Rev Med Chile 2026; 154(3): 339-350. DOI: 10.4067/s0034-98872026000300339

HPV Trends and Genotypes in Chilean and Immigrant Women: 10-Year Surveillance Study (2014–2023)

Nicole Bruneau[1], Monserrat Balanda[1], Héctor San Martín[1], Francisco Roldán[1], Daniela Hernández[1], Jorge Fernández[2], Cecilia Carrasco[3], Eugenio Ramírez[1,].*

[1]Sección Virus Oncogénicos, Subdepartamento de Enfermedades Virales, Instituto de Salud Pública de Chile, Ñuñoa, Santiago, Chile.
[2]Subdepartamento Genética Molecular, Instituto de Salud Pública de Chile, Ñuñoa, Santiago, Chile.
[3]Salud Sexual y Reproductiva, Departamento de Salud de I. Municipalidad de Huechuraba, Santiago, Chile.

Tendencias y Genotipos del VPH en Mujeres Chilenas e Inmigrantes: Estudio de Vigilancia de 10 Años (2014-2023)

ABSTRACT

Cervical cancer is the fourth most common cancer in women worldwide. In Chile, 13,093 women died from cervical cancer between 2002 and 2022, making it the second leading cause of death for women aged 25 to 64, after breast cancer. Since 2019, Chile has been promoting molecular-based HPV screening to reduce cervical cancer incidence and mortality. ***Aim:*** *To describe the prevalence, genotypic distribution, and temporal trends of HPV in Chilean and immigrant women based on a 10-year surveillance program conducted from 2014 to 2023.* ***Methods:*** *During the study period, 8,324 samples were collected from 7,410 Chilean and 908 foreing women aged 25 to 64 in five primary care centers in Santiago. HPV DNA of cervical smears were amplified by qPCR. Genotyping was performed by PCR-RLB and Sanger sequencing.* ***Results:*** *HPV was detected in 17.06% of Chilean and 23.11% of foreign women, with infection rates increasing over the 10-year period. The highest positivity rate was observed in the 25-34 age group for Chilean (23.82%) and for foreign (29.26%) women. The most frequent High-Risk genotypes were HPV-16, HPV-31, and HPV-59 in Chilean women; and HPV-16, HPV-58, and HPV-66 in foreign women. Low-Risk genotypes increased with age, being more prevalent in immigrants (55.30%) than in Chilean women (42.46%).* ***Conclusions:*** *HPV infection rates have been increasing over time. HR genotypes different than HPV-16/18 were the most common, followed by HPV-16. This information is crucial for HPV surveillance, evaluation of vaccination programs, and prevention of cervical cancer in Chile.*

**Corresponding author: Eugenio Ramírez / eramirez@ispch.clVirus Oncogénicos, Subdepto de Enfermedades Virales, Instituto de Salud Pública de Chile, Avenida Marathon 1000, Ñuñoa, Santiago.*

Funding. This study was partially supported by ANID-ANDID projects (Agencia Nacional de Investigación y Desarrollo, and Agencia Nacional de Dispositivos Médicos, Innovación y Desarrollo de Instituto de Salud Pública de Chile), which we gratefully acknowledge.

The authors declare no conflict of interest.

Received: June 26, 2025.
Accepted: December 1, 2025.

Keywords: *Genotype; Mass Screening; Papillomavirus Infections; Polymerase Chain Reaction; Uterine Cervical Neoplasms; Vaccination.*

RESUMEN

El cáncer cervicouterino (CCU) es el cuarto cáncer más común en mujeres a nivel mundial. En Chile, 13.093 mujeres murieron por CCU entre 2002 y 2022, siendo la segunda causa de muerte después del cáncer de mama en mujeres de 25 a 64 años. Desde 2019, Chile ha estado promoviendo el tamizaje molecular del VPH para reducir la incidencia y mortalidad por CCU. ***Objetivo:*** *Describir la prevalencia, distribución genotípica y tendencias temporales del VPH en mujeres chilenas e inmigrantes, basado en un programa de vigilancia de 10 años realizado entre 2014 y 2023.* ***Métodos:*** *En el periodo estudiado se recolectaron 8.324 muestras de 7.410 mujeres chilenas y 908 mujeres extranjeras, de entre 25 y 64 años, en cinco centros de atención primaria de Santiago. El ADN del VPH en las muestras cervicales fue amplificado mediante qPCR. El genotipado se realizó mediante PCR-RLB y secuenciación de Sanger.* ***Resultados:*** *El genoma de VPH se detectó en el 17,06% de las mujeres chilenas y en el 23,11% de las mujeres extranjeras, observándose un aumento en las tasas de infección durante el período de 10 años. La mayor tasa de positividad se registró en el grupo de 25 a 34 años, tanto en mujeres chilenas (23,82%) como extranjeras (29,26%). Los genotipos de alto riesgo más frecuentes en mujeres chilenas fueron HPV-16, HPV-31 y HPV-59; y en mujeres extranjeras, HPV-16, HPV-58 y HPV-66. Los genotipos de bajo riesgo aumentaron con la edad, siendo más prevalentes en mujeres inmigrantes (55,30%) que en mujeres chilenas (42,46%).* ***Conclusiones:*** *Las tasas de infección por VPH han aumentado con el tiempo. Los genotipos de alto riesgo distintos a HPV-16/18 fueron los más comunes, seguidos por HPV-16. Esta información es crucial para la vigilancia del VPH, la evaluación de los programas de vacunación y la prevención del CCU en Chile.*

Palabras clave: *Genotipo; Infecciones por Papilomavirus; Neoplasias del Cuello Uterino; Reacción en Cadena de la Polimerasa; Tamizaje Masivo; Vacunación.*

Human Papillomavirus (HPV) accounts for 90% of cervical cancer cases globally, as well as other cancers affecting the anogenital region and upper aerodigestive tract[1]. In Chile, 420 women aged 25–64 died from cervical cancer in 2022, making it the second leading cause of female cancer death after breast cancer[2]. National cervical cancer mortality and cumulative risk rates are twice as high of other high-income countries.

Since 2019, the Chilean Ministry of Health (MINSAL) has promoted molecular HPV screening for women aged 30–64, targeting only HPV-16 and -18, with pooled results for other high-risk (HR) genotypes, alongside the Papanicolaou (PAP) test[3].

