Module 5: Population Health

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Accreditation:

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Sponsor:

This program is developed in collaboration with the Canadian Paediatric Society, the Public Health Agency of Canada and Health Canada.
Competency: Applies relevant principles of population health for improving immunization coverage rates.

Learning Objectives
Upon successful completion of this continuing education lesson, you will be better able to:

1. Use specific examples to show how immunization is a population-based health strategy.
2. Explain the concept of herd immunity (also called community immunity) in non-scientific terms.
3. Explain, using examples, why vaccine-preventable diseases return when immunization coverage rates decrease.
4. Explain how immunization registries can benefit not only individuals but also populations.
5. Present the case for the importance of having a highly immunized health care workforce.
6. Use a health promotion planning model to identify barriers (economic, educational, system-based, and social factors) to immunization uptake.
7. Use health promotion strategies to improve immunization coverage rates.

Test Your Current Knowledge
Based on your current knowledge, determine if the following statements are true or false.

1. The objectives of a vaccination program are dependent upon vaccine efficacy, ability to reach target populations and epidemiology of disease.
   a. True
   b. False

2. The latency period is the time from infection until the patient presents with symptoms.
   a. True
   b. False

3. Pathogenicity is the portion of people exposed to a disease who become infected.
   a. True
   b. False

4. Varicella has high infectiousness and pathogenicity but low virulence.
   a. True
   b. False

5. A new condition has a basic reproductive rate (R0) of 16. This means that a single case can infect 16 people of a susceptible population.
   a. True
   b. False

6. All conditions require approximately the same immunization rates amongst the population to offer herd immunity.
   a. True
   b. False
7. Lower immunization rates in health care professionals do not generally lead to a higher mortality in that population but can have a significant effect on the mortality of their patients.
   a. True
   b. False

Role of Immunizations in Population Health

Defining Population Health and a Population Health Approach
Population health is an approach that aims to improve the health of the entire population and to reduce health inequities among population groups. To reach these objectives, it looks at and acts upon the broad range of factors and conditions that have a strong influence on health.¹

Action is directed at the health of an entire population, or sub-population, rather than at individuals.² This is done through evidence-based decision making to identify priorities and strategies to improve health.²

Role of Immunizations in Population Health
Immunizations have had a dramatic impact on health both nationally and worldwide, with a reduction in vaccine-preventable diseases. A meta-analysis looking at the effectiveness of clinical preventive services demonstrated that immunizations were a highly effective prevention strategy for public health.³

Watch Dr. Caroline Quach’s presentation, which discusses Table 1 and 2

Table 1 – Effective Clinical Preventative Services

<table>
<thead>
<tr>
<th>Preventive service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ASA chemoprophylaxis</td>
<td>Discuss daily ASA for prevention of cardiovascular events for men &gt; 40 and women &gt; 50 or other high-risk conditions</td>
</tr>
<tr>
<td>2. Childhood immunization series</td>
<td>Diphtheria; tetanus; pertussis; poliomyelitis; <em>H. influenza</em> type B (Hib); measles; mumps; rubella; varicella; pneumococcal conjugate vaccine, meningococcal conjugate vaccine, rotavirus</td>
</tr>
<tr>
<td>3. Tobacco-use screening and brief intervention</td>
<td>Screening; counselling; pharmacotherapy</td>
</tr>
<tr>
<td>4. Colorectal cancer screening</td>
<td>Screen adults aged 50 years and older with sigmoidoscopy or colonoscopy</td>
</tr>
</tbody>
</table>
5. Hypertension screening
Measure blood pressure routinely in all adults and treat to prevent cardiovascular disease

6. Influenza immunization
For adults aged 50 years and over – annually

7. Pneumococcal immunization
For adults aged 65 years and over

<p>| Table 2 – Effects of the Canadian Immunization Program on Vaccine-Preventable Diseases |
|-----------------------------------------------|-------------------|----------------|</p>
<table>
<thead>
<tr>
<th>Disease</th>
<th>Immunization started</th>
<th>Annual number of cases</th>
<th>Before vaccination</th>
<th>Now</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diphtheria</td>
<td>1930</td>
<td>9,000</td>
<td>0-1</td>
<td></td>
</tr>
<tr>
<td>Pertussis</td>
<td>1940</td>
<td>~20,000</td>
<td>~5,000</td>
<td></td>
</tr>
<tr>
<td>Tetanus</td>
<td>1940</td>
<td>40-50 Deaths per year</td>
<td>1-10</td>
<td></td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>1955 (IM) 1962(PO)</td>
<td>1,500</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Measles</td>
<td>1970</td>
<td>200,000-300,000</td>
<td>~200</td>
<td></td>
</tr>
<tr>
<td>Rubella</td>
<td>1971</td>
<td>~5,000</td>
<td>&lt;30</td>
<td></td>
</tr>
<tr>
<td>Mumps</td>
<td>1976</td>
<td>~43,500</td>
<td>~200</td>
<td></td>
</tr>
</tbody>
</table>

**Infectious Disease Epidemiology**
To understand the role of immunization in the prevention of disease in the populations, it is important to understand the role of the Agent, Host and Environment on the epidemiology of the disease. **Figure 1** lists the interaction.

Watch Dr. Caroline Quach’s presentation, which discusses Figure 1 and the interactions
The Goal of Immunization Programs on Improving Population Health

Watch Dr. Caroline Quach’s presentation, which discusses Table 3

Elimination of disease would be the ideal goal for immunization programs. Unfortunately this is not always possible for many infectious diseases. **Table 3** lists the objectives of a vaccination program.

**Table 3 – Objectives of an Immunization Program**

- Depends on:
  1. Availability and efficacy of vaccines
  2. Capacity to reach target populations
  3. Epidemiology of disease
Stop and Learn - Key Definitions

Watch Dr. Caroline Quach's presentation, which discusses definitions

Latency – The time from infection with an infectious agent to the minimum level to transmit the disease

Incubation period – The time between infection and when the patient starts demonstrating symptoms

Symptomatic Period – The time from when the patient displays symptoms to the point when they have ended
The Spread of a Disease in a Population, the Importance of Infectiousness, Pathogenicity and Virulence

The spread of a disease in a susceptible population is dependent on the characteristics of the infecting agent.

1. Once exposed:
   - Not infected vs. Infected
   - **Infectiousness:** Proportion of exposed persons who become infected

2. Once infected:
   - No apparent disease vs. Disease
   - **Pathogenicity:** Proportion of infected people who develop clinical disease

3. Once sick:
   - Not severe vs. Severe disease
   - **Virulence:** Proportion of people with clinical disease who become severely ill or die

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Infectivity</th>
<th>Pathogenicity</th>
<th>Virulence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varicella</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Cold</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Measles</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

**Herd Immunity**

Herd immunity describes the phenomenon that occurs when the vaccination of a portion of the population (or herd) provides protection to unprotected individuals. Transmission decreases when the number of immune people increases, because there are fewer susceptible people in the population, there are fewer cases, and thus, less risk of exposure to the unprotected. This phenomenon leads to greater protection for the population as a whole (immunized and unimmunized) and this is the basis for a population-based immunization program.

The level of immunization that is required to achieve herd immunity is dependent upon the basic reproductive rate of the infecting agent.
Basic Reproductive Rate or $R_0$

Watch Dr. Caroline Quach’s presentation, which discusses basic reproductive rate

Basic reproductive rate or $R_0$ - Number of secondary cases generated from a single infectious case introduced into a susceptible population.

- If $R_0 > 1$: disease will increasingly spread (epidemic)
- If $R_0 = 1$: disease will stabilize (endemic)
- If $R_0 < 1$: disease will disappear

Herd Immunity – Measles Example

Watch Dr. Caroline Quach’s presentation, which discusses a measles example for herd immunity

- To eradicate measles (World Health Organization):
  - $R_0 = 15$ (Western Countries)
- To prevent a measles epidemic – using herd immunity:
  - Proportion of people immunized $> 1 - 1/R_0 = 1 - 1/15 = 0.94$

Insert Animation Slide 14

Thresholds to Maintain Herd Immunity

Watch Dr. Caroline Quach’s presentation, which discusses thresholds

- Threshold under which epidemics may occur and another above which disease will disappear.
These thresholds will depend on:
- Type of infection
- Attack rate
- Mode of transmission
- Immunization coverage rates if the disease is vaccine-preventable

For some diseases, immunity is maintained naturally through contacts with infected individuals. Vaccination programs may need to be adapted if these diseases disappear (e.g. varicella through immunization) as a booster dose(s) then may be needed.

