Seasonal Trends and Epidemiological Characteristics of COVID-19 in Mexico City Primary Care Facilities: A Descriptive Study.

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ABSTRACT

Aims: To determine Seasonal Trends and Epidemiological Characteristics on COVID-19 at a Primary Care Setting, in Mexico City.
Study design: A descriptive and cross-sectional study was conducted.
Place and Duration of Study: Ambulatory Care Medical Unit. The study was conducted from July 1st to November 30th, 2024, with Mexican patients attending the Family Medicine Speciality outpatient consultation at the Family Medicine Clinic "División del Norte", in Mexico City, from January 1st, 2022 to December 31st, 2022.
Methodology: Data on health and sociodemographic variables were collected through a retrospective design, using the SIMEF system.
Results: We included 2,847 patients with COVID-19 (ICD-10 code U07.1), of a total of 17,918 persons, mainly females (n=1,868; 65.6%, CI95% 64.0-67.4). COVID-19 activity displayed seasonal patterns, with primary peaks occurring in winter and summer. The overall prevalence of COVID-19 was 15.9% (CI95% 13.3-16.4). However, the prevalence of COVID-19 varies significantly (p<0.001) across the major age groups: among children, it was higher (6.8%; CI95% 5.1-8.6) compared to adolescents (3.8%; CI95% 2.6-5.1) and elderly population (5.6%; CI95% 5.1-6.1). The mature adult population had the highest prevalence of COVID-19 (26.6%; CI95% 25.7-27.4). Similarly, the comorbidities in patients with COVID-19 vary significantly across major age groups. Among children, the most prevalent comorbidities are exclusively respiratory diseases (acute nasopharyngitis=17.54%, allergic rhinitis=14.03%). In adolescents there is a more diverse range of comorbidities (myopia=8.82%, gastroenteritis and colitis of unspecified origin=2.94%). In mature adults (acute pharyngitis; AP=9.65%, hypertension=8.11%, and type 2 diabetes; T2D=6.96%) and elderly (hypertension=25.84%, T2D=19.08%, and AP=8.45%), the top three diseases are the same but differ in order.

Conclusion: The analysis of COVID-19 patients in the primary care level provides an overview of seasonal trends and epidemiological characteristics, identifying key areas for development interventions. The high incidence of respiratory infections in children underscores the need for targeted public health policies. Strengthening epidemiological surveillance and implementing age—and gender-specific prevention strategies are essential to effectively addressing seasonal patterns.

Keywords: Communicable diseases; COVID-19; epidemiological profile; non-communicable diseases; primary care; seasonal variation.

1. INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a proinflammatory, and highly contagious infectious disease caused by severe acute respiratory syndrome, coronavirus 2 (SARS-CoV-2) [1-4]. Since the peak of the COVID-19 pandemic, the infectivity and mortality rates associated with SARS-CoV-2 have declined [5]. COVID-19 transmission occurs continuously throughout the year [6]. However, seasonal peaks are observed, along with increases in hospitalization and mortality rates, during the traditional winter season for viral respiratory infections, in the United States and Europe [6]. Many respiratory virus illnesses show distinct seasonal patterns and result in waves during the winter months due to environmental conditions and human behaviours [6]. COVID-19 activity tends to fluctuate with the seasons, which meaning it has some seasonal patterns. It has peaks in the winter and also at other times of the year, including the summer [6-7]. COVID-19 activity shows seasonal patterns, with peaks occurring in both winter and summer [6-7]. The highest winter peaks are typically seen in December and January, while summer peaks are most common in July and August [7]. Despite these patterns, SARS-CoV-2 is not a typical "winter" respiratory virus due to the unpredictable emergence of new variants [7]. Data on COVID-19 cases, hospitalisations, and deaths highlight these seasonal fluctuations, underscoring its unique behaviour compared to other respiratory viruses. Moreover, there is still discussion about whether SARS-CoV-2 currently follows, or will follow in the future, similar seasonal patterns to other respiratory viruses, such as influenza and respiratory syncytial virus [7-10]. Compounding this uncertainty, it is the continued emergence of new SARS-CoV-2 variants, such as KP.2, KP.3, and LB.1, which pose a persistent risk to public health [1]. Understanding the seasonal trends of COVID-19 peaks is crucial for optimising public health strategies and recommendations [7]. This knowledge supports improved healthcare system preparedness and more efficient resource allocation [7]. It remains unclear whether SARS-CoV-2 will eventually become a seasonal virus or continue circulating year-round. This uncertainty highlights the importance of conducting research into the seasonality of COVID-19. Such studies are essential for understanding the virus's transmission patterns, predicting potential surges, and improving public health preparedness. Insights into seasonality can also inform vaccination strategies, optimise resource allocation, and strengthen the overall response to future outbreaks. Despite global studies on COVID-19's seasonality, there is limited data on its seasonal trends and epidemiological characteristics in Mexico City. This study addresses this gap by analysing COVID-19 trends and patterns in a primary care facility across Mexico City. The findings will contribute to a better understanding of how SARS-CoV-2 behaves in this unique setting, supporting more effective public health planning and interventions. [11]

1.1 The Aim of the Study.

To determine Seasonal Trends and Epidemiological Characteristics on COVID-19 at a Primary Care Setting, in Mexico City.

