Trend Analysis of Confirmed Cases of *Streptococcus pneumoniae* from 2014 to 2017 in Select Municipal Kansas Counties

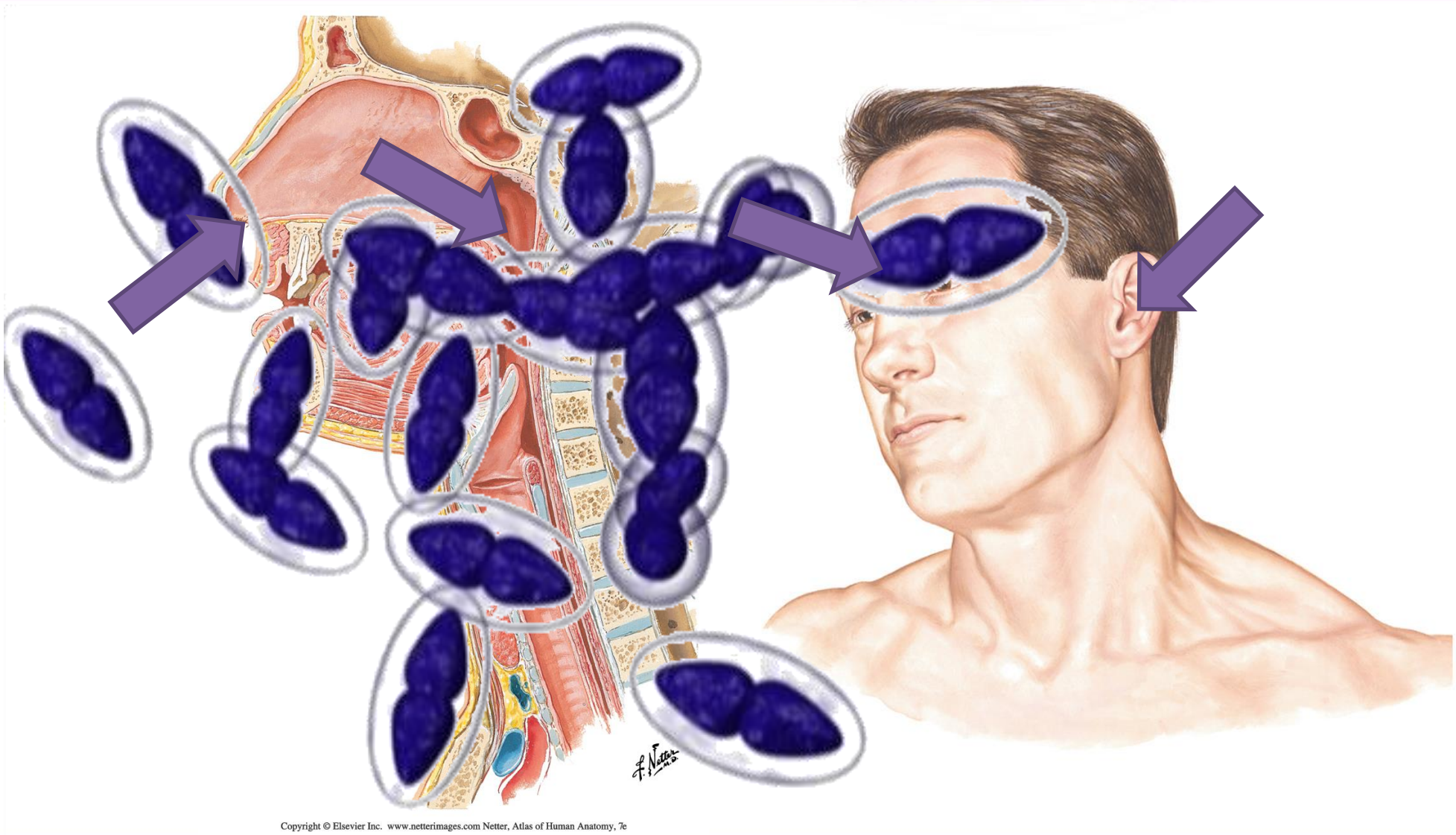
By Colin N. Ferrel

Overview

- What's the problem?
  - Disease
  - Disease Burden on Public Health
  - Vaccines and Serotype Shift
- Why should I care/Who's being affected?
  - Frequency
  - Rates & Chi-square
  - Statistical Models
- What's the Solution?

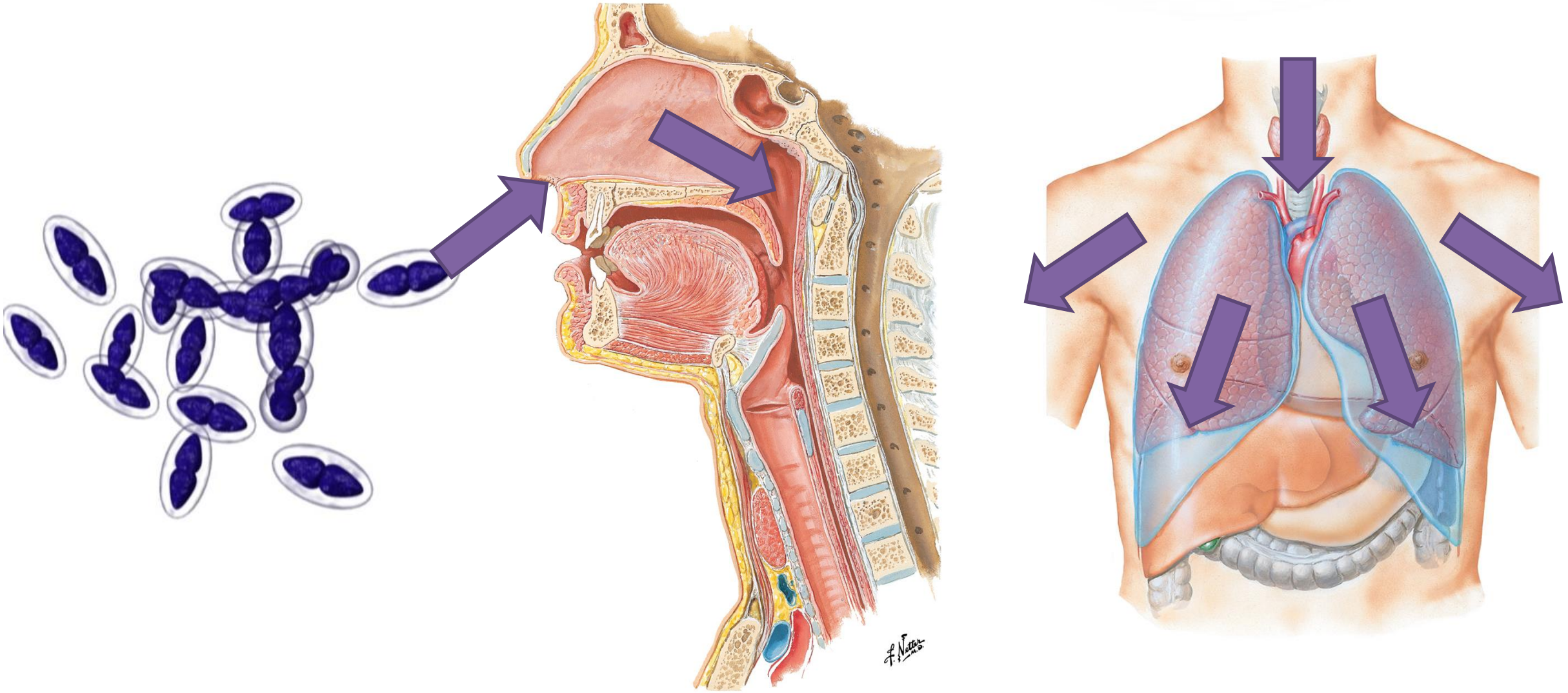
What's the Problem?

Streptococcus pneumoniae (Pneumococcal Disease)



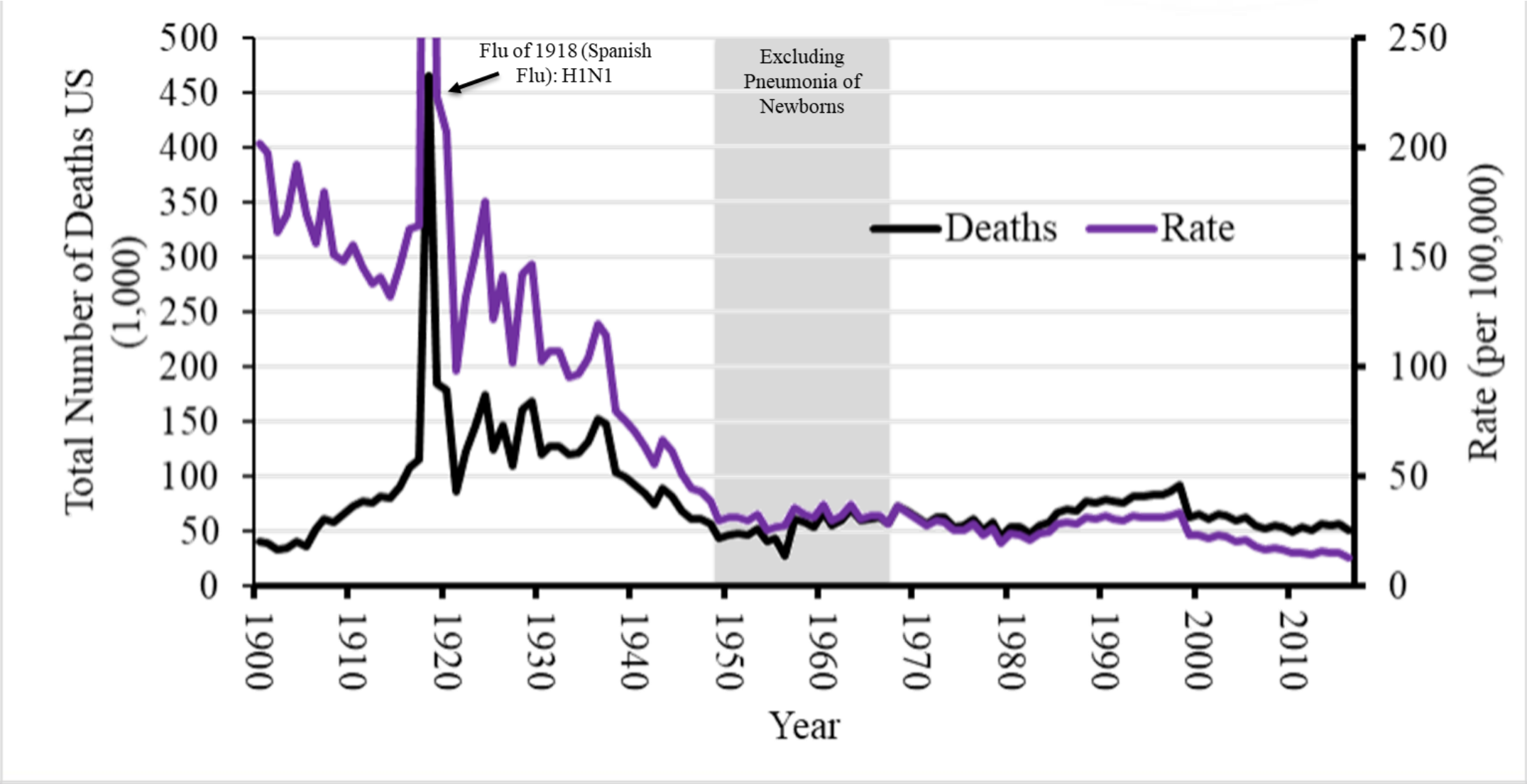
References: http://www.bacteria.cz/bacteria-pneumococcus-03.html
https://netterreference.com/content/netter_atlas_7e/?task=home

Streptococcus pneumoniae (Pneumococcal Disease)



