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Laboratory-based influenza surveillance in New Caledonia, 1999—2003

Alain Berlioz-Arthaud[a,*], **Ian G. Barr**[b]

[a] *Institut Pasteur de Nouvelle-Calédonie, B.P. 61, 98845 Nouméa-Cedex, New Caledonia*
[b] *WHO Collaborating Centre for Reference and Research on Influenza, 45 Poplar Road, Parkville, Victoria 3052, Australia*

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New Caledonia

Summary We aimed to evaluate the annual incidence of influenza in New Caledonia and to identify the circulating viral types and subtypes in order to gather information for the local vaccination programme and regional influenza surveillance. A surveillance network was set up in 1999; it included sentinel practitioners in Nouméa and the virology department of the Pasteur Institute. Influenza circulated in New Caledonia every year, regularly during the southern hemisphere winter and occasionally during March—May. Isolates were generally consistent with world surveillance, except in 1999, when a new A/H1N1 variant was identified. This study emphasises the need for regular influenza surveillance, even when performed on a limited scale. Importantly the optimal time for local vaccination was found to be in December or January each year.

1. Introduction

New Caledonia is an overseas territory that belongs to the French national community (a statute resulting from the 1998 Nouméa Agreement) and is located in the South Pacific, approximately 1600 km east of Australia, at latitude 21° South and longitude 165° East. In 2002, its total population was estimated to be 212 709 inhabitants, divided between the three administrative provinces: Southern Province (68.3%), where more than half lives in Nouméa; Northern Province (21.0%); and the Loyalty Islands (10.7%). The population is relatively young (31% are less than 15 years old) and the main ethnic groups are Melanesians (44.1%), Caucasians (34.1%), and Wallisians (9%). The other communities are Asians and Polynesians (DASS-NC, 2001). The climate is subtropical and oceanic, with two marked seasons: a warm, wet season from December to March (average temperature 28 °C) and a cooler season from June to September (average temperature 20 °C).

Influenza, in its non-complicated form, is generally not considered to be a major public health

* Corresponding author. Tel.: +687 27 02 85; fax: +687 27 33 90.
E-mail address: aberlioz@pasteur.nc (A. Berlioz-Arthaud).

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problem, even though it can be severe or even fatal when it occurs in immunosuppressed patients or at the community level when new viruses are emerging. Recent reports however, have shown that even the influenza viruses currently circulating can be associated with severe morbidity and occasional mortality in young adults (Michigan, 2003 [CDC, 2003]) or even more deadly outbreaks, as seen in Madagascar (WHO, 2002) and the Democratic Republic of Congo in 2002 (WHO, 2003a).

In New Caledonia, influenza viruses circulate annually, with variable intensity, ranging from some sporadic cases to large epidemics such as occurred in the 1996 A/H3N2 outbreak, which had an estimated 4200 cases (DASS-NC, 1997). The main influenza season in New Caledonia occurs during the cooler months, but it can also occur at other periods of the year, often linked with large population movements from the northern hemisphere. An accurate understanding of these periods of circulation of influenza virus was needed to validate the timing of annual immunization campaigns. This led to the setting up in 1999 of a sentinel network, in order to improve local surveillance and gather information for vaccination programs. Currently New Caledonia is one of the few countries and territories in the central Pacific region performing routine influenza surveillance.

This report presents the results from these surveillance activities for a five-year period, from 1999 to 2003.

