Mathematical Modeling of Human Papillomavirus in College "Hook-up Culture"

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Introduction

Infection with human papillomavirus (HPV) has been known to cause genital warts, cervical and other cancers, and respiratory papillomatisis. It is the most common sexually transmitted infection (STI) affecting nearly all sexually active individuals at some point in their life. While the effects of HPV and cervical cancer has been modeled before, none of the models consider the effect of populations with different sexual behavior. Concerns about cervical cancer has been modeled before, led to the question of how increased numbers of sexual interactions of high and low contact individuals leads to varying prevalence of cervical cancer after 30 years.

Main Questions

- Does the number of sexual partners differ between traditional dating and "hook-up culture"? Do males and females differ in their susceptibility to HPV?
- How do we include different sexual contact populations (high and low contact) and both sexes into our model?
- How does changing the proportion of the population in each subpopulation affect the incidence rate of cervical cancer?

Assumptions

- Males and females are equally susceptible to infection by HPV. [1]
- The sum of all sexual interactions is equal in both males and females.
- The population size is 2.

Model of Progression

System of Differential Equations

\[
\begin{align*}
\frac{dS_{HC}}{dt} &= -\beta_{HH}S_{HC}I_{HC} - \beta_{HL}S_{HC}I_{LC} \\
\frac{dS_{LC}}{dt} &= -\beta_{HL}S_{LC}I_{LC} - \beta_{HH}S_{LC}I_{HC} \\
\frac{dS_{HC}}{dt} &= -\beta_{HH}S_{HC}I_{HC} + \beta_{HL}S_{HC}I_{LC} \\
\frac{dS_{LC}}{dt} &= -\beta_{HL}S_{LC}I_{LC} + \beta_{HH}S_{LC}I_{HC} \\
\end{align*}
\]

Parameters

- \( \beta_{HH} = 0.5 \cdot 0.20 = 0.100 \)
- \( \beta_{HL} = 1.5 \cdot 0.20 = 0.300 \)
- \( \beta_{HH} = 4.5 \cdot 0.20 = 0.900 \)
- \( \beta_{HL} = 0.5 \cdot 0.20 = 0.100 \)
- \( \gamma_{S} = 1/0.625 = 1.600 \)
- \( \gamma_{C} = 1.152033 = 0.668 \)

Table 1: Current conditions as estimated by [1],[2],[3].

Initial Conditions

- We assumed 0.3% of high contact and 0.1% of low contact individuals of both males and females were infected. We generated the available susceptible proportion breakdown as follows.

<table>
<thead>
<tr>
<th>Population</th>
<th>Current</th>
<th>High Contact</th>
<th>Low Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>proportion breakdown</td>
<td>proportion breakdown</td>
<td></td>
</tr>
<tr>
<td>males</td>
<td>females</td>
<td>males</td>
<td>females</td>
</tr>
<tr>
<td>high contact</td>
<td>0.15</td>
<td>0.1</td>
<td>0.85</td>
</tr>
<tr>
<td>current</td>
<td>males</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>high contact</td>
<td>males</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 2: Available susceptible proportions

Results

- Given the current conditions, the chance of a female developing cervical cancer was 0.470%, in good accord with the current cervical cancer statistics which suggest 0.49%.
- High contact conditions saw a 30% increase in cervical cancer incidence over current conditions.

Results Continued

- Sexually active individuals should be highly encouraged to practice safe sex, have few sexual partners, and be vaccinated against HPV.
- Educational programs regarding the potential for HPV related cervical cancer should be in place for communities with a large high contact population.

Future Directions

- Hook-up culture"? Do males and females differ in their susceptibility to HPV?
- How do we include different sexual contact populations (high and low contact) and both sexes into our model?
- How does changing the proportion of the population in each subpopulation affect the incidence rate of cervical cancer?

Assumptions

- Males and females are equally susceptible to infection by HPV. [1]
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Figure 2: Low, current, and high contact population outcomes of an HPV outbreak

References


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