**Neisseria meningitidis**: Epidemiological Study and Modeling on a Student Population

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Abstract: - *Neisseria Meningitidis* (meningococcus) causes a variety of clinical syndromes ranging from meningitis to severe septicemia in children and young adults. All recent studies have shown that freshman living in dormitories have higher risk of developing meningococcal infections as non-resident students. In this paper, we report the findings in approximately 100 freshman students who were tested for carriage of the organism. It was found that smoking and socializing did not contribute to the increase. The data showed correlations between lowered immunity (associated stress and upper respiratory infections) with increase in meningococcal carriage. Statistical analysis and mathematical modeling tools were employed to picture and quantify the correlation between the above risk factor and the development of meningococcal infections.

Key words: - *Neisseria meningitidis*, meningococcus, carriage, stress, immunity, epidemiology, mathematical modeling.

1. Introduction

*Neisseria meningitidis* colonizes the oro-nasopharynx and spreads from person to person via respiratory droplets. The organism may remain in the upper respiratory tract without causing disease, or it may become invasive, giving rise to meningitis and septicemia. The incidence of meningococcal infection is low. In the United States, there were 0.8-1 per 100,000 population [1], and 10 to 25 cases per 100,000 persons in the developing countries [2]. The rapid onset of the disease, the fulminant course of the infection in some individuals, and the high mortality rate in the absence of immediate antimicrobial treatment, are the reasons for the profound impact of this infection. There are about 3000 cases of meningococcal infection in the United States each year. The mortality rate is 13% and about 15% of survivors develop permanent hearing loss or other neurological damage [3]. The course of this disease is intensely rapid. From the onset of symptoms to death, the time period is approximately 24 hours if not treated.

In non epidemic periods, meningococcus is present in 5-10% of the population in asymptomatic carriers in the United States [4]. The endemic form has an incidence of 1 to 5 cases per 100,000 population annually, while in epidemics the incidence is 500 cases per 100,000 [5]. While the overall meningococcal rates are low, they have been rising among young adults – from 1 to more than 2 per 100,000 people (ages 15-24) since 1991. Health centers started keeping statistics on college students in 1998, outbreaks seem to have been rising in this group as well. All recent studies have shown that freshman living in dormitories have seven times as much risk of developing meningococcal infections as college students overall [6].

2. Objective

This study was to determine the risk factors for meningococcal disease. Recent studies indicated
cigarette smoking and bar patronage are risk factors for meningococcal infection [7 and 8]. Upper respiratory infections have also been reported as a risk factor [9 and 10]. Since there is a direct relationship between the carrier state and the acquisition of the disease, this study was to determine which risk factors are associated with the carrier state.

3. Design and Methods
The study group consisted of approximately 100 freshmen at Texas A&M University-Corpus Christi. The students were given a questionnaire to complete, and posterior nasal swabs were obtained for identification of the presence of Neisseria meningitidis. The questionnaire contained questions on place of residence, active and passive smoking, visits to bars and night clubs, and recent symptoms of upper respiratory tract infection. Posterior nasal swabs were done at three different times throughout the semester. The first was at the beginning of the semester; the second at the week before midterms, and the third during the week of finals. The swab samples were immediately plated onto selective medium for Neisseria. Gram stain was performed on bacteria cultures. If gram negative diplococci were seen under the microscope, sugar utilization tests were performed to confirm that the organisms isolated were Neisseria meningitidis.

4. Results
Data from our study was analyzed using descriptive statistical tools to view the impact of smoking (Graph 1), socialization (Graph 2), living on campus (Graph 3), and low immunity which includes feeling stressed and recent influenza or viral upper respiratory infections (Graph 4), on the percentage of students colonized with Neisseria meningitidis.
Graph 2: Correlation between Socialization and Incidence of Colonization of *Neisseria Meningitidis*

(Graph 2 with bars for number of students who socialized vs. percentage of colonization)

Graph 3: Correlation between Living on Campus and Incidence of Colonization of *Neisseria Meningitidis*

(Graph 3 with bars for number of students who lived on campus vs. percentage of colonization)

Graph 4: Correlation between Immune System Levels and Incidence of Colonization of *Neisseria Meningitidis*

(Graph 4 with bars for number of students with reportedly low immune system vs. percentage of colonization)
Mathematical Models

Mathematical modeling is a safe, economic and effective way of studying the parameters that control the dynamics of a biological structure. Furthermore, it is a process that can be employed to provide a rigorous, systematic, and quantitative linkage between a biological phenomena and its environment. Based on the above descriptive statistical analysis, we use the simplest mathematical modeling tool, Trend Line, in order to find the best fit to our data.

The only factor that had a direct relationship with carriage was the immune status of the students (Graph 5). For future prediction of colonization percentage of *Neisseria meningitidis*, we could use the model \( y = 0.0055x^2 - 0.4431x + 18.333 \) where \( x \) is number of students with low immunity and \( y \) is percentage of students colonized by *Neisseria meningitidis*.

Graph 5: # of students with low immune system vs % of colonization

\[ y = 0.0055x^2 - 0.4431x + 18.333 \]

\[ R^2 = 1 \]
5. Conclusion
Our data show that meningococcal carriage increased from 10% at the beginning of the semester to 15% at midterm, and 20% at the end of the semester. At first glance, there seemed to be no correlations between smoking and carrier status. However, the number of student smokers remained the same, but the number of carriers climbed steadily. It is therefore possible that smoking may contribute to susceptibility to *Neisseria Meningitidis* infection and increase in the number of carriers. There was no direct relationship between students who frequently visited bars and night clubs (“socialization”) and the carrier status. In fact, at the end of the semester, the number of students frequenting bars and night clubs decreased, whereas the number of meningococci carriers increased. Living on campus cannot be ruled out as a risk factor. The number of students living on campus varied insignificantly, but the number of carriers continued to rise as the semester progressed. It is possible that living on campus increased the students’ susceptibility to infection, and hence the numbers of carriers were higher. Subsequent studies should separate the living on campus group from the off campus group. The only factor that had a direct relationship with carriage was the immune status of the students. The immune status of the students was based on the stress level and recent upper respiratory infections, such as influenza and the common cold. As the number of students was classified as being in the “low immunity” category, increased from 30 at the beginning of the semester to 84 at the end of the semester, the carrier number increased concomitantly from 10% at the beginning of the semester to 20% at the end of the semester. The correlation between low immunity and increased carriage was substantiated by the mathematical model in Graph 5. In summary, there is no correlation between the amount of socialization and carrier status. Smoking and on campus living, may possibly contribute to susceptibility to meningococcal infections and increase in the number of asymptomatic carriers. The data demonstrated that stress and upper respiratory infections (categorized as “low immunity”) are directly related to increased meningococcal carriage. It is most likely that stress and viral infections result in lowered immune status, rendering the individuals more susceptible to *Neisseria Meningitidis* infections.

In view of the fact that a rigorous academic schedule can be very stressful for many students, it would be advisable for universities to provide information on meningococcal infection, and the benefits of vaccination. A tetravalent serogroup A/C/Y/W-135 polysaccharide vaccine is available in the United States. A polysaccharide vaccine for serogroup B is not available because serogroup B polysaccharide is poorly immunogenic in humans. Currently, development of non-polysaccharide-based vaccine is in progress (11). Immunization has been reported to be successful in controlling meningococcal infections in the military (12).

References:


