine	

Ln 1, Col 1

100% Unix (LF) UTF-8

SNiPP

Surveillance of Non-invasive Pneumococcal Pneumonia

Connecticut Electronic Disease Surveillance System





Workflows

Workflow Queue	Events
ABCs ELR Lab Reports	383 (0)
ABCs Report Notification	23 (0)
Legionella - Health Care Exposure	213 (0)
Legionella Case Not Interviewed workflow	33 (0)
Legionella ELR Lab Reports	3 (0)
More ...	

Tasks

Type	Priority	Name	Disease OR Condition
No tasks to display			
More ...			

Recent Cases

Event ID	Name	Disease OR Condition
100781387		Streptococcus pneumoniae
105325748		Streptococcus pneumoniae
105325311		Streptococcus pneumoniae
		Streptococcus

CTEDSS System Support and Contact Information

When you are finished working in CTEDSS, please **make sure you LOG OUT of the system** before closing the browser window. Simply closing the window does not end your CTEDSS session and continues to tie up system resources.

Contact information for CTEDSS:

- During regular business hours (M-F, 8:30 am - 4:30 pm) Phone: 860-509-7994 Email: dph.ctedss@ct.gov
- If using email, please send a detailed description of the problem and include screen shots if possible. If you see an error message, please include that in your description.
- For CTEDSS after hours, weekends or holiday **outages only**, call **860-509-7777** (the DPH IT HelpDesk). Please leave your name, a contact phone number and a brief description of the problem.

CTEDSS System News and Tips

- To return to this **"Splash Screen"** from your event dashboard, click on your name at the top right portion of the screen and select **Close Record**, or click on the 'X' to the far right of the Event Summary title bar.
- A CTEDSS Training Course:** All users of the CTEDSS program are required to complete an on-line CTEDSS training course. To obtain training information for new staff, please e-mail dph.ctedss@ct.gov and we will provide details on how to register for this training.
- Animal Rabies Search:** Before searching for cases of Animal Rabies, the State field must be set to blank.
- HASS data:** HASS information is no longer collected here. If you have questions, please email DPH.Syndromic@ct.gov.
- Case Definitions** for CDC Nationally Notifiable Diseases and Other conditions: wwwn.cdc.gov/nndss/conditions/

SNiPP

Surveillance of Non-invasive Pneumococcal Pneumonia

The screenshot shows the SNiPP web application interface. It includes sections for patient information, vaccination history, vaccination status, and a patient list. The interface is designed for healthcare providers to track and manage pneumococcal pneumonia surveillance data.

The screenshot shows a detailed view of a patient's vaccination history in the SNiPP web application. The interface displays a table with columns for Date, Type, Dose, Status, and Vaccine. The table lists several vaccinations, including PCV13, PPV23, and PCV7, with their respective dates and statuses.

Date	Type	Dose	Status	Vaccine
2008/08/08	Subcutaneous	1st dose	Completed	PPV23
2008/08/08	Subcutaneous	1st dose	Completed	PCV13
2008/08/08	Subcutaneous	1st dose	Completed	PCV7
2008/08/08	Subcutaneous	1st dose	Completed	PPV23
2008/08/08	Subcutaneous	1st dose	Completed	PCV13
2008/08/08	Subcutaneous	1st dose	Completed	PCV7
2008/08/08	Subcutaneous	1st dose	Completed	PPV23
2008/08/08	Subcutaneous	1st dose	Completed	PCV13
2008/08/08	Subcutaneous	1st dose	Completed	PCV7
2008/08/08	Subcutaneous	1st dose	Completed	PPV23
2008/08/08	Subcutaneous	1st dose	Completed	PCV13
2008/08/08	Subcutaneous	1st dose	Completed	PCV7

SNiPP

Surveillance of Non-invasive Pneumococcal Pneumonia

Logged in as 748603 | Log out

My Projects

Project Home and Design

Project Home · Codebook

Project status: Production

Data Collection — CT

Record Status Dashboard

Add / Edit Records

Show data collection instruments

Applications

Calendar

Data Exports, Reports, and Stats

Data Import Tool

Logging

Field Comment Log

File Repository

CDC REDCap Resource Center

Reports

Search

Organize

Edit

Data Exports, Reports, and Stats

VIDEO: How to use Data Exports, Reports, and Stats

Create New Report

My Reports & Exports

Other Export Options

View Report: 2019 case counts CT

Stats & Charts

Export Data

Print Page

Edit Report

Number of results returned: 238

Total number of records queried: 957

Report execution time: 0.1 seconds

2019 case counts CT

Search

Table not displaying properly ?

State ID: pstateid	7a. Hospital/Lab I.D. Where UAT Identified? hospid	4a. Date first positive urine antigen test collected (Date Specimen Collected) uatdt	Complete? pldemographics_complete	5. CRF Status status
CT11002			Unverified (1)	Not a case (5)
CT11069		01-24-2020	Complete (2)	Complete (1)
CT11070			Complete (2)	
CT11071			Complete (2)	
CT11072			Complete (2)	
CT11073			Complete (2)	

Your Turn



CT SNiPP goals

- Contribute to national analyses of non-invasive pneumococcal pneumonia trends
- Inform adult vaccine recommendations
- Save money, improve clinical management, reduce antibiotic use, etc.

Preview

- Time series analysis!

ysph.yale.edu
sph.yale.edu/dsde

@YaleSPH

**Data Science and Data Equity
Yale School of Public Health
60 College Street, New Haven, CT 06510**

Yale SCHOOL OF PUBLIC HEALTH

Pneumococcal Diagnostics

How do we find IPD?



