Epidemiological Insights and Statistical Analysis of a Recent Conjunctivitis Outbreak in Lahore, Pakistan

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This study presents a comprehensive epidemiological analysis of a recent outbreak of conjunctivitis, known as pink eye disease, in Lahore, Pakistan. Conjunctivitis is a highly contagious eye infection that poses a significant public health concern, particularly in social environments. The research focuses on understanding the prevalence and influencing factors of this ailment through a statistical analysis of patient data. The gender distribution among patients revealed a slightly higher prevalence among males (52.5%) as compared to females (47.5%). Young adults (age 18-25) comprised the highest affected group (89%), emphasizing the higher infection's prevalence among this demographic. Symptom analysis highlights moderate to severe manifestations as predominant, significantly impacting patients' daily routines. Males exhibit a higher severity, potentially associated with increased social engagement compared to females. Notably, the infection commonly affects both eyes (86%), and individuals with a history of prior eye infections demonstrate a reduced likelihood of contracting conjunctivitis (11%). The onset of symptoms is typically sudden (85%), with a gradual presentation in some cases (15%). Despite the contagious nature of the infection, its spread to family members' remains relatively limited (36.8%). Remarkably, although symptoms are severe, the duration of the infection is brief, with most patients recovering within 2-5 days, even without medical consultation. Moreover, the spatial distribution showed that redness and itchiness were very severe in location 1(latitude 31.4972, and longitude 74.2735) and severe in location 4 (latitude 31.508, and longitude 74.327). In conclusion, this study is the first to report on the rapid yet severe nature of a conjunctivitis outbreak in Lahore. Key trends, including gender disparities, previous eye infection history, sudden onset of symptoms, and limited familial transmission, have emerged. Understanding these dynamics is crucial for implementing targeted preventive measures and developing effective management strategies for this contagious eye infection. The findings contribute valuable epidemiological insights that can guide public health interventions in similar scenarios.

Keywords: Statistical Analysis; Epidemiology; Contagious Eye Infection; Disease Prevalent; Social Environments.

Introduction:

Many eye infections exposed in humans, such as glaucoma, retinal ischemia (damage of eye nerve tissues), and corneal diseases, are major reasons for blindness [1][2][3][4][5][6][7]. One of them is "Conjunctivitis", which is commonly known as "Pink Eye" infection. Conjunctivitis is a highly contagious disease and it spreads unusually [8]. It is commonly transmitted in areas with high social interaction, such as public spaces, classrooms, and hostels. It occurs due to inflammation of the conjunctiva, which protects the sclera (the white part of the eye), and can be caused by various factors, primarily viral, bacterial, or allergic reactions. Conjunctivitis can affect individuals of all age groups, with bacterial conjunctivitis being a common source of infection in children and adults due to contaminated practices and environmental factors. The most common symptoms noticed are itchiness, redness in the eye(s), discharge from the eyes, swelling of the eyelids, watery eyes, Photophobia (eyes may be more sensitive to light than usual), and pain level. These symptoms may manifest suddenly or gradually, significantly disrupting normal daily activities. Discharge from the eye can vary depending on the type of Conjunctivitis [9][10]. In bacterial conjunctivitis, the color of discharge is yellow or greenish which can cause the eyelid to stick together after sleeping. In viral conjunctivitis, the discharge from the eye is typically clear and watery but may include light-yellow mucus [11][12].

The findings of our study have significant implications for public health strategies and patient care. Understanding the demographics, transmission patterns, and symptomatology specific to Lahore can aid in developing targeted preventive measures, such as focused awareness campaigns for young adults and males who are at higher risk. Moreover, recognizing the limited familial transmission can help in optimizing isolation guidelines. The rapid yet severe nature of the outbreak highlighted by our study suggests the need for prompt treatment protocols and efficient healthcare responses to manage symptoms and prevent widespread transmission. Ultimately, these insights can guide local health authorities in formulating effective interventions and contribute to global knowledge on managing conjunctivitis outbreaks.

