Epidemiol. Infect. (2005), **133**, 861–869. © 2005 Cambridge University Press
doi:10.1017/S0950268805004437 Printed in the United Kingdom

Rubella and measles seroprevalence among women of childbearing age, Argentina, 2002

G. H. DAYAN[1]*, M. S. PANERO[2], A. URQUIZA[3], M. MOLINA[4], S. PRIETO[5], M. DEL CARMEN PEREGO[6], G. SCAGLIOTTI[7], D. GALIMBERTI[8], G. CARROLI[9], C. WOLFF[10], D. BI[1], W. BELLINI[11], J. ICENOGLE[11] AND S. REEF[1]

[1] *Epidemiology and Surveillance Division, National Immunization Program, Centers for Disease Control and Prevention, Atlanta, GA, USA*
[2] *Vigi+A Program, Ministry of Health, Buenos Aires, Argentina*
[3] *Direction of Primary Care, Salta, Argentina*
[4] *Lagomaggiore Hospital, Mendoza, Argentina*
[5] *Scaravelli Hospital, Tunuyán, Mendoza, Argentina*
[6] *Sarda Maternity Hospital, Buenos Aires, Argentina*
[7] *Pirovano Hospital, Buenos Aires, Argentina*
[8] *Alvarez Hospital, Buenos Aires, Argentina*
[9] *Martin Maternity Hospital, Rosario, Argentina*
[10] *Ministry of Health, Buenos Aires, Argentina*
[11] *Division of Viral and Rickettsial Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, GA, USA*

(*Accepted 9 March 2005*)

SUMMARY

To assess rubella and measles susceptibility among women of childbearing age we conducted a cross-sectional seroprevalence study in four cities and one rural area in Argentina. A convenience sample of women aged 15–49 years seeking care in public health-care institutions was selected ($n=2804$). Serum specimens were tested for rubella and measles IgG antibody titres. The overall susceptibility to rubella and measles was 8·8 and 12·5% respectively. Seroprevalence differences were found for both rubella ($P<0·001$) and measles ($P=0·002$) across sites. Rubella seroprevalence was higher in women aged $\geqslant 40$ years than in younger women ($P=0·04$). Measles seroprevalence tended to increase with age ($P<0·001$). Approximately 15% of women aged 15–29 years were not immune to measles. No risk factors were associated with rubella seronegativity; however, age ($P<0·001$) and having less than four pregnancies ($P<0·001$) were factors associated with measles seronegativity. Our findings support the introduction of supplemental immunization activities targeting adolescents and young adults to prevent congenital rubella syndrome and measles outbreaks over time.

INTRODUCTION

Rubella and measles are rash illnesses usually seen in children. Although rubella is usually a mild illness, when a pregnant woman becomes infected during the first trimester, serious consequences can result such as spontaneous abortions, fetal deaths, stillbirths and a constellation of birth defects known as congenital rubella syndrome (CRS). Approximately 85% of infants born to mothers infected during the first 11 weeks of pregnancy will develop CRS [1, 2]. The most common congenital defects are cataracts, heart defects and

* Author for correspondence: Dr G. H. Dayan, Centers for Disease Control and Prevention, National Immunization Program, 1600 Clifton Rd, Mailstop E-61, Atlanta, GA 30333, USA. (Email: gdayan@cdc.gov)

hearing impairment [3]. In Argentina, data regarding rubella surveillance based on clinical diagnosis, available since 1970, have shown a cyclic pattern, with incidence peaking every 3–5 years. During 2000–2001, most rubella cases occurred among children aged 4–14 years; however, during large outbreaks, cases have occurred among young adults as well.

In 1998, rubella vaccine was introduced in Argentina's national immunization schedule, with two doses of measles, mumps, and rubella (MMR) vaccine recommended at 1 and 6 years of age. No surveillance system for CRS exists. Mathematical models suggest that when childhood vaccination with inadequate coverage is implemented, CRS rates may increase because the number of susceptible women of childbearing age (WCBA) increases [4]. However, at the time of the study, no additional immunization activities were in place to protect susceptible WCBA. To determine the optimal age range for additional immunization activities, understanding the rubella seroimmunity among WCBA is critical.