Tools to Track Vaccine-Preventable Disease Outbreaks
The Council on Foreign Relations has developed an interactive map of global outbreaks of measles, mumps, whooping cough, polio, rubella and other diseases that are easily preventable by inexpensive and effective vaccines. The Vaccine-Preventable Outbreaks – Interactive Map tool can be useful to monitor outbreaks in your region and as a patient education tool.

Rates of Infection of Invasive Pneumococcal Disease in Québec
A perfect example of how effective immunization programs protect the entire population, both immunized and unimmunized, can be seen in the figure below. In Québec when the PC-7 immunization was introduced at the start of 2005 there was not only a decrease in the pneumococcal disease rates in the target group of children by age, but there was also a decrease in the children of other ages not targeted by this program. This demonstrates the importance of herd immunity on the overall health of the community.

The Return of Disease When Immunization Rates Go Down
As immunization rates increase, the vaccine-preventable disease (VPD) diminishes to the point that the general population may become more concerned about the potential of adverse events from the
immunization. When this occurs, it can generate a loss of confidence and a decrease in immunization rates. Subsequently, if an outbreak occurs, a re-uptake of immunizations occurs and confidence in the vaccine program returns. In some cases the vaccine-preventable disease is eradicated and the immunization program can be stopped for that infection (smallpox is the only example to date, but great progress has been made with polio).

The Lifecycle of a Vaccination Program

Watch Dr. Caroline Quach’s presentation, which discusses the figure below

![Lifecycle of a Vaccination Program](image)

Figure 1 Potential stages in the evolution of an immunization programme, showing the dynamics of the interaction between vaccine coverage, disease incidence and incidence of vaccine adverse events

See a short animation of how immunization works.

Pertussis Example of the Effect of a Decrease in Immunization Rates

Watch Dr. Caroline Quach’s presentation

- Concerns arose in the UK because of allegations of encephalopathy secondary to pertussis whole-cell vaccine
- Immunization uptake:
  - > 80% in 1967
  - 31% in 1976
- 1982: Resurgence of pertussis ( > 65,000 cases) with 14 deaths
- 1990s: Increased immunization coverage rates again
Watch Dr. Caroline Quach’s presentation, which discusses the figure below

**Figure 2**

Whooping Cases & Vaccine Coverage England and Wales 1940-2005 Q3

Watch Dr. Ian Gemmill’s presentation

Vaccine Registries

Ideally, all individuals should be protected against vaccine-preventable diseases and have their own immunization records. A vaccine registry is a computerized tool in the immunization program strategy allowing the documentation of immunizations of each individual nationwide and capable of sharing information while maintaining privacy and confidentiality.

Vaccine registries are a powerful tool and have benefits for patients, immunizers, public health officials and ultimately the community through lower rates of vaccine-preventable diseases. Table 5 lists some of the key benefits of vaccines registries. In Canada, each of the provinces immunizations records are captured differently. Immunization registries are at varying stages of development and effectiveness and efficacy for capturing immunization data. All practitioners should be aware of registries in their province or region and facilitate the entry of immunizations that they administer into these registries.

<table>
<thead>
<tr>
<th>Table 5 – Benefits of Vaccine Registries$^7$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>For Patients:</strong></td>
</tr>
<tr>
<td>• All immunizations an individual has received are kept in one site</td>
</tr>
<tr>
<td>• Help to ensure immunizations are up-to-date</td>
</tr>
<tr>
<td>• Provide opportunities to use recalls when immunizations have been missed</td>
</tr>
</tbody>
</table>

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- Ensure timely immunizations for children that have moved or switched to another immunizer
- Prevent duplication in immunizations

- Provide definitive information on immunizations due or overdue
- Provide current recommendations and information on new vaccines
- Produce reminders and recalls for immunizations due or overdue
- Complete required school, camp, and day-care immunization records
- Facilitate introduction of new vaccines or changes in the vaccine schedule
- Help manage vaccine inventories
- Facilitate identification of patients who have received specific lot numbers of vaccine when a problem is identified