References: http://www.bacteria.cz/bacteria-pneumococcus-03.html
https://netterreference.com/content/netter_atlas_7e/?task=home

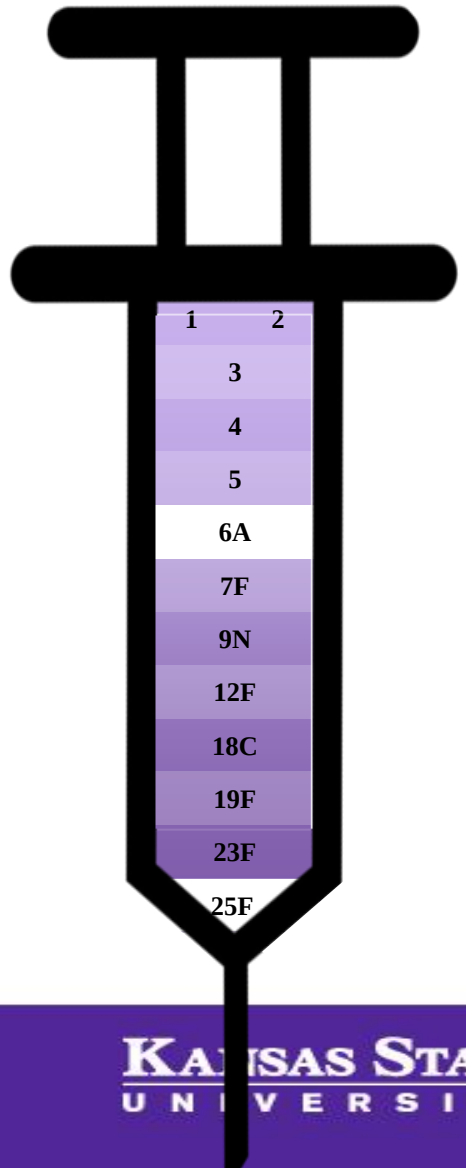
Death Toll of Influenza & *S. pneumoniae* for U.S. (1900-2016)



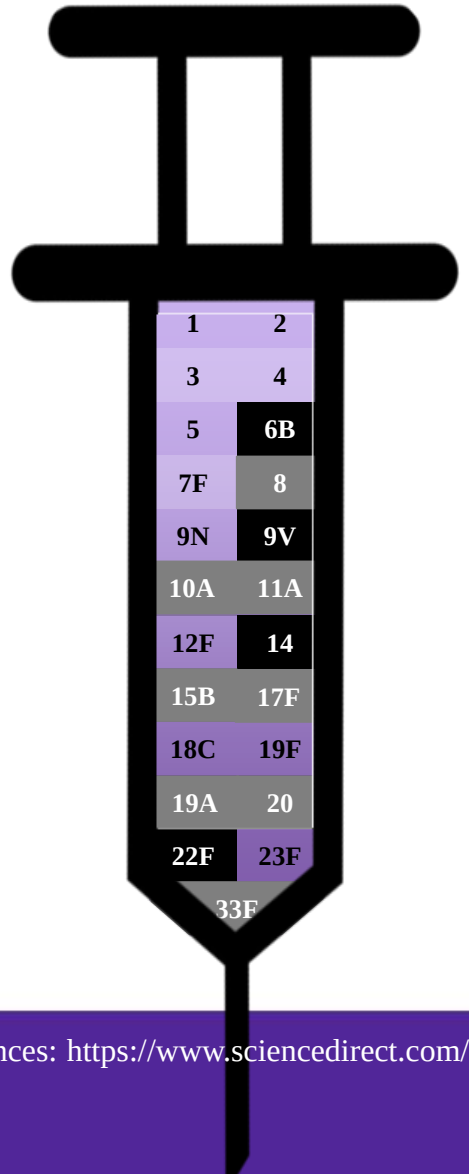
References: https://www.cdc.gov/nchs/data/dvs/lead1900_98.pdf
https://www.cdc.gov/nchs/data-visualization/mortality-leading-causes/