Literature Review:

Previous studies have highlighted the global prevalence and impact of conjunctivitis, with significant outbreaks reported in various geographical regions such as the United States, India, and China. These studies have provided valuable insights into the epidemiology, transmission patterns, and demographic factors associated with conjunctivitis. However, there remains a gap in literature specific to Pakistan, and more importantly, to Lahore. This underscores the significance of our study as it addresses this gap and provides region-specific data that can inform public health interventions. 87 conjunctivitis outbreak reports from 49 countries from July 17, 2012, through July 2, 2017 [13]. Another study analyzed global adenovirus-associated conjunctivitis outbreaks from 1953 to 2013. It found that different types of adenoviruses were associated with specific patterns: [14]

• Epidemic Keratoconjunctivitis (EKC): Circulated predominantly in Asia during early winter and spring.

- **Acute Hemorrhagic Conjunctivitis (AHC):** It is prevalent in Asia.
- **Pharyngoconjunctival Fever (PCF):** Circulated mainly in China, Australia, and the United States during the summer.

As of epidemiological week (EW) 23 of 2017, five countries and territories of the Americas have reported outbreaks of conjunctivitis: Bahamas, Brazil, the Dominican Republic, Guadeloupe, and Martinique [15]. In India, over 38,000 cases of conjunctivitis were reported in Himachal Pradesh in August, according to the state's Health Department [16]. Over the last decade, there has been an increasing incidence of conjunctivitis epidemics globally, with experts citing higher incidences in Latin America, central sub-Saharan Africa, and southern

Latin America [17]. Recent reports indicate increased cases of conjunctivitis in Vietnam, India, and Pakistan. In Vietnam, Ho Chi Minh City and Hanoi have seen rising cases, posing a risk of an epidemic. Similar trends may be observed in other regions [18].

Acute conjunctivitis can be caused by bacteria, allergies, viruses, or parasites, approximately 80% of cases of acute conjunctivitis are caused by viruses.[19] The higher prevalence of allergic conjunctivitis in the study is probably because of its timing in the dry season (November to March) where there is usually dust and pollen in the air. [20] The recent outbreak of acute hemorrhagic conjunctivitis in Hyderabad, India, was attributed to the Coxsackievirus A24 strain GIV C5. This identification was based on the presence of enterovirus in 16.36% of samples and subsequent phylogenetic analysis of the VP2 gene [21]. Further genetic analysis of CVA24v strains from multiple outbreaks in China (1988, 1994, 2007) revealed significant variations, including nucleotide deletions and amino acid changes, showcasing the virus's rapid evolution and its impact on outbreak intensity. The study highlighted the virus's rapid evolution rate (7.45×10^{-3} substitutions/site/year) [22].

Additionally, the 2023 acute hemorrhagic conjunctivitis outbreak in India was linked to CVA24v strains with two novel mutations, T213C, and C475T, in the 5' UTR, potentially enhancing the virus's transmissibility. These mutations, not previously described in CVA24v but known to increase virulence in other enteroviruses, highlight the need for further research to develop effective antiviral therapies [23]. During the COVID-19 Delta surge, human adenovirus D (HAdV-D) emerged as the most common pathogen linked to infectious conjunctivitis in India, underscoring the need for robust seasonal surveillance to detect emerging pathogens [24].

The epidemiological trends of AHC (acute hemorrhagic conjunctivitis) in mainland China showed stability in post-2010, with increased incidence in low- and middle-income provinces and higher rates among children aged 0-3 years, emphasizing the need for targeted public health interventions based on demographic and environmental factors [25]. The first genetic characterization of CV-A24v isolates from the 2017 AHC outbreak in southeastern Mexico further expanded our understanding, revealing a novel clade related to genotype IV and a unique mutational pattern, aligning with strains from French Guiana and Uganda. This highlights the importance of continuous genetic monitoring to comprehend the diversity and evolution of CV-A24v, thereby enhancing our strategies for managing and mitigating future outbreaks [26].

To understand and manage the spread of conjunctivitis, a study employing a fractional-order stochastic epidemic model that incorporates media awareness was developed, revealing the significant role of public awareness in outbreak control and the necessity for targeted communication strategies in public health policy [27]. Moreover, forecasting models that integrate environmental data have been shown to offer superior density forecasts for conjunctivitis, linking factors such as SO2, O3 surface concentration, and precipitation to higher attendance rates, thus aiding in outbreak preparation and healthcare planning [28]. In the realm of technology, iConDet2 has emerged as a significant advancement for the early screening of conjunctivitis, offering higher accuracy and faster diagnosis than its predecessor, which is crucial for early detection and differentiation, including its association with COVID-19 [29].

State policies on managing conjunctivitis in school-age students vary widely, with many lacking comprehensive guidelines, thus highlighting the need for uniform policies referencing credible sources like the CDCP (Centers for Disease Control and Prevention) to enhance public health outcomes [30]. The findings of this study align with previous global research on conjunctivitis, reinforcing the established patterns of transmission and symptomatology. The high exposure among young adults and the higher infection rates in densely populated areas in Lahore reflect trends noted in outbreaks in Vietnam, where cities like Ho Chi Minh City and

Hanoi have reported rising cases, and India, where over 38,000 cases were recorded in Himachal Pradesh in August 2023.

The seasonal patterns observed in this study, conducted in August and September, are notable. While previous studies in Asia have reported higher prevalence during the dry season (November to March), the findings from Lahore suggest that environmental factors other than seasonal dryness, such as increased dust or pollen during these months, may also play a significant role in the incidence of conjunctivitis. This aligns with observations from other regions where environmental conditions significantly influence outbreak severity.

The geographic specificity of severe symptoms in areas like Iqbal Town and Garden Town could be attributed to local environmental factors, similar to observations made in studies from China and the United States, where environmental conditions like air quality and population density influenced outbreak severity. These patterns highlight the necessity of considering local environmental conditions in understanding and managing conjunctivitis outbreaks. Furthermore, the reduced transmission within families, despite the contagious nature of conjunctivitis, is an important finding that aligns with the concept of diverse individual immunity and controlled transmission dynamics noted in previous studies.

Objectives:

The study aims to evaluate the prevalence and demographic distribution of conjunctivitis during the outbreak in Lahore, Pakistan, concentrating on the most affected groups. It assesses symptom severity, the impact on daily routines, mutual infection rates, and the influence of previous history of eye infections. Additionally, the research examines the onset trends of symptoms, familial transmission rates, and recovery duration. The findings give valuable understanding to enlighten the targeted public health interventions and effective management strategies for controlling conjunctivitis outbreaks.

The study is limited by the fact that data was randomly collected from a limited number of patients, which may indirectly represent the entire population of Lahore. Additionally, the study focused on epidemiological aspects without identifying specific etiological agents, which could provide a more comprehensive understanding of the outbreak. Future research should aim to include a larger and more diverse sample size, incorporate molecular analyses to determine relevant pathogens, and explore the long-term effects of conjunctivitis outbreaks on public health. These areas of future research will further enhance our understanding and management of conjunctivitis outbreaks. To the best of our knowledge, this is one of the initial works done for the recent outbreak of the disease that occurred in August 2023 in Lahore In the next sections of this study, we will discuss the materials and methods used for the analysis and the results we obtained from the data analysis.

Material and Methods:

The data of 200 volunteer subjects (patients) affected by Pink Eye infection is acquired by conducting a survey, including diverse age and gender groups. The authors acquired the data by conducting a survey, which was prepared and administered under ethical approval. The survey form included a section for patients to indicate the severity of their symptoms using a scale from 1 to 5, where:

- 1 represents very mild,
- 2 represents mild,
- 3 represents moderate,
- 4 represents severe, and
- 5 represents very severe.

This scale allowed us to quantify the severity of symptoms as reported by patients. For this study, we focused exclusively on patients who reported severe symptoms (levels 4 or 5). Additionally, the survey included a question regarding the number of family members affected

by the infection. This enabled us to collect data on the familial impact of the outbreak, providing insights into the spread of conjunctivitis within households.

The survey included a form in which different questions related to Pink Eye infection were asked of the patients. The gender-wise distribution of data is shown in Figure 1, with males (102 subjects) accounting for 52.5% and females (98 subjects) accounting for 47.5%. We divided the data into 3 categories, teenagers (less than 18), young adults (18-25), and adults (greater than 25). The distribution of disease among various age groups is shown in Figure 2.

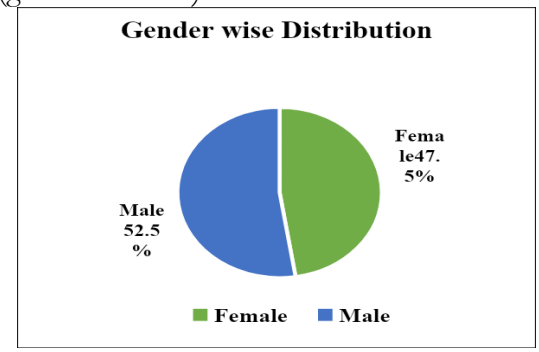

Figure 1: Gender-wise Distribution of subjects.

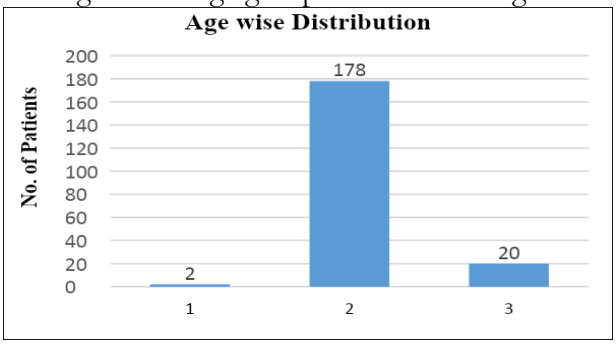

Figure 2: Age-wise Distribution of subjects.

A statistical analysis was conducted for each symptom to evaluate its severity level (very mild, mild, moderate, severe, and very severe). We assessed the data to examine the number of family members of subjects affected by this infection and also reported the onset duration of the symptoms. Our analysis focused on patients who believed that they got the infection without any volunteer contact with infected individuals. The detailed flow of our research methodology is presented in Figure 3. The following information is also analyzed:

- Effected Eyes (Left, right, or both)
- The onset of symptoms (Sudden or Gradual)
- Any previous eye infection history?

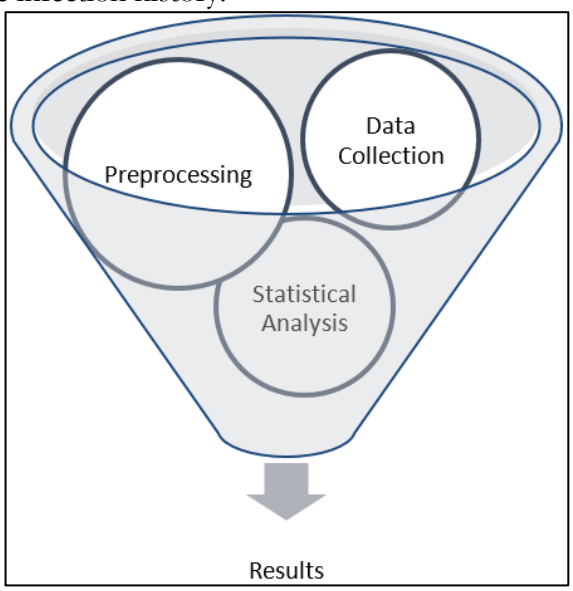

Figure 3: The Flow chart of Research Methodology

Result and Discussion:

Before investigating the findings and implications of this study, it is necessary to recognize the growing significance of conjunctivitis, commonly referred to as 'Pink Eye,' within social environments. A moderate growth rate of conjunctivitis infection has been observed in Lahore in August and September 2023. By September 2023, Punjab had reported

a total of 86,133 cases of pink eye [31]. Given its contagious nature and potential impact on daily life, understanding the demographic patterns and symptomatology of this infection is essential for effective management and preventive strategies. This investigation focuses on analyzing the statistical data concerning to recent outbreak of the disease in Lahore, aiming to provide insights into the occurrence, symptom severity, affected demographics, and the infection's public or familial transmission. By explaining these factors, we aim to contribute to a comprehensive understanding of this infection and its consequences within the studied population.

Symptom Analysis:

Pink eye infections exhibit several symptoms including redness, itchiness, swelling of the eyes, and watery eyes. The mildness and severity level of each symptom are shown in Figure 4. The graph shows that the maximum number of patients lie in the category of moderate and severe levels, with only a small number reporting very mild or very severe symptoms. The Graph demonstrates that the most prevalent symptoms are itchiness, Redness, and Watery Eyes.

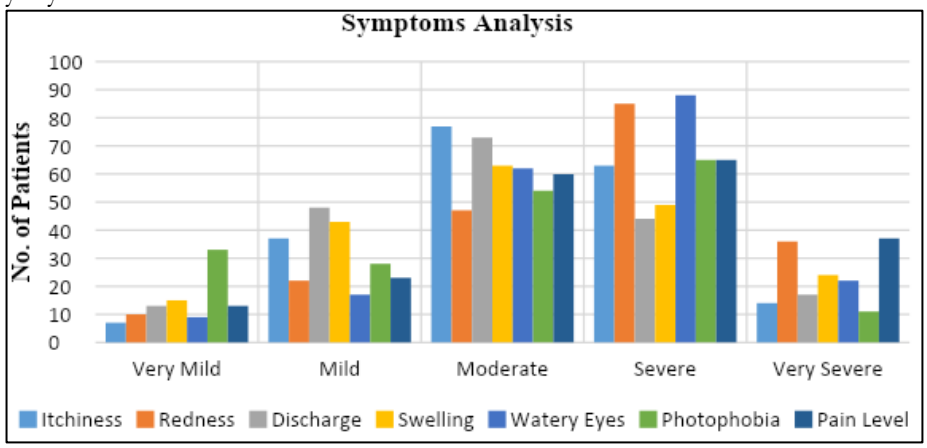

Figure 4: Each Symptom's Mildness and Severity Level.

Severity by Gender-Wise:

The gender-wise distribution of data for each symptom severity level is shown in Figure 5. The analysis of data indicates a higher impact of infection on male subjects. The observation is influenced by the bias in the dataset due to its limited availability. The data suggests that one intuitive reason for this observation could be the significantly higher social engagement of males compared to females as shown in Figure 4.

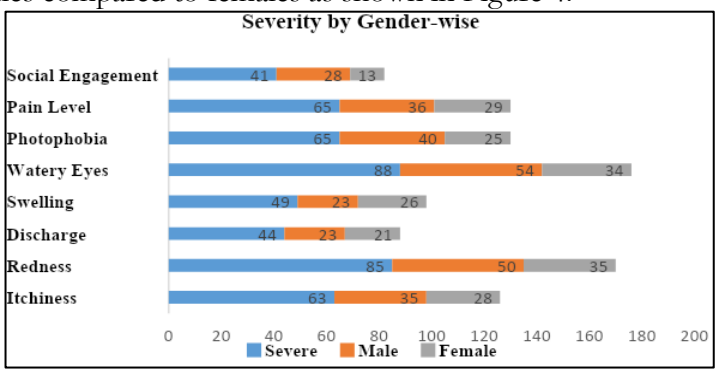

Figure 5: Severity of Symptoms Gender-Wise.

Effected Eye(s):

Conjunctivitis is a condition that can affect one or both eyes. Typically, the infection starts in one eye (either the left or right) and gradually spreads to the other eye. The data of affected eyes (Left, Right, or both) of patients is collected to analyze this behavior. According to the analysis, 12.5% of patients had the infection in the left eye, 12.5% in the right eye, and

75% had both eyes affected, as shown in Figure 6. The graphical analysis reported that most patients have both eyes affected.

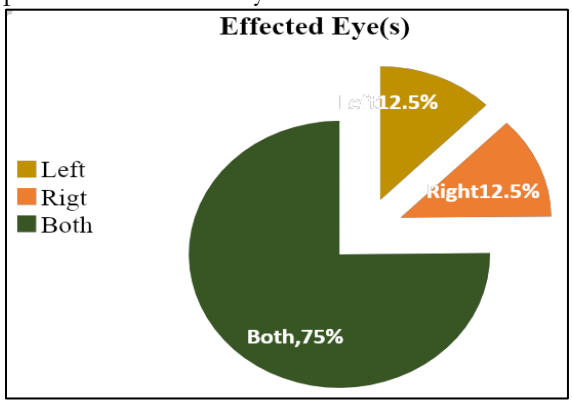

Figure 6: The distribution of affected eyes (left, right or both).

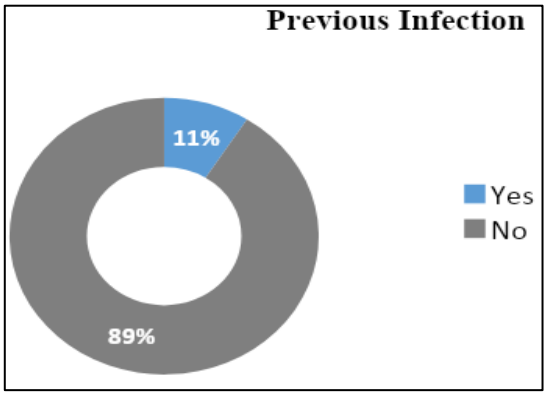

Figure 7: Previous eye infection percentage of patients in comparison to the patients having no medical history related to eye infection.

Previous Eye Infection History:

A pertaining question arises, "Can a patient get the infection a second time in life?" While it is challenging to definitively say "yes," it is generally uncommon. Some individuals may have a medical history related to a specific disease, rendering their bodies already immune to that disease. This immunity can be acquired naturally, through vaccines (active immunity) or by injecting antibodies (passive immunity) [32][33][34]. It is commonly believed that the likelihood of contracting the same disease again is lower in such patients. According to data, only 11% of patients had a previous eye infection and subsequently contracted conjunctivitis again. The percentage of subjects having (or not having) a previous eye infection history is shown in Figure 7.

Onset of Symptoms:

The symptoms in most of the patients appeared suddenly, with many reporting the onset of symptoms after they woke up in the morning. However, some of the patients reported that the symptoms appeared gradually. Firstly, there is a watering in the eye and then gradually they observed redness and itchiness in the eye. Similarly, they observed other symptoms after one another. The percentage of onset of symptoms is shown in Figure 8. There are only 15% of patients in which symptoms appeared gradually.

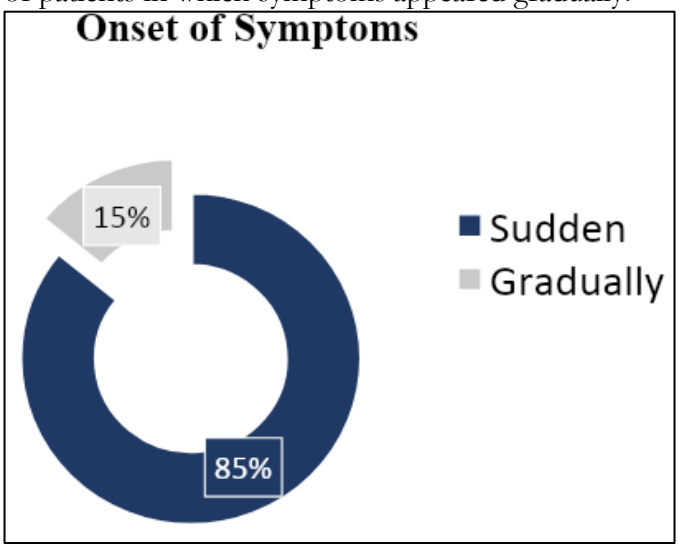

Figure 8: Gradual and Sudden appearance of symptoms

Duration of Symptoms:

The symptoms remain severe in patients as shown in Figure 3, but the duration of symptoms was limited and diverse. The patients recovered in 2-5 days as shown in Figure 9. This indicates the rapid recovery. Although half of the patients did not consult doctors, they recovered in a short period.