2. Materials and methods

2.1. Patient recruitment

Routine hospital requests for patients (out-patients and in-patients), mainly young children and babies, suffering from acute respiratory infections, provided a minimum year round surveillance. In order to measure the impact of influenza in the general population better, a sentinel network was set up in Nouméa in 1999 that included medical staff from nine sentinel sites. They represented the different health units available in Nouméa, including hospitals, and public and private medical clinics. When faced with a clinically suspected case of influenza, the practitioner filled in a standardized questionnaire and prescribed specific laboratory tests for influenza diagnosis. Information collected included demographic, epidemiological and clinical features. The case definition used the following minimum criteria: sudden onset of fever >38 °C and cough or runny nose, in the absence of other diagnoses. The major differential diagnosis for influenza in New Caledonia is respiratory syncytial virus (RSV) infection, but other locally important epidemic-prone diseases, such as dengue and leptospirosis, can also present in the clinics with acute fever and respiratory symptoms. Most of the specimens were collected in the laboratory of the Pasteur Institute in Nouméa and processed immediately. Where epidemic alerts occurred outside of Nouméa, these sites were temporarily added to the network. The network was activated during expected high risk periods or following cases of clinical or viral alert (first laboratory confirmed case). Sentinel examinations were supported by the New Caledonian Department of Health, and patients were not charged when enrolled, but were informed of the public health use made with the result of their laboratory test.

2.2. Virological tests

Samples examined were mainly nasal or pharyngeal secretions collected on swabs or by aspiration. When sample processing was delayed, samples were added to tryptose phosphate broth transport medium. In order to enhance virus recovery, and as previously described (Leitmeyer et al., 2002), sentinel sites were instructed to take samples within two days of onset of disease where possible.

Because of the difficulties in recovering viable viruses when sample shipping was delayed from provincial centres, the laboratory diagnoses were in these cases limited to direct examinations of fixed smears. Viruses in fixed smears of respiratory secretions were detected by indirect immunofluorescence, using type-specific (A or B) monoclonal antibodies (Monofluo-kit Influenza, Sanofi Diagnostics Pasteur/BioRad, Marnes la Coquette, France). Further analysis was done on selected samples by the isolation of influenza using Madin Darby Canine Kidney cell lines (MDCK cells, CSL Ltd, Parkville, Australia). After 5 to 10 day incubation, or when a cytopathic effect could be seen, confirmation of the virus was obtained using either the same immunofluorescence technique or by haemagglutination. Type and subtype identification was performed by haemagglutination inhibition assay (HIA) using the CDC—WHO kit which was updated annually. Representative local strains were sent to the WHO Influenza Collaborating Centre in Melbourne, Australia, where further analysis, including sequencing of haemagglutinin (HA) and neuraminidase genes from selected strains, was performed as previously described (Barr et al., 2003).

A diagnosis of influenza was considered as confirmed if at least the immunofluorescent assay was positive.

2.3. Data analysis

The epidemiological and viral data were processed anonymously using EPI Info 6.04b (ENSP-Epiconcept, 01/1997) and Excel 2000® (Microsoft) software. Fisher's exact test (*P*) was used for statistical comparisons.

3. Results

3.1. Epidemiology

Between 1 January 1999 and 31 December 2003, 2505 patients, aged 7 days to 85 years (mean: 8.6 years), including 807 patients (32%) recruited by the sentinel network, were tested for influenza viruses in respiratory samples (mainly nasal secretions collected on swabs or by aspiration in babies).

Most subjects lived in Nouméa or its suburbs. Only two limited alerts, recorded in 1999 and 2000, in the north of the territory (the village of Poum) and on Lifou Island, required the temporary implementation of sentinel sites outside the main town; these events involved fewer than 20 patients.

Of 723 sentinel samples where information on the date of onset and the date of sample collection was available, 68% were taken within the three first days of illness. Statistical analysis showed that influenza-positive samples were taken earlier (within three days of onset of illness) than negative ones, as shown in Table 1. The male/female ratio amongst all the recruited patients was 1.21, and 0.99 in influenza-confirmed patients. Of the 327 patients that tested positive, 215 (66%) were identified by the sentinel network. Their ages ranged from 7 days to 85 years (mean age: 14.4 years). As shown in Figure 1, more than 50% of positive samples came from children aged 0 to 10 years. The rates of influenza infection amongst various age groups is presented in Table 2 and showed that the highest rates were present in the 1—5 years old age group. The 0—1-year-old group was increased by the enrolment of babies, suspected of having respiratory infections involving viruses other than influenza, mainly RSV.