Vaccines

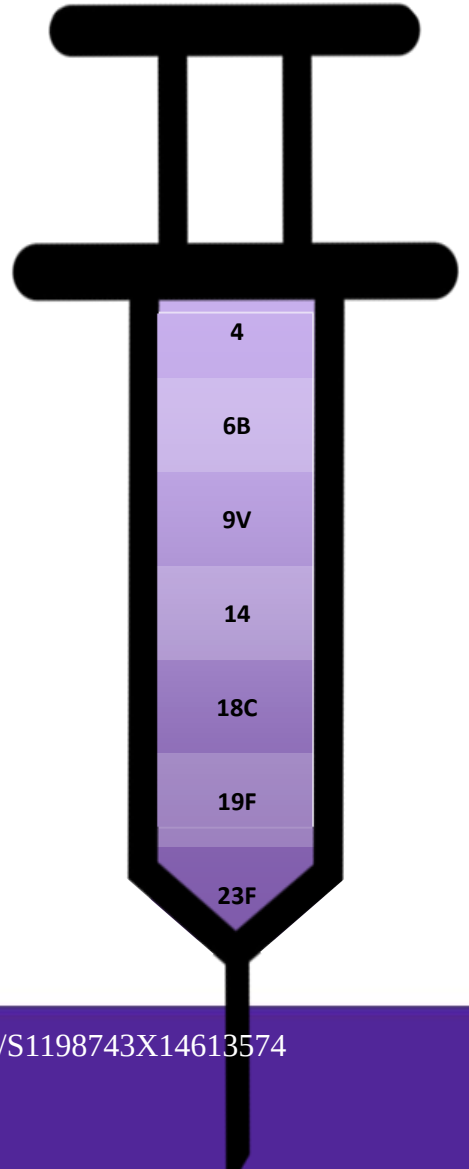
PPSV-14
1977 - 1983



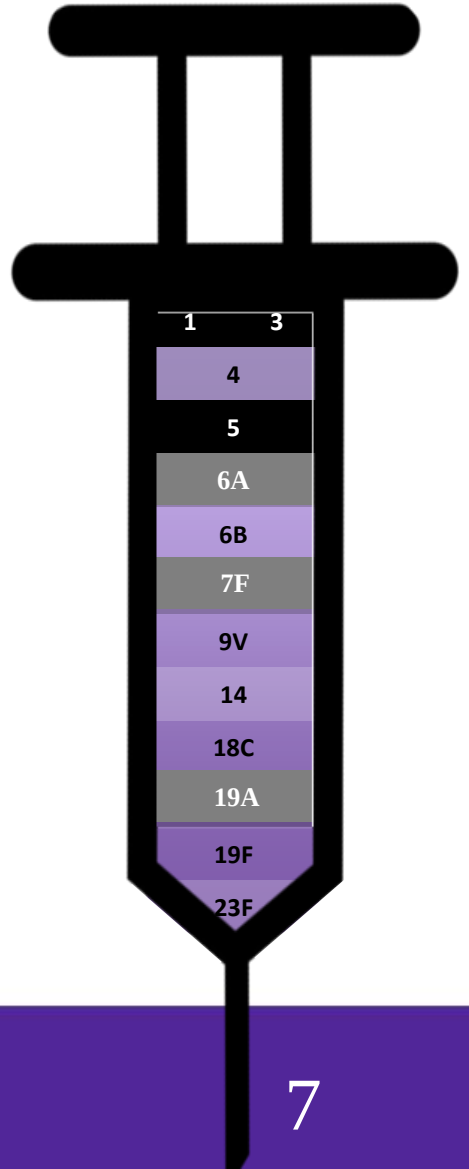
PPSV-23
1983 - Present



PCV-7
2000 - 2010

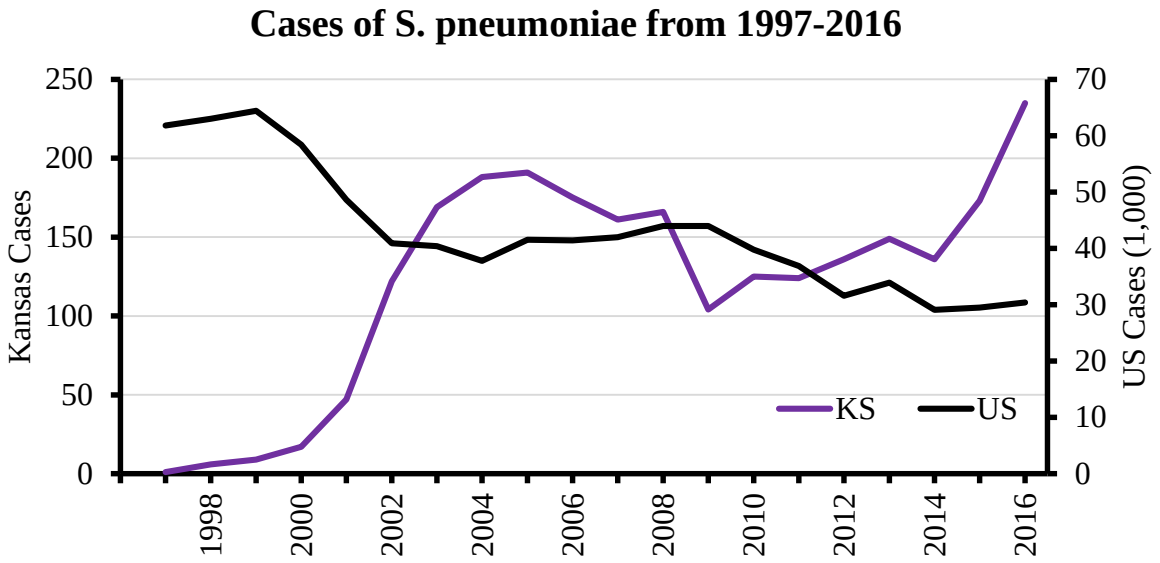


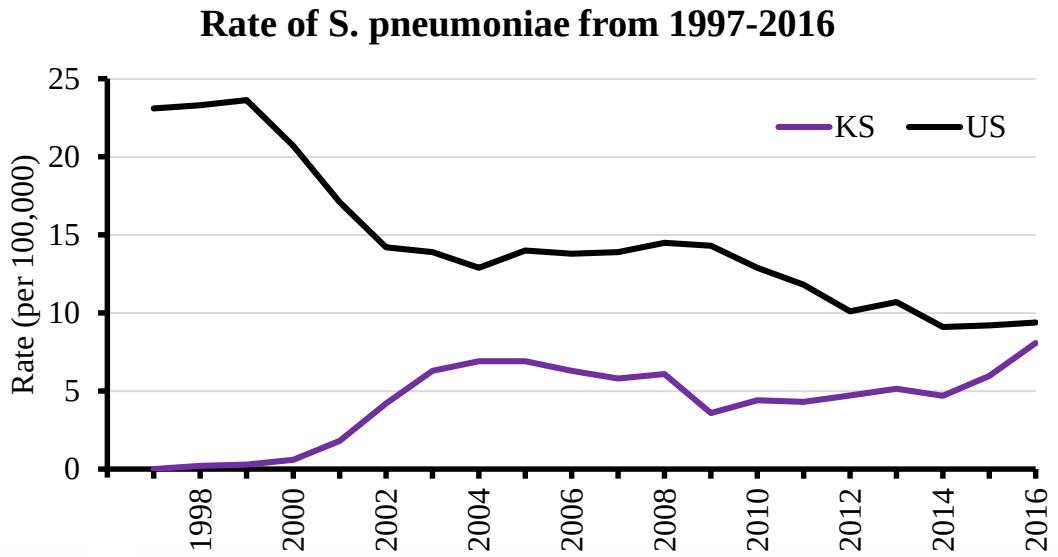
PCV-13
2010 - Present



References: https://www.sciencedirect.com/science/article/pii/S1198743X14613574

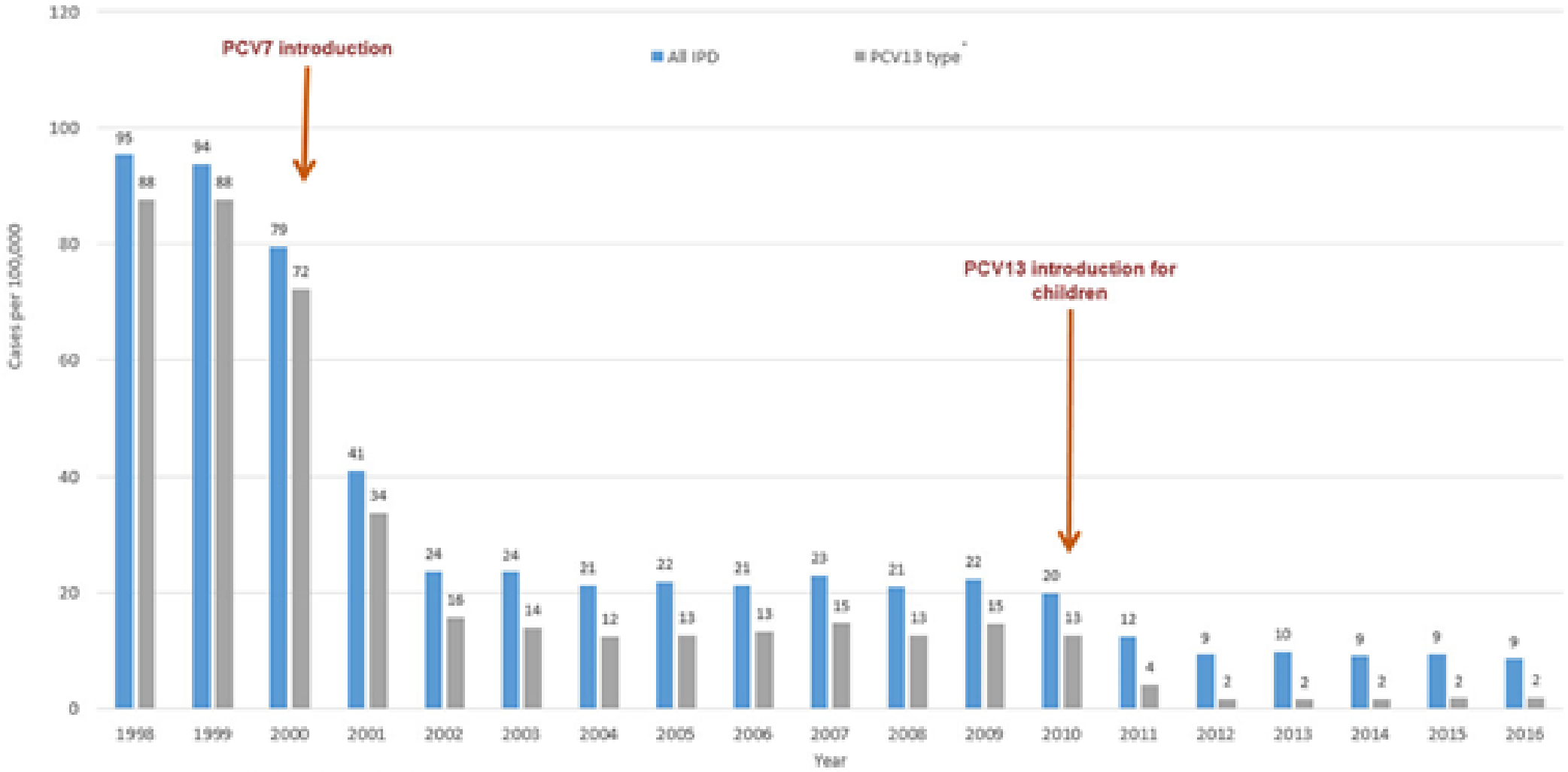
Comparison between Kansas & National Trends of Invasive Pneumococcal Disease, 1998-2016





References: http://www.kdheks.gov/epi/annual_summary.htm
https://www.cdc.gov/abcs/methodology/surv-pop.html

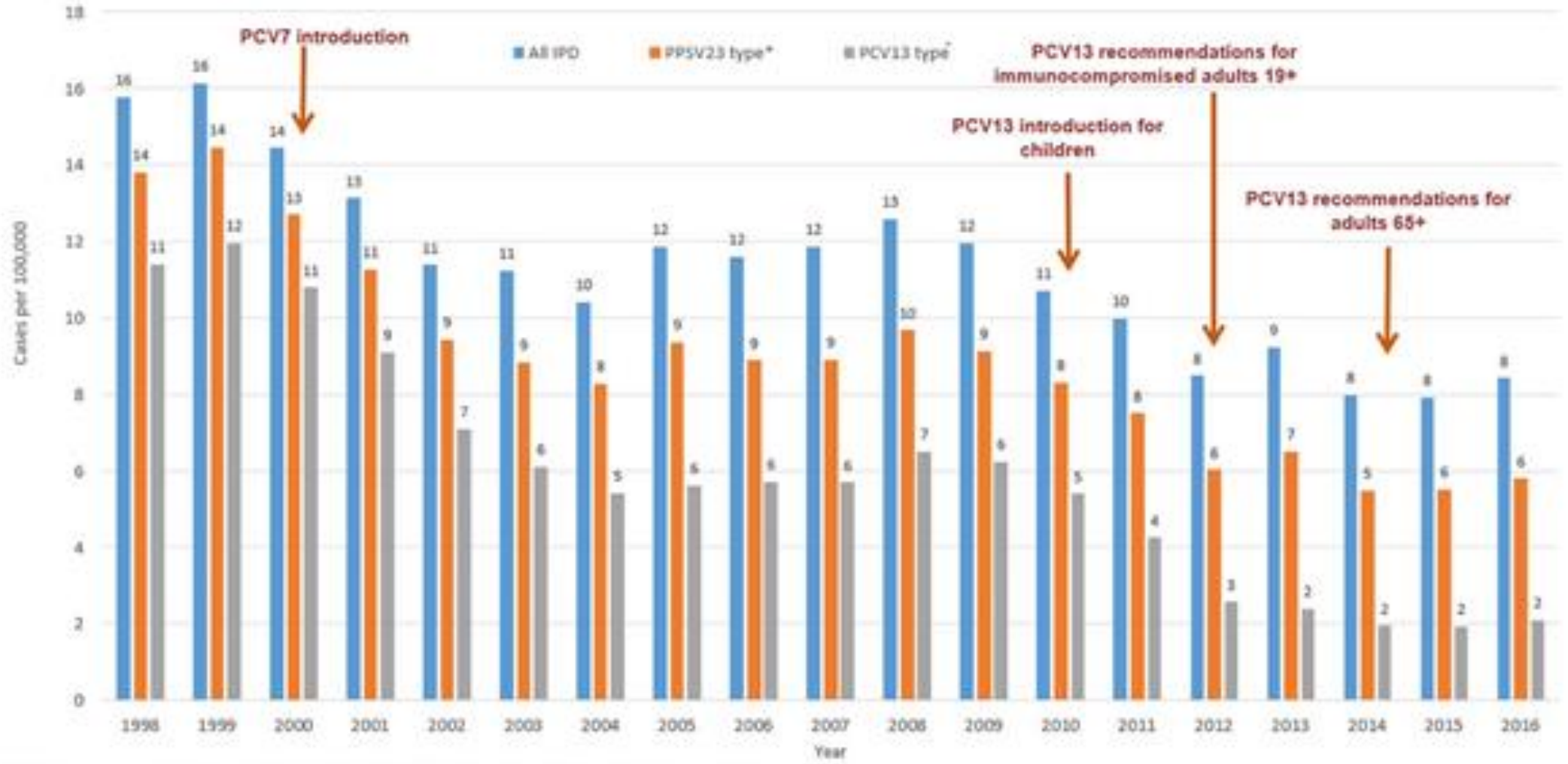
Trends in Invasive Pneumococcal Diseases Among Children Aged <5 Years Old (1998-2016)



*PCV13 serotype: 1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F, and 23F

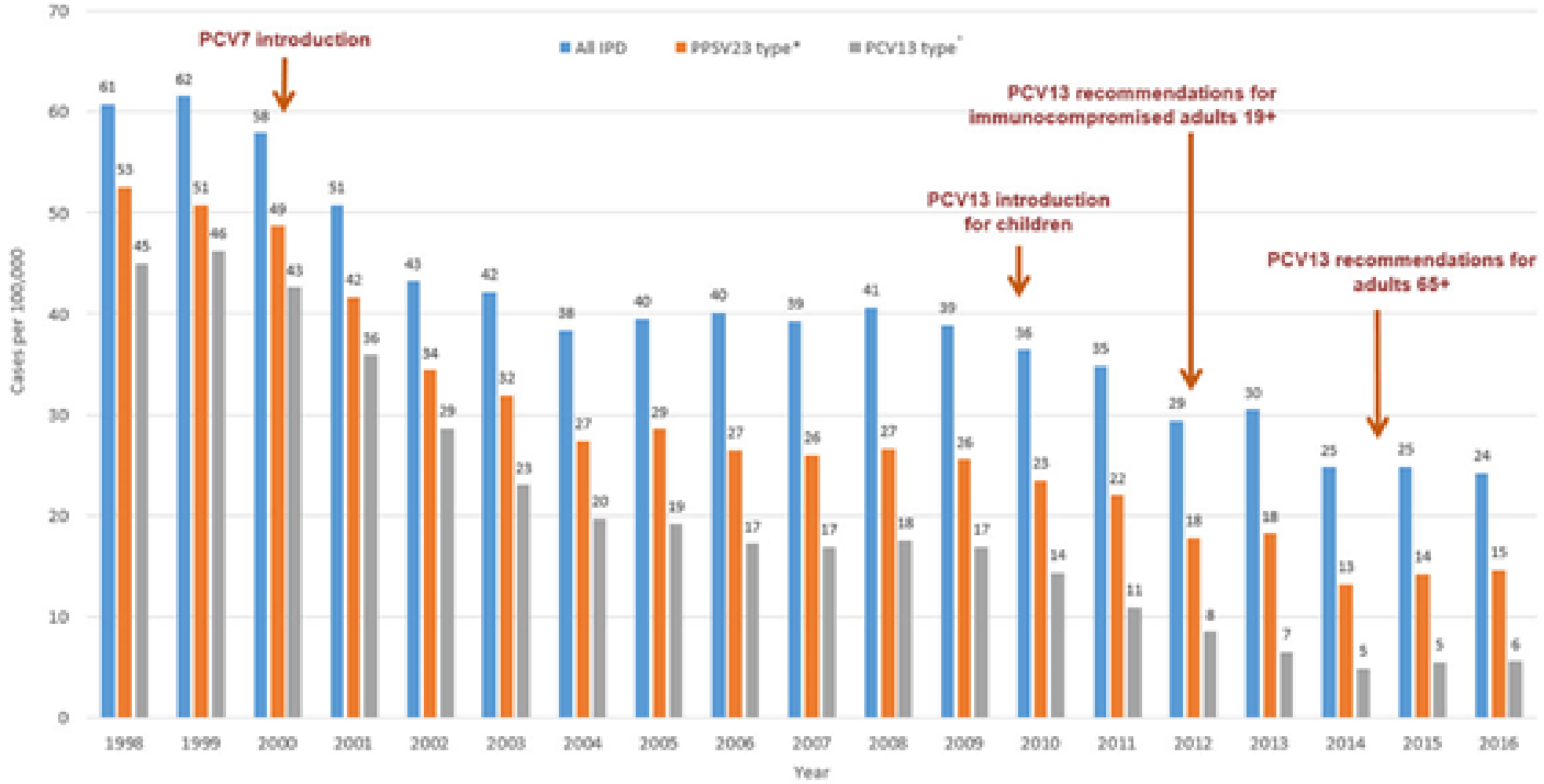
References: https://www.cdc.gov/pneumococcal/surveillance.html