Blood culture guidelines for CAP

Table 2. Differences between the 2019 and 2007 American Thoracic Society/Infectious Diseases Society of America Community-acquired Pneumonia Guidelines

Recommendation	2007 ATS/IDSA Guideline	2019 ATS/IDSA Guideline
Sputum culture	Primarily recommended in patients with severe disease	Now recommended in patients with severe disease as well as in all inpatients empirically treated for MRSA or <i>Pseudomonas aeruginosa</i>
Blood culture	Primarily recommended in patients with severe disease	Now recommended in patients with severe disease as well as in all inpatients empirically treated for MRSA or <i>P. aeruginosa</i>
Macrolide monotherapy	Strong recommendation for outpatients	Conditional recommendation for outpatients based on resistance levels

Criteria for severe CAP

Table 1. 2007 Infectious Diseases Society of America/American Thoracic Society Criteria for Defining Severe Community-acquired Pneumonia

Validated definition includes either one major criterion or three or more minor criteria

Minor criteria

Respiratory rate ≥ 30 breaths/min

$\text{PaO}_2/\text{FiO}_2$ ratio ≤ 250

Multilobar infiltrates

Confusion/disorientation

Uremia (blood urea nitrogen level ≥ 20 mg/dl)

Leukopenia* (white blood cell count $< 4,000$ cells/ μl)

Thrombocytopenia (platelet count $< 100,000/\mu\text{l}$)

Hypothermia (core temperature $< 36^\circ\text{C}$)

Hypotension requiring aggressive fluid resuscitation

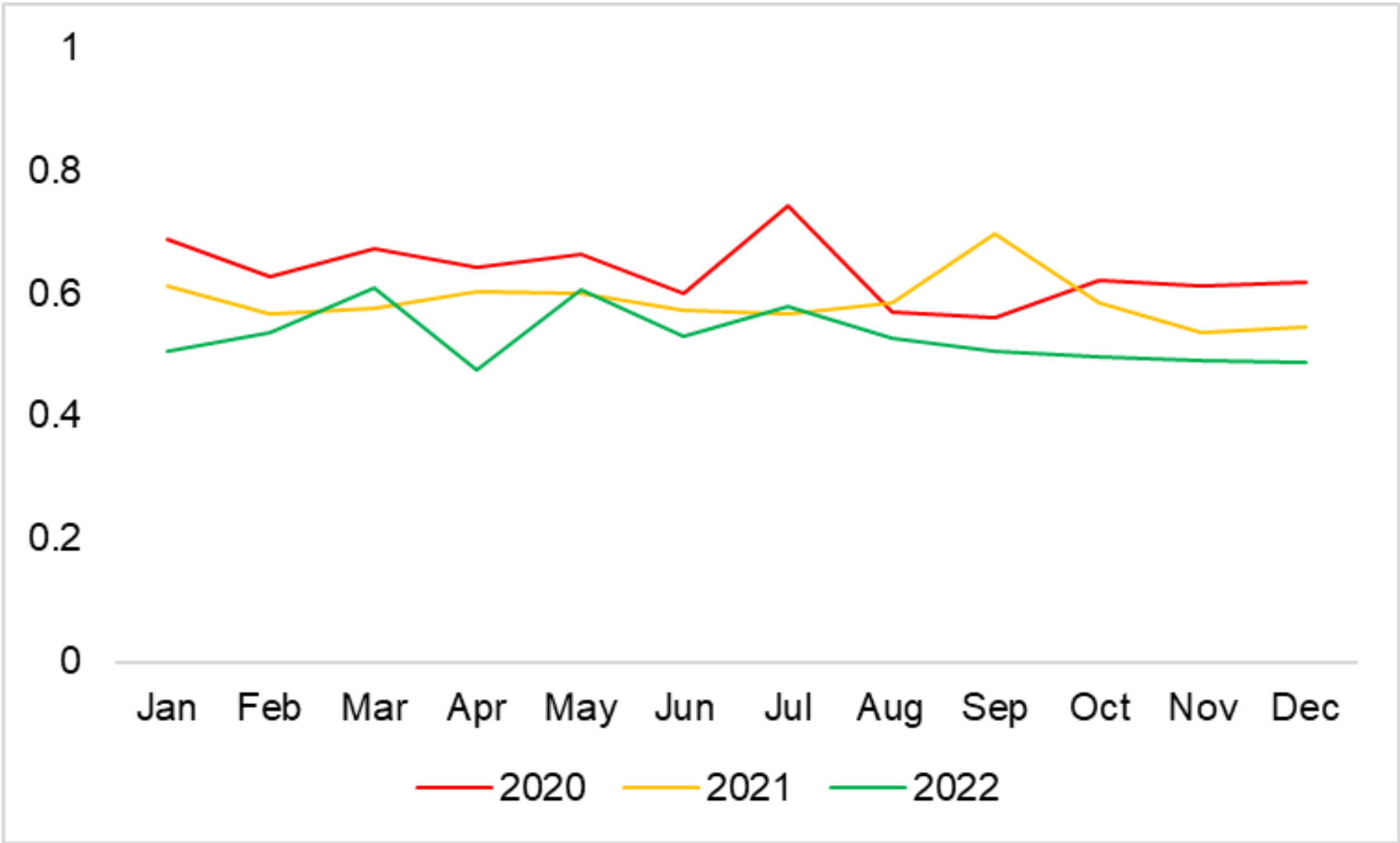
Major criteria

Septic shock with need for vasopressors

Respiratory failure requiring mechanical ventilation

*Due to infection alone (i.e., not chemotherapy induced).

YNHH Admissions with a primary diagnosis of pneumonia, proportion of cases with blood culture



YNHH Admissions with a primary diagnosis of sepsis, proportion of cases with blood culture