Measles is one of the most contagious infectious human diseases causing many complications and deaths [5]. In Argentina, measles vaccination was introduced into the routine vaccination schedule at the end of the 1970s and a two-dose schedule with the first dose at 12 months and the second at 6 years was instituted nationwide in 1998. During the 1980s, reported measles routine vaccination coverage increased from 58% in 1980 to 89% in 1989, remaining at over 90% during the 1990s [6]. According to the Pan American Health Organization recommendations [7], a measles 'catch-up' vaccination campaign targeting all children aged 1–14 years, regardless of previous vaccinations, was conducted in 1993. The 'catch-up' coverage rate was 97%. In addition, a second opportunity for measles immunization is provided through 'follow-up' campaigns targeting all children aged 1–4 years [7]. The first 'follow-up' measles vaccination campaign was conducted in 1998, and the second in 2002, with reported coverage rates of 98 and 87% respectively. Although reported routine measles vaccination coverage has been relatively high, outbreaks of measles have occurred. In 1984, and 1991 two measles outbreaks were reported, with $\sim$30 000 and $\sim$42 000 measles cases respectively. The last major outbreak occurred during 1997–1998, with $\sim$10 000 measles cases [8]. An increasing number of cases among adolescents and young adults was observed in the last outbreaks. During 1997–1998, most of the cases occurred in children $<$1 year of age, children aged 1–4 years, and in adults aged 20–40 years, particularly teachers and health-care workers. Data on measles seroprevalence among adults are needed to determine if additional vaccination activities need to be implemented.

The objectives of this seroprevalence study were: to determine the level of rubella immunity among WCBA in different areas of the country and to detect factors associated with lower immunity. This study provided the opportunity to determine the level of measles immunity in the same population and determine factors associated with low measles immunity.

METHODS

Study design

A multicentre cross-sectional study was conducted during August–November 2002. Because $\sim$90% of the population of the country lives in the main cities [9], the study was conducted in four main cities in Argentina (i.e. Buenos Aires, the capital located in the central eastern region; Rosario, in the central region; Mendoza, in the western region; and Salta in the northwestern region) (Fig. 1). Because Buenos Aires is traditionally divided into three main zones (i.e. Northern, Central and Southern) with different demographic characteristics, each zone was counted as a different site. In addition, one rural area (i.e. Valle de Uco area in Mendoza Province) was also studied (Fig. 1). The study population consisted of a convenience sample of women seeking care in public health-care institutions. In each site, except for Salta and Valle de Uco, the main public hospital with delivery facilities was selected. In Salta the study was conducted in seven health-care centres where pregnant women in the public sector are seen for prenatal screening. In the rural area, the participating institutions included the three rural hospitals and four health-care centres.

Sample size and selection

The sample size of 400 participants per site was calculated using an estimated seroprevalence of 90% and targeting 95% confidence interval bounds within 3% of the survey estimate.

In Argentina, only 0·45% of births occur among women aged $<$15 years and 0·021% in women aged $<$50 years [9]; thus, only women aged 15–49 years were recruited. Five age groups were considered to better describe age-specific seroprevalence and these

https://doi.org/10.1017/S0950268805004437

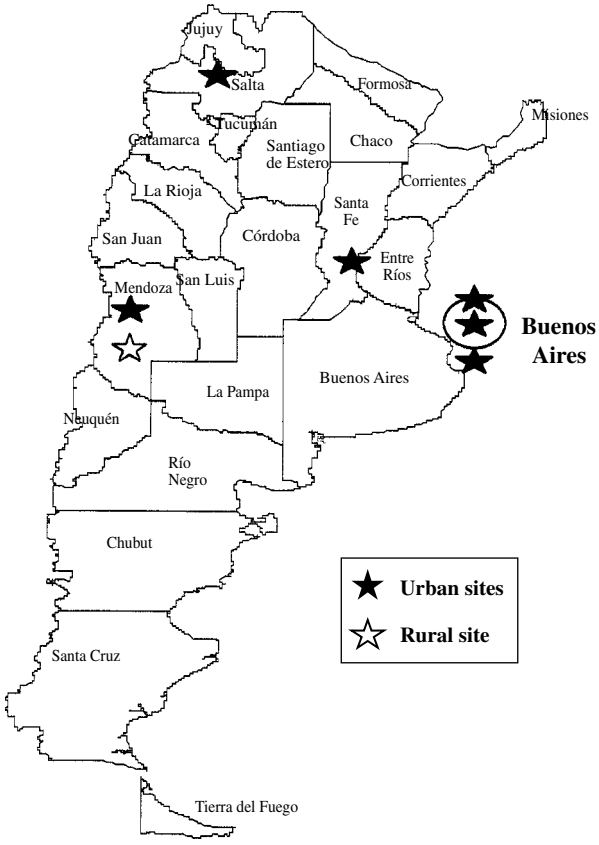

Fig. 1. Rubella and measles seroprevalence study, Argentina, 2002.

were: 15–19, 20–24, 25–29, 30–34, 35–49 years. Eighty patients were enrolled in each age group in each site. All eligible women attending the selected sites were asked to volunteer for the study. Women were enrolled consecutively and the study continued at each site until the enrolment targets were met.

Data collection

After informed consent was obtained, a questionnaire was completed by trained interviewers. Potential risk factors for susceptibility were collected: demographic data (age, time living in the same place, number of bedrooms, number of persons living in the same house, household income, number of persons aged <15 years living in the same household, private health insurance), number of pregnancies, and history of rubella vaccination.

Specimen handling and laboratory testing

The serum specimens were obtained from an aliquot of sera routinely obtained for other testing during prenatal care. All specimens were stored at $-15\,^{\circ}C$ at each local site. At the end of the study, the specimens were shipped in dry ice to the Centers for Disease Control and Prevention (CDC), Atlanta, to be tested for the presence of rubella and measles-specific IgG antibodies.

An indirect rubella IgG test (Wampole, Princeton, NJ, USA) was used for the detection of antibodies by enzyme immunoassay (EIA). This test was run according to the manufacturer's specifications, running control sera in the same test plate. The manufacturer reports sensitivity and specificity of the test when evaluated against haemaglutination inhibition (HAI) as 100 and 95·8% respectively. Results were reported as positive, negative or equivocal, according to the manufacturers' cut-off values. All specimens showing negative or equivocal results, as well as 10% of the positives were retested using the same laboratory test. Measles-specific IgG antibodies were assayed by use of a previously described EIA [10]. Measles IgG antibody test results were reported as positive, negative, or indeterminate. The indirect measles EIA gives predictive values for both positive and negative tests in excess of 90%, with sensitivity $>90\%$ and specificity $>98\%$ [11]. All indeterminate results were retested using the same laboratory test. The laboratory was blinded to information on participants. All laboratory data were recorded in a computerized Excel spreadsheet.

Data management

The data were entered into Epi-Info version 6 (CDC, Atlanta, GA, USA). Study results were analysed using Epi-Info 2002. For statistical analysis, negative and equivocal laboratory results were grouped together and classified as seronegative. Age-specific seropositive rates were tested for trend using the χ^2 test for trend. Association between seronegativity and the potential predictor variables was assessed using χ^2 or Fisher's exact test (two-tailed). Stratified analysis was performed to adjust for study site, using the Mantel–Haenzel summary χ^2 test to assess statistical significance. In addition, a logistic multivariate logistic regression model was also performed to identify independent predictors of seronegativity.

Benefits of participation

As soon as the results from the laboratory testing were available, the study coordinator in each site was notified and vaccination against measles and rubella

https://doi.org/10.1017/S0950268805004437

Table 1. *Characteristics of the sample of women of childbearing age (n = 2807) in the measles and rubella seroprevalence study, Argentina, 2002*

Characteristic	Northern BA (*n* = 392) %	Central BA (*n* = 390) %	Southern BA (*n* = 407) %	Rosario (*n* = 405) %	Mendoza (*n* = 402) %	Salta (*n* = 411) %	Rural (*n* = 400) %
Residence							
< 5 years living in the same area	36·2	37·9	35·6	6·4	24·9	8	28·8
⩾ 5 years living in the same area	61·5	59·7	64·4	89·9	75·1	72·5	71·0
Unknown	2·3	2·3	0·0	3·7	0·0	19·5	0·2
Crowding							
⩽ 2 persons per bedroom	67·1	60·8	70·5	53·8	46·5	41·8	52·0
> 2 persons per bedroom	32·1	39·0	29·0	45·4	53·5	58·2	48·0
Unknown	0·8	0·3	0·5	0·7	0·0	0·0	0·0
Household monthly income							
< 75 US$	16·1	18·2	36·9	41	35·3	51·8	38·0
⩾ 75 US$	81·4	80·3	63·1	58·5	64·5	45·0	61·8
Unknown	2·5	1·5	0·0	0·5	0·2	3·2	0·2
Number of household members < 15 years							
⩽ 2	81·4	75·1	83·0	74·6	60·4	57·2	69·8
> 2	18·1	24·9	17·0	24·4	39·3	42·6	30·3
Unknown	0·5	0·0	0·0	1·0	0·2	0·2	0·0
Health insurance							
Yes	18·9	11·0	2·0	10·4	21·9	12·9	19·5
No	81·1	89·0	98·0	89·6	78·1	86·9	80·5
Unknown	0·0	0·0	0·0	0·0	0·0	0·2	0·0
Number of pregnancies							
< 4	86·2	85·1	88·5	79·3	74·9	74	77·3
⩾ 4	13·8	14·9	11·5	20·7	25·1	26	22·8
Unknown	0·0	0·0	0·0	0·0	0·0	0·0	0·0
Education							
Primary incomplete	6·4	10·0	3·2	16·8	14·7	4·9	21·3
Primary complete	45·4	54·1	54·8	56·5	54·0	57·7	53·2
Secondary complete	33·4	25·6	36·9	19·3	18·9	30·1	19·0
Tertiary or University complete	14·3	10·3	5·1	7·4	12·2	7·3	6·5
Unknown	0·5	0·0	0·0	0·0	0·2	0·0	0·0
Rubella vaccination history							
Positive	28·6	19·7	33·7	23·8	12·4	12·4	15·3
Negative/does not know	71·2	80·3	66·3	76·0	87·6	87·6	84·7
Unknown	0·3	0·0	0·0	0·2	0·0	0·0	0·0

BA, Buenos Aires.

(MR) was offered to women found to be susceptible to rubella and/or measles after delivery.

RESULTS

Study population

A total of 2807 women were enrolled in the study. In each site, the number of women attending the selected health-care institutions constituted 30–90% of the population seen in the public sector during the period of enrolment. The number of enrolled women was 3–10% of the annual total number of births in that city/area. Demographics differed by site (Table 1). The lower percentage of people living for > 5 years in the same place in Buenos Aires reflects the internal migration for job seeking. Crowding, calculated as the number of people divided by the number of bedrooms

https://doi.org/10.1017/S0950268805004437

Table 2. *Rubella and measles laboratory results by place, seroprevalence study, Argentina, 2002*

		Rubella*						Measles†					
		Positive		Negative		Equivocal		Positive		Negative		Equivocal	
Site	*n*	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Northern BA	389	87·1	(83·4–90·3)	10·8	(8·0–14·4)	2·1	(1·0–4·2)	88·7	(85·1–91·7)	10·5	(7·8–14·1)	0·8	(0·2–2·4)
Central BA	390	87·9	(84·3–91·0)	9·5	(6·9–12·9)	2·6	(1·3–4·8)	92·3	(89·1–94·7)	7·7	(5·3–10·9)	0	(0·0–1·2)
Southern BA	407	91·9	(88·8–94·4)	6·6	(4·5–9·6)	1·5	(0·6–3·3)	82·3	(78·2–85·8)	17·2	(13·7–21·3)	0·5	(0·1–2·0)
Rosario	405	90·4	(87·1–93·1)	7·6	(5·3–10·8)	2	(0·9–4·0)	88·9	(85·4–91·8)	10·6	(7·9–14·1)	0·5	(0·1–2·0)
Mendoza	402	91·8	(88·7–94·3)	6·5	(4·3–9·5)	1·7	(0·8–3·7)	87·3	(83·7–90·4)	11·7	(8·8–15·3)	1	(0·3–2·7)
Salta	411	95·6	(93·0–97·3)	3·4	(1·9–5·8)	1	(0·3–2·6)	85·4	(81·5–88·6)	14·4	(11·2–18·2)	0·2	(0·0–1·6)
Rural	400	93	(89·9–95·2)	6	(4·0–8·9)	1	(0·3–2·7)	88	(84·4–91·0)	12	(9·1–15·7)	0	(0·0–1·2)
Total	2804	91·2	(90·0–92·2)	7·2	(6·3–8·2)	1·7	(1·2–2·2)	87·5	(86·2–88·7)	12·1	(10·9–13·3)	0·4	(0·2–0·8)

CI, confidence interval, BA, Buenos Aires.
* $P<0·001$ χ^2 test.
† $P=0·002$ χ^2 test.

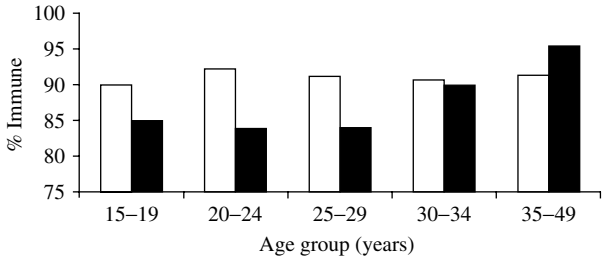

Fig. 2. Rubella (□) and measles (■) seroprevalence by age, Argentina, 2002. Measles: Trend test $P<0·001$.

in the house, was higher in Salta and Mendoza. Households with a monthly income of <75 US$ were also more frequent in Salta, reflecting the poorest socioeconomic conditions. The higher percentage of WCBA vaccinated against rubella was in Buenos Aires and Rosario reflecting easier access to vaccines in the biggest cities.

Rubella and measles seroprevalence

Of the 2807 women enrolled, serum was available and tested for rubella and measles IgG in 2804 (99·9%); among these, the overall seroprevalence was 91·2% for rubella and 87·5% for measles. Seroprevalence differed by study site (Table 2), ranging from 87·1% in northern Buenos Aires to 95·6% in Salta city for rubella ($P<0·001$), and from 82·3% in southern Buenos Aires to 92·3% in central Buenos Aires for measles ($P=0·002$). No significant trend was observed when comparing rubella seroprevalence across age groups (Trend test $P=0·72$) (Fig. 2). However, rubella seroprevalence was higher in women aged ⩾40 years (95·1%) than in women aged <40 years (90·8%) ($P=0·04$). Measles seroprevalence tended to increase with age (Trend test $P<0·001$). Approximately 15% of the women aged 15–30 years, ~10% aged 30–34 years and <5% aged 35–49 years were not immune.

Risk factors associated with lack of immunity

Living in a household with ⩽2 people per bedroom, and having less than four previous pregnancies were factors marginally associated with seronegativity for rubella in the univariate analysis (data not shown). However, no significant associations were found in the stratified analysis adjusting for study site (Table 3). Age ($P<0·001$) and having less than four pregnancies ($P<0·001$) were the only factors associated with measles seronegativity in both univariate (data not shown) and stratified analysis (Table 3). The first pregnancy is targeted for post-partum rubella vaccination if the woman is susceptible. Approximately 37% of women giving birth have a first child in Argentina [12], therefore, women with first pregnancies were also considered for rubella susceptibility risk-factor analysis.

However, having first pregnancies was not significantly associated with rubella seronegativity neither in the univariate nor in the stratified analysis. A

https://doi.org/10.1017/S0950268805004437

Table 3. *Stratified analysis of risk factors for seronegativity to rubella and measles in WCBA, seroprevalence study, Argentina, 2002*

	Rubella not immune			Measles not immune		
Characteristic	*n*	%	*P* value*	*n*	%	*P* value*
Age group (years)						
15–19	54	10·0	0·76	81	15	<0·001
20–24	47	7·8		97	16·1	
25–29	53	8·8		96	15·9	
30–34	49	9·3		52	9·9	
35–49	45	8·5		24	4·5	
Residence						
<5 years living in the same area	76	10·7	0·24	77	10·9	0·16
⩾5 years living in the same area	168	8·5		258	13·0	
Crowding						
⩽2 persons per bedroom	154	9·8	0·162	198	12·6	0·75
>2 persons per bedroom	93	7·6		149	12·2	
Household monthly income						
<75 US$	82	8·6	0·40	115	12·0	0·29
⩾75 US$	163	9·0		229	12·6	
Number of household members <15 years						
⩽2	191	9·5	0·22	247	12·3	0·79
>2	57	7·2		100	12·7	
Health insurance						
Yes	31	8·1	0·52	41	10·6	0·40
No	217	9·0		309	12·8	
Number of pregnancies						
⩾4	35	6·5	0·08	33	6·1	<0·001
<4	213	9·4		317	14·0	
Education						
Primary incomplete	34	11	0·12	34	11	0·7
Primary complete	133	8·8		183	12·1	
Secondary complete	60	8·2		108	14·7	
Tertiary or University complete	21	8·3		25	9·9	
Rubella vaccination history						
Positive	54	9·3	0·96	n.a.		
Negative/does not know	194	8·7		n.a.		

n.a., Not applicable.
* Maentel–Haenzel summary χ^2 *P* values adjusted for study site.

multivariate regression model including age, place of residence, crowding, number of household members <15 years old, number of pregnancies and site, showed the same results.

DISCUSSION

Our study revealed that susceptibility to rubella and measles virus infection in Argentinian WCBA is 8·8 and 12·5% respectively. Regional differences were seen that were probably due to different viral circulation patterns. No significant differences in rubella antibody seropositivity were found among women aged <40 years; however, measles seropositivity tended to increase with age. Having more than four pregnancies was also associated with increased measles seropositivity when adjusted for the study sites.

The overall seropositivity rates found in our study were in agreement with the results of other previous rubella seroprevalence studies carried out in some major cities of Argentina [13–19], and suggest that 90% of women have rubella infection before 15 years of age. Although increasing age has been associated with an increased percentage of rubella seropositivity in other studies [20, 21], no significant increase

https://doi.org/10.1017/S0950268805004437

with age was found in a seroprevalence study among WCBA in Switzerland [22] and among pregnant Turkish women [23]. The lower measles seroprevalence levels found in women <30 years old may reflect increased susceptibility in cohorts born after the introduction of vaccination in the 1970s with insufficient vaccination coverage. In addition, this difference may be explained by lower antibody titres after vaccination than after natural infection [24].

Although rubella immunity in females of low socioeconomic status was much higher than in women of higher socioeconomic class in India [25], our findings agreed with other studies conducted in The Netherlands [26], England [27] and a large seroepidemiological study conducted in Mexico [28]. Measles immunity has been related to socioeconomic status. Living at or above the poverty line or in a non-crowded household and a greater level of education of the head of household has been associated with susceptibility in the United States [29], probably reflecting lower antibody titres induced by measles vaccine. However, higher socioeconomic status has been linked to lower risk of disease and higher vaccination coverage [30].

Regional differences, as those found in our study were observed also in other countries for both rubella [22, 28] and measles [31], which may be a result of different epidemiological patterns and different vaccination coverage rates [32] among regions. Lower rubella incidence of seropositivity in rural females, probably due to a lower population density, was observed in different studies in different parts of the world [25, 28, 33]. However, such differences do not seem to be observed in the southern cone of South America, as reported in a World Health Organization study in the Americas, which showed no urban-rural differences in susceptibility to rubella in Argentina, Brazil, Chile and Uruguay [34].

Lower rubella susceptibility rates in parous women have been found in England [35] and in never-married women after a live birth in the United States [21]. However, no significant increase in rubella seropositivity with parity was observed among WCBA in Switzerland, despite the general recommendation of vaccination of WCBA [22]. In Argentina we did not find significant differences in rubella seroprevalence by parity; however, measles seroprevalence was significantly higher among women with more than four pregnancies, probably because rubella is not so contagious. Therefore, women may not be infected even if they have contact with more children.

One limitation of our study is that it was a convenience sample which included mainly cities, therefore, the results may not be representative of the population. A better estimate of age differences would require a representative sample of the population with a finer age stratification [36]; however, such studies are costly and difficult to conduct in a country like Argentina. Also, the study did not include participants of some regions of the country, the Southern region for example, and the epidemiology and seroprevalence may be different in that region. Since the sensitivity of the laboratory techniques used in this study was lower than the reference methods, susceptibility rates may have been overestimated. In fact, some individuals with low levels of antibody, not detected by EIA, may still be immunologically primed to rubella/measles via vaccination, and therefore, protected, because exposure to virus will result in a rapid secondary immune response. However, EIA tests are considered suitable methods for measuring seroprevalence and the test used in our study performed better than the predominant commercial assay [10]. Reference tests are very expensive and labour-intensive for large-scale seroepidemiological studies. Finally, some demographic or socioeconomic factors used in this analysis to predict susceptibility were collected on the current status which many not necessarily reflect an individual's historical socioeconomic status that may be related to the risk of exposure or vaccination.

The rubella seroprevalence of WCBA found in our study was 91·2%. However, extrapolation of this rate of susceptibility to the entire population shows that $\sim$800 000 WCBA may be expected to be susceptible to rubella infection. The Pan American Health Organization has established a goal of rubella/CRS elimination for 2010 [37]. Achieving elimination of rubella and CRS will require maintaining high rubella vaccination coverage of children and increasing rubella vaccination coverage among WCBA. One of the easiest ways to vaccinate WCBA is through post-partum vaccination (PPV). PPV for all women after delivery was introduced in Argentina in 2002; however, the Pan American Health Organization Technical Advisory Group on Vaccine Preventable Diseases recommends a one-time mass vaccination campaign targeting children $\geqslant 5$ years of age and adults. The upper age limit ranging from 29–39 years should be determined based on the patterns of fertility and expected susceptibility to rubella [38]. The 15% level of measles susceptibility in persons aged 15–29

https://doi.org/10.1017/S0950268805004437

years provides the potential for large outbreaks, especially because people in this age group can be conglomerated in schools or universities. These cohorts should, where possible, be targeted to be vaccinated. In addition, in light of experience with transmission of measles in medical settings [39], measles and rubella immunity among health-care workers should be ensured through vaccination of susceptibles. Seroepidemiological studies in conjunction with modelling techniques [40] should be used to predict the impact of the different vaccination strategies. Finally, data from this study could be used in other countries with similar vaccination history where seroprevalence data are not available to provide guidance on measles and rubella vaccination strategies.