Trends in Invasive Pneumococcal Disease Among Adults Aged 19-64 Years Old, 1998-2016



References: https://www.cdc.gov/pneumococcal/surveillance.html

Trends in Invasive Pneumococcal Disease Among Adults Aged ≥65 Years Old, 1998-2016



*PPSV23 serotypes: 1, 2, 3, 4, 5, 6B, 7F, 8, 9N, 9V, 10A, 11A, 12F, 14, 15B, 17F, 18C, 19A, 19F, 20, 22F, 23F, and 33F
†PCV13 serotype: 1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F, and 23F

References: https://www.cdc.gov/pneumococcal/surveillance.html

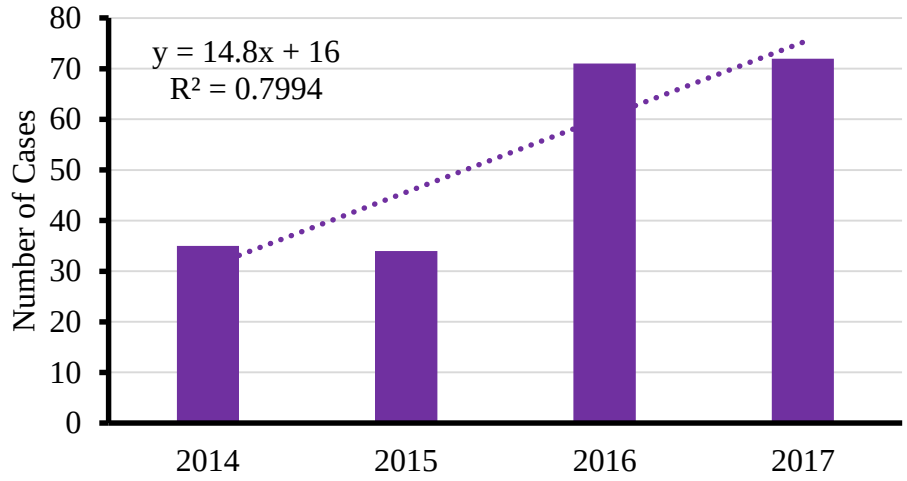
Who’s being affected?

Project Goals

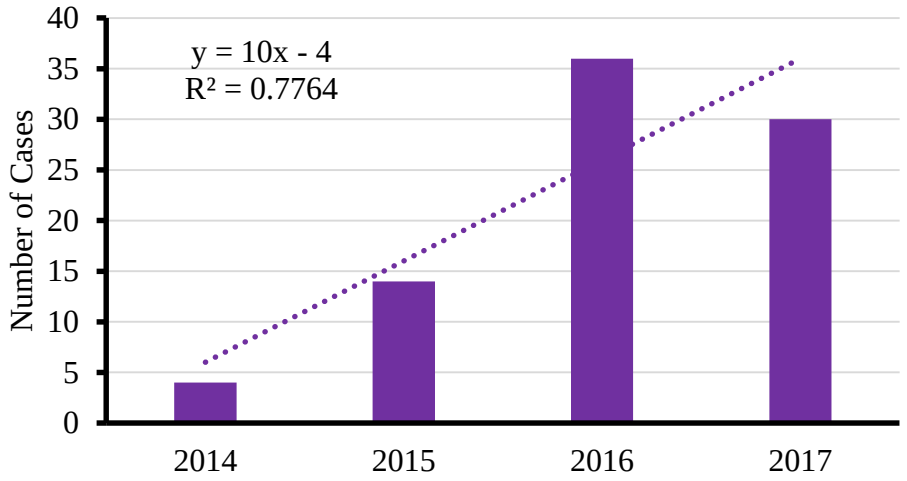
1. Trend Analysis
2. Case Demographics
3. Comparing Counties' Mortality
4. Determine Vaccine Efficacy
5. Comparing Counties' Morbidity

Prevalence of Invasive Pneumococcal Disease in Kansas (2014-2017)