Early findings showed that 70% of positive cases were non-16/18 HR genotypes[4]. The prevalence and impact of these genotypes remain unclear due to non-differentiating methods.

Since 2014, the National Institute of Health (ISP) has conducted genotyping on HPV-positive samples from primary healthcare centers in Huechuraba (North Metropolitan area), identifying both HR and low-risk (LR) genotypes wether or not a lesion is present[4,5].

Under the National Vaccination Program, the Chilean Ministry of Health (MINSAL) has administered the quadrivalent Gardasil vaccine —targeting HPV types 6, 11, 16, and 18— to 9-year-old girls since 2014 and to boys since 2019. As of the second half of 2024, the program began administering the nonavalent vaccine to both 9-year-old boys and girls[6].

Migration affects public health dynamics. Chile's immigrant population reached 1,918,583 in 2023, primarily from Venezuela, Peru, Colombia, Haiti, and Bolivia[7]. Nearly 500,000 immigrant women aged 25–64 reside in the Metropolitan Region and are included in the HPV screening program[7,8].

This study aimed to analyze cervical smear samples from Chilean and immigrant women aged 25 to 64, who received care at primary healthcare centers in the Huechuraba district of Santiago between 2014 and 2023, in order to determine the prevalence of HPV infection, the distribution of HPV genotypes, and the rates of single and multiple infections in both populations.

Methods

Study Population

The Municipal Health Corporation of Huechuraba, within five primary healthcare centers (CESFAM Dr. Salvador Allende Gossens, CESFAM El Barrero, CESFAM Dr. Víctor Castro Wiren, CECOSF Los Libertadores and SAR La Pincoya), collected 8,324 cervical samples from March 2014 to December 2023, in 25 to 64 years old women residing in Huechuraba, Santiago (North Metropolitan area) of Chile. Women (Chilean or foreign) were classified according to the National Document of Identification (NDI). All samples were collected in tubes with 2 ml transport medium (Phosphate Buffered Saline, Fetal Bovine Serum, gentamicin and amphotericin B). Samples were stored at 4°C until subsequent analyses. The complete protocol for sample collection and testing, including clinical examination, patient interview, cervical sampling, and laboratory analysis, was conducted according to official guidelines issued by the Chilean Ministry of Health.

DNA isolation

Cervical samples were treated with 2 ml lysis buffer (cat. 200292; NuclisSENS; bioMérieux, France). DNA was isolated by an automated technique (NucliSENS®easyMAG®, cat. 280140, bioMérieux, France), yielding a 60 µl product for PCR amplification.

Real time and conventional PCR

HPV DNA was amplified using GP5+/GP6+ primers for L1 gene, and PC04/GH20 for β-globin as internal control. If the sample did not amplify the internal control, the sample resulted as invalid. Then, conventional PCR using PGMY09/11 primers amplified DNA of positive samples. For the internal control, amplification of the HLA gene was used. Thermocycling was performed using a conventional thermocycler (Mastercycler nexus – PCR Thermal Cycler, Eppendorf, Hamburg, Germany). PCR products were analyzed by electrophoresis in 2% agarose/TBE gel (cat.50004; Lonza, Rockland, ME, USA; cat. 15581-044, Grand Island, NY, USA) and visualized using a ChemiDoc MP Imaging System (Biorad).

HPV genotyping by Reverse Line Blot (RLB) and Sanger sequencing

Amplification products were hybridized using DNA-specific oligo-probes for each genotype. Positive reactions were revealed by chemiluminescence using Amersham ECL Detection Reagents according to manufacturer recommendations (GE Healthcare, Little Chalfont, UK). Subsequently, Sanger sequencing was performed by the Big Dye Terminator V.3.1 cycle sequencing kit (Applied Biosystem) in a 3500 Genetic Analyzer (Applied Biosystem) to confirm these results. Bioinformatics

analyses used reference HPV strains (International Human Papillomavirus Reference Center, Karolinska Institute)[9].

Statistical analyses

A database was created using Microsoft Excel (version 2016). The data were analyzed using the same software. HPV infection rates were estimated within four age groups (25-34, 35-44, 45-54, and 55-64 years). Linear regression analysis was performed to calculate the curves equation and slopes, thereby quantifing the rate of increase or decrease in the percentage of HPV infections.

Results

Study Population

Between March 2014 and December 2023, 8,324 cervical smear samples were collected from five primary healthcare centers in Huechuraba, Northern Metropolitan Region of Chile. After excluding six misregistered samples, 8,318 were valid: 7,410 from Chilean and 908 from immigrant women. In the Chilean group, 328 samples were excluded due to age (300 under 25 and 28 over 64), 130 due to invalid PCR results, and one duplicate, leaving 6,951 samples. Among them, 1,186 tested positive for HPV, resulting in an infection rate of 17.06% (Figure 1). In the immigrant group, 48 samples were excluded for age (47 under 25, one over 64) and 25 due to invalid PCR results. The final sample size was 835, with 193 positives, corresponding to a 23.11% infection rate (Figure 1).

HPV Infection Rates (2014–2023)

Among Chilean women, HPV positivity increased from 9.27% in 2014 to 23.43% in 2023, with a peak of 29.50% in 2020. The average annual increase was approximately two percentage points, except for 2018–2019 when it remained stable (Table 1, Figure 2). Immigrant women showed a similar pattern: from 13.33% in 2014 to 27.52% in 2023, also peaking in 2020 at 29.41% (Table 1, Figure 2). Despite the overall rise, the trends differed slightly: Chilean women experienced a steadier increase (slope= 1.53), while immigrant women showed more variability (slope= 1.25) (Figure 2).

HPV Infection by Age Group

In Chilean women, the highest infection rate was observed in the 25–34 group (23.82%), decreasing with age to 10.26% in the 55–64 group (Figure 3A). Immigrant women also had the highest rate in the 25–34 group (29.24%), however the infection rate increased in the 55–64 group (17.71%) following a decline in the 45–54 group (15.03%), forming a U-shaped curve (Figure 3A). Across all age groups, infection rates were consistently higher in immigrant women, with the largest difference (7.45%) in the oldest group (Figure 3A).

Age Trends by Period

In Chilean women, comparisons between 2014–2018 and 2019–2023 revealed consistent trends: higher infection rates in all age groups in the latter period, particularly among those aged 35–44 (8.18% increase) (Figure 3B). Among immigrants, trends were less consistent. In 2014–2018, the lowest rate was in the 45–54 group (10.64%), whereas in 2019–2023, it was the 55–64 group (16.44%). Only the 25–34 and 45–54 groups showed increases in the second period (Figure 3C).