For Communities

- Help control vaccine-preventable diseases
- Help identify high-risk and under immunized populations
- Help prevent disease outbreaks
- Provide information on community and provincial coverage rates
- Streamline vaccine management

For Public Health Officials

- Provide information to identify pockets of need, target interventions and resources, and evaluate programs
- Promote reminder and recall of children who need immunizations
- Ensure that providers follow the most up-to-date recommendations for immunization practice
- Facilitate introduction of new vaccines or changes in the vaccine schedule
- Integrate immunization services with other public health functions
- Can help monitor and conduct appropriate follow-up for adverse events
- Improved ability to generate standardized vaccinee-specific and aggregate or summary reports: pregnant woman exposed to diseases such as measles or varicella

Immunization of Health Care Workers

The importance of immunization of health care workers (HCWs) needs to be emphasized. HCW immunization is an excellent way to protect themselves and their families, and prevent the transmission...
of vaccine-preventable illnesses for the patients under their care. During an outbreak, unimmunized HCWs may be excluded from work at a time when they would be most needed. Also, if unimmunized, they are more likely to be ill and unavailable for duty. A well-immunized health care workforce is an essential component in reducing the transmission of vaccine-preventable diseases.

Watch Dr. Caroline Quach’s presentation, which discusses the graph below

Vaccination uptake among HCW and mortality among patients

Carman. The Lancet 2000; 355: 93

Strategies to Improve Immunization Rates

Barriers to immunization can lead to a resurgence of vaccine-preventable diseases. Identified barriers include:

Economic barriers

- Cost of the vaccine (if it is not part of the publicly funded program)
- Time away from work for vaccine administration
- Accessibility to immunization and immunization professionals

System-based barriers

- Increasingly complex immunization schedules
- Different schedules across Canada
- Inadequate documentation
- Lack of a unique immunization record (paper or electronic)
- Absence of standing orders (e.g. post-partum rubella immunization)
- Inadequate tracking of immunization delay
Socially-related barriers

- Lack of education of immunization providers and/or recipients
- Inadequate communication of the complications of vaccine-preventable diseases
- Increasing focus on the potential adverse effects of immunizations

Health promotion strategies to improve immunization rates need to take into account the recipient and family members, the provider, and the delivery system. Another essential constituent is the need to overcome identified barriers. Ideally, such strategies should be delivered in combination. Here are a few examples:

**Education**

- Increase education of the general public on benefits of immunization and risk of complications of vaccine-preventable diseases. This education could include posters and badges for health care professionals, indicating that they have been immunized.
- Educate and counsel patients and family at every teachable moment.
- Improve communication skills to counteract misinformation about immunizations.
- Integrate immunization education in elementary and secondary school science and biology curriculum.

**Public health**

- Develop strategies to identify barriers.
- Advocate for publicly-funded systemic immunization programs.
- Implement methods to increase access to vaccination opportunities (such as offering immunization services on weekends and evenings).
- Offer immunization in expanded contexts (workplace, school, shopping mall...all opportunities).
- Implement inducement programs to promote immunization
- Utilize non-traditional immunization sites, such as pharmacies, workplace, schools, shopping malls, etc.

**Health care professionals**

- Consistently offer immunization to your patients as this has been shown to increase immunization rates.
- Incorporate systems in clinical practices:
  - Reminder is sent to patients when vaccines are due or late
  - Reminder is put in the patient’s chart
- Ensure easily-retrievable immunization documentation (e.g. a summary page) from patient’s hospital chart.
- Participate in local immunization promotional campaign.
- Ensure appropriate messaging:
  - Be professional (research barriers and enablers)
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- Be proactive
- Be penetrative (remember only the childhood program is strongly ingrained in both the population and amongst health professionals)
- Conduct quality assurance activities like auditing the immunization coverage rate in your practice.