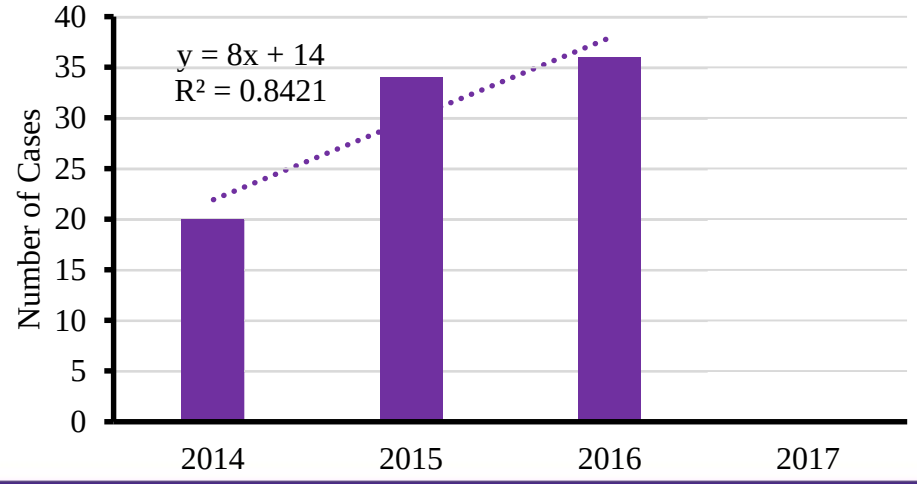
Sedgwick County *S. pneumoniae* Cases



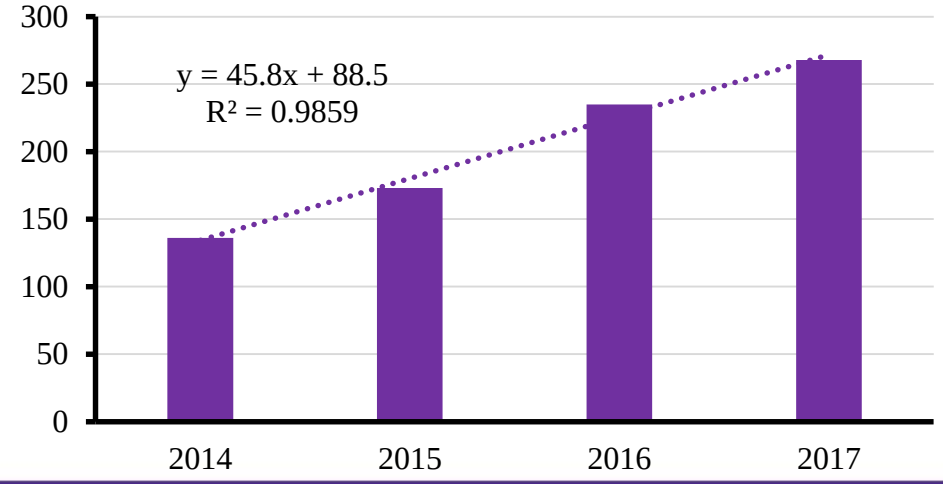
Shawnee County *S. pneumoniae* Cases



Johnson County *S. pneumoniae* Cases

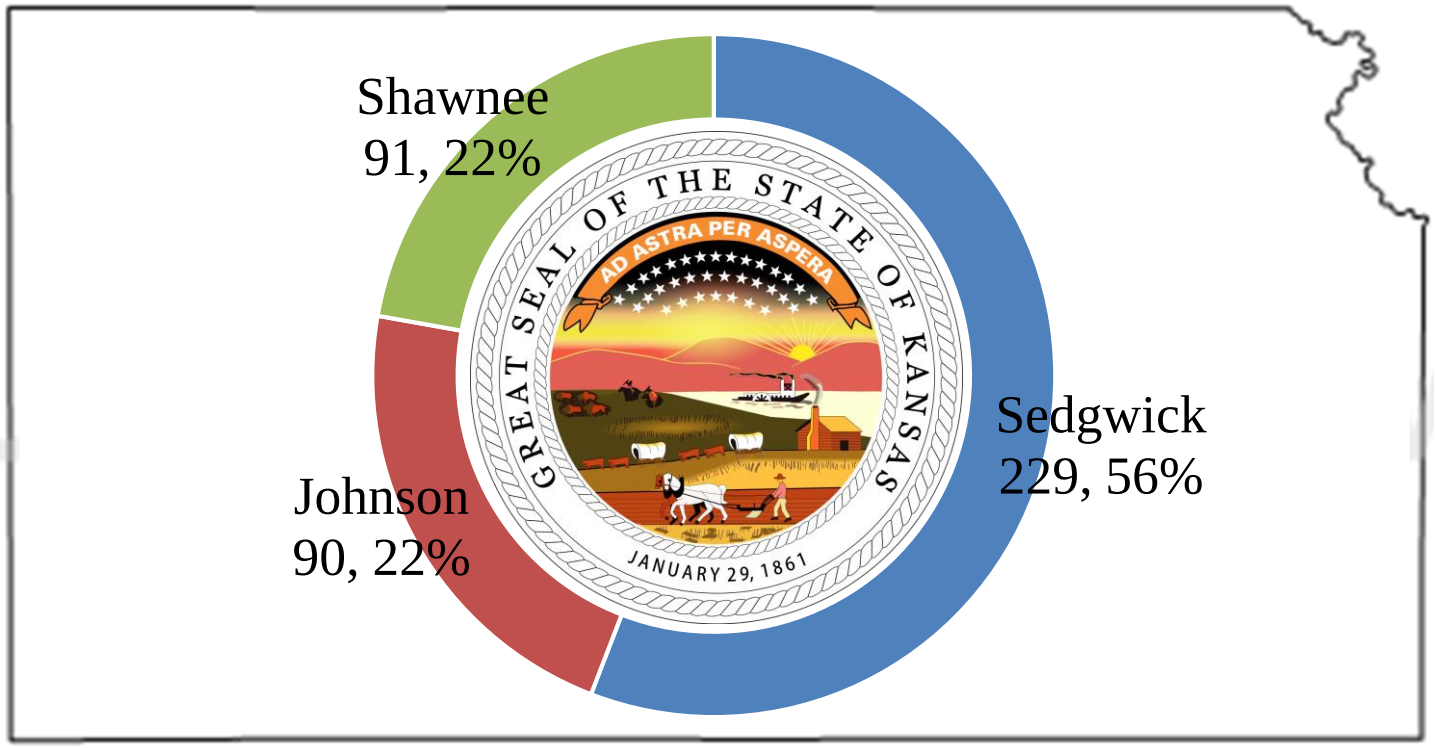


Kansas *S. pneumoniae* Cases

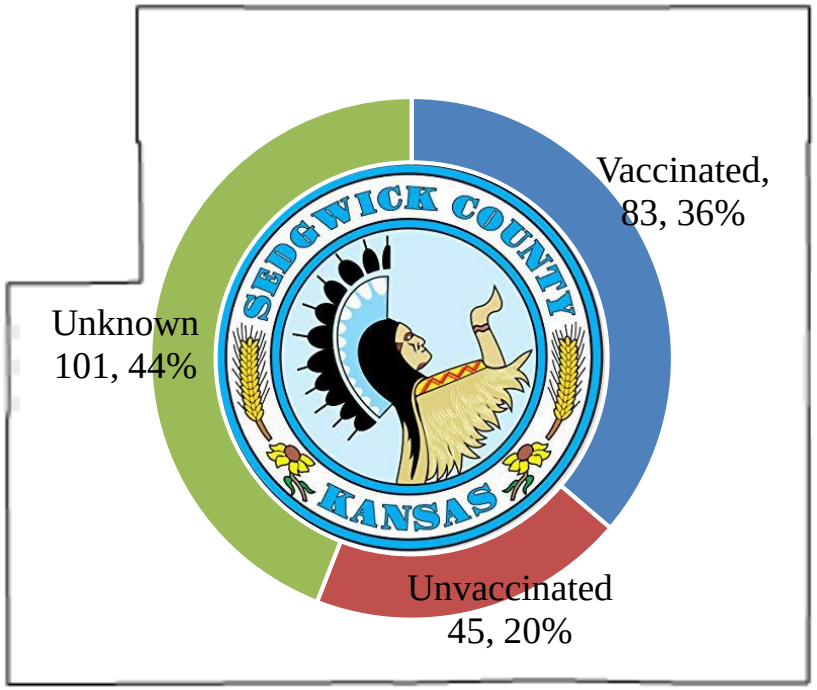


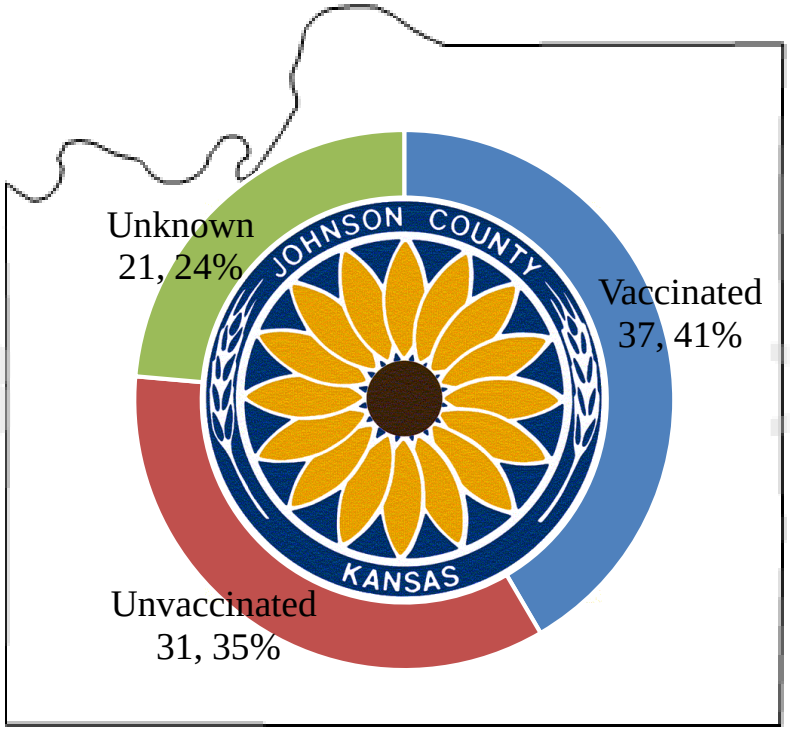
References: http://www.kdheks.gov/epi/case_reports_by_county.htm

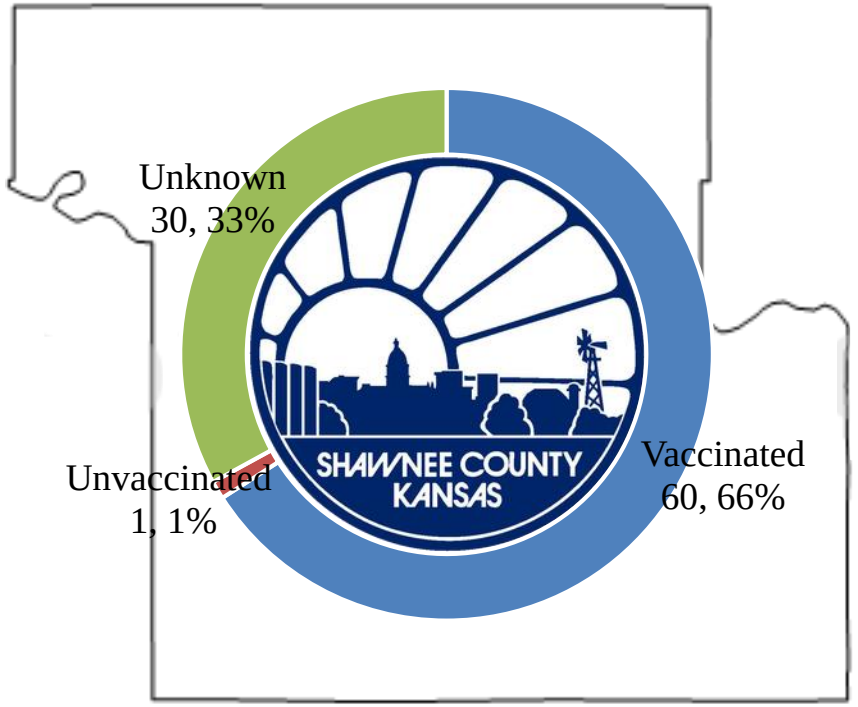
Frequency of *S. pneumoniae*: Counties



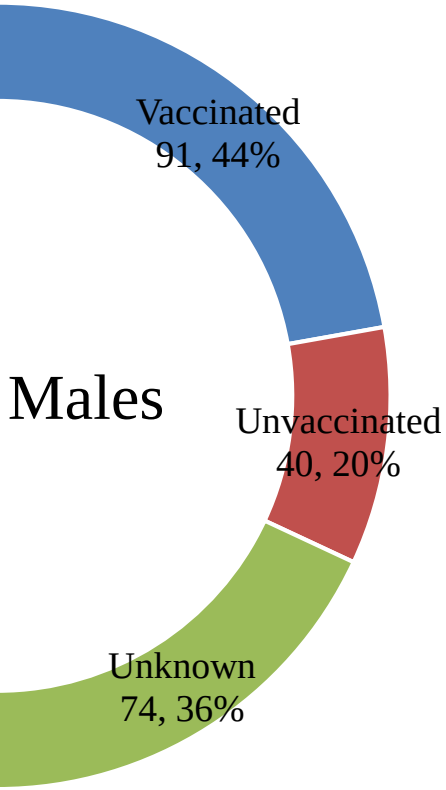
Frequency of *S. pneumoniae*: Counties

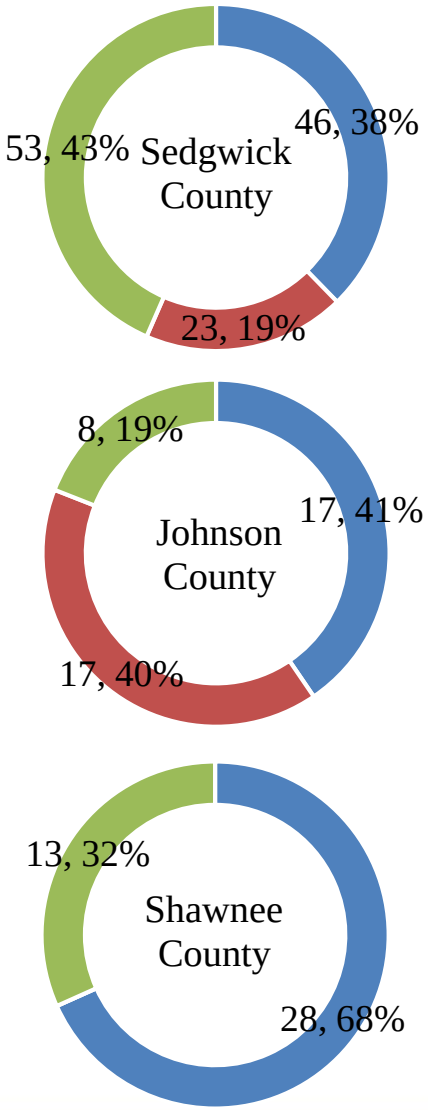


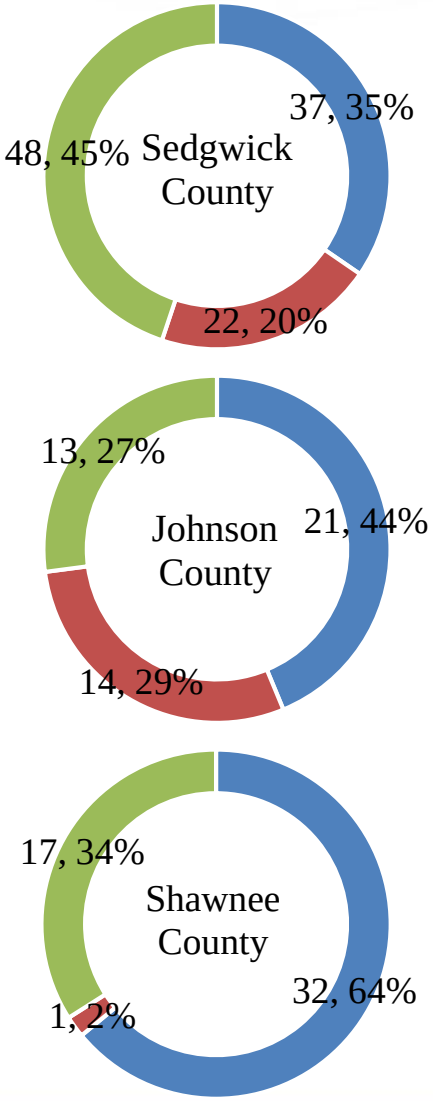


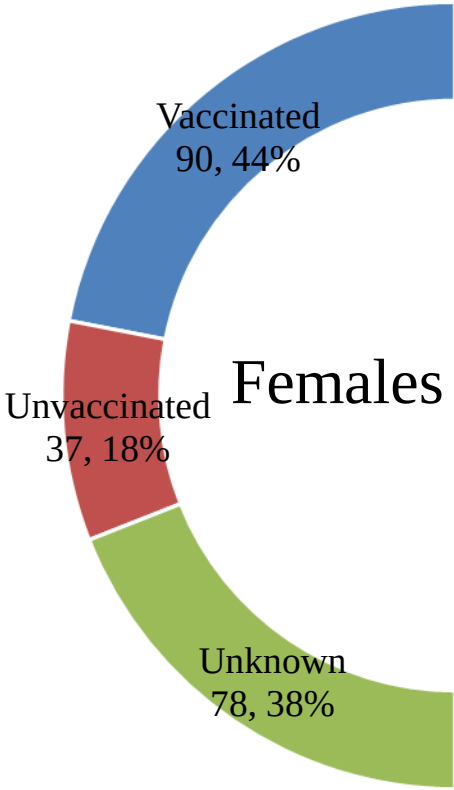


Frequency of *S. pneumoniae*: Gender



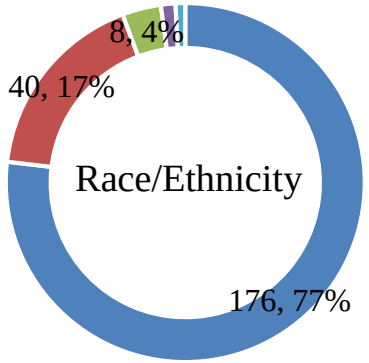


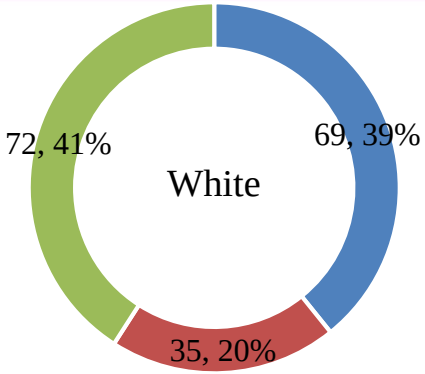


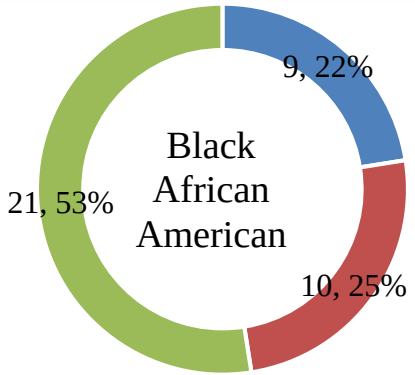


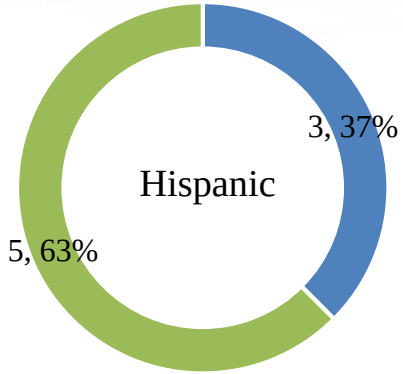
Frequency of *S. pneumoniae*: Race/Ethnicity

