

# Circulation of *Streptococcus pneumoniae* clone Colombia<sup>5</sup> ST289 in nine Latin American countries

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## ABSTRACT

**Objective.** To determine genetic relatedness of clone Colombia<sup>5</sup> ST289 with invasive *Streptococcus pneumoniae* serotype 5 isolates recovered in nine Latin American countries.

**Methods.** Forty-four invasive *S. pneumoniae* serotype 5 isolates recovered from children under 5 years of age in Bolivia, Chile, Dominican Republic, Ecuador, Nicaragua, Panama, Paraguay, Peru, and Venezuela were studied. Pulsed-field gel electrophoresis patterns of DNA treated with SmaI restriction enzyme were classified using Tenover's criteria and analyzed with the Fingerprinting II program to determine their genetic relatedness with the Colombian clone.

**Results.** All isolates had a genetic similarity of 78.5% or more with the Colombian clone. Thirteen electrophoretic subtypes derived of pattern A were identified, and five of them (A5, A6, A8, A13, A27) comprised 61.4% of the isolates.

**Conclusions.** Clone Colombia<sup>5</sup> ST289 is disseminated in Latin America. This is important because *S. pneumoniae* serotype 5 frequently causes invasive disease in the region and is associated with trimethoprim-sulfamethoxazole resistance.

## Key words

*Streptococcus pneumoniae*; epidemiology, molecular; Latin America; electrophoresis, gel, pulsed-field; surveillance, Latin America.

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*Streptococcus pneumoniae* is one of the leading pathogens causing pneumonia, otitis media, bacteremia, and meningitis worldwide (1). In developing coun-

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tries, approximately two million children younger than 5 years of age die each year due to acute respiratory infections, which are the main cause of death in this age group (2). Based on structural differences of capsular polysaccharides, 90 serotypes of *S. pneumoniae* have been identified; the serogroups 1, 4, 5, 6, 9, 14, 18, 19, and 23 have been identified among the causes of approximately 80 to 90% of invasive diseases in the world (3).

While the main serotypes of *S. pneumoniae* associated with invasive diseases

have been determined in various countries and age groups (3, 4), it is important to establish if these isolates are genetically related and if they are disseminated internationally as well as locally. Several molecular studies have shown that the prevalence of some serotypes is due to the presence of clones that are mainly associated with antibiotic resistant traits and have a wide geographic distribution (5). Since the first description of *S. pneumoniae* isolates non-susceptible to penicillin, there has been a rapid dissemination of clones resistant to that antibiotic, particularly serotypes 23F and 19F clones (5). The dissemination of penicillin-susceptible clones has been reported as well (6).

Since 1994, the Regional Vaccine System (SIREVA) of the Pan American Health Organization (PAHO) has carried out a surveillance program to identify the distribution of capsular types and antimicrobial susceptibility of *S. pneumoniae* isolates in the Latin American region. Based on the results of the program, it has been possible to determine that *S. pneumoniae* serotype 5 isolates are one of the most important causes of invasive disease in young children (1, 4, 7) and one of the most frequently isolated serotypes in Latin America (3, 8, 9). In Colombia, it was determined that *S. pneumoniae* serotype 5 isolates are genetically related according to the chromosomal DNA restriction patterns, suggesting the circulation of one clone, which is phenotypically characterized for being penicillin-susceptible as well as tetracycline- and chloramphenicol-resistant (10), and is defined by the Pneumococcal Molecular Epidemiology Network (PMEN) as the clone Colombia<sup>5</sup> ST289 (6), formerly called the Colombia<sup>5</sup>-19 clone.

In 2002, a molecular study on *S. pneumoniae* serotype 5 isolates recovered in Argentina, Brazil, Guatemala, Mexico, and Uruguay was performed as part of surveillance of capsular types and antimicrobial susceptibilities of *S. pneumoniae* in the Latin American region, and the circulation of the Colombia<sup>5</sup> ST289 clone in those countries was established (11). Currently, all countries of the region participate in the surveillance program. The objective of the current study was to determine the genetic relatedness of the Colombia<sup>5</sup> ST289 clone with the invasive *S. pneumoniae* serotype 5 isolates recovered in nine Latin American countries as a way of exploring the circulation of the Colombian clone in those

countries and thus contributing to the surveillance program.

## MATERIALS AND METHODS

### Isolates

Forty-four *S. pneumoniae* serotype 5 isolates recovered in the nine countries between 2000 and 2005 from cerebral spinal fluid (50%), blood (31.8%), and pleural liquid (18.2%) of children less than 5 years old, with diagnosis of invasive disease such as meningitis (45.5%), pneumonia (27.3%), sepsis (18.2%), and others (9.1%), were studied. The countries of origin of the isolates were Bolivia ( $n = 8$ ), Chile ( $n = 7$ ), Dominican Republic ( $n = 7$ ), Ecuador ( $n = 6$ ), Nicaragua ( $n = 4$ ), Panama ( $n = 2$ ), Paraguay ( $n = 5$ ), Peru ( $n = 3$ ), and Venezuela ( $n = 2$ ). The number of invasive *S. pneumoniae* serotype 5 isolates studied was determined by the number of isolates of this type submitted by the nine collaborating national laboratories (study participants). Latin American countries without isolates of this type did not participate in the study.

All invasive *S. pneumoniae* isolates recovered from children less than 5 years old in the nine participating countries between 2000 and 2005 are shown in Table 1, as well as the number and proportion of isolates submitted to the authors of the current study. Isolates submitted for study were shipped in Amies transport medium with activated charcoal (12). The nine study participants provided the results of the isolate serotyping, which was done using the quellung reaction with antisera produced by the Statens Seruminstitut of Copen-

hagen, Denmark (12), as well as the data on antimicrobial susceptibility to penicillin, ceftriaxone, vancomycin, erythromycin, tetracycline, chloramphenicol, and trimethoprim-sulfamethoxazole (TMP-SMX), which were determined by both the disk diffusion method (Kirby-Bauer) and broth microdilution, according to National Committee for Clinical Laboratory Standards (NCCLS) (13) (now Clinical and Laboratory Standards Institute, CLSI).

The 44 isolates were susceptible to penicillin, ceftriaxone, vancomycin, and erythromycin. In addition, 40 (91%) and 41 (93.2%) were also susceptible to tetracycline and chloramphenicol respectively. The four isolates recovered in Nicaragua were resistant to tetracycline, and three of them were also resistant to chloramphenicol. In regard to TMP-SMX, resistance was observed in 30 (68.2%) of the isolates: four (out of seven) from Chile; four (out of five) from Paraguay; three (out of four) from Nicaragua; and the 19 isolates recovered in Bolivia, Ecuador, Panama, and Peru. All seven isolates from the Dominican Republic and both isolates from Venezuela were TMP-SMX-susceptible.

### Pulsed-field gel electrophoresis

Pulsed-field gel electrophoresis (PFGE) was carried out according to the protocol of Vela et al. (14). The isolates were embedded in 1.5% SeaKem Gold agarose plugs (Cambrex Corporation, East Rutherford, NJ, USA). The plugs were digested with 5- $\mu$ g/mL ribonuclease A, 1-mg/mL proteinase K, and 20 U of *Sma*I restriction enzyme (Promega, Madison,

**TABLE 1. Number of invasive *Streptococcus pneumoniae* serotype 5 isolates recovered, and submitted for study, out of all invasive *S. pneumoniae* isolates recovered from children less than 5 years old in nine Latin American countries between 2000 and 2005**

Country	Total invasive <i>S. pneumoniae</i> isolates recovered (No.)	Invasive <i>S. pneumoniae</i> serotype 5 isolates			
		Recovered		Studied	
		No.	%	No.	%
Bolivia	151	8	5.3	8	100
Chile	2 003	116	5.8	7	6.0
Dominican Republic	415	13	3.1	7	53.8
Ecuador	55	6	10.9	6	100
Nicaragua	39	4	10.2	4	100
Panama	54	2	3.7	2	100
Paraguay	478	74	15.5	5	6.8
Peru	143	12	8.4	3	25
Venezuela	407	38	9.3	2	5.3
Total	3 475	273	7.8	44	16.1

WI, USA). *S. pneumoniae* Spn 1439-106 (ATCC BAA-341) was used as the reference for electrophoretic pattern A of the clone Colombia<sup>5</sup> ST289 (10). Strain R6 (donated by Alexander Tomasz of The Rockefeller University, New York, NY, USA) was used as a control for sample processing and electrophoretic conditions, and a lambda phage (New England Biolabs Inc., Ipswich, MA, USA) was used as a molecular weight marker. A clamped homogeneous electric field DRII apparatus (Bio-Rad Laboratories Inc., Hercules, CA, USA) was used to run the gels. Running conditions were 23 h at 11.3° C at 6 V/cm, with switch times ramped from 5 s to 35 s (14). Gels were stained with 0.5-mg/mL ethidium bromide and photographed with a Polaroid MP4 Land Camera.

### DNA restriction patterns analysis

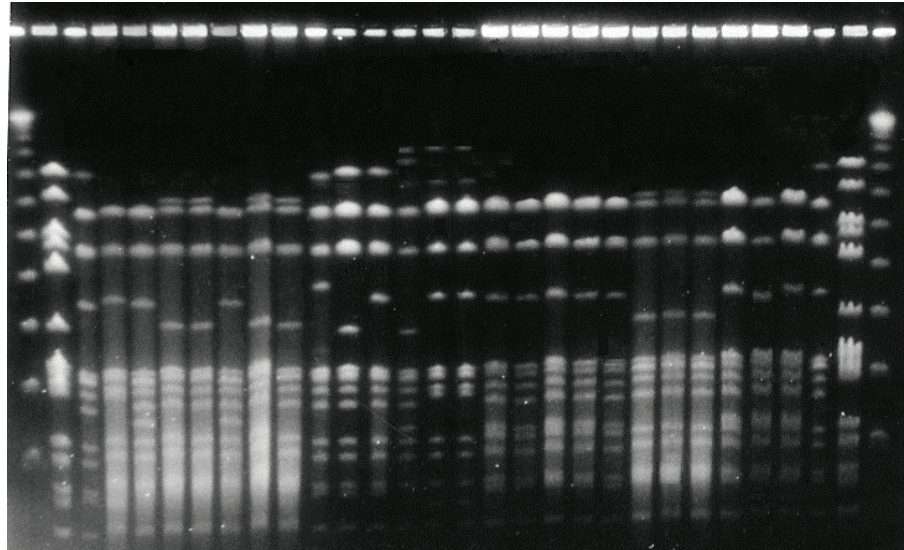
Isolate band patterns obtained by PFGE were classified according to Tenover's criteria (15) (i.e., isolates with the same number of bands and same molecular size were designated as genetically indistinguishable and assigned a single pattern, with an isolate considered closely or possibly related to the pattern when its PFGE profile differed in 2–3 bands or in 4–6 bands, respectively) and analyzed with the Fingerprinting II program (Bio-Rad), which calculates the Dice similarity coefficient ( $S_p$ ) according to the electrophoretic patterns. The unweighted pair group method of average linkage (UPGMA) was used to generate a dendrogram and to determine genetic similarity between isolates.

The electrophoretic patterns identified in the current study were compared with those previously determined in Colombia and other Latin American countries (11, 16) to determine if the same patterns are present in different countries of the region.

### RESULTS

All 44 invasive *S. pneumoniae* serotype 5 isolates recovered in the nine participating countries and submitted for this study were genetically related to the Colombia<sup>5</sup> ST289 clone, according to DNA restriction patterns obtained by PFGE. Figure 1 shows some of the band patterns for invasive *S. pneumoniae* serotype 5 isolates recovered across the nine countries, derived from PFGE. Table 2

**FIGURE 1.** Pulsed-field gel electrophoresis band patterns of invasive *Streptococcus pneumoniae* serotype 5 isolates recovered from children less than 5 years old in some Latin American countries<sup>a</sup> between 2000 and 2005<sup>b</sup>



<sup>a</sup> Bolivia (Bol), Ecuador (Ecu), Nicaragua (Nic), Panama (Pan), Paraguay (Par), Peru (Per), and Venezuela (Ven).

<sup>b</sup> Lanes 1 and 30 contain lambda phage, lanes 2 and 29 contain reference strain R6, and lanes 3 and 28 contain clone Colombia<sup>5</sup> ST289 (A). Lane 4, Bol 16 (A28); lane 5, Ecu 8 (A5); lane 6, Ecu 19 (A8); lane 7, Ecu 24 (A8); lane 8, Ecu 49 (A5); lane 9, Ecu 91 (A8); lane 10, Ecu 100 (A8); lane 11, Nic 18 (A31); lane 12, Nic 20 (A32); lane 13, Nic 34 (A); lane 14, Nic 38 (A33); lane 15, Pan 16 (A34); lane 16, Pan 75 (A34); lane 17, Par 291 (A5); lane 18, Par 577 (A5); lane 19, Par 802 (A5); lane 20, Par 1042 (A5); lane 21, Par 1213 (A5); lane 22, Per 19 (A8); lane 23, Per 20 (A8); lane 24, Per 21 (A8); lanes 25 and 26, Ven 227218 (A5); and lane 27 Ven 230183 (A5).

shows the 13 subtypes identified as derived of pattern A among the 44 isolates. Subtypes A5, A6, A8, A13, and A27, originally identified in previous studies (11, 16), comprised 61.4% of the isolates. In contrast, subtypes A28 to A35 were recognized for the first time in this study and included 38.6% of the isolates. Two of the three most frequent subtypes (A5 and A8) were found in more than one of the nine countries, whereas the remaining subtypes were found in only one country. Subtype A28 was concentrated in Bolivia. Three other countries (Panama, Paraguay, and Peru) each had one subtype. The other five countries had more than one subtype (Table 2).

According to the PFGE band patterns, all isolates identified across 15 Latin American countries in this study and in previous studies (11, 16) had a genetic similarity higher than 78.5% (Figure 2), which indicates that all of them belong to the same clonal group. Based on the results of this study and the previous studies mentioned above, a map of the geographic distribution of the main electrophoretic subtypes identified thus far in the 15 countries was elaborated (Figure 3). In addition, all electrophoretic subtypes identified in each of the 15 countries are presented in Table 3.

Isolates recovered in Nicaragua presented an approximately 340-kb restriction band. Susceptibility to TMP-SMX was mainly observed in the isolates from the Dominican Republic, which were grouped in subtype A6; the two isolates from Venezuela were grouped in subtype A5.

### DISCUSSION

The genetic relatedness found between the invasive *S. pneumoniae* serotype 5 isolates recovered in Bolivia, Chile, Dominican Republic, Ecuador, Nicaragua, Panama, Paraguay, Peru, and Venezuela with the clone Colombia<sup>5</sup> ST289, along with evidence of genetic relatedness among isolates found in Argentina, Brazil, Colombia, Guatemala, Mexico, and Uruguay (11), provides evidence for the assertion that this clone was disseminated in Latin America between 1988 and 2005. The low genetic diversity among *S. pneumoniae* serotype 5 isolates can be attributed to the fact that the isolates are rarely recovered from the nasopharynx and thus have a low probability for genetic exchange with isolates of different serotypes or with other microorganisms present in the bacterial flora (1).

**TABLE 2.** Distribution of invasive *Streptococcus pneumoniae* serotype 5 isolates recovered from children less than 5 years old, by subtypes identified through pulsed-field gel electrophoresis (PFGE) band patterns, in nine Latin American countries between 2000 and 2005

Subtype	No.	%	Country (No.)
A5 <sup>a</sup>	9	20.5	Paraguay (5) Venezuela (2) Ecuador (2)
A28	8	18.2	Bolivia (8)
A8 <sup>a</sup>	7	15.9	Ecuador (4) Peru (3)
A6 <sup>a</sup>	5	11.4	Dominican Republic (5)
A27 <sup>a</sup>	4	9.1	Chile (4)
A30	2	4.5	Chile (2)
A34	2	4.5	Panama (2)
A <sup>b</sup>	1	2.3	Nicaragua (1)
A31	1	2.3	Nicaragua (1)
A32	1	2.3	Nicaragua (1)
A33	1	2.3	Nicaragua (1)
A13 <sup>a</sup>	1	2.3	Dominican Republic (1)
A29	1	2.3	Dominican Republic (1)
A35	1	2.3	Chile (1)
Total	44	100	

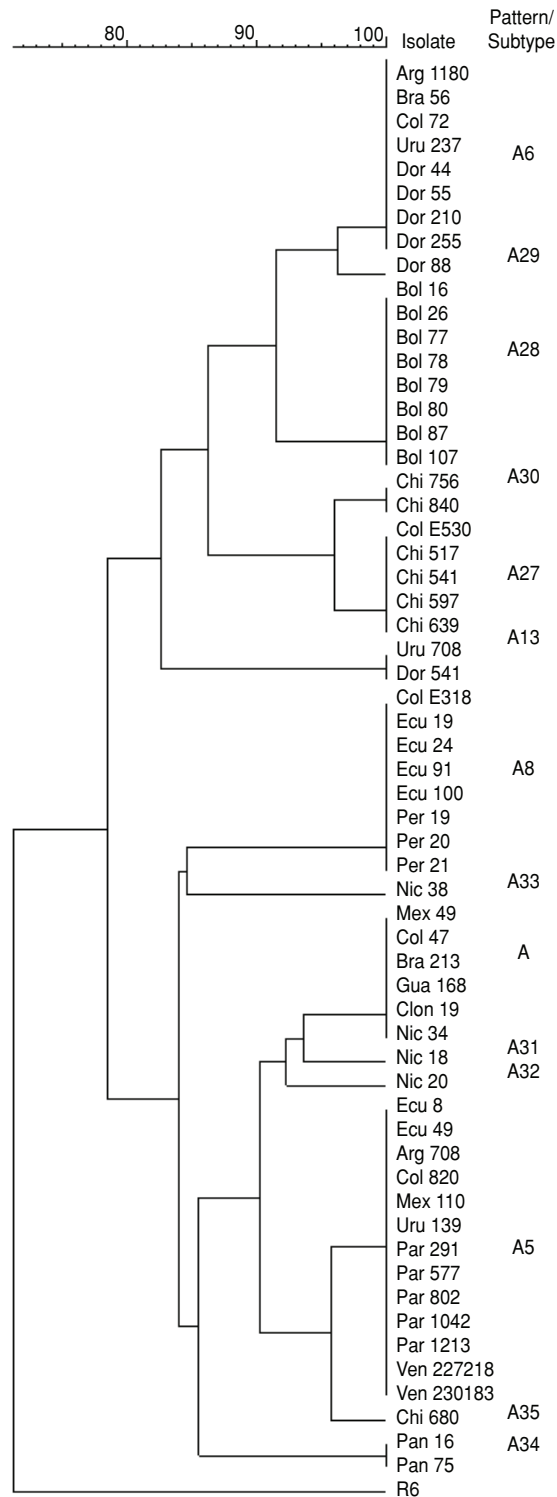
<sup>a</sup> PFGE band pattern identified in Gamboa L, Camou T, Hortal M, Castañeda E; the Sireva-Vigía Working Group. Dissemination of *Streptococcus pneumoniae* clone Colombia<sup>5</sup>-19 in Latin America. *J Clin Microbiol.* 2002;40(11):3942–50; and Firacative C, Moreno J, Castañeda E. Caracterización molecular de aislamientos invasores colombianos de *Streptococcus pneumoniae* serotipo 5, recuperados entre 1994 y 2004. *Biomédica.* 2006;26(2):295–301.

<sup>b</sup> PFGE band pattern of Colombia<sup>5</sup> ST289 clone.

Electrophoretic subtype A28 was identified in Bolivia for the first time in this study, which suggests that the subtype could be derived from one common ancestor established in the country (15). The dispersion of subtype A8 was limited to the border area between Peru, Ecuador, and Colombia, whereas subtypes A, A5, A6, and A27 have been identified in several geographically distant countries (11). These results indicate that different *S. pneumoniae* serotype 5 isolates, although all genetically related to the clone Colombia<sup>5</sup> ST289, display different dispersion behaviors in Latin America (Table 3).

Tetracycline and chloramphenicol resistance of the Nicaragua isolates (subtypes A, A31, A32, and A33) was associated with an approximately 340-kb fragment restriction that has been related to this type of resistance in the A pattern of the Colombia<sup>5</sup> ST289 clone (10) as well as some other subtypes, including A1, A3, A16, and A28 (11, 16). Tetracycline resistance can be attributed to the selec-

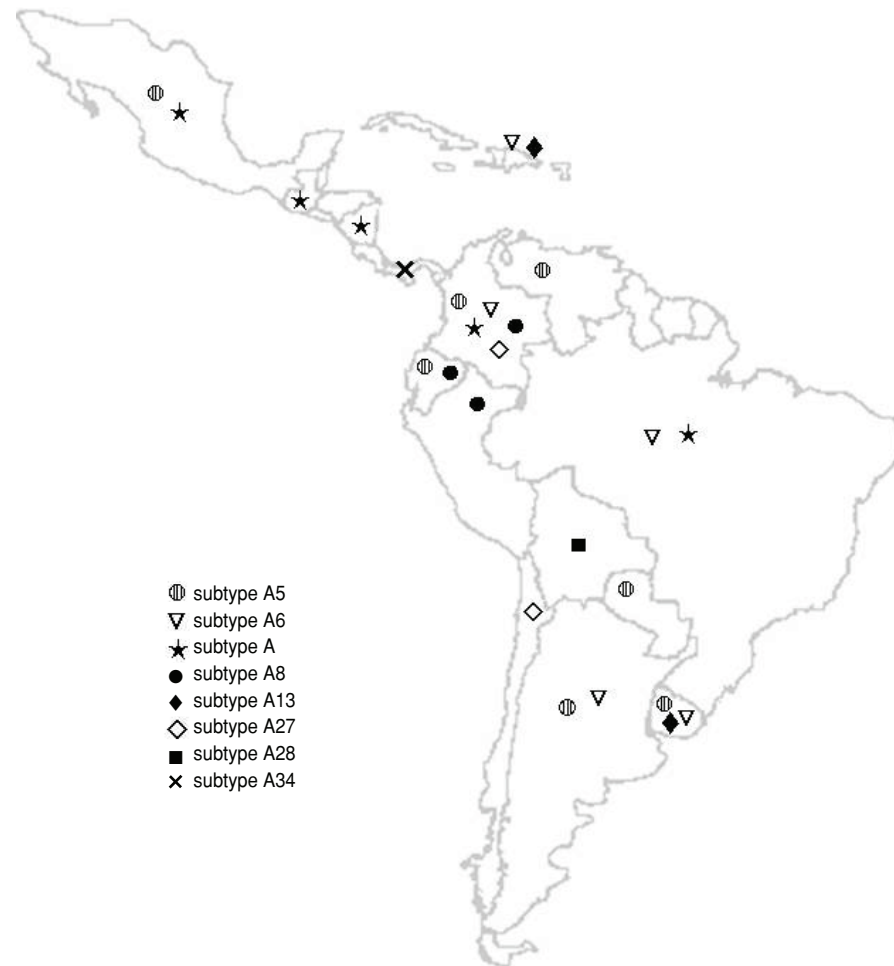
**FIGURE 2.** Dendrogram of invasive *Streptococcus pneumoniae* serotype 5 isolates recovered from children less than 5 years old, by electrophoretic subtypes identified through pulsed-field gel electrophoresis (PFGE),<sup>b</sup> in 15 Latin American countries<sup>a</sup>



<sup>a</sup> Argentina (Arg); Bolivia (Bol); Brazil (Bra); Chile (Chi); Colombia (Col); Dominican Republic (Dor); Ecuador (Ecu); Guatemala (Gua); Nicaragua (Nic); Mexico (Mex); Panama (Pan); Paraguay (Par); Peru (Per); Uruguay (Uru); Venezuela (Ven).

<sup>b</sup> PFGE band patterns identified in Gamboa L, Camou T, Hortal M, Castañeda E; the Sireva-Vigía Working Group. Dissemination of *Streptococcus pneumoniae* clone Colombia<sup>5</sup>-19 in Latin America. *J Clin Microbiol.* 2002;40(11):3942–50; and Firacative C, Moreno J, Castañeda E. Caracterización molecular de aislamientos invasores colombianos de *Streptococcus pneumoniae* serotipo 5, recuperados entre 1994 y 2004. *Biomédica.* 2006;26(2):295–301.

**FIGURE 3.** Geographic distribution of the main electrophoretic subtypes (identified through pulsed-field gel electrophoresis<sup>a</sup>) of invasive *Streptococcus pneumoniae* serotype 5 isolates recovered from children less than 5 years old in 15 Latin American countries<sup>b</sup>



<sup>a</sup>Pulsed-field gel electrophoresis (PFGE) band patterns identified in Gamboa L, Camou T, Hortal M, Castañeda E; the Sireva-Vigía Working Group. Dissemination of *Streptococcus pneumoniae* clone Colombia<sup>5</sup>-19 in Latin America. *J Clin Microbiol.* 2002;40(11):3942–50; and Firacative C, Moreno J, Castañeda E. Caracterización molecular de aislamientos invasores colombianos de *Streptococcus pneumoniae* serotipo 5, recuperados entre 1994 y 2004. *Biomédica.* 2006;26(2):295–301.

<sup>b</sup>Argentina, Bolivia, Brazil, Chile, Colombia, Dominican Republic, Ecuador, Guatemala, Nicaragua, Mexico, Panama, Paraguay, Peru, Uruguay, Venezuela.

tive pressure generated by the use of this antibiotic as treatment for pneumococcal diseases (1, 5). For this reason, the low frequency of tetracycline-resistant isolates found in this study (9.1%) can be explained by the fact that isolates were recovered from children less than 5 years of age, in whom tetracycline is not a recommended treatment (17). In Colombia, tetracycline is used in the treatment of pneumonia in adults (18, 19), and it has been reported that 55.6% of *S. pneumoniae* isolates recovered from patients older than 5 years of age are resistant (16). The proportion of isolates in this study that were resistant to TMP-SMX (68.2%) was lower than the overall resistance (80.8%) reported by Argentina, Brazil, Colombia,

Mexico, and Uruguay (11). The TMP-SMX resistance of *S. pneumoniae* serotype 5 isolates has been steadily increasing in Colombia (from 58.1% in 1994 to 97.6% in 2004) (11, 16) as well as other countries (e.g., in Israel it rose from 36% in 1995 to 62.8% in 1999) (20, 21). The increase in TMP-SMX resistance could indicate that this trait can be clonally propagated both within and across countries, as has occurred with other *S. pneumoniae* antimicrobial-resistant clones that have been disseminated in several countries (17, 22, 23). However, the dissemination of clones susceptible to the major classes of antimicrobial agents, such as the Colombia<sup>5</sup> ST289 clone, is probably due to virulence factors, mainly the capsular type, which

**TABLE 3.** Subtypes of Colombia<sup>5</sup> ST289 clone identified through pulsed-field gel electrophoresis (PFGE) band patterns,<sup>a</sup> in 15 Latin American countries

Country	Subtypes
Colombia	A, A1, A3–A6, A8, A16–A28
Argentina	A5, A6
Bolivia	A28
Brazil	A, A2, A6, A7
Chile	A27, A30, A35
Dominican Republic	A6, A13, A29
Ecuador	A5, A8
Guatemala	A, A14, A15
Nicaragua	A, A31, A32, A33
Mexico	A, A3, A5
Panama	A34
Paraguay	A5
Peru	A8
Uruguay	A5–A7, A9–A13
Venezuela	A5

<sup>a</sup>PFGE band patterns identified in Gamboa L, Camou T, Hortal M, Castañeda E; the Sireva-Vigía Working Group. Dissemination of *Streptococcus pneumoniae* clone Colombia<sup>5</sup>-19 in Latin America. *J Clin Microbiol.* 2002;40(11):3942–50; and Firacative C, Moreno J, Castañeda E. Caracterización molecular de aislamientos invasores colombianos de *Streptococcus pneumoniae* serotipo 5, recuperados entre 1994 y 2004. *Biomédica.* 2006;26(2):295–301.

allow them to spread and cause diseases, as opposed to the dissemination of resistant clones as a result of the selective pressure generated by the antimicrobials (24–27).

Considering the fact that the Colombia<sup>5</sup> ST289 clone has been identified outside Latin America, in countries as far away as Israel (20, 21), Portugal (22), and Mali (28), and that the frequency of *S. pneumoniae* serotype 5 isolates in Latin America varies from 2.2% in Mexico (3, 8, 9) to 15.5% in Paraguay (SIREVA II,<sup>12</sup> personal communication, 28 November 2006), it is possible that in other regions where these invasive isolates have been recovered in similar percentages, such as Africa (e.g., 14% in Gambia (29), 13% in Kenya (30), and 10% in Mozambique (31)), the Colombia<sup>5</sup> ST289 clone may be circulating undetected. For example, in Canada, before 2005, serotype 5 isolates were rarely recovered, but currently they are commonly recovered from adults and are related to the Colombia<sup>5</sup> ST289 clone (M. Lovgren, National Centre for Streptococcus, Edmonton, Alberta, Canada, personal communication, 9 February 2007). Therefore, systematic study of the genetic relatedness between the isolates and the clone is recommended to

<sup>12</sup> Network Surveillance System for the Bacterial Agents Responsible for Pneumonia and Meningitis.



contribute to the molecular surveillance of the *S. pneumoniae* serotype 5 isolates.

In contrast to the first report about the circulation of the Colombian clone in some countries of Latin America (11), this study was limited by the fact that not all *S. pneumoniae* serotype 5 isolates recovered by the participating countries were analyzed. Although study of the unexamined isolates is recommended, to complement the results of the current study, it was possible, with a few number of isolates, to carry out this study's aim, which was to demonstrate the circulation of the Colombia<sup>5</sup> ST289 clone in Latin American countries where this had not been previously determined. In addition, this study provides useful information that may stimulate further research in this field.

In conclusion, the dissemination of the Colombia<sup>5</sup> ST289 clone in Latin America supports the need for continuous surveillance of *S. pneumoniae* serotype 5 isolates in the region, because these isolates are associated with TMP-SMX resistance and are one of the main causes of invasive diseases in Latin American countries (3, 24). Moreover, current surveillance programs designed to establish genetic relatedness among invasive *S. pneumoniae* serotype 5 isolates, which are not included in the heptavalent conjugate vaccine currently available in Latin America, could contribute to evaluation of the selective pressure that may be gen-

erated when the 9-valent and 11-valent vaccines are introduced by allowing for the detection of genetic changes of the isolates or the emergence of new clones (3).

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## RESUMEN

### Circulación de *Streptococcus pneumoniae* clon Colombia<sup>5</sup> ST289 en nueve países de América Latina

**Objetivo.** Determinar la relación genética del clon Colombia<sup>5</sup> ST289 con los aislamientos invasores de *Streptococcus pneumoniae* serotipo 5 provenientes de nueve países latinoamericanos.

**Métodos.** Se estudiaron 45 aislamientos invasores de *Streptococcus pneumoniae* serotipo 5 procedentes de niños menores de 5 años de Bolivia, Chile, Ecuador, Nicaragua, Panamá, Paraguay, Perú, República Dominicana y Venezuela. Los patrones en electroforesis en gel de campo pulsante del ADN tratado con la enzima de restricción *Sma*I se clasificaron mediante el criterio de Tenover y se analizaron con el programa Fingerprinting II para determinar su relación genética con el clon colombiano.

**Resultados.** Todos los aislamientos tuvieron una similitud genética de 78,5% o mayor con el clon colombiano. Se identificaron 13 subtipos electroforéticos derivados del patrón A y cinco de ellos (A5, A6, A8, A13 y A27) constituyeron 61,4% de los aislamientos.

**Conclusiones.** El clon Colombia<sup>5</sup> ST289 está diseminado por América Latina. Esto es importante ya que *S. pneumoniae* serotipo 5 es causa frecuente de enfermedades invasoras en la Región y está asociado con la resistencia a trimetoprim-sulfametoxazol.

## Palabras clave

*Streptococcus pneumoniae*, vigilancia, epidemiología molecular, electroforesis en gel de campo pulsado, América Latina.