Interventions in Combination

Watch Dr. Caroline Quach’s presentation

Key Learning Points

1. Childhood immunizations are one of the most effective preventive health strategies that can be offered to patients.
2. Vaccines are effective at reducing infectious disease and lead to decreases in cases of disease in the community.
3. A decrease in immunization rates in a community can eventually lead to resurgence of the number of disease cases.
4. The transmission of disease in a patient and the community is dependent upon:
   - Infecting agent (pathogenicity, infectiousness, infectious dose)
   - Patient factors (age, gender, genetics, behaviours, exposures, immunity)
   - Environmental factors (social (crowding), physical (barriers, climate))
5. Immunity is maintained naturally through contact with infected individuals. Vaccination programs may need to be adapted if these opportunities for natural boosting disappear by adding booster doses to immunization programs.
6. Herd immunity is only effective if a sufficient portion of the population is immunized.
7. The percentage of the population required to be immunized to offer herd immunity will depend on how many patients a single infected patient can infect (the basic reproductive rate or R₀ value).
8. The evolution of an immunization program can lead to varying levels of immunization based on the prominence of the condition in the community and the focus that patients have on the potential of adverse effects from the vaccine.
9. High immunization rates amongst health care professionals leads to a lower mortality among patients.
10. Health care professionals can increase immunizations rates by:
   - Enhancing vaccine access
   - Utilizing provider based interventions
   - Increasing patient demand

Post-Test
Mrs. J. Todd is in for a regular appointment with her son Mark. You know from previous discussions that she is not a 100% supporter of the immunization program and you need to discuss the release of a new vaccine for a new vaccine-preventable disease called “XYZ syndrome”. This condition has a high
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*degree of infectiousness and pathogenicity and a moderate virulence rate. The R₀ score for this new condition is 12 and there have been some widespread cases and complications in other parts of the world.*

*When you bring up the topic of immunizing Mark with this new vaccine she is very reluctant. She states that many of her friends have not immunized their children against this disease as it is not overly communicable and Mark will be protected as the rest of the community will become immunized. She is not sure if the immunization is the best approach for her son.*

1. The R₀ score for this new condition is 12. What does this mean?
   a. 1 in 12 people that develop this condition develops symptoms
   b. A single infected person can infect 12 other susceptible people
   c. This condition has a high complication rate
   d. 12% of patients with the condition will die from it

2. You start to discuss herd immunity with Mrs. Todd. Which of the following statements would be the MOST appropriate to use when discussing this concept with the parent?
   a. We have very high immunization rates in this country so I am sure Mark will be protected
   b. Mrs. Todd, there is no way that Mark will be protected
   c. Mrs. Todd, to get community protection, a very high proportion of the population will need to be immunized. The only way that we will be able to protect our community from this disease is to make sure that we have enough of our population immunized. You cannot rely on this effect to ensure that your son is protected from this nasty disease, and to be sure that he is protected, I advise this vaccine for your son
   d. Mrs. Todd, immunizing the community will have little effect on the protection of your son

3. What is the proportion of the population that requires immunization for the entire community to benefit from herd immunity?
   a. 8%
   b. 18%
   c. 58%
   d. 92%

4. Looking at the condition’s infectiousness, pathogenicity and virulence rates, which of the following statements best describes this disease?
   a. This condition is not readily transmittable, but has a high symptom rate and severe illness rate
   b. This condition is readily transmittable, but most patients will not develop symptoms
   c. This condition is readily transmittable and has a high symptom rate
   d. This condition is not readily transmittable but if a patient becomes infected it is likely to cause severe illness

5. Which of the following is NOT a benefit of a vaccine registry?
   a. Central record of every person’s immunizations
   b. Prevention of duplication
   c. Allows for schools to directly access and identify if a specific child is immunized
d. Improved ability to generate standardized client-specific and aggregate/summary reports

6. Which of the following is a strategy to improve immunization rates
   a. Include immunization education in elementary and secondary school science/biology curriculum
   b. Increase education of the general public on benefits of immunization
   c. Advocate for publicly-funded systemic immunization programs
   d. All of the above

Discussion Forum

1. Immunizations have played a crucial role in population health. Some parents have questioned the usefulness of these programs as the rates of vaccine-preventable infections in Canada are so low. What counselling techniques do you use when approached by these parents?

2. Herd immunity is crucial to protect our communities from vaccine-preventable infections. Do you have any tips that you can share with your colleagues that you use when a parent states that there is no need to vaccinate their child as they will be protected by all the other immunized children?

3. What is the status of the vaccine registry in your province of practice? If available, can you share some of the key information it provides that you have found useful in your day to day immunization practice?

4. Immunization rates of health care professionals are very low. Can you comment on why you feel this is the case, and if you have any strategies that would be effective in improving immunization rates in this population?
References