Sedgwick County

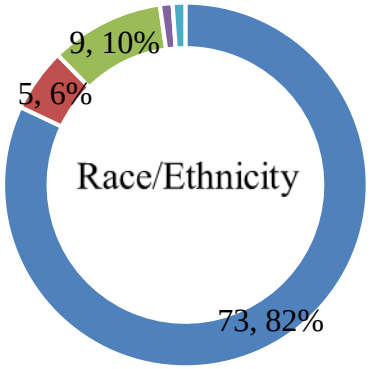


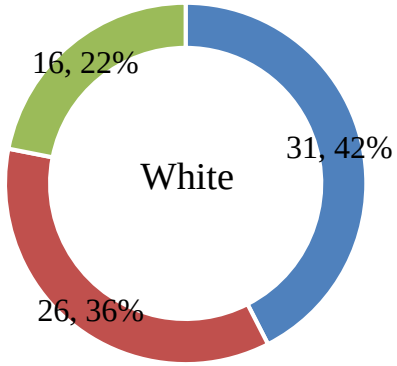


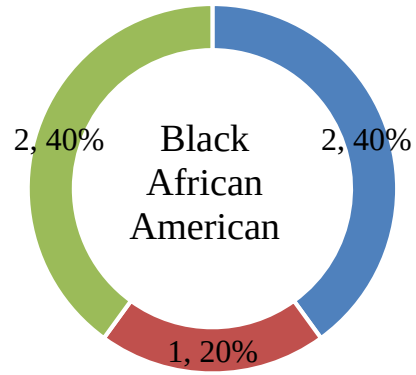


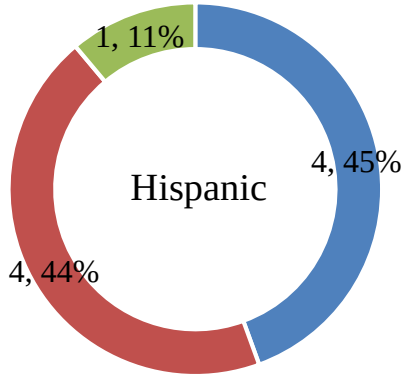


Johnson County

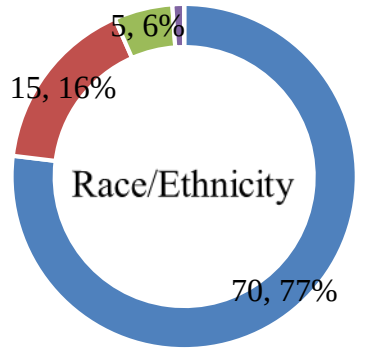


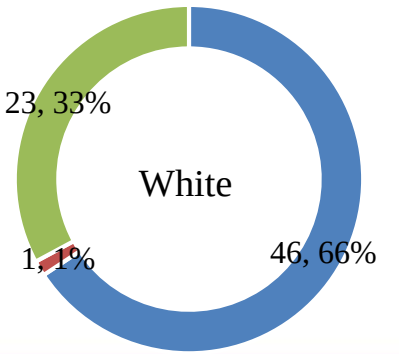


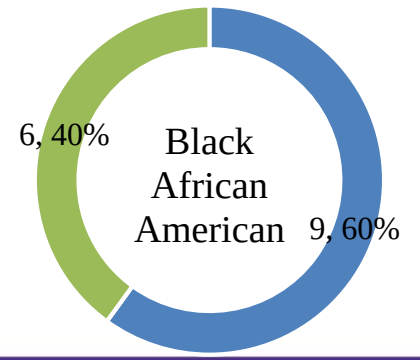


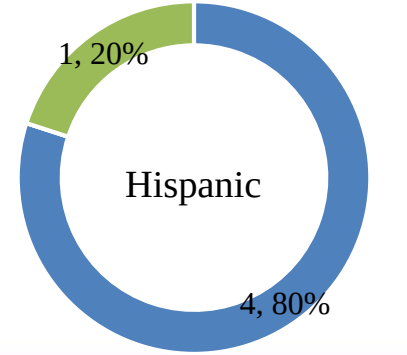


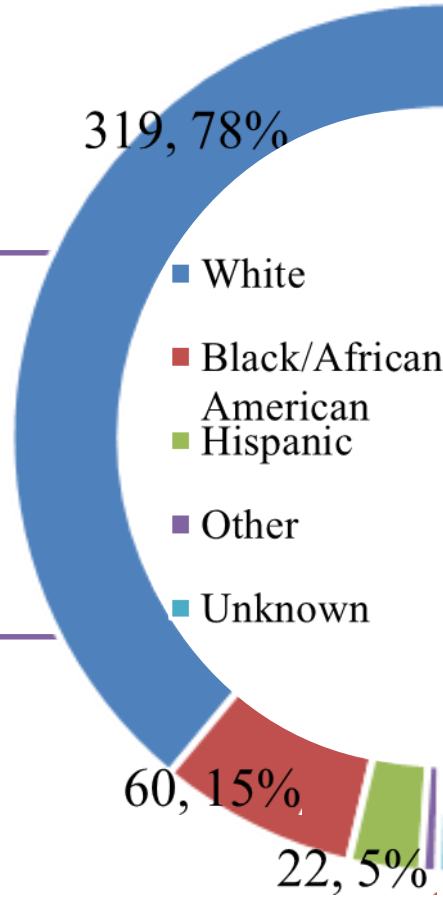
Shawnee County





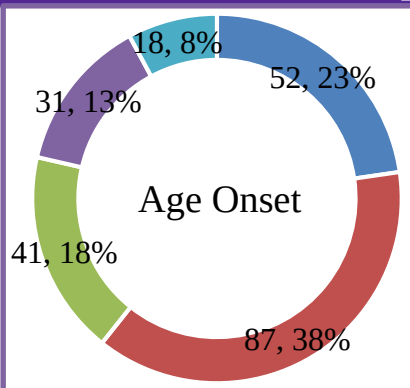




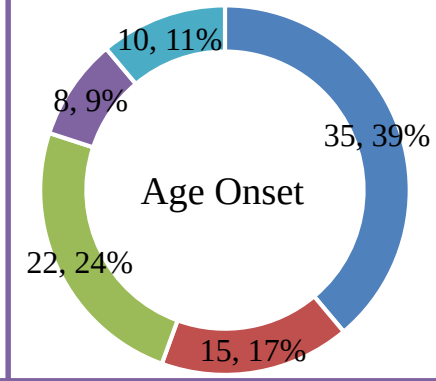


Frequency of *S. pneumoniae*: Age Onset

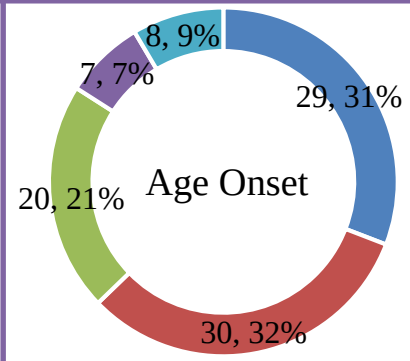
Sedgwick County

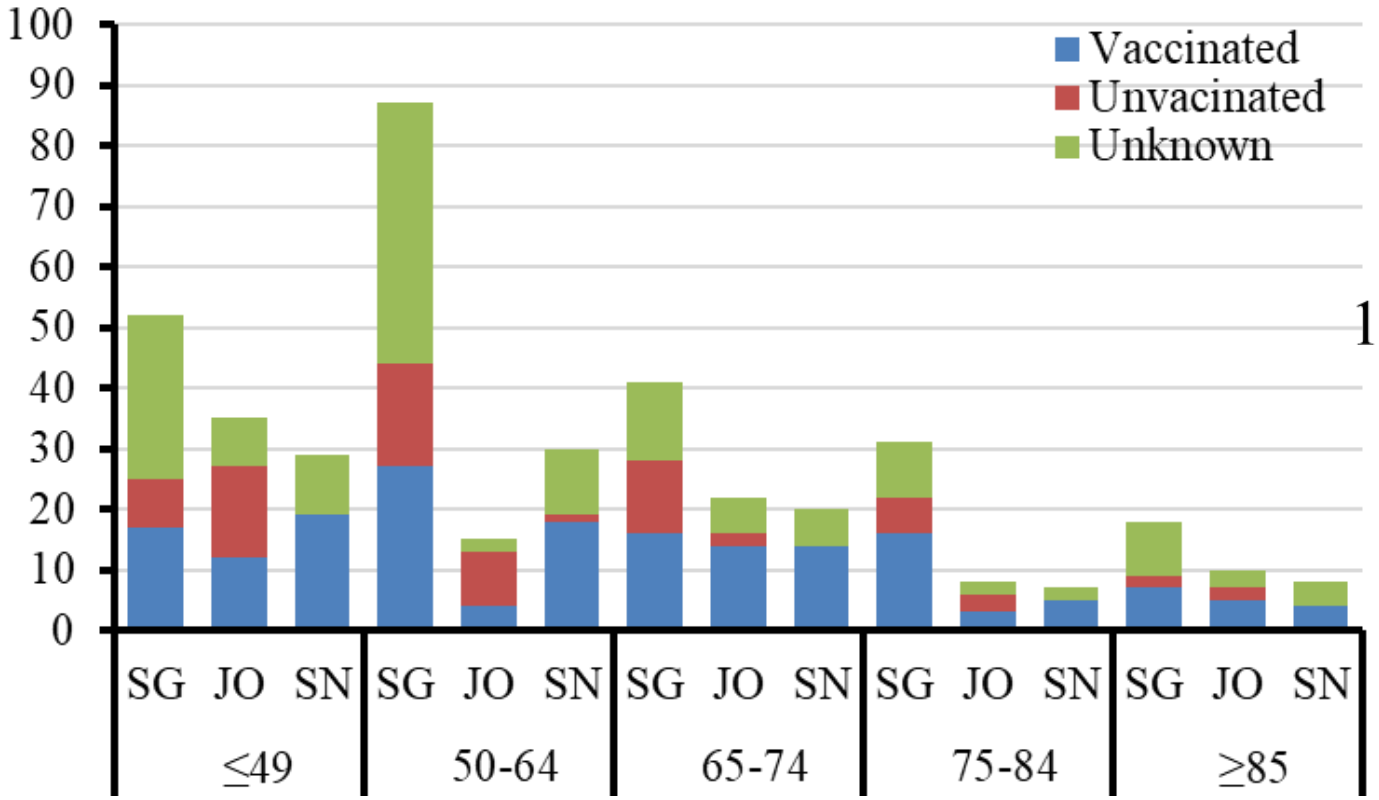


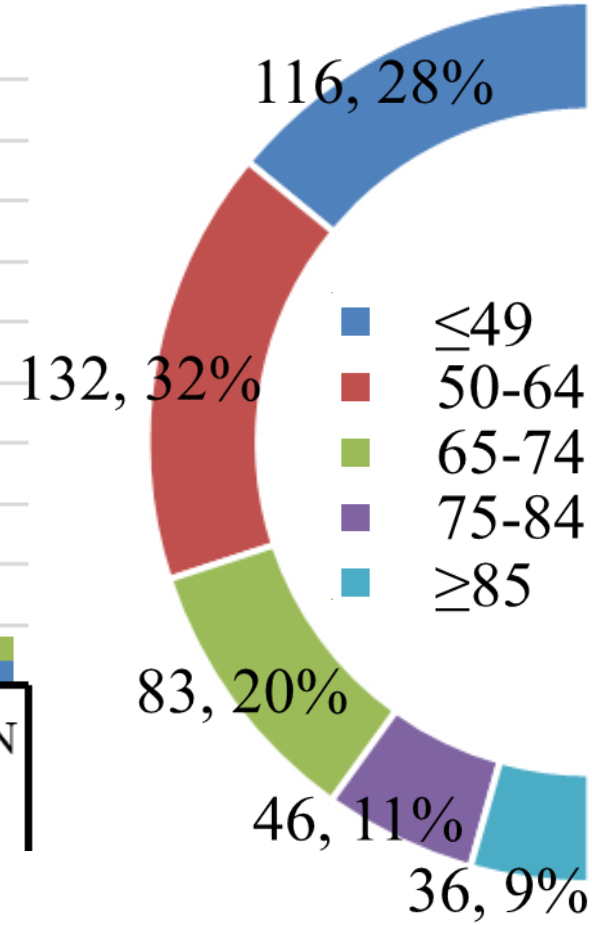
Johnson County



Shawnee County

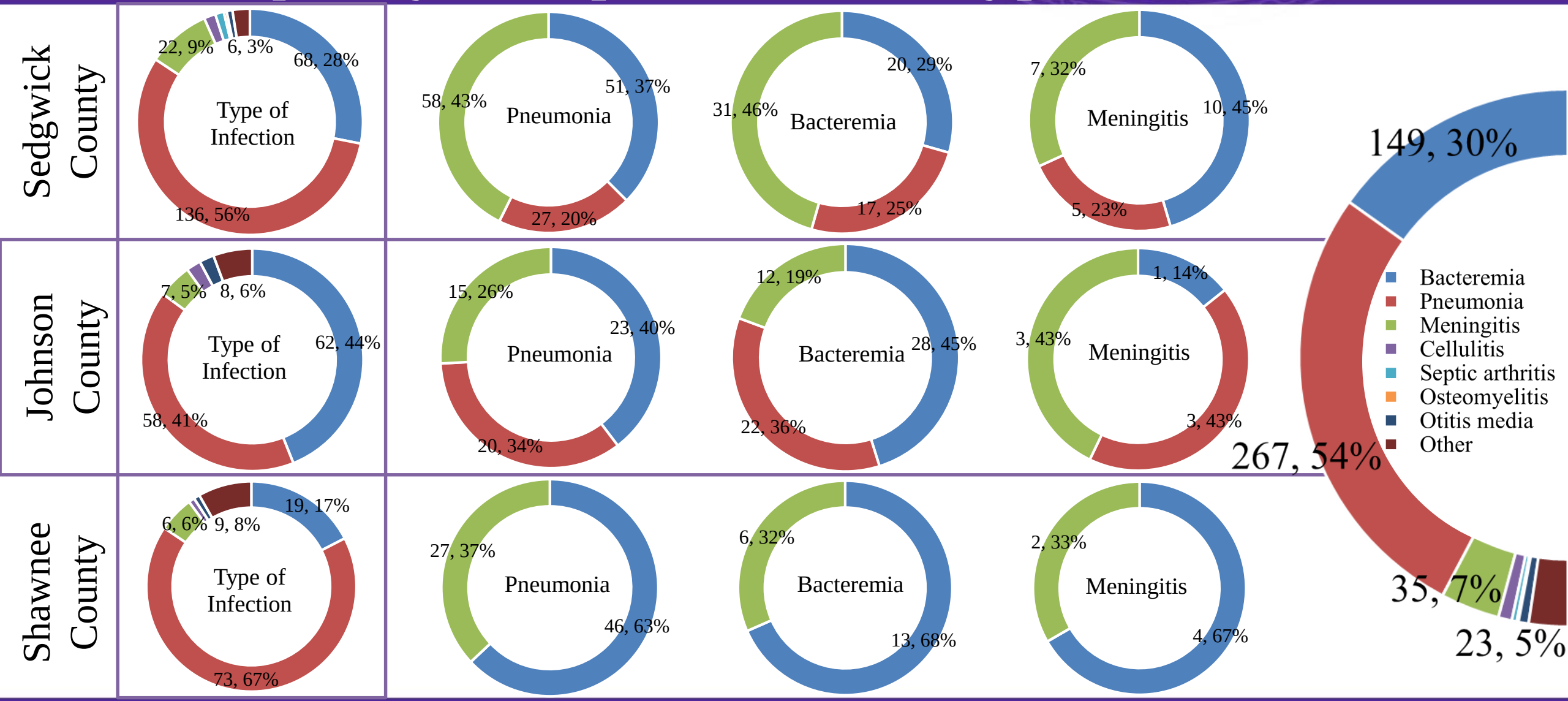






Frequency of *S. pneumoniae*: Underlying Medical Condition

Frequency of *S. pneumoniae*: Type of Infection



Rate of *S. pneumoniae* by County: Gender and Race/Ethnicity

Characteristic or Variable	2014			2015			2016			2017		
	SG	JO	SN	SG	JO	SN	SG	JO	SN	SG	JO	SN
Gender												
Males	0.8762	0.2852	0.2326	0.7118	0.5995	0.9259	1.2699	0.5953	1.5143	1.9768	-	2.0956
Females	0.5478	0.411	0.2186	0.5849	0.642	0.7661	1.5133	0.6397	2.4084	1.5088	-	2.0802
Race/Ethnicity												
White	0.6696	0.4029	0.1471	0.7541	0.5682	0.8857	1.4787	0.5953	2.0015	2.0128	-	2.1608
Black/African American	1.5547	0	0.5921	0.7671	0.642	0.5907	2.7353	0.9649	3.5962	2.7301	-	4.2094
Hispanic	0.2803	0.2331	0	0	0.92	0.9316	0.5399	0.9089	0.9261	0.2643	-	0.449
Other	0.3454	0	2.029	0.3354	0	0	0	0.3058	0	0.3325	-	0
Asian	0	0	0	0.4111	0	0	0	0.3293	0	0.404	-	0
American Indian/Alaskan Native	1.8023	0	4.8088	0	0	0	0	0	0	0	0	0
Unknown	-	-	-	-	-	-	-	-	-	-	-	-

Rate of *S. pneumoniae* by County: Mortality and Age

Characteristic or Variable	2014			2015			2016			2017		
	SG	JO	SN	SG	JO	SN	SG	JO	SN	SG	JO	SN
Mortality												
Died	0.2155	0.0521	0	0.078	0.0172	0.0559	0.1363	0.0171	0.0561	0.2525	-	0.0561
Recovered	0.4899	0.2951	0.2239	0.5653	0.567	0.7825	1.2467	0.58	1.907	1.4566	-	2.0195
Unknown	-	-	-	-	-	-	-	-	-	-	-	-
Age												
≤49	0.2304	0.2054	0.266	0.2013	0.4091	0.4445	0.5195	0.281	1.1679	0.5494	-	0.7211
50-64	1.037	0.2674	0.2706	1.5541	0.4424	1.3599	2.3813	0.6186	3.2866	4.0747	-	3.3444
65-74	2.744	0.9604	0	1.2999	1.5758	2.4334	3.5033	2.3221	4.0779	2.8255	-	5.016
75-84	2.033	0.9977	0	2.0403	2.4504	1.1449	5.5811	0.4766	0	5.9527	-	6.6087
