How Immunizations Work and Results From a Statewide Immunization Coverage Analysis

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Disclosures

• No financial disclosures
• No political disclosures
  • Member of Colorado Children’s Immunization Coalition
• Not a practitioner
Discussion outline

• Introduction to the immune system function and the function of immunizations

• How are vaccine made

• Benefits of vaccines

• Study of immunization coverage
Immune system: An overview

Specific (Adaptive, memory)
- T cells
- B cells

Non-Specific (Innate)
- Skin, some internal defenses

Immune System

Specific (Adaptive, memory)
- T cells
- B cells
How does our immune system work?

CAUTION
ANALOGIES AHEAD
PROTECTIVE HEADGEAR MUST BE WORN IN THIS AREA
What stimulates the immune system?

• **Antigens (the invader)**
  
  – Viruses, bacteria, fungi, parasites, foreign proteins

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Measles virus

[Image: http://phil.cdc.gov/PHIL_Images/8429/8429_lores.jpg]

Haemophilus Influenzae


Tapeworm

[Image: Getty Images]

Animal dander

[Image: Getty Images]
Question: What are the two “arms” of the immune system?

• Red: Specific and non-specific
• White: Specific and memory
• Blue: Non-specific and innate
• Yellow: Left and Right
Question: What are the two “arms” of the immune system?

• Red: Specific and non-specific
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• Yellow: Left and Right
Immune system = your body’s military

- Private E-1 (PV1)
- Private E-2 (PV2)
- Private First Class (PFC)
- Master Gunnery Sergeant (MgySgt)
- Sergeant Major (SgtMaj)
- Sergeant Major of the Marine Corps (SgtMajMC)
- General (GEN)
- General of the Army (GA)

Phagocyte
Bacterium

BCR
CD4 protein
CD8 protein
Helper T-lymphocyte
Cytotoxic T-lymphocyte
Each cell has approximately 100,000 receptors.
Your country’s “borders”

Innate, non-specific:
- skin
- sweat
- mucous

McGraw Hill
The “infantry”

Innate, non-specific:

- “phagocytes” engulf foreign antigens
- Fever
- Inflammation
The borders are breached: time to call the Sergeant and General!

Specific response, adaptive

Where vaccines have the most use

Chemical messengers + Kill infected cells + memory T cells

Antibodies + memory B cells
The receptors/antibodies are VERY specific
Summary of immune function

Non-specific response
- fever
- inflammation
No memory

Specific response
- B cells recognize measles antigens
- T cells recognize infected cells
- Clonal proliferation
Memory
Question: What role do B cells play in immunity?

- Red: Kill cells
- White: Produce antibodies
- Blue: Cause fevers
- Yellow: Nothing
Question: What role do B cells play in immunity?

- Red: Kill cells
- White: Produce antibodies
- Blue: Cause fevers
- Yellow: Nothing
Immunizations (“trick the system”)

- **Primary immune response**
  - Initial exposure to antigen
  - Time
  - Antibody concentration

- **Secondary immune response**
  - Second exposure to antigen
  - Response is larger
  - Response is faster

Figure 49-16 Biological Science, 2/e © 2005 Pearson Prentice Hall, Inc.
Role of immunizations

-Different types, but most use a part of a virus or bacteria as antigen to stimulate the immune system to generate memory.
Role of immunizations

If we do the math:
~100,000 receptors/cell
~3 million T cells
~3 million B cells
~2,000,000,000 receptors

Studies suggest 3-400 receptors needed to activate an immune response

Cold virus=4-10 antigens
Strep throat=25-50

Bacteria around us: 1 tsp of topsoil~1 billion bacteria

Pertussis vaccine=4 antigens
Vaccine production

Vaccines contain:

-Suspending fluid...saline... the “fluid” part of the vaccine

-Stabilizer/preservatives.....albumin, glycine....these function to keep the antigen unchanged

-Enhancers/adjuvants.....help to generate an immune response
Vaccine production

### Vaccine production

<table>
<thead>
<tr>
<th>Vaccine Type</th>
<th>Vaccines of this type on US immunization schedule</th>
</tr>
</thead>
</table>
| Live, attenuated (weakened version of virus)      | MMR  
Varicella                                        |
|                                                  | Influenza                                        |
|                                                  | Rotavirus                                        |
| Inactivated/Killed                               | Polio                                            |
|                                                  | Hepatitis A                                      |
| Toxoid (inactivated toxin)                       | Diptheria                                        |
|                                                  | Tetanus (DTaP)                                   |
| Subunit/conjugate (contain pieces of pathogen)   | Hepatitis B                                      |
|                                                  | Influenza                                        |
|                                                  | Hib                                              |
|                                                  | Pertussis                                        |
|                                                  | Pneumococcal                                     |
|                                                  | Meningococcal                                    |
|                                                  | *HPV                                             |
Why these diseases?
Importance of “herd immunity”

When a critical portion of a community is immunized against a contagious disease, most members of the community are protected against that disease because there is little opportunity for an outbreak. Even those who are not eligible for certain vaccines—such as infants, pregnant women, or immunocompromised individuals—get some protection because the spread of contagious disease is contained. This is known as "community immunity."
Who should NOT be vaccinated?