Among the 807 patients recruited by the sentinel network, laboratory-confirmed influenza cases were significantly more often associated with a familial outbreak of influenza than with unconfirmed patients (Table 1). Recent immunization (vaccinated less than 1 year previously) was only recorded in a few cases ($n = 24$), and two of them, diagnosed in 2003, tested positive for influenza (Table 1). These two patients, aged 59 and 62, received their annual influenza vaccine injection nine and five months before they were infected.

3.2. Clinical features in sentinel patients

Sudden onset, fever, cough or runny nose were the most frequently recorded symptoms. They were significantly more frequent in influenza-confirmed patients (Table 3). During this five-year period, no influenza-related fatal cases were recorded in New Caledonia. Most of the hospitalized patients were babies with high fever and bronchiolitis or with convulsions.

3.3. Virological data

The yearly distribution of confirmed patients ranged from a low of 21 in 2000 (5.6% of total samples) to a high of 107 in 2002 and 2003 (17.7% of total samples tested in 2003). Sentinel samples had a higher rate of positive samples in all years compared to non-sentinel sites (Table 4).

As shown in Figure 2, one to three distinct peaks were seen every year, each of them usually involving a single subtype of influenza virus: three peaks in 1999: February—March (A/H3N2), May—June (A/H1N1) and July—August (B); two peaks in 2000: May—June (A/H3N2) and July—August (B); one mixed peak in 2001: July—September (A/H1N1 and B); two peaks in 2002: March—May (A/H3N2) and June—July (B); and one single and late peak in 2003: September—October (A/H3N2). The viruses identified were usually consistent with those recently described by the worldwide surveillance, except for the A/H1N1 viruses identified in 1999, hence known as A/New Caledonia/20/99-like strains (Table 5). This last strain was initially isolated from a patient living in Nouméa who was enrolled by the sentinel network in May 1999. Viruses of this type have been circulating worldwide from 1999—2003, and a high growth reassortant based on the A/New Caledonia/20/99 strain has been included in both the northern and southern hemisphere influenza vaccines since 1999 (WHO, 1999, 2003b).

3.4. Phylogenetic analysis of New Caledonia influenza isolates

Figure 3 shows the phylogenetic analysis of the HA1 region of the haemagglutinin gene from

Table 1 Epidemiological context, immunization status and delay in sampling after disease onset among suspected influenza patients recruited by sentinel practitioners, New Caledonia, 1999—2003

Epidemiological context	Total sentinel patients ($n = 807$) n (%)	Influenza-positive patients ($n = 215$) n (%)	Influenza-negative patients ($n = 592$) n (%)	P[b]
Sporadic outbreak	479 (59)	112 (52)	367 (62)	<0.01
Familial outbreak	244 (30)	91 (42)	153 (26)	<0.01
Unknown context[a]	84 (11)	12 (6)	72 (12)	—
Vaccination <1 year	24 (3)	2 (1)	22 (4)	0.04
Sample taken within 3 days of onset	491 (61)	147 (68)	344 (58)	<0.01

[a] Information on the epidemiological context available in only 723 of the 807 patients.
[b] P measures the significance of differences between the two groups of influenza-positive or -negative patients.

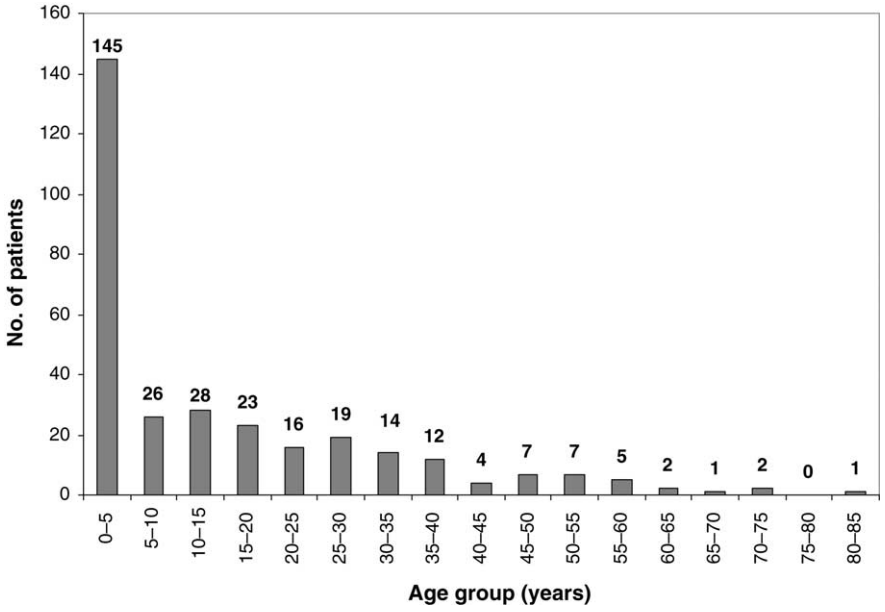


Figure 1 Age distribution of influenza-positive patients (direct immunofluorescence or virus isolation from respiratory samples of 312 patients with recorded age) in New Caledonia, 1999—2003.

selected isolates from New Caledonia from A/H1, A/H3 and B viruses. In some years during the study period, no isolates were available from New Caledonia for sequencing (H1: 2000, 2002 and 2003; H3: 2001; B: 2003). The H1 dendrogram (Figure 3A) shows the emergence of a new variant of the H1 lineage typified by the A/New Caledonia/20/99 virus which was still the predominant lineage

Table 2 Rate of influenza confirmation by age group in New Caledonia, 1999—2003

Age group (years)	Total patients tested	Influenza-positive patients	Positive per age group (%)
0—1	1551	67	4.32
1—5	160	78	48.75
5—20	302	77	25.50
20—60	369	84	22.76
≥60	33	6	18.18
Total[a]	2415	312	12.92

[a] 2415 patients with recorded age.

Table 3 Distribution of clinical symptoms among influenza-positive patients recruited by sentinel practitioners, New Caledonia, 1999—2003

Symptom	Total sentinel patients ($n = 807$) *n* (%)	Influenza-positive patients ($n = 215$) *n* (%)	Influenza-negative patients ($n = 592$) *n* (%)	*P*[a]
Fever	714 (88)	202 (94)	512 (86)	<0.01
Sudden onset	578 (72)	185 (86)	393 (66)	<0.01
Runny nose	606 (75)	180 (84)	426 (72)	<0.01
Cough	624 (77)	181 (84)	443 (75)	<0.01
Myalgia	404 (50)	137 (64)	267 (45)	<0.01
Headache	344 (43)	120 (56)	224 (38)	<0.01
Tiredness	515 (64)	158 (73)	357 (60)	<0.01
Sore throat	355 (44)	100 (47)	255 (43)	0.36

[a] *P* measures the significance of differences between the two groups of influenza-positive or -negative patients.

circulating in 2003 in many parts of the world (e.g. A/Malaysia/687/2003 and A/Christchurch/1/2003). Analysis of the H3 dendrogram (Figure 3B) shows the gradual drift in the HA of New Caledonia isolates from 1999 to 2003 from the A/Moscow/10/99-like viruses through A/Chile/6416/2001-like viruses to the current A/Fujian/411/2002-like viruses. This transition appeared to parallel changes seen in the region and elsewhere during this period with the exception that no A/H3 isolations were made in 2001 in New Caledonia. The B dendrogram (Figure 3C) confirmed the antigenic analysis with B viruses from the B/Yamagata lineage circulating in New Caledonia in 1999, 2000 and 2001 and viruses of the B/Victoria/2/87 lineage circulating in 2002. These findings again reflected the regional fluctuations seen with these two B virus lineages.

4. Discussion

4.1. Role of the sentinel network

Due to the non-specific nature of clinical presentations with influenza, the accurate monitoring of influenza requires laboratory confirmation. However, for the majority of patients with suspected influenza who are seen by general practitioners in normal practice, virological testing is not usually requested. The advantage of active surveillance, based on a sentinel network of highly motivated clinicians, combined with reliable laboratory support, is obvious for influenza. The monitoring carried out in New Caledonia between 1999 and 2003 confirmed this with 66% of the confirmed cases during this period coming from the network which recruited only 32% of the total patients. This trend is even more evident when influenza circulation occurred at a low level. In 2000, the sentinel network provided 81% of the total positive samples and 95% in 2001. During these two years, the passive monitoring, made outside of the network, would not have allowed correct estimations of the annual circulation period of influenza.

4.2. Age of influenza patients

In a territory such as New Caledonia, where the annual immunization in people aged more than 60 years is free of charge and thus well followed, very

Table 4 Yearly distribution of influenza-positive patients (direct immunofluorescence or virus isolation from respiratory samples), New Caledonia, 1999—2003

Year	Total samples		Non-sentinel samples		Sentinel samples	
	No.	Positive *n* (%)	No.	Positive *n* (%)	No.	Positive *n* (%)
1999	509	70 (13.8)	350	24 (6.9)	159	46 (28.9)
2000	371	21 (5.7)	268	4 (1.5)	103	17 (16.5)
2001	382	22 (5.8)	228	1 (0.4)	154	21 (13.6)
2002	638	107 (16.8)	431	37 (8.6)	207	70 (33.8)
2003	605	107 (17.7)	421	46 (10.9)	184	61 (33.2)
1999/2003 total	2505	327 (13.1)	1698	112 (6.6)	807	215 (26.6)

young children constitute the major risk group for influenza infection with more than 50% of the confirmed patients identified between 1999 and 2003 being younger than five years. It was also noted that the rate of positive samples among age groups decreased regularly from nearly 50% in children aged one to five years to 18% in adults aged more than 60 years.

The group of children aged less than one year must be considered separately, as their recruit-