Frequency of HR HPV Genotypes

Among Chilean women, the most common HR genotype was HPV-16 (21.43%), followed by HPV-31 (9.16%), HPV-59 (8.77%), HPV-66 (8.70%), and HPV-58 (7.61%). Less frequent genotypes included HPV-33 (2.95%), HPV-35 (1.94%), HPV-68 (1.71%), HPV-73 (2.33%), and HPV-82 (1.24%) (Figure 4A). Multiple infections (57.22%) were more common than single infections (42.78%). HPV-16, -18, -33, and -68 were more often found in single infections.

Among immigrants, HPV-16 was also the most frequent (13.85%), followed by HPV-58 (9.74%), HPV-66 (9.23%), HPV-35 (8.21%), HPV-33 and -59 (7.18%). The least common were HPV-18, -45, -52, and -56 (5.13%), HPV-51 (4.62%), HPV-73 (3.08%), HPV-68 (2.05%), and HPV-82 (1.54%) (Figure 4A). Multiple infections were even more common (64.62%) than single infections (35.38%). While certain genotypes such as HPV-68 were detected only in single infections, others like HPV-

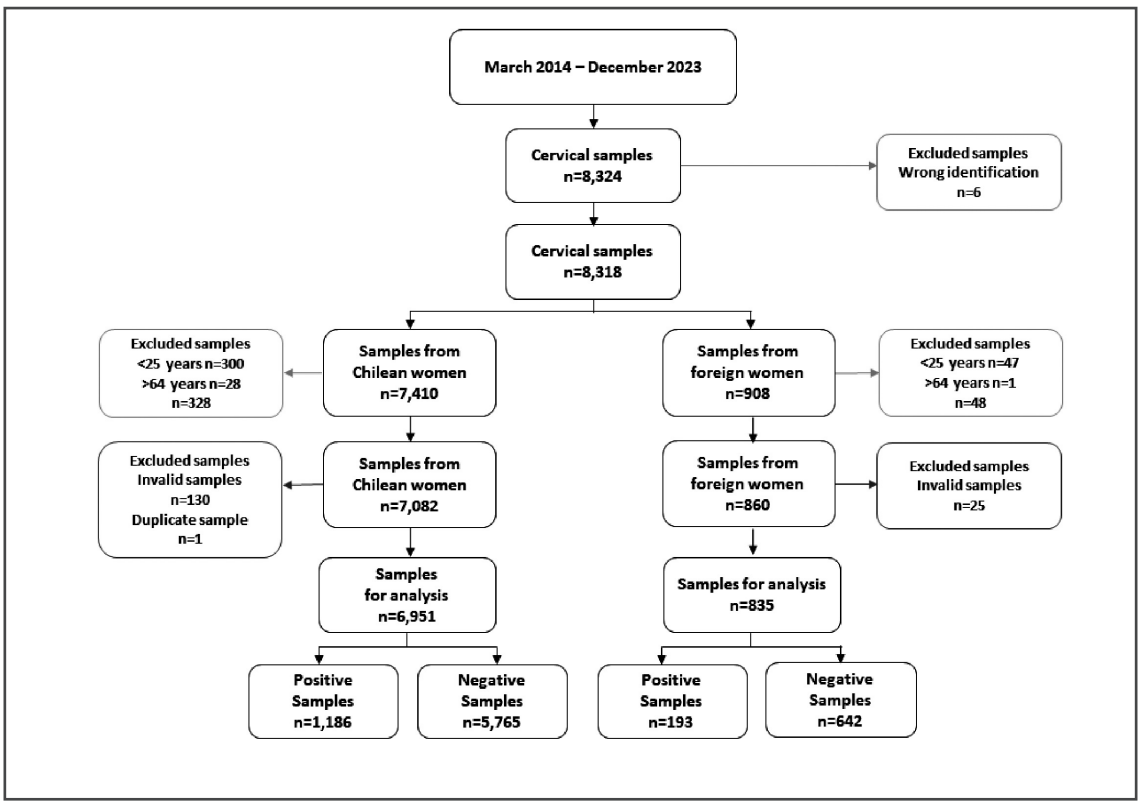

Figure 1: *Flowchart of study population. The total of samples was collected between March 2014 to December 2023. In blue, 6 samples excluded because of wrong identification, in green 376 samples excluded because of age rate, and in purple 155 samples excluded because of an invalid PCR result. The "n" is the number of cervical samples.*

Table 1. Percentage of positive HPV samples in Chilean and foreign women between 2014-2023.

Group \Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Chilean (N)	1,251	631	414	540	1,425	1,040	200	706	330	414	6,951
Chilean (n)	116	76	61	93	282	199	59	131	72	97	1,186
Chilean (%)	9.27	12.04	14.73	17.22	19.79	19.13	29.50	18.56	21.82	23.43	17.06
Foreign (N)	30	16	19	53	164	182	34	165	63	109	835
Foreign (n)	4	3	3	11	43	41	10	33	15	30	193
Foreign (%)	13.33	18.75	15.79	20.75	26.22	22.53	29.41	20.00	23.81	27.52	23.11

N= total cervical samples received, n = number of positive HPV samples, (%) = percentage of positive HPV samples.