• TALK TO YOUR HEALTHCARE PROVIDER!!!
  – Allergies to vaccine components
  – Immunosuppressed
    • (SCID, DiGorge, Ab deficiency)
  – HIV status
  – Chemotherapy
  – Organ Transplants
  – Pregnancy

• Vaccine Adverse Event Reporting System
  – https://vaers.hhs.gov/index

• Vaccine Safety Datalink
  – http://www.cdc.gov/vaccinesafety/Activities/VSD.html
Vaccine Risks

• The primary objectives of VAERS are to:
  – Detect new, unusual, or rare vaccine adverse events (VAEs);
  – Monitor increases in known adverse events;
  – Identify potential patient risk factors for particular types of adverse events;
  – Identify vaccine lots with increased numbers or types of reported adverse events; and
  – Assess the safety of newly licensed vaccines.
Vaccine Risks

- Fever, soreness at injection site
- Allergic reactions
- Risk : Benefit
  - 10 million vaccines/year
  - 30,000 VAERS reports (0.3%)
  - 13% of reports serious (3900 cases, 0.039%)

https://vaers.hhs.gov/about/index
Immunizations: Deciphering fact versus fiction

Truth: Since 2001 thimerosal (mercury) was removed in childhood vaccines

Truth: Hundreds of studies and reviews have shown no link between vaccines and autism. The study that started this argument by Wakefield, was found to be fraudulent and was discredited. Several studies suggest a genetic link to autism spectral disorders.
Truth: Not vaccinating puts the child (and the immunosuppressed or too young to vaccinate) at increased risk for diseases that can manifest into life threatening complications.

Truth: Everyday our immune systems encounter millions of bacteria/viruses (aka “antigens”) The amount of antigens in vaccines are a fraction of this amount.
Measles Cases and Outbreaks
January 1 to March 20, 2015*

178 Cases

4 Outbreaks representing 89% of reported cases this year

U.S. Measles Cases by Year

*Provisional data reported to CDC’s National Center for Immunization and Respiratory Diseases

Changes in Pertussis Reporting by State from 2013 to 2014†

*Data for 2014 are provisional and subject to change. †Cases reported through week 12 in 2013 were compared with cases reported through week 12 in 2014.
FIGURE. Estimated percentage of children enrolled in kindergarten who have been exempted from receiving one or more vaccines* and with <90% coverage with 2 doses of measles, mumps, and rubella (MMR) vaccine — United States, 2013–14 school year

Seither, 2013
• To evaluate if relationships exist between the demographics of K-12 institutions and exemption rates.
Study Design

• Data
  – Exemption Rates from chalkbeat.org
  – Demographic Data from National Center of Educational Statistics

• An OLS regression was conducted on K-12 institutions to determine the relationship of predictor variables on the percent of students exempted from immunization.
  – Population weighting was utilized to account for differences in school size.
School Districts in Analysis

- Academy School District
- Adams 12 Five Start Schools
- Aurora Joint District
- Boulder Valley School District
- Brighton School District
- Cherry Creek School District
- Colorado Springs School District
- Denver Public Schools
- Douglas County School District
- Falcon School District
- Greeley School District
- Harrison School District
- Jefferson County School District
- Littleton School District
- Mesa County Valley School District
- Poudre School District
- Pueblo School District
- St. Vrain Valley School District
- Thompson School District
- Westminster School District
## Results – Immunization Exemption Rates

- Increase in the immunization exemption rate among schools with a higher proportion of white students.
- Increase in the immunization exemption rate among schools with a higher proportion of white students on free and reduced lunch.

<table>
<thead>
<tr>
<th>Relationship of School Demographics on Immunization Exemption Rates</th>
<th>Coefficient</th>
<th>Robust Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(% FRL)</td>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>ln(% White)</td>
<td>0.5***</td>
<td>0.05</td>
</tr>
<tr>
<td>ln(% FRL * White)</td>
<td>0.12**</td>
<td>0.05</td>
</tr>
<tr>
<td>ln(% Male)</td>
<td>-0.31</td>
<td>0.37</td>
</tr>
</tbody>
</table>
Results – Immunization Exemption Rates
Results – Immunization Compliance Rates

- Decrease in immunization compliance rates among schools with a higher proportion of students on free and reduced lunch.