2. MATERIAL AND METHODS

2.1 Study design and settings.

A descriptive, cross-sectional study was designed and conducted with Mexican patients attending outpatient consultations in the Family Medicine Specialty and General Medicine departments at the "División del Norte" FMC, ISSSTE, in Mexico City. The aim of the study was to determine Seasonal Trends of COVID-19 patients across all population groups in a Primary Care Setting, in Mexico City. The data collection followed a retrospective approach and was sourced from secondary data, from January 2022 to December 2022. The SIMEF system (Sistema de Información Médico Financiero by its acronym in Spanish) was used to gather sociodemographic variables (such as age, sex, outpatient consultations data) and comorbidities. The study was conducted from July 1sall t to November 30st, 2024.

2.2 Study Population, Data Collection and Instruments.

The study population included all subjects with COVID-19 (U07.1 ICD-10, n=2,847, of a total of 17,918 persons) attending outpatient consultations from new-borns to elderly population (both sexes). It is important to note that studies encompassing the entire population, as in this case, do not require selection criteria. The data was collected through the "SIMEF" records.

Initially, the patients were identified by using this system. Thenceforward, a data collection sheet was employed to gather detailed information (patient name, medical record number, date of birth, address, date of outpatient consultations) and sociodemographic factors (sex and age). The working tools included Excel files generated by the system monthly. The collected data was stored in an Excel workbook, which served as the statistical database for subsequent analysis. This procedure ensured the accuracy, quality, and reliability of the extracted data, supporting the integrity of our study's findings.

2.3 Statistical analysis.

The study analysed all COVID-19 cases reported in the FMC "División del Norte", ISSSTE (a primary care facility across Mexico City), ensuring a comprehensive dataset without filtering or excluding particular groups. This approach aligns with the study's objective to assess seasonal trends and epidemiological characteristics across the entire population. The categorical variables are described as absolute frequency and percentage, and quantitative variables as mean, standard deviation (SD), and interquartile range (IQR). Confidence Interval 95% (CI95%) was included. Categorical variables were compared using Yates' corrected chi-square (X^2) test and likelihood ratio, as appropriate. Quantitative variables were compared using the Mann-Whitney U test or Student's T test as appropriate. A P value < 0.05 (two-tailed test) was considered significant.

2.4 Ethical Considerations.

The study was conducted in accordance with the Good Clinical Practice Guidelines of our laws and the Declaration of Helsinki for human experiments. The protocol was approved by two committees: The Research Committee and the Ethics Committee in Research of the FMC "División del Norte", ISSSTE. The Data was treated confidentially. Since this study utilized a secondary database, authorization was obtained from the relevant committees to ensure proper handling of the information in compliance with ethical guidelines. To guarantee confidentiality, only the principal investigators had access to the complete dataset, including identifiable patient information (e.g., names). The patient names were replaced with unique identification numbers. The assigned number allows the data to be linked to a specific individual without revealing the individual's identity. This approach ensured that all patient data were handled under ethical standards and maintained the highest level of confidentiality throughout the study. This anonymization was conducted before sharing the dataset for statistical analysis with some researchers. After the statistical analysis, only the processed statistical data were made available to the rest of the research team.

3. RESULTS AND DISCUSSION.

3.1 Characteristics of the study population.

We included 2,847 patients with COVID-19 (ICD-10 code U07.1), of which 1,868 are females (65.6%, CI95% 64.0-67.4) and 979 are males (34.4%, CI95% 32.6-36.0). The average age was 45.90 years old (SD=13.505, range=100, minimum age=0 [new-borns], maximum age=100 years old, median age=47 [IQR=37-55]) years old. Similarly, to the total study population, the average age of the COVID-19 patients (males 45.28 years old, SD=14.971 vs. females 46.22 years old, SD =12.661) was similar (p= 0.106, using U Mann-Whitney test). However, the median age was higher in female patients (47.00 years old, IQR=38-55, range=100 years old, minimum age=0 [new-borns] years old, maximum age=100 years old) compared to male patients (46.00 years old, IQR=36-55, range=93 years old, minimum age=1-year-old, maximum age=94 years old; p=0.001, Median Test between independent groups). In addition, the average number of diseases was 3.15 (SD=3.106) and the median number of diseases was 2 (IQR=1-4).

3.2 Seasonally trend for cases of COVID-19.

In our population study, COVID-19 activity displayed seasonal patterns, with primary peaks occurring in winter (particularly in January) and summer (mainly in June and July). Furthermore, this seasonal trend was consistent for both males and females (Figure 1).

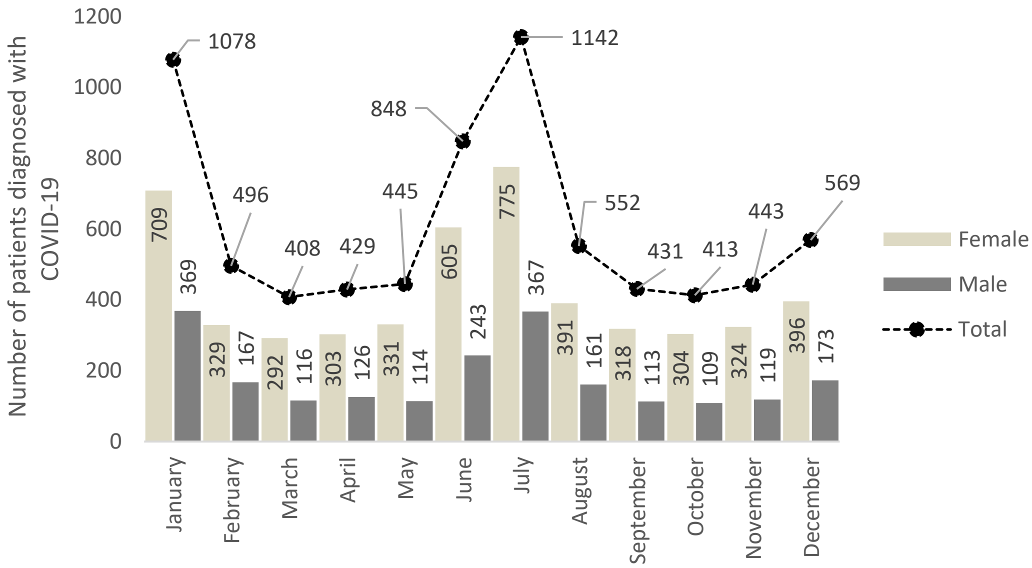

Fig. 1. Seasonal pattern of COVID-19 activity in the total population study.

Source: Prepared by the authors using data from the Medical Financial System (SIMEF) in 2022.

For children aged 0 to 9 years old, the seasonal pattern differed from the overall population study. Among girls, three distinct peaks were observed in winter (essentially in January), summer (predominantly in June), and autumn (mostly in November), whereas for boys, the main peaks occurred in winter (also in January), spring (chiefly in April), summer and autumn (Figure 2).

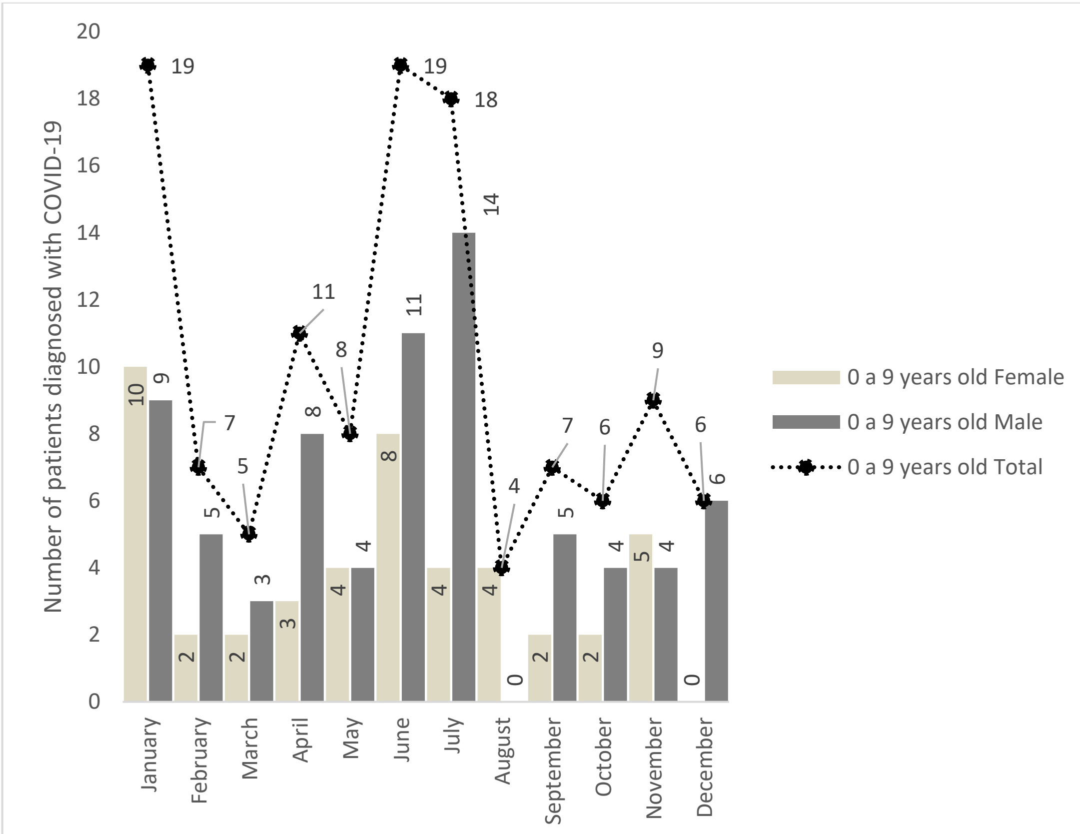

Fig. 2. Seasonal pattern of COVID-19 activity in the children population aged 0 to 9 years.

Source: Prepared by the authors using data from the Medical Financial System (SIMEF) in 2022.

Among the adolescent population, the seasonal trend in female adolescents mirrors that pattern of the total population, with peaks in winter (preponderantly in January) and summer (primarily in June). However, in male adolescents, two dissimilar peaks were observed in spring (principally in March and April). Additionally, two similar peaks to those in the total population were identified in summer (predominantly in June and July). (Figure 3).

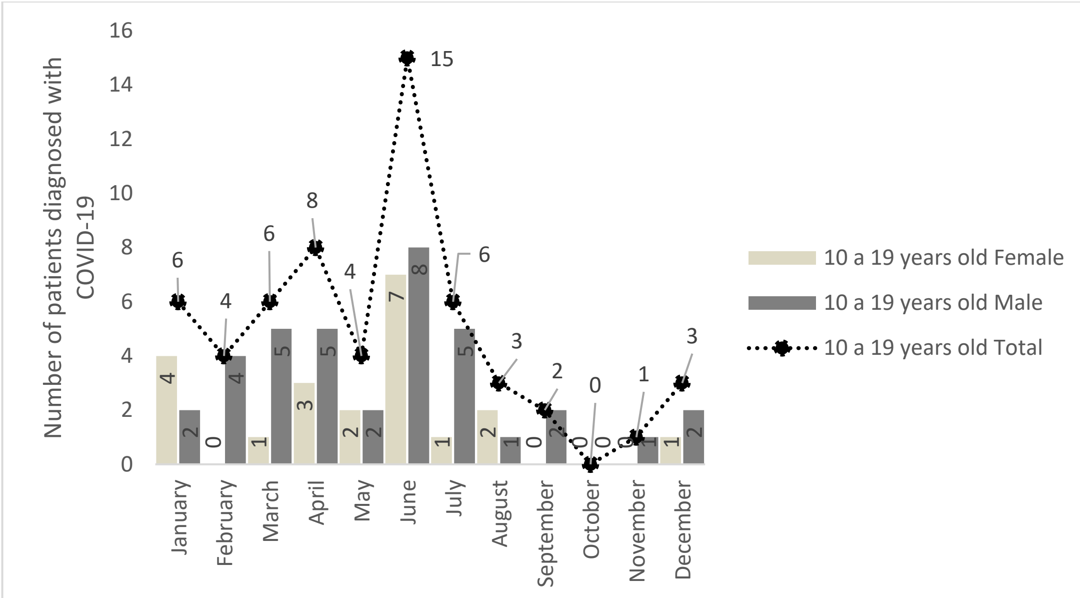

Fig. 3. Seasonal pattern of COVID-19 activity in the adolescent population aged 10 to 19 years.

Source: Prepared by the authors using data from the Medical Financial System (SIMEF) in 2022.

In adult population (mature and elderly), a similar seasonal trend was observed in both sexes, characterized by four peaks: one in winter (markedly in January), two in summer (especially in June and July), and one in autumn (notably in December) (Figures 4 and 5, respectively).

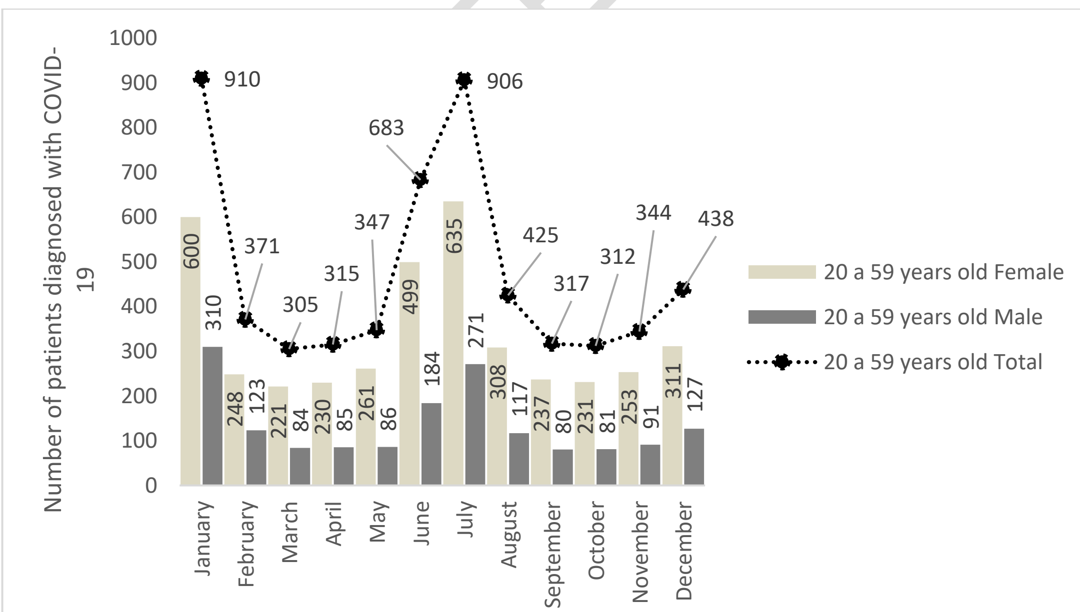

Fig. 4. Seasonal pattern of COVID-19 activity in the adult mature population aged 20 to 59 years.

Source: Prepared by the authors using data from the Medical Financial System (SIMEF) in 2022.

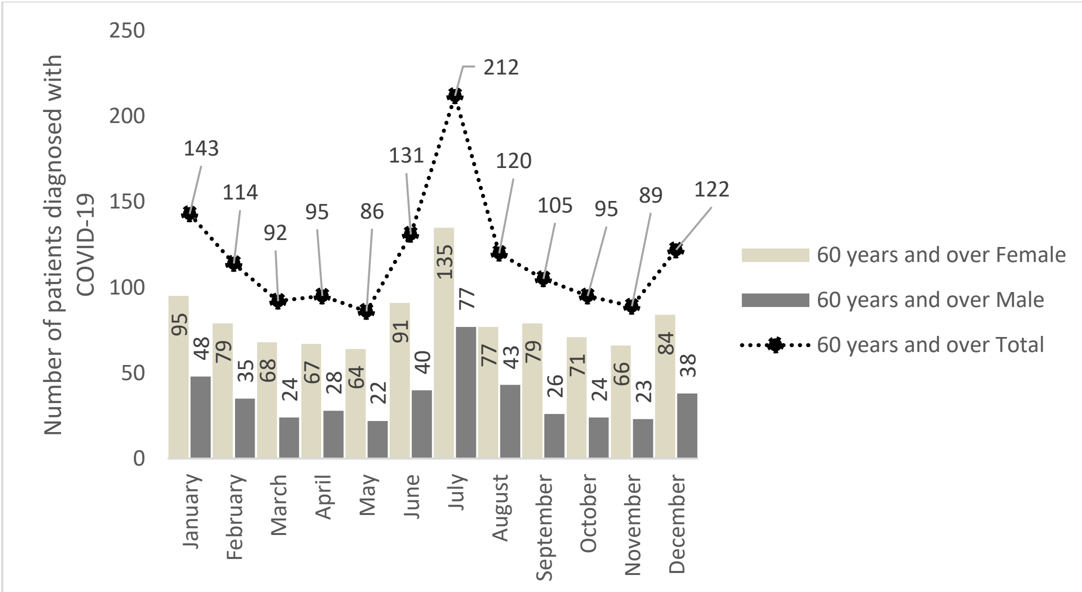

Fig. 5. Seasonal pattern of COVID-19 activity in the elderly population aged 60 and over years.

Source: Prepared by the authors using data from the Medical Financial System (SIMEF) in 2022.

3.3 Epidemiological Profile of COVID-19 in Patients Treated at a Primary Care Unit.

The overall prevalence of COVID-19 in our population study was 15.9% (CI95% 13.3-16.4). Meanwhile, the prevalence among female patients (16.5%; CI95% 15.8-17.2) was significantly higher compared to male patients (14.8%; CI95% 13.4-15.7; p=0.0017). However, the prevalence of COVID-19 varies significantly (p<0.001) across the major age groups. Among children, the prevalence of COVID-19 was higher (6.8%; CI95% 5.1-8.6) compared to adolescents (3.8%; CI95% 2.6-5.1) and elderly population (5.6%; CI95% 5.1-6.1). Finally, the mature adult population had the highest prevalence of COVID-19 (26.6%; CI95% 25.7-27.4).

3.3 Comorbidities in patients with COVID-19.

The five main causes of non-communicable chronic diseases were: hypertension, acute pharyngitis, type 2 diabetes (T2D), obesity (due to excess calories), and gastroenteritis and colitis of unspecified origin. Regarding to comorbidities observed in COVID-19 population, the highest prevalence was hypertension (table 1).

Table 1. Prevalence of the main non-communicable diseases and communicable diseases, in the total COVID-19 population, according to International Classification Diseases, revision 10th.

Code	Prevalence	Diagnosis
I10X	10.4	Essential (primary) hypertension.
J029	9.4	Acute pharyngitis, unspecified.
E119	8.5	Type 2 diabetes mellitus.
E660	5.8	Obesity due to excess of calories.
A099	5.2	Gastroenteritis and colitis of unspecified origin.
U072	4.5	COVID-19, virus not identified.
E669	4.2	Obesity, unspecified.
M545	3.8	Low back pain.

Z124	3.6	Special screening examination for neoplasm of cervix.
E785	3.5	Hyperlipidaemia, unspecified.
N390	3.5	Urinary tract infection, not specified site.
E039	3.4	Hypothyroidism, unspecified.
J00X	3.1	Acute nasopharyngitis [common cold].
J039	2.5	Acute tonsillitis, unspecified.
R730	2.2	Abnormal glucose tolerance test.
U099	2.1	post–COVID-19 condition, unspecified.
I872	2.0	Venous insufficiency (chronic)(peripheral).
E782	1.9	Mixed hyperlipidaemia.
K589	1.9	Irritable bowel syndrome without diarrhoea
F419	1.9	Anxiety disorder, unspecified

Source: Prepared by the authors using data from the Medical Financial System (SIMEF) in 2022.

Regarding to the prevalence of the found NCDs, by sex, we can observe that the first three diseases are hypertension, T2D and obesity in both sexes, but the prevalence of hypothyroidism is significantly higher in females compared to males (females 4.7% vs. males 2.1%; p<0.001) (table 2). However, the prevalence of hypertension and T2D is higher in males (without a statistically significant difference), but the prevalence of obesity was higher in females. Finally, the prevalence of hyperlipidaemia is higher in males compared to females (males 3.8% vs. females 3.4%) (table 2).

Table 2. Comparison of the main non communicable diseases, per sex, in the COVID-19 population.

Females			Males		
Code	Prevalence	Diagnosis	Code	Prevalence	Diagnosis
I10X	10.0	Hypertension.	I10X	11.2	Hypertension.
E119	8.3	Type 2 diabetes.	E119	8.9	Type 2 diabetes.
E660	6.3	Obesity.	E660	4.8	Obesity.
E039*	4.7	Hypothyroidism.	E785	3.8	Hyperlipidaemia.
M545	4.3	Low back pain.	M545	2.9	Low back pain.

Source: Prepared by the authors using data from the Medical Financial System (SIMEF) in 2022. *p value <0.001. The comparison was with Chi-Square test.

Although we did not find a statistically significant difference between the first five more prevalent comorbidities, all observed CDs were higher in females than in males (Table 3). The most prevalent CD in COVID-19 population was acute pharyngitis for both sexes, but, the order of the prevalences were different by sex (table 3).

Table 3. Comparison of the main communicable diseases, per sex, in the COVID-19 population.

Females			Males		
Code	Prevalence	Diagnosis	Code	Prevalence	Diagnosis
J029	10.1	Acute pharyngitis.	J029	8.0	Acute pharyngitis.
A099	5.5	GCUO.	A099	4.7	GCUO.
N390*	4.6	UTI.	J00X	2.6	ANP [common cold].
J00X	3.4	ANP [common cold].	J039	2.1	Acute tonsillitis.
J039	2.7	Acute tonsillitis.	N390*	1.4	UTI.

Source: Prepared by the authors using data from the Medical Financial System (SIMEF) for the year 2022. *p value <0.001. The comparison was with Chi-Square test. GCUO= Gastroenteritis and colitis of unspecified origin. UTI= Urinary tract infection. ANP= Acute nasopharyngitis [common cold].

Regard to transmissible diseases the main illnesses are related to respiratory and gastrointestinal diseases, and the urinary tract.

The comorbidities in patients with COVID-19 vary significantly across major age groups. Among children, the five most prevalent comorbidities are exclusively respiratory diseases. In contrast, adolescents show a more diverse range of comorbidities, including blood and immune system disorders, gastrointestinal illnesses, metabolic conditions, and neurological diseases. Among mature adults and elderly, the top three diseases are the same but differ in order. The fourth and fifth diseases also differ: in elderly, they are primarily metabolic conditions, while in mature adults, they include both metabolic and gastrointestinal diseases (Table 4).

Table 4. Comparison of the Main Non-Communicable and Communicable Diseases in the COVID-19 Population, Categorised by Major Groups.

Infants	Adolescents	Mature adults	Elderly
J00X (17.54%)	H521 (8.82%)	J029 (9.65%)	I10X (25.84%)
J304 (14.03%)	A099 (2.94%)	I10X (8.11%)	E119 (19.08%)
J029 (10.53%)	D591 (2.94%)	E119 (6.96%)	J029 (8.45%)
J039 (7.02%)	E888 (2.94%)	E660 (5.76%)	E039 (7.73%)
J310 (7.02%)	G809 (2.94%)	A099 (5.21%)	E785 (7.49%)

Source: Prepared by the authors using data from the Medical Financial System (SIMEF) for the year 2022. J00X= acute nasopharyngitis [common cold], J304= allergic rhinitis, J029= acute pharyngitis, J039= acute tonsillitis, J310= chronic rhinitis, H521= myopia, A099= gastroenteritis and colitis of unspecified origin, D591= other autoimmune haemolytic anaemias, E888= other specified metabolic disorders, G809= cerebral palsy, unspecified, I10X= hypertension, E119= type 2 diabetes, E660= obesity (due to excess calories), E039= hypothyroidism, E785= hyperlipidaemia.

3.3 Discussion.

The findings of this study highlight key epidemiological and clinical characteristics of COVID-19 across different demographic groups, emphasizing variations in age, sex, and comorbidities.

3.3.1 Study Population Characteristics

The global impact of COVID-19 has continued to grow over time, reflecting the enduring challenge posed by the pandemic. In 2022, the virus caused over 650 million confirmed cases and 6.6 million deaths worldwide. [12] By September 15th, 2024, these figures increased sharply to over 776 million confirmed cases and more than seven million deaths globally. [13] This significant increase highlights the persistent spread and impact of the SARS-CoV-2, despite extensive vaccination campaigns, public health interventions, and global efforts to mitigate its effects. Regional data from 2022 illustrate the unequal burden of the pandemic. In Europe, this burden accounted for 41.3% of global cases (the highest proportion worldwide), followed by the Americas region with 28.4%. The Western Pacific region reported 15.9%, Southeast Asia 9.3%, the Eastern Mediterranean 3.6%, and Africa only 1.4%. [12] This geographic variation highlights the influence of different social determinants of health and underscores disparities in population density, healthcare capacity, and reporting practices, all of which likely affect case numbers and outcomes. Our study revealed a higher prevalence in females compared to males, with a median age of 47 years old (similar to another's studies in Mexico City). [11] This data differs from prior studies suggesting higher susceptibility among

Argentinian, Chinese, Mexican, and Spanish males in both ambulatory and hospital care settings. [14-19] The median age difference between sexes was statistically significant, with females being slightly older. These differences could reflect variations in health-seeking behaviour, underlying conditions, or exposure risks. On the other hand, Ukwishaka et al., reported a review and meta-analysis, where they analysed 52 researches conducted between 2019 and 2022, involving a total sample size of 3,623,655 patients, in order to evaluate the prevalence of COVID-19 reinfection. [12] The overall reinfection prevalence was estimated at 4.2%, though, significant heterogeneity was observed across studies and regions. Africa informed the highest prevalence at 4.7%, while Oceania and the Americas region had notably lower estimates of 0.3% and 1%, respectively. In Europe, the prevalence of reinfection was 1.2% and in Asia, 3.8%. [12] These findings highlight the variability in COVID-19 reinfection prevalence across regions. Factors such as testing capacity, population demographics, and health system differences likely contribute to these variations.

3.3.2 Seasonal Trends in COVID-19 Cases

COVID-19 cases exhibited distinct seasonal patterns across age groups and sexes. Peaks during winter and summer dominated the overall population trends, consistent with seasonal respiratory virus activity. However, the pattern in children was unique, showing additional peaks in autumn among girls and spring among boys, suggesting potential age- and sex-specific environmental or behavioural factors influencing transmission. Similarly, adolescent males displayed unique spring peaks, contrasting with trends in adolescent females and the general population. In mature and elderly adults, consistent peaks in winter, summer, and autumn highlighted a broader vulnerability in these age groups. These findings align with the hypothesis that sex-based differences influence the severity of COVID-19, higher rates of hospitalisation, ICU admissions, and clinical presentation as well. This is supported by the study reported by O'Brien et al., in Canadian population. [20] The study highlights that while the absolute number of COVID-19 cases was higher in females, the incidence rate among females was lower than that of males when high-risk populations (as healthcare workers and residents of long-term care facilities, predominantly female groups), were excluded. [20] This finding suggests that higher exposure rates in these settings contributed to the elevated numbers among females. Our setting is similar, with a higher prevalence of COVID-19 in females, likely due to the population pyramid is characterized by a higher proportion of elderly population and females. [21] Our finding that in general; females have a higher incidence of COVID-19 is inconsistent with reports from several countries. [20, 22-28] Interestingly, in Canadian population, the sex-based differences in incidence rates were most pronounced among females of reproductive age (20–49 years old), who exhibited lower rates compared to males of the same age group. In contrast, postmenopausal females (60 years or older) showed less pronounced differences, and women aged 80 or older were more likely to develop COVID-19 compared to their male counterparts. [20] However, men are at greater risk of more severe COVID-19 outcomes than women, suggesting that both sex (i.e., biological differences) and gender (i.e., sociocultural and behavioural differences) play fundamental roles. [4, 25]

Wiemken et al., in their study, revealed a clear annual seasonality in COVID-19 cases, hospitalizations, and mortality rates, predominantly occurring between November and April. [6] These findings are similar to our results in infant and adolescent population, but, different to adults' population. Moreover, in the United States and Europe, the seasonal impact was most pronounced from January to March. [6] Kyaw et al., showed that across the 3 years of the COVID-19 pandemic, only Saudi Arabia and Mexico displayed a seasonal pattern consistently each year from 2020 to 2023. Saudi Arabia experienced waves from May to August, and Mexico exhibited waves from December to February. Brazil experienced COVID-19 waves from June to September in 2020 and from November to December in 2022. However, Philippines experienced waves of COVID-19 from July to December in 2020 and

2022. Similarly, Singapore experienced waves of COVID-19 from October to December in 2021 and 2022. South Africa exhibited waves from December to February in 2020 and 2021 as well as 2021 and 2022. No clear seasonal pattern of COVID-19 was observed in Argentina, Thailand, Bahrain, Malaysia, Morocco and Qatar. [29] Additionally, seasonality patterns and environmental components by each country suggest that the occurrence of COVID-19 outbreaks could be predicted based on a seasonal pattern of temperature variations. [29-30] For instance, the seasonality of COVID-19 has been explored in temperate countries, demonstrating a reduction in COVID-19 mortality during the summer and an increased mortality in autumn. [29, 31] In Russia, temperature seasonality observed in the humid continental region and the diurnal temperature range (in the sub-Arctic region) were found to have the greatest impact on COVID-19 transmission. [29, 32] Moreover, D'Amico et al., through a review article on global COVID-19 seasonality patterns, reported that mortality rates were significantly lower in countries where temperature were higher. [31] In this study, we observed similar seasonal patterns to influenza virus, with waves in spring or summer, but within specific age groups.

3.3.3 Comorbidities Across Age Groups and Sexes

The analysis of comorbidities revealed substantial variation by age and sex. Respiratory diseases predominated in children, reflecting the vulnerability of their immune system to pathogens. Adolescents exhibited a more heterogeneous profile, including metabolic, neurological, and immune system disorders. These differences underline the physiological and developmental shifts that occur during adolescence. Also, these data highlight the vulnerability of this population to vaccine-preventable diseases, and through strategies of health education.

In mature adults and the elderly, the top three comorbidities were similar but varied in rank order. Metabolic conditions, including diabetes and obesity, were prominent, especially among the elderly, while gastrointestinal conditions were more common in mature adults. The higher prevalence of metabolic disorders among elderly aligns with aging-related metabolic changes and underscores the need for targeted interventions.

According to Silaghi-Dumitrescu et al., 75% of hospitalized patients with COVID-19 have at least one comorbidity. [33] The most common comorbidities are hypertension, diabetes, cancer, neurodegenerative diseases, cardiovascular diseases, obesity, and kidney diseases. These findings are similar to our data's. Hypertension, diabetes and obesity are common comorbidities associated with COVID-19, and increased the severity and mortality of patients. [1. 4. 35] Even more, in the United States, a study carried out on 12 hospitals found that diabetes was the third most common comorbidity (~34% of patients), compared to hypertension (56%) and obesity (42%) [33-34]. We found different order, but hypertension, T2D and obesity are the top three comorbidities in COVID-19 patients. Other study in Mexican population reported that diabetes, hypertension, and obesity were the only comorbidities that were statistically significant in all models of association. [35]

3.3.4 Sex Differences in Comorbidities

Sex-specific analysis revealed notable differences in disease prevalence. Hypertension and T2D were common in both sexes, but obesity was significantly more prevalent in females, potentially reflecting hormonal and lifestyle factors. Hypothyroidism was also significantly more common in females, while males had a higher prevalence of hyperlipidaemia. These findings support existing evidence of sex-based differences in the epidemiology of chronic diseases and highlight the importance of tailored healthcare strategies. Moreover, our findings show a clear epidemiological transition: CD predominate in children and adolescents, while

NCDs are concentrated in mature adults and elderly population. This pattern reflects the cumulative impact of social determinants of health, including ageing and demographic transitions.

3.3.5 Communicable Diseases and COVID-19

Communicable diseases in COVID-19 population were dominated by respiratory and gastrointestinal illnesses, with acute pharyngitis being the most prevalent in both sexes. However, the rank order of other diseases, such as urinary tract infections and acute nasopharyngitis, varied by sex. These findings suggest that coexisting infections may influence COVID-19 outcomes differently across demographic groups. Despite advances in treatment and prevention (including widespread vaccine availability), these data reveal the enduring threat of COVID-19. They emphasize the need for robust global health surveillance, equitable resource distribution, and sustained collaboration to address the ongoing public health crisis.

3.4 Limitations and applications.

The variability in comorbidities across age groups and sexes underscores the need for personalized approaches to managing COVID-19. Preventive strategies and treatment protocols should account for demographic-specific vulnerabilities, particularly in managing chronic diseases and addressing seasonal peaks in infections. Additionally, sex-based differences in disease prevalence highlight the importance of sex-sensitive public health initiatives.

Seasonal variations highlight the need for targeted public health interventions. The variability in comorbidities across age groups and sexes underscores the need for personalized approaches to manage COVID-19. Preventive strategies and treatment protocols should account for demographic-specific vulnerabilities, particularly in managing chronic diseases and addressing seasonal peaks in infections. Additionally, sex-based differences in disease prevalence highlight the importance of sex-sensitive public health initiatives. In the context of COVID-19 disease, a complex interaction between seasonal respiratory infections and SARS-CoV-2 has been observed. The coexistence of multiple respiratory pathogens has generated additional challenges in the diagnosis and management of these diseases at the first level of care. In addition, the pandemic has affected the transmission dynamics of other respiratory viruses, altering traditional seasonal patterns. This highlights the need for continuous and adaptive epidemiological surveillance to effectively respond to changing in disease trends.

This study contributes to a better understanding of COVID-19 seasonality and its implications for public health planning, particularly at the primary care level. One practical application is the implementation of age-specific vaccination campaigns. However, given the high incidence of respiratory infections in children during peak seasons, targeted vaccination efforts should focus on this vulnerable group. Moreover, seasonal vaccination drives before anticipated peaks in winter or summer could reduce severe cases and alleviate the burden on primary care facilities.

Primary care centres can also use these findings to improve resource allocation by increasing staffing, securing medical supplies, and expanding testing capacity before seasonal surges. Additionally, enhanced epidemiological surveillance during peak periods can help detect early signs of new variants or unexpected outbreaks. This proactive approach allows for timely adjustments, such as revising vaccination schedules or reactivating community health campaigns to address emerging challenges.

Public health messaging should also build on these seasonal insights to encourage preventative behaviours. Campaigns can promote practices like mask-wearing and minimizing indoor gatherings during high-risk periods, particularly in winter, when transmission rates tend to peak. These efforts, combined with vaccination strategies and enhanced surveillance, can strengthen the overall response to COVID-19 and reduce the strain on primary care facilities.

Additionally, further research is required to examine how local factors, such as population behaviours and climate, influence these trends, as well as to investigate the underlying mechanisms driving demographic variations and their impact on COVID-19 outcomes. Understanding these factors will be essential for improving preparedness and response strategies for future pandemics.

4. CONCLUSION.

Our findings on the seasonal trends and epidemiological characteristics of COVID-19 patients in primary care settings provide valuable insights into public health challenges and highlight key areas for intervention. The high prevalence of non-communicable diseases such as hypertension, diabetes, and obesity in older adults underscores the urgent need for comprehensive prevention strategies and effective risk factor management. Similarly, the high incidence of respiratory infections in children emphasizes the importance of implementing public health policies to mitigate seasonal effects and protect this vulnerable population. To optimize the response at the primary care level, it is essential to adopt strategies tailored by age group and sex, integrate prevention programs with differentiated approaches, and strengthen epidemiological surveillance to better identify and respond to seasonal patterns. This proactive approach will enable more efficient resource allocation, improve health outcomes, and reduce the burden on healthcare systems. Addressing both social and environmental determinants of health is critical to developing effective interventions that strengthen primary care and enhance public health preparedness. Based on the seasonal trends identified in this study, we propose an age-specific vaccination plan. For children, vaccination campaigns should be conducted twice annually, in late autumn (November) and late spring (May), to pre-empt winter and summer peaks. For adolescents, campaigns should target late winter (February) and late spring (May), addressing spring and summer surges. For adults, particularly those with chronic conditions such as hypertension, diabetes, and obesity, vaccinations should be scheduled in late autumn (November) and early summer (May). In the elderly population, campaigns should be conducted in early winter (November) and late spring (May) to protect against seasonal peaks in winter and summer. Additionally, aligning COVID-19 vaccination schedules with annual influenza vaccination drives could improve both efficiency and uptake, enhancing overall immunization coverage and preparedness. These integrated and targeted strategies provide a framework for strengthening public health responses and reducing the impact of seasonal COVID-19 surges.

DISCLAIMER.

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

CONSENT.

A medical professional informed all participants about the study's objective, its benefits, and potential adverse events. After providing a clear explanation, the collection of the signatures of those who voluntarily decided to participate in the study, ensuring that participants had sufficient time to read and sign the corresponding informed consent form.

ETHICAL APPROVAL.

This study was conducted in accordance with good clinical practices as defined by Mexican legislation and the Declaration of Helsinki for research involving human subjects. The protocol was approved by two committees: The Research Committee and the Ethics Committee in Research of the Family Medicine Clinic "División del Norte", ISSSTE. The Data was treated confidentially.

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