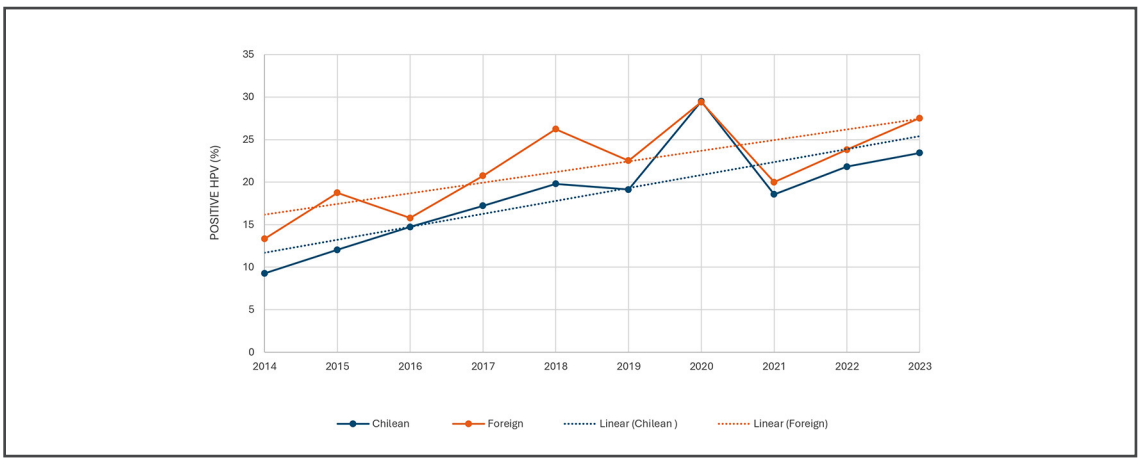

Figure 2: *Percentage of HPV positive samples in Chilean (blue) and foreign (orange) women between 2014-2023. Dotted lines = Linear regression analysis of percentage values of HPV positive samples. Slope of curve Chilean women= 1.53 lope of curve foreign women= 1.25.*

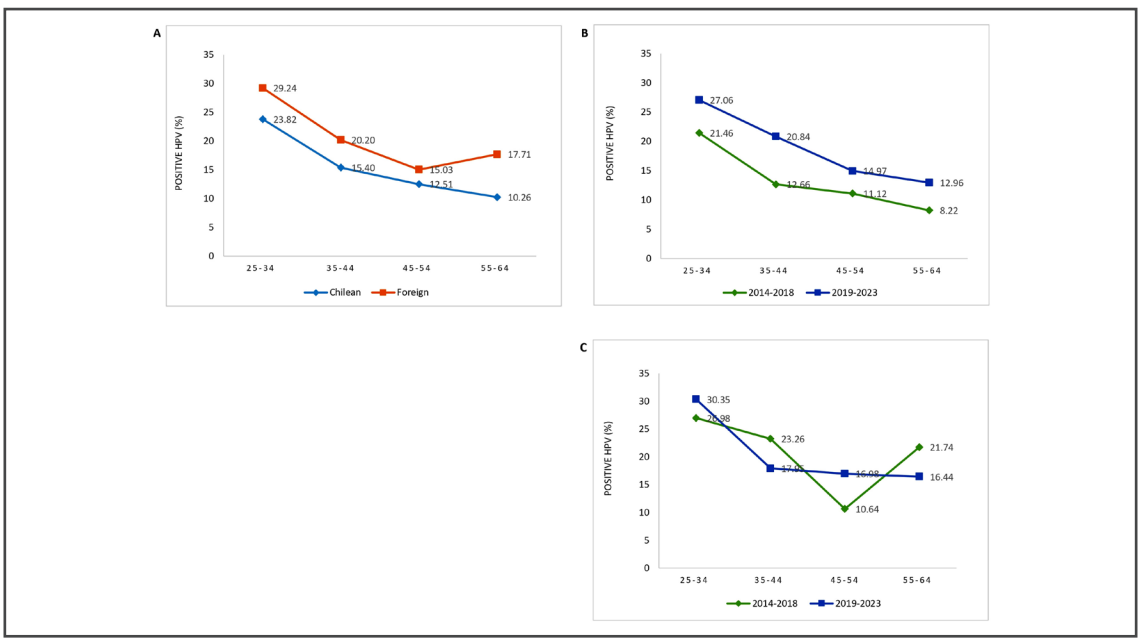

Figure 3: *Percentage of HPV positive samples in Chilean and foreign women between 2014 and 2023 by age group.*
A) HPV positive samples (%) by age group in Chilean and foreign women between 2014-2023. Comparison of percentage of positive samples in Chilean (blue) and foreign women (orange) by age group (25-34, 35-44, 45-54 and 55-64 years). Slope curve of linear regression analysis for percentage of HPV positive in Chilean women= -4.37. Slope curve of linear regression analysis for percentage of HPV positive in foreign women: -3.98. B) HPV positive samples (%) in Chilean women by age group in two different periods. Comparison of percentage of positive samples in Chilean women between 2014-2018 (green) and 2019-2023 (blue). Slope curve of linear regression analysis for percentage of HPV positive between 2014 to 2018= -4.13. Slope curve of linear regression analysis for percentage of HPV positive between 2019 to 2023= -4.82. C) HPV positive samples (%) in foreign women by age group in two different periods. Comparison of percentage of positive samples in foreign women between 2014-2018 (green) and 2019-2023 (blue). Slope curve of linear regression analysis for percentage of HPV positive between 2014 to 2018= -2.84. Slope curve of linear regression analysis for percentage of HPV positive between 2019 to 2023= -4.27.

51 were found exclusively in multiple infections.

HPV-16 was the dominant genotype in both study groups. However, HPV-31 was more common in Chileans, while HPV-33 and HPV-35 showed a higher frequency in immigrants.

Frequency of Low-Risk (LR) HPV Genotypes

Among Chilean women, the most prevalent LR types were HPV-42 (15.37%), HPV-53 (14.50%), HPV-54 (13.42%), HPV-6 (11.69%), and HPV-70 (8.87%) (Figure 4B). The least common included HPV-26 and -69 (1.95%), HPV-34 and -57 (0.87%), and HPV-43 (0.65%). Most LR genotypes appeared in multiple infections (68.83%). HPV-43 was exclusively detected in single infections, and HPV-57 only in multiple ones.

Among immigrant women, the most frequent LR genotypes were HPV-54 (19.19%), HPV-53 (16.16%), HPV-42, HPV-70, and HPV-83 (11.11%) (Figure 4B). The rarest were HPV-26, -34, -57, and -69 (1.01%), and no cases of HPV-43 were reported. LR genotypes were also more frequent in multiple infections (70.71%). HPV-69 was exclusively detected in single infections, while HPV-6, -26, -34, -40, and -57 were only found in multiple ones.

Both groups shared most of the frequent LR genotypes, with HPV-6 more common in Chileans and HPV-83 in immigrants. The least frequent was HPV-43 in both, and HPV-57 was only detected in multiple infections.