### Relationship of School Demographics on Immunization Compliance Rates

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<tr>
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<th>Coefficient</th>
<th>Robust Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(% FRL)</td>
<td>-0.02***</td>
<td>0.004</td>
</tr>
<tr>
<td>ln(% White)</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>ln(% FRL * White)</td>
<td>-.01</td>
<td>0.01</td>
</tr>
<tr>
<td>ln(%Male)</td>
<td>-.01</td>
<td>0.04</td>
</tr>
</tbody>
</table>
Results – Immunization Compliance Rates
## Rates by District

<table>
<thead>
<tr>
<th>District</th>
<th>Exemption Rate</th>
<th>Compliance Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACADEMY SCHOOL DISTRICT NO. 20 I</td>
<td>13.53%</td>
<td>95.26%</td>
</tr>
<tr>
<td>ADAMS 12 FIVE STAR SCHOOLS</td>
<td>2.89%</td>
<td>98.66%</td>
</tr>
<tr>
<td>AURORA JOINT DISTRICT NO. 28 OF</td>
<td>1.96%</td>
<td>91.78%</td>
</tr>
<tr>
<td>BOULDER VALLEY SCHOOL DISTRICT N</td>
<td>11.23%</td>
<td>93.51%</td>
</tr>
<tr>
<td>BRIGHTON SCHOOL DISTRICT NO. 27J</td>
<td>5.58%</td>
<td>94.16%</td>
</tr>
<tr>
<td>CHERRY CREEK SCHOOL DISTRICT NO.</td>
<td>3.80%</td>
<td>96.83%</td>
</tr>
<tr>
<td>COLORADO SPRINGS SCHOOL DISTRICT</td>
<td>2.34%</td>
<td>91.83%</td>
</tr>
<tr>
<td>DOUGLAS COUNTY SCHOOL DISTRICT N</td>
<td>5.68%</td>
<td>96.43%</td>
</tr>
<tr>
<td>FALCON SCHOOL DISTRICT NO. 49 IN</td>
<td>5.69%</td>
<td>98.72%</td>
</tr>
<tr>
<td>GREELEY SCHOOL DISTRICT NO. 6 IN</td>
<td>4.28%</td>
<td>98.65%</td>
</tr>
<tr>
<td>HARRISON SCHOOL DISTRICT NO. 2 I</td>
<td>1.71%</td>
<td>91.18%</td>
</tr>
<tr>
<td>JEFFERSON COUNTY SCHOOL DISTRICT</td>
<td>5.20%</td>
<td>91.74%</td>
</tr>
<tr>
<td>LITTLETON SCHOOL DISTRICT NO. 6</td>
<td>5.67%</td>
<td>84.78%</td>
</tr>
<tr>
<td>MESA COUNTY VALLEY SCHOOL DISTRICT</td>
<td>7.09%</td>
<td>99.98%</td>
</tr>
<tr>
<td>Poudre School District R-1</td>
<td>9.27%</td>
<td>99.33%</td>
</tr>
<tr>
<td>PUEBLO SCHOOL DISTRICT NO. 60 IN</td>
<td>9.39%</td>
<td>99.02%</td>
</tr>
<tr>
<td>SCHOOL DISTRICT NO. 1 IN THE COU</td>
<td>2.63%</td>
<td>90.24%</td>
</tr>
<tr>
<td>ST. VRAIN VALLEY SCHOOL DISTRICT</td>
<td>7.44%</td>
<td>93.57%</td>
</tr>
<tr>
<td>THOMPSON SCHOOL DISTRICT R-2J</td>
<td>9.15%</td>
<td>99.98%</td>
</tr>
<tr>
<td>WESTMINSTER SCHOOL DISTRICT NO.</td>
<td>2.15%</td>
<td>94.22%</td>
</tr>
</tbody>
</table>
Conclusion

- These data may be used to target certain areas and demographic groups to provide education and improve immunization rates among high exempt-out schools and districts.
- Need to target increasing the compliance of parents providing immunization records to schools.
- Because of some districts having a high number of non-compliant students, we are unsure of immunization status among those students.
Future directions

• Partner with high need schools and populations to bring immunizations and education directly to the schools
• Immunizations can be administered by Regis pharmacists and pharmacy students
• Partnership with local pharmacies to provide immunizations
• Focus groups to better understand rationale for not keeping children up to date on immunizations
• Adams 12 School district
• Derrick Waller, Regis University
Works Cited

- Seither R, Masalovich S, Knighton CL, Mellerson J, Singleton JA, Greby SM. Vaccination Coverage Among Children in Kindergarten — United States, 2013-14 School Year MMWR. 2014;63(41);913-920.