≥85	4.4668	2.7316	0	2.1853	0.8938	0	5.4245	5.2434	6.918	7.3937	-	4.6264

Comparison of General Population to *S. pneumoniae* Population

Characteristic or Variable	Sedgwick		Shawnee		Johnson		Kansas	
	x^2	P-value	x^2	P-value	x^2	P-value	x^2	P-value
Gender								
Males	0.0028	0.9578	0.0025	0.9601	0.0011	0.9735	.0005	0.9822
Females	0.0028	0.9578	0.0023	0.9617	0.0011	0.9735	.0004	0.9840
Race/Ethnicity								
White	0.0069	0.9998	0.0002	>0.9999	<0.0001	>0.9999	<0.0001	>0.9999
Black/African American	0.0551	0.9966	0.0534	0.9968	0.0001	>0.9999	0.0955	0.9924
Hispanic or Latino	0.0812	0.9940	0.0352	0.9982	0.0087	0.9998	0.0931	0.9927
Other	0.0347	0.9983	0.0105	0.9997	0.0350	0.9983	0.0036	>0.9999
Age, years								
≤49	0.3000	0.9898	0.1518	0.9973	0.1206	0.9983	25.9315	<0.0001**
50-64	0.1950	0.9955	0.0014	>0.9999	0.0040	>0.9999	8.9114	0.0634
65-74	0.1357	0.9978	0.1670	0.9967	0.3669	0.9851	17.3754	0.0016**
75-84	0.2415	0.9933	0.0152	>0.9999	0.0814	0.9992	10.6816	0.0304*
≥85	0.2040	0.9951	0.0391	0.9998	0.4368	0.9794	15.3103	0.0041**

*= P-value of less than or equal to .05

** = P-value of less than or equal to .01

Comparison Between each County's *S. pneumoniae* Populations

Characteristic or Variable	SN vs SG		JO vs SG		JO vs SN	
	x^2	P-value	x^2	P-value	x^2	P-value
Vaccination Status						
Vaccinated	24.3238	<0.0001**	0.9868	0.6105	13.3151	0.0013**
Conjugate	0.0720	0.9646	0.2234	0.8943	0.0213	0.9894
Polysaccharide	0.0116	0.9942	0.0021	0.9990	0.0188	0.9906
Both	0.2855	0.8670	0.0263	0.9869	0.1854	0.9115
Unvaccinated	17.5116	0.0002**	11.1320	0.0038**	32.2751	<0.0001**
Unknown	2.8090	0.2455	9.7822	0.0075**	3.9833	0.1365
Gender						
Males	1.2713	0.2595	0.8200	0.3652	0.0583	0.8092
Females	1.4498	0.2286	0.9352	0.3335	0.0478	0.8269
Race/Ethnicity						
White	<0.0001	>0.9999	0.2350	0.9718	0.2282	0.9729
Black/African American	0.0561	0.9965	8.1195	0.0436*	7.2358	0.0648
Hispanic or Latino	1.1461	0.7660	12.1433	0.0069**	3.7049	0.2951
Other	0.0337	0.9984	0.0305	0.9986	0.0001	>0.9999
Age, years						
≤49	3.6947	0.4489	11.5276	0.0212*	1.5463	0.8184
50-64	0.6633	0.9558	11.9648	0.0176*	8.0585	0.0895
65-74	0.9300	0.9201	2.3895	0.6645	0.2753	0.9914
75-84	2.5275	0.6397	1.5969	0.8093	0.1873	0.9959
≥85	0.7146	0.9495	1.3438	0.8539	5.7531	0.2184
Mortality						
Died	0.0940	0.9541	0.0619	0.9695	0.0155	0.9923
Recovered	0.0183	0.9909	0.0097	0.9952	0.0012	0.9994
Unknown	0.0044	0.9978	0.0104	0.9948	-	-

*= P-value of less than or equal to .05
** = P-value of less than or equal to .01