Frequency of HR Genotypes Other Than HPV-16/18 by Age

In both populations, HR genotypes other than HPV-16/18 were found to be the most frequent across all age groups. In Chilean women, their frequency increased with age: from 58.48% in the youngest group to 92.75% in the oldest (Figure

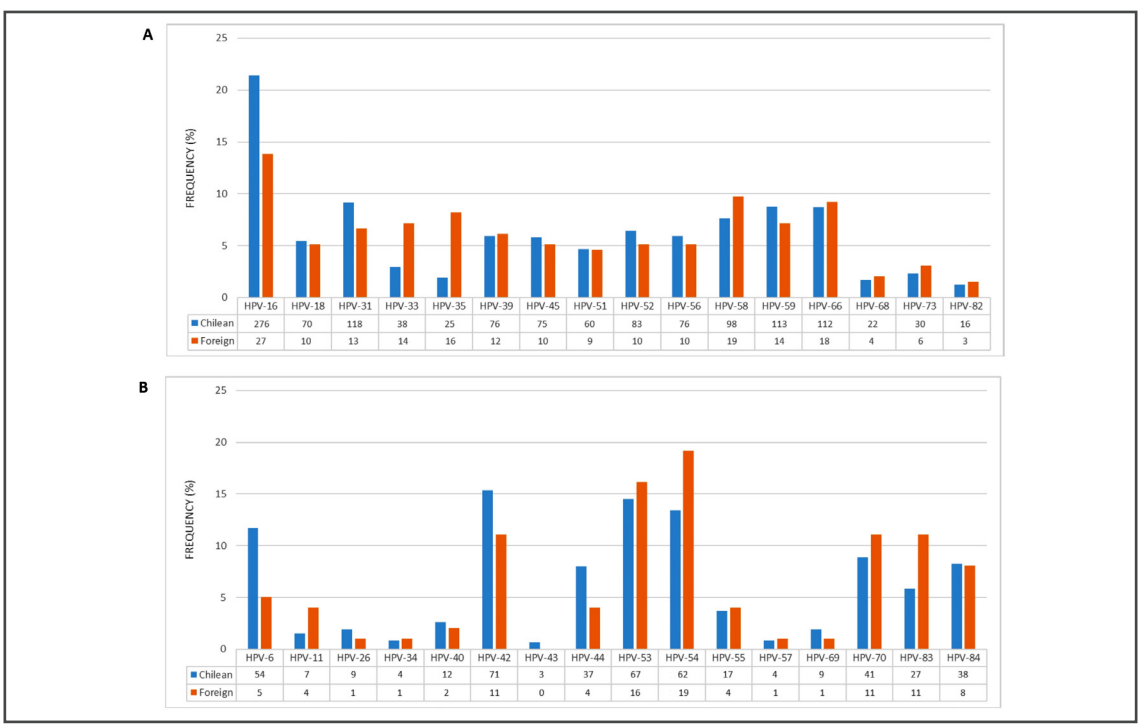

Figure 4: *Frequency (%) of different HPV genotypes in Chilean and foreign women between 2014 to 2023. A) High-risk genotypes and B) Low-risk genotypes in Chilean (blue) and foreign (orange) women. Bars indicate the percentage of frequency for each genotype regarding the total HPV frequency in each group. The numbers below show the amount of positive samples received for each genotypes.*

5A). Among immigrants, rates also rose, from 68.97% to 90.00% (Figure 5B).

In contrast, HPV-16 and HPV-18 infections declined with age. In Chilean women, HPV-16 dropped from 32.38% to 5.80%, and HPV-18 from 8.19% to 1.45% (Figure 5A). In immigrant women, HPV-16 decreased from 22.99% to 10.00%, and HPV-18 was mostly found in the 35–44 group (12.00%) with no cases in the oldest (Figure 5B). Coinfections with both genotypes were rare in both groups (~1%).

Frequency of LR Genotypes by Age Group

The prevalence of LR genotypes increased with age in both groups (Figure 5C). In Chilean women, infection rates were 33.11%, 37.64%, 47.62%, and 51.46% in the oldest group. Among immigrants, the rates were consistently higher: 48.21%, 56.10%, 52.17%, and 64.71%. The largest difference occurred in the 35–44 group, where immigrant women had an 18.46% higher rate than Chilean women (Figure 5C).

Frequency of Single vs. Multiple Infections by Age

In both groups, single-genotype infections were more common overall (Figure 5D). Among Chilean women, the ratio was 66% single vs. 34% multiple infections. The 35–44 group exhibited the greatest imbalance (70.34% single), while the 25–34 group had the highest rate of co-infection (39.18%) (Figure 5D). For immigrant women, the ratio was 60% single to 40% multiple infections. The largest difference was observed in the 45–54 group (69.57% single

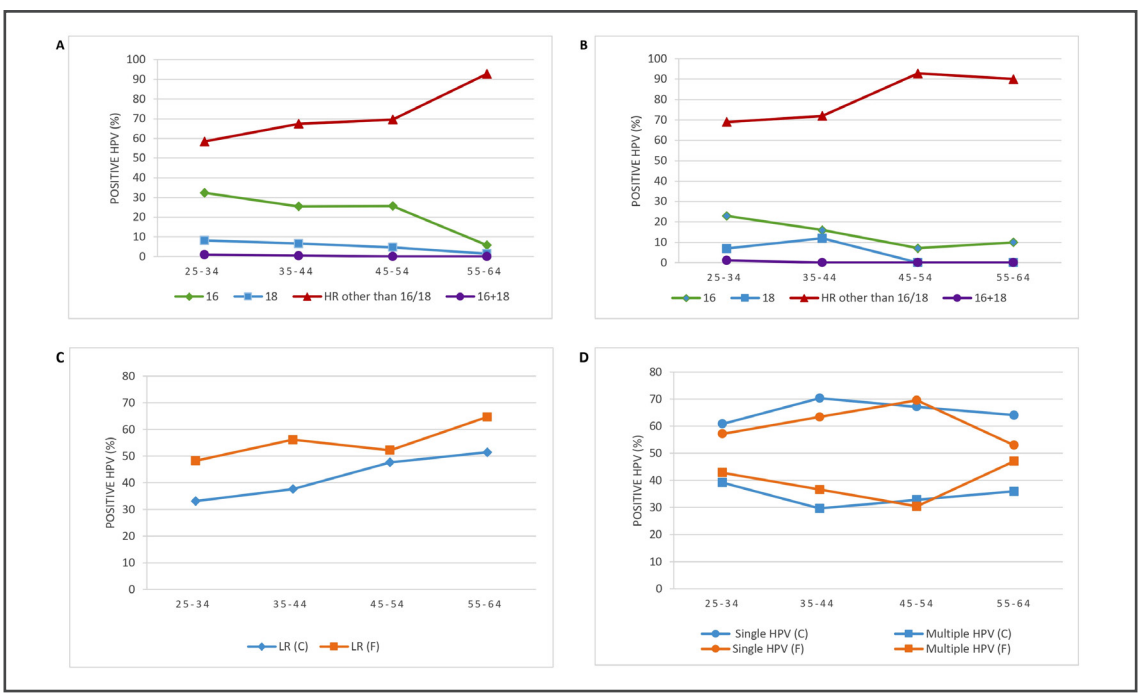

Figure 5: *Percentage of HR and LR HPV infection in Chilean and foreign women by age group between 2014 to 2023. A) Infection of HR-HPV genotypes in Chilean and B) Infection of HR-HPV in foreign women by age group (25-34, 35-44, 45-54 and 55-64 years). Infections with HPV-16 (green), HPV-18 (blue), HPV-16 + HPV-18 together (purple), and HR-HPV other than HPV16/18 (red). HR-HPV genotypes other than HPV-16/18 were HPV-31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, 68, 73 and 82. C) Distribution of percentage of LR-HPV infection between Chilean (blue) and foreign (orange) women by age group. LR-HPV genotypes were HPV-6, 11, 26, 34, 40, 42, 43, 44, 53, 54, 55, 57, 69, 70, 83 and 84. D) Distribution of percentage of single and multiple infections between Chilean (blue) and foreign (orange) women by age group. C: Chilean women, F: foreign women.*

vs. 30.43% multiple). Interestingly, the highest co-infection rate was in the 55–64 age group (47.06%) (Figure 5D).

Discussion

Fifteen HR-HPV genotypes are linked to cancer development[10], causing 90% of cervical cancer cases worldwide[1]. In Chile, cervical cancer remains a major public health issue, with 420 deaths in 2022, ranking second among cancer-related deaths in women aged 25–64[2]. Despite having lower incidence and mortality than many other Latin American and Caribbean countries, Chile's rates are still twice as high as the ones reported by other high-income nations[2]. Immigration in Chile has surged since 2018, with nearly 1.9 million foreign residents by 2022—mostly from Venezuela, Peru, Colombia, Haiti, and Bolivia[7]. Approximately 500,000 immigrant women aged 25–64 reside in the Metropolitan Region, highlighting the need for targeted HPV screening in this population to better understand genotype distribution and inform prevention strategies.

Since 2019, the Chilean Ministry of Health has implemented molecular-based HPV screening for women aged 30–64, with a focus on HPV-16 and HPV-18, and pooled reporting for other HR genotypes. Initial findings indicated that 70% of positive cases involved HR types other than HPV-16/18, underscoring the limited understanding of the clinical impact of these genotypes in primary care[4].

Few studies have investigated the prevalence of HPV among Chilean women attending primary healthcare centers[4,5,11]. Ferreccio et al. reported a prevalence rate of 12.8%, with genotypes such as HPV-16, 56, and 58 being the most frequent[11]. Our previous studies also found positivity rates ranging from 11.1% to 12.0%, with a predominance of HR genotypes, including HPV-16, 66, and 59[4,5]. We now confirm a marked increase in HPV infection among women aged 25–64 between 2014 and 2023, with prevalence rising from 12% to 23.4%. Immigrant women consistently exhibited higher infection rates—approximately six percentage points higher—although both groups demonstrated upward trends. In 2020, positivity rates peaked at 29% in both groups, possibly reflecting the reduced sample volume during the COVID-19 pandemic.

HPV prevalence varies globally among women with normal cytology. A meta-analysis found an overall prevalence of 10.4%, with 22.1% in Africa, 13.0% in the Americas, 8.1% in Europe, and 8.0% in Asia[12]. In South America, prevalence was 12.3%, compared to 20.4% in Central America. Rates in Asia ranged from 2.4% in Kuwait to over 12% in China[13,14,15,16,17]. Our findings align with these trends, showing lower HPV prevalence in Chilean women compared to immigrants from other Latin American countries. HR-HPV genotypes vary across regions. In sub-Saharan Africa, HPV-16 and 52 are most common in the Southeast, while HPV-16 and 35 dominate in the West[18]. In China, HPV-52, 16, and 53 are most prevalent[19], while in Mexico, HPV-53, 16, 58, and 31 lead[20]. In our study, Chilean women were most frequently infected with HPV-16, followed by HPV-31, 59, 66, and 58. Among immigrant women, HPV-16 also ranked first, followed by HPV-58, 66, 35, and 33.

Chile introduced the quadrivalent HPV vaccine in 2014, protecting against types 6, 11, 16, and 18. In 2024, a nonavalent vaccine covering nine genotypes, including HPV-31, 33, 45, 52, and 58, was added for 9-year-old boys and girls[6]. However, common HR types such as HPV-35, 59, and 66 are not included in any current vaccines. Thus, many women remain unprotected despite vaccination. Similar gaps exist elsewhere. In South Africa, only 37% of prevalent genotypes were covered by the nonavalent vaccine[21]. Ghana and China also reported high prevalence of genotypes not covered by vaccines[22]. In Denmark, 35% of vaccinated women still tested positive for HR-HPV, mostly with non-vaccine types[23]. In China, the HR-HPV infection rate was 12.5%, with genotypes covered by the nonavalent vaccines accounting for 8.3%; non-vaccine HR types represented 5.7%[24]. In Shanghai, HR-HPV prevalence reached 22.9%, with HPV-16, 39, 53, 56, and 51 being most common—though HPV-39, 51, 53, and 56 are not included in current vaccines[25]. Similarly, in the U.S., HPV-35 and HPV-59 are among the

most prevalent non-vaccine genotypes[26]. These data underscore the importance of aligning vaccine coverage with regional genotypes.

Our results show that HR-HPV types like HPV-16, 58, 59, and 66 were common in both Chilean and immigrant women. HPV-18, a key vaccine target, had a low prevalence of 5% in both groups. Interestingly, HPV-33 and 35 were more frequent among immigrants, suggesting that migration may have altered genotype patterns in Chile. These genotypes were found in women without cervical lesions, while HPV-16, 18, and 45 remain most linked to invasive cancer[27]. Since participants were attending routine screening, lesion presence may be minimal or undetectable. Future studies should include women with different lesion grades to assess which genotypes are truly pathogenic.