In conclusion, the present study offers seroepidemiological information about rubella and measles immunity in different regions of Argentina. Such data are important to guide and monitor vaccination strategies to prevent CRS and measles outbreaks over the time.

ACKNOWLEDGEMENTS

We thank all the people in the hospitals, health-care centres and laboratories who participated in sera collection and Ms. Clara Chocron for her help with data entry.

REFERENCES

1. **Miller E, Cradock-Watson JE, Pollock TM.** Consequences of confirmed maternal rubella at successive stages of pregnancy. Lancet 1982; **2**: 781–784.
2. **South MA, Sever JL.** Teratogen update: the congenital rubella syndrome. Teratology 1985; **31**: 297–307.
3. **Zimmerman L, Reef S.** Congenital rubella syndrome VPD surveillance manual, 3rd edn, chapter 12. Centers for Disease Control and Prevention Atlanta, GA, 2002.
4. **Anderson RM, Grenfell BT.** Quantitative investigations of different rubella vaccination policies for the control of congenital rubella syndrome (CRS) in the United Kingdom. J Hyg (Camb) 1986; **96**: 305–333.
5. **WHO.** Global measles. Mortality reduction and regional elimination. Strategic plan 2001–2005. World Health Organization, Geneva, Switzerland, 2001. WHO/V&B/01.15.
6. **WHO.** Department of Immunization, Vaccines and Biologicals. WHO vaccine-preventable diseases: 2004 Global Summary. World Health Organization, Geneva Switzerland, 2004. WHO/IVB/2004.
7. **de Quadros CA, Olive JM, Hersh BS, et al.** Measles elimination in the Americas – evolving strategies. J Am Med Assoc 1996; **275**: 224–229.
8. **Pan American Health Organization.** Alert: Measles outbreak in Argentina and Bolivia. Pan American Health Organization Weekly Bulletin 1998; **4**: 32.
9. **Instituto Nacional de Estadísticas y Censos.** National Institute for Statistics and Census. Population projections by sex and age group: urban–rural and employment status (1990–2010). Serie 7. Análisis demográfico.
10. **Hummel KB, Erdman DD, Heath J, Bellini WJ.** Baculovirus expression combinant protein in diagnostic enzyme immunoassays. J Clin Microbiol 1992; **30**: 2874–2880.
11. **Erdman DD, Anderson LJ, Adams DR, Stewart JA, Markowitz LE, Bellini WJ.** Evaluation of monoclonal antibody-based capture enzyme immunoassays for detection of specific antibodies to measles virus. J Clin Microbiol 1991; **29**: 1466–1471.
12. **Ministerio de la Nación. Secretaría de Políticas, Regulación y Relaciones Sanitarias.** Subsecretaría de Relaciones Sanitarias e Investigación en Salud. Dirección de Estadística e Información en Salud. Estadísticas Vitales Información Básica 2003. Dic 2004. ISSN 1668-9054. Serie 5, Número 77 (http://www.msal.gov.ar/htm/site/pdf/Serie5n47.pdf). Accessed 2 Feb. 2005.
13. **Passegi C, Zukas P, Gollán A.** Immunity to rubella virus in Santa Fe city. Universidad 1979; **93**: 145–150.
14. **Marquez A, Zapata M.** Epidemiology of rubella in Córdoba Province. Boletín de la Oficina Sanitaria Panamericana (OSP) 1984; **97**: 14–25.
15. **Pereira F, Uez O.** Rubella antibodies in female applicants for premarital health certificates in Mar del Plata, Argentina. Bull Pan Am Health Organ 1986; **20**: 179–185.
16. **Faus G.** Study of rubella antibodies among women requesting marriage certificate in 1983, Santa Rosa, La Pampa. National Epidemiological Bulletin. Ministry of Health of Argentina 1984.
17. **Suárez AM, Zamora AM, López de Caillou MS, Castagnaro NR.** Rubella: a problem to solve. Acta Bioquímica Clínica Latinoamericana 1998; **4**: 517–522.
18. **Ruiz B, Waisman M, Nadal M, Palonsky C.** Rubella susceptibility prevalence among female staff of an urban hospital. Preliminary Report. Rev Hosp Mat Inf Ramón Sardá 1996; **1**: 30–34.
19. **Ellis A, Gentile A, Barral MF, Sabbag D, Altcheh J, Sosa E, Fernández NR.** Rubella prevention program among female staff of a paediatric hospital. Arch Arg Pediatr 1993; **91**: 7–11.
20. **Yamamoto L, Mejía E, López MR, Gallardo E, Gómez B.** Suseptibility to rubella infection in females at high risk. Immune protection associated to population density. Trop Geogr Med 1995; **47**: 235–238.
21. **Dykewicz CA, Kruszon-Moran D, McQuillan M, et al.** Rubella seropositivity in the United States, 1988–1994. Clin Infect Dis 2001; **33**: 1279–1285.
22. **Zufferey J, Jacquier P, Chappuis S, et al.** Seroprevalence of rubella among women of childbearing age in Switzerland. Eur J Clin Microbiol Infect Dis 1995; **14**: 691–696.