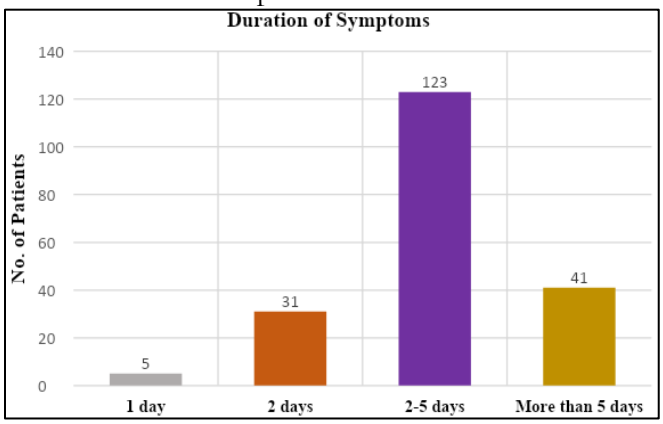

Figure 9: The duration of symptoms with the patient's population.

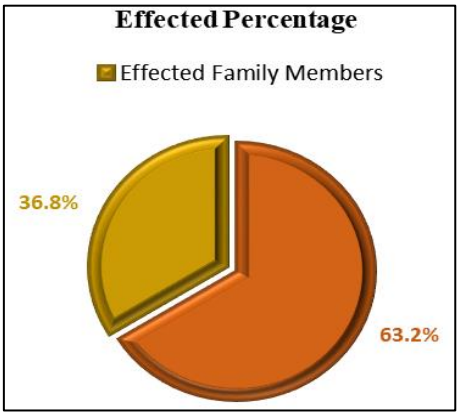

Figure 10: Percentage of affected and unaffected family members

Affected Family Members:

This is a contagious disease that typically spreads by contact. We acquired data from 200 subjects to analyze its transmission within homes. Each recorded subject was queried about the total household members and those impacted. As per the data provided by participants, there were a total of 1416 family members, with 521 (36.8%) reported as affected. The result shows that fewer family members were affected by this infection as shown in Figure 10.

This study explores the recent developments of the conjunctivitis outbreak in Lahore, Pakistan, offering critical epidemiological insights through a focused statistical examination of patient data. The research identifies key demographic patterns, symptom dynamics, and recovery rates, providing a comprehensive understanding of the disease's impact.