The 25–34 age group showed the highest HPV positivity. Among Chilean women, infection decreased with age, while among immigrants, it followed a "U"-shaped curve—high in younger women, decreasing in midlife, and rising again in older groups. This pattern is common in Latin America and the Caribbean, and has also been reported in China and other Eastern countries[28,29]. In contrast, the US and Denmark show a steady decline in infection with age[29].

Women aged 25–34 represented 37% of Chilean and 46% of immigrant samples—consistent with this age group being the largest among immigrants in Chile (40.1%)[7]. However, older women were underrepresented, comprising only 14% of Chilean and 12% of immigrant samples. This low sampling may explain the reduced positivity in these age groups. Increasing screening coverage among older women is a key goal in many countries[30].

This study focused on women attending cervical cancer screening, possibly explaining the low detection of low-risk (LR) types HPV-6 and 11. These are more commonly found in STD clinics, especially among men or women with other STDs[31,32,33]. The predominance of HR types in this cohort highlights the need to refine prevention strategies, including vaccine formulation and genotype-specific screening.

Strengths and Limitations

This study analyzed trends in HPV infection over a decade, covering both HR and LR genotypes in a large sample of Chilean and immigrant women. A major strength was the comprehensive genotyping of all positive samples, allowing assessment of prevalent genotypes before the national implementation of molecular screening. Limitations include a low number of immigrant samples in earlier years and lack of detailed country-of-origin data, as immigration status was inferred from national ID numbers. The study was geographically limited to one area in the Metropolitan Region. Future studies should include other cities with different immigration patterns and cervical cancer rates to explore genotype distribution and lesion severity more broadly.

Conclusions

HPV infection rates in women aged 25–64 have nearly doubled since 2014, especially among immigrants and younger women. HPV-16 and 58 were among the most prevalent HR genotypes in both groups, while genotypes like HPV-33 and 35 were more common among immigrants. These findings highlight the need for targeted prevention strategies, including broader vaccine coverage and improved screening, to reduce HPV-related disease in both Chilean and immigrant populations.

Acknowledgment

We are grateful to members of the Subdepartamento de Genética Molecular, Instituto de Salud Pública de Chile, for their excellent technical assistance in sequencing L1 gene. Also, we extend our thanks to all primary care workers in Huechuraba Municipality for collecting all samples and for their trust in our work since 2014. Dr. Rodrigo Fasce for his critical feedback and editing of the manuscript.

Author contributions

NB and ER designed the manuscript. ER supervised the study. MB, HSM, and NB process all the samples and made all the technical assays for HPV genotyping. FR and DH made the separation

process and carried out the electrophoresis. JF made the sequencing analysis. CC contributed in the involvement of the technicians and workers of the primary care centers of Huechuraba. NB wrote the draft of the manuscript, performed the figures, and made the statistical analyses. All authors read and approved the manuscript.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

1. *De Martel C, Georges D, Bray F, Ferlay J, Clifford GM. Global burden of cancer attributable to infections in 2018: A worldwide incidence analysis. Lancet Glob Health. 2020; 8(2): 180-190. doi: 10.1016/S2214-109X(19)30488-7*
2. *International Agency for Research on Cancer (IARC). Accessed June 6, 2025. https://gco.iarc.who.int/today/en/dataviz/tables?mode=cancer&types=1&sexes=2&cancers=23&populations=904&multiple_populations=1&age_start=5&age_end=12&group_populations=1*
3. *Ministerio de Salud (MINSAL). Implementación Test Molecular de Virus Papiloma Humano (2022). Accessed June 6, 2025. https://schigo.cl/wp-content/uploads/2022/07/MANUAL-IMPLEMENTACION-TEST-VPH.pdf*
4. *Vergara N, Espinoza G, Balanda M, Quiero A, Hidalgo W, San Martin H, et al. Prevalence of Human Papillomavirus infection among Chilean women from 2012 to 2016. J Med Virol. 2017; 89(9): 1646-1653. doi: 10.1002/jmv.24805*
5. *Balanda M, Quiero A, Vergara N, Espinoza G, San Martin H, Rojas G, et al. Prevalence of human papillomavirus infection among women presenting for cervical cancer screening in Chile, 2014-2015. Med Microbiol Immunol. 2016; 205(6): 585-594. doi: 10.1007/s00430-016-0473-y*
6. *Ministerio de Salud (MINSAL). Vacuna escolar contra el VPH (2025). Accessed April 16, 2025. https://saludresponde.minsal.cl/vacuna-escolar-contra-el-vph/*
7. *Instituto Nacional de Estadísticas (INE). Estimaciones de extranjeros (2025). Accessed April 25, 2025. https://serviciomigraciones.cl/estudios-migratorios/estimaciones-de-extranjeros/*
8. *Ministerio de Salud (MINSAL). Actualización Plan Nacional de Cáncer 2022 – 2027 (2024). Accessed April 21, 2025. https://www.minsal.cl/plan-nacional-de-cancer/*
9. *International Human Papillomavirus Reference Center (HPV Center). HPV reference clones (2025). Accessed January 13, 2025. https://www.hpvcenter.se/human_reference_clones/*
10. *Muñoz N, Bosch FX, De Sanjosé S, Herrero R, Castellsagué X, Shah K, et al. Epidemiologic classification of human papillomavirus types associated with cervical cancer. N Engl J Med. 2003; 348(6): 518-527. doi: 10.1056/NEJMoa021641*
11. *Ferreccio C, Prado RB, Luzoro AV, Ampuero S, Snijders P, Meijer C, et al. Population-based prevalence and age distribution of human papillomavirus among women in Santiago, Chile. Cancer Epidemiol Biomarkers Prev. 2004; 13(12): 2271-2276. doi: 10.1158/1055-9965.2271.13.12*
12. *De Sanjosé S, Diaz M, Castellsagué X, Clifford G, Bruni L, Muñoz N, et al. Worldwide prevalence and genotype distribution of cervical human papillomavirus DNA in women with normal cytology: a meta-analysis. Lancet Infect Dis. 2007; 7(7): 453-459. doi: 10.1016/S1473-3099(07)70158-5*
13. *Al-Awadhi R, Chehadeh W, Kapila K. Prevalence of human papillomavirus among women with normal cervical cytology in Kuwait. J Med Virol. 2011; 83(3): 453-460. doi: 10.1002/jmv.21981*
14. *Daneshvar F, Haghshenas M, Majleci F, Rahimi A. The prevalence and genotype distribution of cervical human papillomavirus DNA in women with normal cytology in north of Iran. Jundishapur J Microbiol. 2017; 10(1): e40823. doi: 10.5812/jjm.40823*
15. *u H, Yi J, Dou Y, Hen Y, Kong LJ, Wu J. Prevalence and genotype distribution of human papillomavirus among healthy females in Beijing, China, 2016–2019. Infect Drug Resist. 2021; 14: 4173-4182. doi: 10.2147/IDR.S332668*
16. *Adejo DS, Aminu M, Ella EE, Oguntayo OA, Obishakin OF. Prevalence of high-risk human papillomavirus genotypes among apparently healthy women with normal and abnormal cervical cytology in Kaduna State, Nigeria. Afr J Clin Exper Microbiol. 2024; 25(1): 17-27. doi: 10.4314/ajcem.v25i1.3*
17. *Bruni L, Diaz M, Castellsagué M, Ferrer E, Bosch X, de Sanjosé S. Cervical human papillomavirus prevalence in 5 continents: meta-analysis of 1 million women with normal cytological findings. J Infect Dis. 2010; 202(12): 1789-1799. doi: 10.1086/657321*
18. *Seyoum A, Assefa N, Gure T, Seyaum B, Mulu A, Mihret A. Prevalence and genotype distribution of high-risk human papillomavirus infection among Sub-Saharan African women: A systematic review and meta-analysis. Front Public Health. 2022: 10;890880. doi: 10.3389/fpubh.2022.890880*
19. *Zeng Z, Austin RM, Wang L, Guo X, Zeng Q, Zheng B, et al. Nationwide prevalence and genotype distribution of high-risk human papillomavirus infection in China: Analysis of 2,458,227 test results from 29 Chinese Provinces. Am J Clin Pathol. 2022; 157(5): 718-723. doi: 10.1093/ajcp/aqab181*
20. *Saldaña-Rodríguez P, Bahena-Román M, Delgado-Romero K, Madrid-Marina V, Torres-Poveda K. Prevalence and Risk Factors for High-Risk Human Papillomavirus Infection and Cervical Disorders: Baseline Findings From an Human Papillomavirus Cohort Study. Cancer Control. 2023; 30: 1-21. doi: 10.1177/10732748231202925*
21. *Mbulawa ZZ, Somdyala NI, Mabunda SA, Williamson AL. High human papillomavirus prevalence among females*