23. **Aksit S, Timocin A, Turpculu A.** Rubella immunity in pregnant Turkish women. Int J Gynaecol Obstet 1999; **66**: 33–34.
24. **Gustafson TL, Lievense AW, Brunell PA, et al.** Measles outbreak in a fully immunized secondary-school population. New Engl J Med 1987; **316**: 771–774.
25. **Yadave S, Gupta S, Kumari S.** Seroprevalence of rubella in women of reproductive age. Indian J Pathol Microbiol 1995; **38**: 139–142.
26. **De Haas R, Van Den Hof S, Berbers GAM, De Melker HE, Conyn-Van Spaendonck MAE.** Prevalence of antibodies against rubella virus in the Netherlands 9 years after changing from selective to mass vaccination. Epidemiol Infect 1999; **123**: 263–270.
27. **Lever AM, Ross MGR, Baboonian C, Griffiths FD.** Immunity to rubella among women of child-bearing age. Br J Obstet Gynaecol 1987; **94**: 208–212.
28. **Gutiérrez Trujillo G, Muñoz O, Tapia Conyer R, et al.** Rubella seroepidemiology among Mexican women. National Representative Survey. Salud Publica Mex 1990; **32**: 623–631.
29. **Hutchins SS, Redd SC, Schrag S, et al.** National serologic survey of measles immunity among persons 6 years of age or older, 1988–1994. Med Gen Med 2001; Jan 24: E5.
30. **Luman ET, Barker LF, Simpson DM, Rodewalds LE, Szilagyi PG, Zhao Z.** National, state, and urban-area vaccination-coverage levels among children aged 19–35 months, United States, 1999. Am J Prev Med 2001; **20** (4S): 88–95.
31. **Gabutti G, Rota MC, Salmaso S, Bruzzone BM, Bella A, Crovari P.** The serological study group.Epidemiology of measles, mumps and rubella in Italy. Epidemiol Infect 2002; **129**: 543–550.
32. **Salmaso S, Rota MC, Ciofi Degli Atti ML, Tozzi AE, Kreidl P.** Infant immunization coverage in Italy: estimates by simultaneous EPI cluster surveys of regions. ICONA Study Group. Bull World Health Organ 1999; **77**: 843–851.
33. **Onyenekwe CC, Kehinde-Agbeyangi TA, Ofor US, Arinola OG.** Prevalence of rubella-IgG antibody in women of childbearing age in Lagos, Nigeria. West Afr J Med 2000; **19**: 23–26.
34. **Dowdle WR, Ferrera W, de Salles Gómez LF, et al.** WHO collaborative study on the seroepidemiology of rubella in Caribbean and Middle and South American population in 1968. Bull World Health Organ 1970; **42**: 419–422.
35. **Tookey PA, Cortina-Borja M, Peckam CS.** Rubella susceptibility among pregnant women in North London, 1996–1999. J Public Health Med 2002; **24**: 211–216.
36. **De Melker HE, Conyn-Van Spaendonck MAE.** Immunosurveillance and the evaluation of national immunization programmes: a population-based approach. Epidemiol Infect 1998; **121**: 637–643.
37. **Pan American Health Organization.** 132 Session of the Executive Committee. Washington, DC, USA, 23–27. June 2003.
38. **Pan American Health Organization.** Technical Advisory Group on Vaccine-Preventable Diseases. Conclusions and Recommendations XV Meeting. Washington DC, USA, 22–23 November 2002.
39. **Davis RM, Orenstein WA, Frank JA, et al.** Transmission of measles in medical settings 1980 through 1984. J Am Med Assoc 1986; **255**: 1295–1298.
40. **Gay NJ.** Modeling measles, mumps, and rubella: implications for the design of vaccination programs. Infect Control Hosp Epidemiol 1998; **19**: 570–573.