Vaccinating Against HPV: Furthering the Prevention of Cervical Cancer

Pamela Fuller, Lindsey Garrett, Toni Wagner, and Mark Yuhas

Rensselaer Polytechnic Institute
Department of Mathematical Sciences, Troy, NY
Objectives

- Explore various vaccination patterns to minimize the number of cervical cancer cases resulting from Human Papillomavirus (HPV).

- Strategy:
  1. Create a network of individuals.
  2. Spread the virus throughout the network.
  3. Implement vaccination patterns and genetic algorithm.
  4. Analyze results.
More than 20 STIs have been identified by the Centers for Disease Control and Prevention (CDC).

STIs result in approximately 30,000 deaths annually.

20 million people develop health complications as a result of sexual activity.

The most common STI is the Human Papillomavirus.
Human Papillomavirus (HPV)

HPV infects the skin and mucous membranes of the human body. It can be contracted through any genital or sexual contact.

- **Strains:**
  - 40 strains are STIs (over 130 exist).
  - Low risk strains can cause genital warts.
  - High risk strains can cause cervical cancer.

- **Detection:**
  - Pap smear for women; cannot tell which strain
  - No FDA approved method for diagnosis in men
There is only one known strain of HPV.

HPV 16 and HPV 18 are discovered.

MERCK begins clinical trials of HPV vaccine.

Before 1970

1976
- HPV DNA discovered in cervical cancer.

1982

1990
- HPV and cervical cancer link is discovered.

2001

2006
HPV Vaccine: Gardasil

- Approved for females 9-26 years old.
- 3 series vaccination:
  - Protects against:
    - HPV 6, 11 (genital warts)
    - HPV 16, 18 (cause 70% of cervical cancer cases)
Network Construction

- Sexual Network
- Characteristics
  - Gender
    - male, female
  - Sexual Orientation
    - heterosexual, homosexual, bisexual
  - Age
    - 9-35
  - State
    - Susceptible, Infective, Recovered, Cervical Cancer
- Connection exists between sexual partners.
Node Status

Susceptible  Infective  Recovered  Cancerous

* path continues on central path

HPV 16  HPV 18
Vaccination

- 12.6% initial protection (safe practices)
- 3 doses provide virtually 100% protection
- Protection Level:

\[ P_n = P_{n-1} + w(1 - P_{n-1}), \]

where:
- \( P \) is % protection,
- \( w \) is % increase in protection per dose
- \( n \) is the number of doses.
- \( P_0 = .126 \)
- \( w = .7 \)
Vaccination Strategies

- Man Made Patterns
  - different patterns based on age group

- Genetic Algorithm
  - breed solutions to find the fittest pattern
Discussion