Spatial Distributions of Infection Symptom

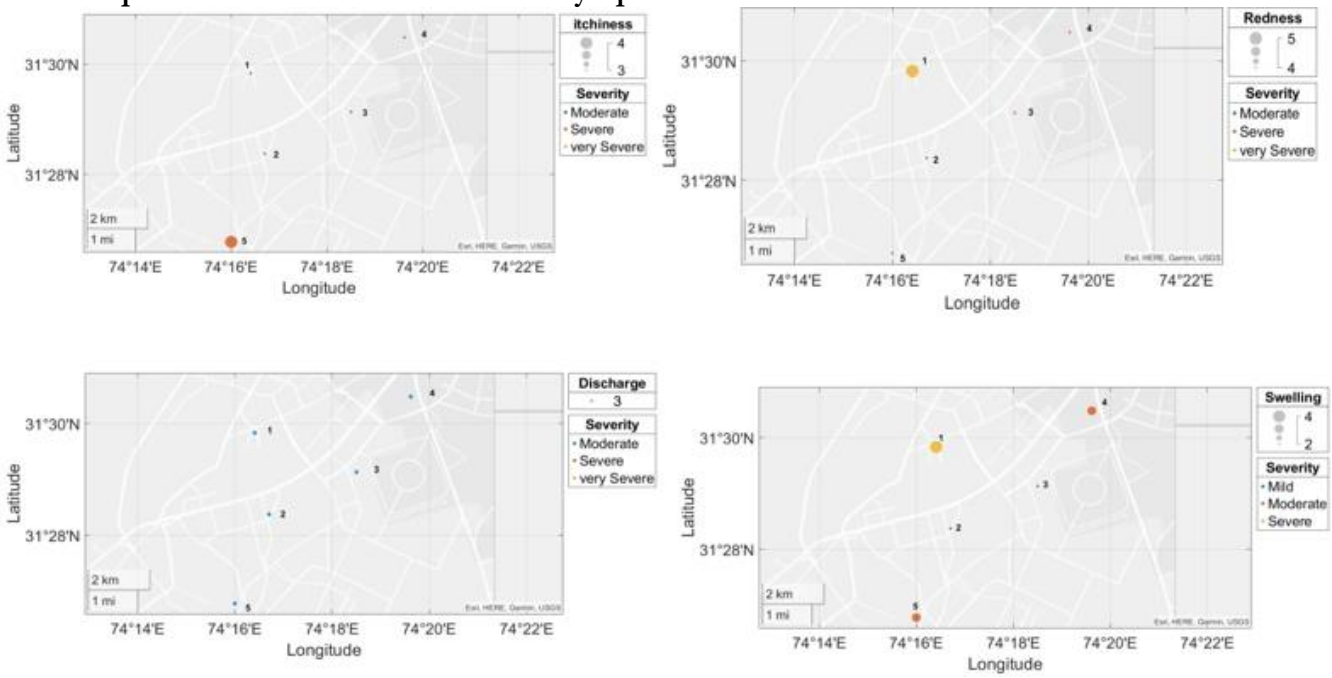

Figure 11: Symptoms distributions across the study site in Lahore.

The study also focused on 5 different locations (towns) within Lahore, as illustrated in Figure 11, with specific details about their locations (latitude and longitude) provided in Table 1. To design an effective and manageable survey near Punjab University, five towns Iqbal Town, Johar Town, Faisal Town, Garden Town, and Wapda Town were randomly selected in their area. Figure 11 presents a spatial analysis of symptoms of pink eye infection for five distinct towns of Lahore. The different colors of the circles in Figure 11. depict the specific symptoms of infection. Notably, the size of the circles represents the severity level of that symptom. Symptoms were selected as an example to illustrate the spatial distribution of the infection, showing that redness and itchiness are very severe in Iqbal Town and severe in Garden Town.

Table 1: List of Towns of Lahore's Location with Latitude and Longitude.

Towns	LAT	LON
Iqbal town	31.4972	74.2735
Johar town	31.4729	74.2784
Faisal town	31.4855	74.3084
Garden town	31.508	74.327
Wapda town	31.4463	74.2667

Conclusion:

The investigation into conjunctivitis in Lahore, Pakistan, revealed insight into the infection's patterns and impacts. The prevalence of the contagious eye disease, commonly known as "Pink Eye," showcased distinct trends among different demographics. Notably, the study highlighted a higher exposure among young adults (89%). The severity of symptoms, particularly in males is linked with higher social engagement. This potentially contributes to a greater infection rate among this group. The involvement of both eyes in Conjunctivitis emphasizes the infection's ability to affect both eyes in the majority of cases as 75% of patients got both eyes affected by infection. Individuals with a history of previous eye infections exhibited a reduced vulnerability, suggesting potential immune responses against conjunctivitis. There are only 11% of such patients who got the pink eye infection again. The sudden onset of symptoms (85%) highlighted the infection's instant manifestation. However, the infection's constrained spread within families (36.8%) indicated controlled transmission despite its contagious nature or diverse individual immunity. Notably, the infection's duration remained short, with most patients experiencing recovery within 2-5 days, regardless of medical consultation.

In summary, this comprehensive study offers valuable insights into the spread of conjunctivitis in Lahore, highlighting symptoms' severity, transmission dynamics, and the infection's transient nature. Moreover, the spatial distribution showed that redness and itchiness were very severe in Iqbal Town and severe in Garden Town. This is the first research work that has been done for a recent outbreak of the disease in Lahore. These findings provide an essential foundation for preventive measures and healthcare strategies, which could ultimately contribute to better management and control of this prevalent eye infection. The alignment of our results with global patterns underscores the importance of local studies in contributing to the broader understanding of conjunctivitis epidemiology. This cross-verification enhances the reliability of our findings and underscores their relevance in the global context of conjunctivitis research.

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Author's Contribution: The concept of the study is provided by MB; All the authors contributed equally to this paper.

Conflict of Interest: There exists no conflict of interest for publishing this manuscript in IJIST.

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