attending high school in the Eastern Cape Province of South Africa. PLoS One. 2021; 16(6): e0253074. doi: 10.1371/journal.pone.0253074

22. *Krings A, Dunyo P, Pesic A, Tetteh S, Hansen B, Gedzah I, et al. Characterization of Human Papillomavirus prevalence and risk factors to guide cervical cancer screening in the North Tongu District, Ghana. PLoS One. 2019; 14(6): e0218762. doi: 10.1371/journal.pone.0218762*
23. *Lynge E, Thamsborg L, Larsen LG. Prevalence of high-risk human papillomavirus after HPV-vaccination in Denmark. Int J Cancer. 2020; 147(12): 3446-3452. doi: 10.1002/ijc.33157*
24. *Bao HL, Jin C, Wang S, Song Y, Xu Z, Yan X, et al. Prevalence of cervicovaginal human papillomavirus infection and genotypes in the pre-vaccine era in China: a nationwide population-based study. J Infect. 2021; 82(4): 75-83. doi: 10.1016/j.jinf.2021.02.017*
25. *Tao X, Zhang H, Wang S, Chen T, Cong Q, Wang L, et al. Prevalence and carcinogenic risk of high-risk human papillomavirus subtypes in different cervical cytology: A study of 124,251 cases from the largest academic center in China. J Am Soc Cytopathol. 2021; 10(4): 391-398. doi: 10.1016/j.jasc.2021.03.006*
26. *Williams EA, Newberg J, Williams KJ, Montesion M, Alexander B, Lin D, et al. Prevalence of high-risk nonvaccine human papillomavirus types in advanced squamous cell carcinoma among individuals of African vs non-African ancestry. JAMA Netw Open. 2021; 4(5): e216481. doi: 10.1001/jamanetworkopen.2021.6481*
27. *Guan P, Howell-Jones R, Li N, Bruni L, de Sanjosé S, Franceshi S, et al. Human papillomavirus types in 115,789 HPV-positive women: A meta-analysis from cervical infection to cancer. Int J Cancer. 2012: 131(10); 2349-2359. doi: 10.1002/ijc.27485*
28. *Franceschi S, Herrero R, Clifford GM, Snijders P, Arslan A, Anh PT, et al. Variations in the age-specific curves of human papillomavirus prevalence in women worldwide. Int J Cancer. 2006: 119(11); 2677-2684. doi: 10.1002/ijc.22241*
29. *Forman D, de Martel C, Lacey CJ, Soerjomataram I, Lortet-Tieulent J, Bruni L, et al. Global burden of human papillomavirus and related diseases. Vaccine. 2012; 30: F12-F23. doi: 10.1016/j.vaccine.2012.07.055*
30. *Roberts JM, Machalek DA, Butler BC, Crescini J, Garland SM, Farnsworth A, et al. Older women testing positive for HPV 16/18 on cervical screening and risk of high-grade cervical abnormality. Int J Cancer. 2023; 152(8): 1593-1600. doi: 10.1002/ijc.34393*
31. *Zhong C, Li X, Teng Y, Tian J. Co-infection with human papillomavirus and sexually transmitted infections among Chinese individuals. Microb Pathog. 2023; 185: 106395. doi: 10.1016/j.micpath.2023.106395*
32. *Unigwe I, Yang S, Song HJ, Lo-Ciganic WH, Hincapie-Castillo J, Cook RL, et al. Trends in sexually transmitted infections in United States ambulatory care clinics from 2005–2016. J Clin Med. 2021; 11(1): 71. doi: 10.3390/jcm11010071*
33. *A D, Bi H, Zhang D, Xiao B. Association between human papillomavirus infection and common sexually transmitted infections, and the clinical significance of different Mycoplasma subtypes. Front Cell Infect Microbiol. 2023; 13: 1145215. doi: 10.3389/fcimb.2023.1145215*