Comparison of 2015 *S. pneumoniae* Population to 2016 *S. pneumoniae* Population

Characteristic or Variable	Sedgwick		Shawnee		Johnson	
	x^2	P-value	x^2	P-value	x^2	P-value
Vaccination Status						
Vaccinated	4.7160	0.0946	12.7027	0.0017**	0.5870	0.7456
Conjugate	2.8032	0.2462	0.8736	0.6461	0.0000	>0.9999
Polysaccharide	0.1772	0.9152	3.0475	0.2179	0.0000	>0.9999
Both	2.8032	0.2462	9.9901	0.0068**	2.4975	0.2869
Unvaccinated	1.7525	0.4163	0.0000	>0.9999	7.7800	0.0204*
Unknown	2.5144	0.2844	0.0000	>0.9999	3.0344	0.2193
Gender						
Males	2.6723	0.2193	2.1169	0.1457	0.0000	>0.9999
Females	6.4492	0.0111*	11.2457	0.0008**	0.2335	0.6289
Race/Ethnicity						
White	5.5671	0.2339	9.1537	0.0574	0.0396	0.9998
Black/African American	3.1112	0.53954	4.5736	0.3339	0.3700	0.9849
Hispanic	1.7500	0.7816	0.0000	>0.9999	0.0000	>0.9999
Other	-	-	0.0000	>0.9999	1.1100	0.8927
Unknown	1.000	0.9098	0.0000	>0.9999	0.0000	>0.9999
Age, years						
≤49	2.9313	0.5694	5.4192	0.2469	2.5298	0.6393
50-64	1.2132	0.8759	4.4951	0.3431	0.6335	0.9593
65-74	2.5278	0.6397	1.4076	0.8429	1.6132	0.8064
75-84	1.9380	0.7472	-	-	17.8401	0.0013**
≥85	0.7872	0.9402	3.3000	0.5089	4.6347	0.3269
Mortality						
Died	0.5608	0.7555	0.0000	>0.9999	0.0000	>0.9999
Recovered	8.3644	0.0153*	12.9315	0.0016**	0.0326	0.9838
Unknown	0.0000	>0.9999	0.0000	>0.9999	1.1100	0.5741

*= P-value of less than or equal to .05

** = P-value of less than or equal to .01

Statistical Models

- Model 1

$$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{\text{County}} + \beta X_{\text{Race/Ethnicity}} + \beta X_{\text{Age Onset}} + \beta X_{\text{Vax Status}} + \beta X_{\text{Medical Cond.}}$$

- Model 2.1

$$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{\text{County}} + \beta X_{\text{Vax Status}} + \beta X_{\text{Days Hosp.}} + \beta X_{\text{Infection Type}} + \beta X_{\text{Medical Cond.}}$$

- Model 2.2

$$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{\text{Age Onset}} + \beta X_{\text{Vax Type}} + \beta X_{\text{Days Hosp.}} + \beta X_{\text{Infection Type}} + \beta X_{\text{Medical Cond.}}$$

- Model 3

$$\text{Counts}(\text{Cases of } S.\,pneumoniae) = \beta_0 + \beta_{\text{County}} X + \beta_{\text{Age Onset}} X + \beta_{\text{Race/Ethnicity}} X$$

Results: Statistical Model 1

Characteristic or Variable	Odds Ratio	Lower CI	Upper CI
		2.5 %	97.5 %
Counties (Reference Sedgwick County)			
Johnson County	0.2636*	0.0707	0.7461
Shawnee County	0.1953*	0.0304	0.7062
Race/Ethnicity	0.9072	0.4755	1.5045
Age, years	1.0007	0.9827	1.0209
Vaccination Status	1.3739	0.7958	2.4270
Underline Medical Condition	1.0951	0.8948	1.2661

*= Odds Ratio Significant

$$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{\text{County}} + \beta X_{\text{Race/Ethnicity}} + \beta X_{\text{Age Onset}} + \beta X_{\text{Vax Status}} + \beta X_{\text{Medical Cond.}}$$

Results: Statistical Model 2.1

Characteristic or Variable	Odds Ratio	Lower CI	Upper CI
		2.5 %	97.5 %
Counties (Reference Sedgwick County)			
Johnson County	0.2623*	0.0618	0.9015
Shawnee County	0.1637*	0.0247	0.6170
Vaccination Status	1.4234	0.8100	2.5658
Number of Days Hospitalized	0.9931	0.9809	1.0047
Type of Infection	1.7832*	1.2258	2.6123
Underline Medical Condition	1.0837	0.8769	1.2458

*= Odds Ratio Significant

$$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{\text{County}} + \beta X_{\text{Vax Status}} + \beta X_{\text{Days Hosp.}} + \beta X_{\text{Infection Type}} + \beta X_{\text{Medical Cond.}}$$

Results: Statistical Model 2.1 (Continued)

Characteristic or Variable	Odds Ratio	Lower CI	Upper CI
		2.5 %	97.5 %
Counties (Reference Sedgwick County)			
Johnson County	0.1879*	0.0381	0.7430
Shawnee County	0.0717*	0.0061	0.3821
Vaccination Status	1.5803	0.8863	2.9120
Number of Days Hospitalized	0.9929	0.9802	1.0045
Type of Infection (Reference Pneumonia)			
Bacteremia	1.0764	0.2745	3.5656
Co-Infection	3.4828*	1.0558	11.5444
Other	2.9327	0.6879	11.0497
Unknown	74.2268*	6.1515	973.5088
Underline Medical Condition	1.0777	0.8354	1.2371

*= Odds Ratio Significant

$$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{\text{County}} + \beta X_{\text{Vax Status}} + \beta X_{\text{Days Hosp.}} + \beta X_{\text{Infection Type}} + \beta X_{\text{Medical Cond.}}$$

Results: Statistical Model 2.2

Characteristic or Variable	Odds Ratio	Lower CI	Upper CI
		2.5 %	97.5 %
Vaccination Type	1.2328	0.9453	1.6313
Days Hospitalized	0.9884*	0.9779	0.9980
Age, years	1.0037	0.9861	1.0230
Type of Infection	1.6168	1.1270	2.3228
Underling Medical Conditions	1.0836	0.8902	1.2526
Race/Ethnicity	0.8738	0.4380	1.4881

*= Odds Ratio Significant

$$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Age\ Onset} + \beta X_{Vax\ Type} + \beta X_{Days\ Hosp.} + \beta X_{Infection\ Type} + \beta X_{Medical\ \ Cond.}$$

Results: Statistical Model 3

Characteristic or Variable	IRR	Lower CI	Upper CI
		2.5 %	97.5 %
Counties			
Sedgwick County	1	0.7649	1.3151
Johnson County	-	-	-
Shawnee County	1	0.7072	1.4018
Race/Ethnicity	1	0.8488	1.1614
Age, years	1	0.9949	1.0053

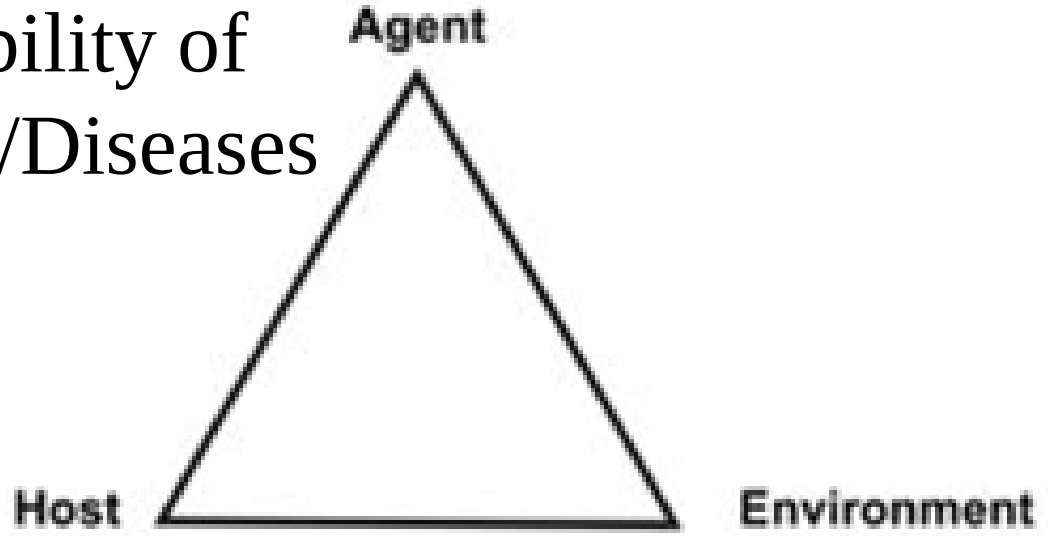
*= Odds Ratio Significant

$$\text{Counts}(\text{Cases of } S.\,pneumoniae) = \beta_0 + \beta_{\text{County}}X + \beta_{\text{Age Onset}}X + \beta_{\text{Race/Ethnicity}}X$$

What's the Solution?

Possible Hypothesis

- Serotype Shift
- Decrease Vaccination Rates
- Increased Survivability of Medical Disorders/Diseases



References: https://www.cdc.gov/OPHSS/CSELS/DSEPD/SS1978/Lesson1/Section8.html#ALT116

Summary

- What's the problem?
  - Disease
  - Disease Burden on Public Health
  - Vaccines and Serotype Shift
- Why should I care/Who's being affected?
  - Frequency
  - Rates & Chi-square
  - Statistical Models
- What's the Solution?

Acknowledgements

- Sedgwick County Division of Health
  - Kaylee Hervey
  - Chris Steward
  - Jill Nieto
  - Megan Sparks
  - Pamaline King-Burns
- Johnson and Shawnee County Epidemiology Departments
- Kansas State's Master of Public Health Department
- Committee Members
  - Dr. Robert Larson
  - Dr. Mike Sanderson
  - Dr. Santosh Aryal
- Friends and Family
  - Diane Solberg
  - Jenifer & Rick Stone
  - Grant Ferrel
  - Mark Ferrel
  - Steven (Kent) Myer
  - Nathanial Vice

Questions

"All that would be required to prevent the disease (cholera) would be such a close attention to cleanliness in cooking and eating, and to drainage and water supply, as is desirable at all times."

— Dr. John Snow

References: https://todayinsci.com/S/Snow_John/SnowJohn-Quotations.htm

MPH Competencies

Core Competencies of Public Health			
Areas of Competency		**Course Requirement**	**Term**
1.	Biostatistics	MPH 701 – Fundamental Methods of Biostatistics	Spring 2017
2.	Environmental Health Sciences	MPH 802 – Environmental Health	Fall 2018
3.	Epidemiology	MPH 754 – Introduction to Epidemiology	Fall 2017
4.	Health Services Administration	MPH 720 – Administration of Health Care Organizations	Spring 2017
5.	Social and Behavioral Sciences	MPH 818 – Social and Behavioral Bases of Public Health	Spring 2018

Core Competencies of Infectious Diseases and Zoonoses			
Areas of Competency		**Course Requirement**	**Term**
1.	Pathogens/pathogenic mechanisms	BIOL 530 Pathogenic Microbiology BIOL 675 Genetics of Microorganisms	Fall 2018 Fall 2018
2.	Host Response to Pathogens/Immunology	BIOL 671 – Immunology Lab DMP 880 – Problems in Pathobiology	Spring 2018 Fall 2018
3.	Environmental/Ecological Influences	DMP 770 – Emerging Diseases	Summer 2017
4.	Disease Surveillance/Quantitative Methods	DMP 854 – Intermediate Epidemiology	Spring 2018
5.	Effective Communication	AAI 801 – Interdisciplinary Process	Fall 2018

MPH Competencies

MPH Area of Emphasis: Evidence-based Approaches to Public Health and Interprofessional Practice		
	Number and Competency	**Description**
# 1.	Apply epidemiological methods to the breadth of settings and situations in public health practice	I used current and historic information and data to select factors that may affect individual's risk of disease (morbidity).
# 2.	Select quantitative and qualitative data collection methods appropriate for a given public health context	I created a database for Sedgwick County and other select counties for possible risk factors and disease outcomes (morality).
# 3.	Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate	I cleaned and preformed statistical analysis on database to determine if any factors had statistical significance on disease outcome.
# 4.	Interpret results of data analysis for public health research, policy or practice	My results and statistical analysis are to be published so that they can be used to create recommendations for policies and practices to protect against future disease.
# 21.	Perform effectively on interprofessional teams	I worked with Sedgwick County's and other select counties epidemiologist to coordinate data and to complete project goals and objectives.