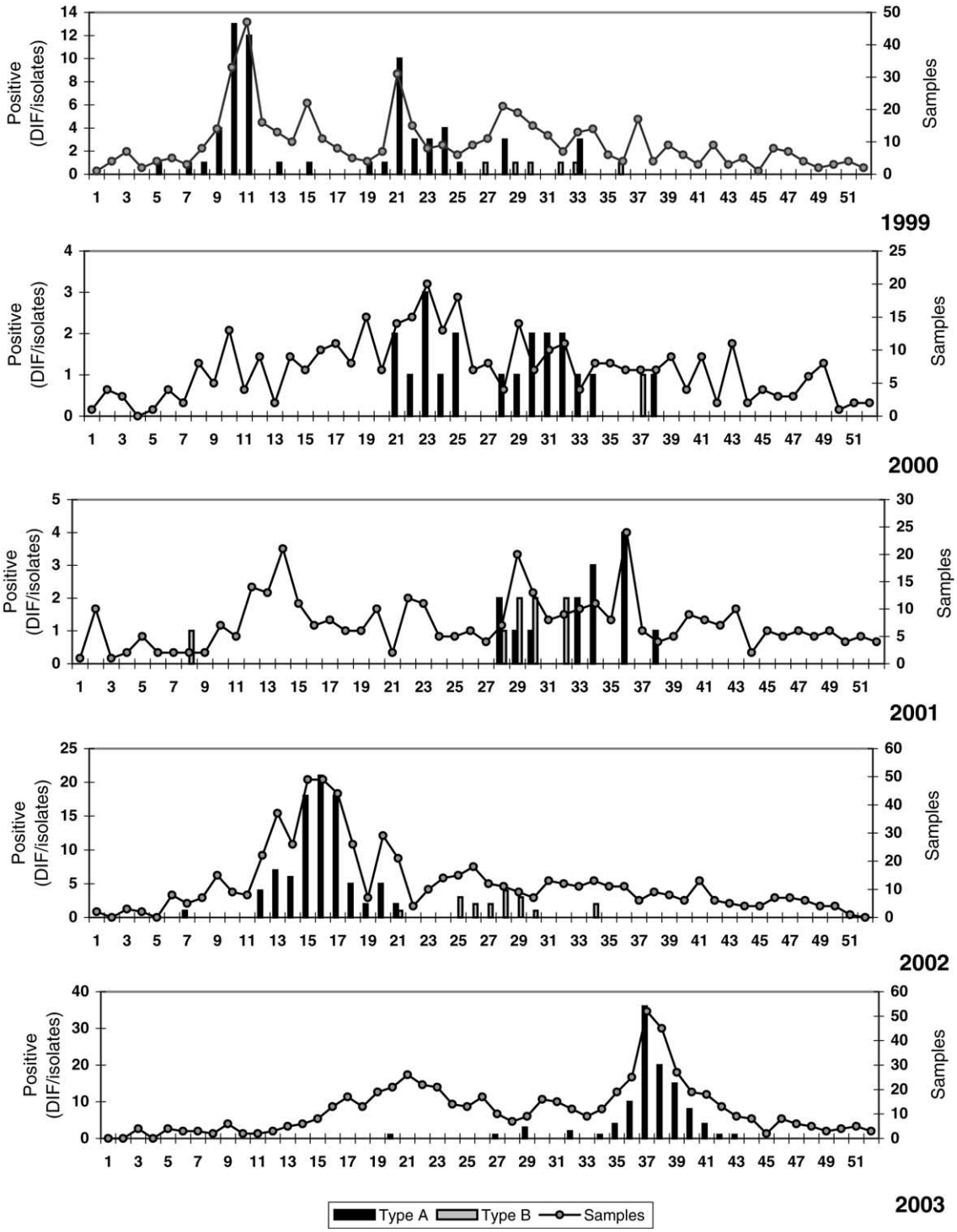


Figure 2 Weekly distribution of respiratory samples examined and influenza-positive ones (direct immunofluorescence or virus isolation) in New Caledonia, 1999—2003.

ment was biased by RSV infection, being the classical differential diagnosis for influenza in this age group (Manuguerra, 2002). The clinical features of both infections are often indistinguishable and severe with bronchiolitis, fever and frequently convulsions. These presentations often justify hospitalization in paediatric wards, where respiratory samples are taken and sent to the laboratory routinely. In fact, our investigation confirms the baseline surveillance provided by paediatric wards, which are therefore recommended for selection as sentinel sites. A French study from 2001 showed that, even during moderate epidemics, children constitute the main reservoir group for influenza viruses, from which dissemination to the entire population can occur (Aymard et al., 2003).

The low incidence of influenza noticed among elderly people was probably due to the high rates of vaccination, but firm conclusions are difficult due to the low numbers ($n = 33$) in this group. The inclusion of geriatric wards and nursing homes as future sentinel sites would allow better assessment of this age group.

4.3. Seasonality of influenza in New Caledonia

In temperate countries, influenza circulates on a seasonal and regular basis during winter. Thus, in the southern hemisphere, these periods are clearly identified between May and September in Australia (Kelly et al., 2000) and New Zealand (Jennings, 1999), and conversely, in the northern hemisphere, between December and February in France (Manuguerra, 2002) and Japan (Nerome et al., 2002). In contrast, in tropical zones, influenza is frequently described as being endemic at low levels throughout the year, with occasional epidemic peaks. This situation has been described, for example, in Senegal (Dosseh et al., 2000) and on Reunion Island (Lassale et al., 1998).

According to the 1999—2003 surveillance, New Caledonia shows a probable intermediate situation, characterized by a discontinuous circulation of viruses, with several annual peaks, resulting from various exposures to temperate countries at the time of their influenza season. Thus, the only peak being regularly seen each year occurs during the cool season (May to October), at the same time or slightly later than the New Zealand and Australian outbreaks. The second peak period, seen in 1999 and 2002, takes place between February and April, during the hotter and wetter months of the year. This period, which is at the end of the summer holidays in New Caledonia, coincides with many travellers returning from Europe, in particular Metropolitan France, where influenza is usually still circulating. Significant and regular flows of tourists coming from the Japanese winter could also be responsible for this early peak.

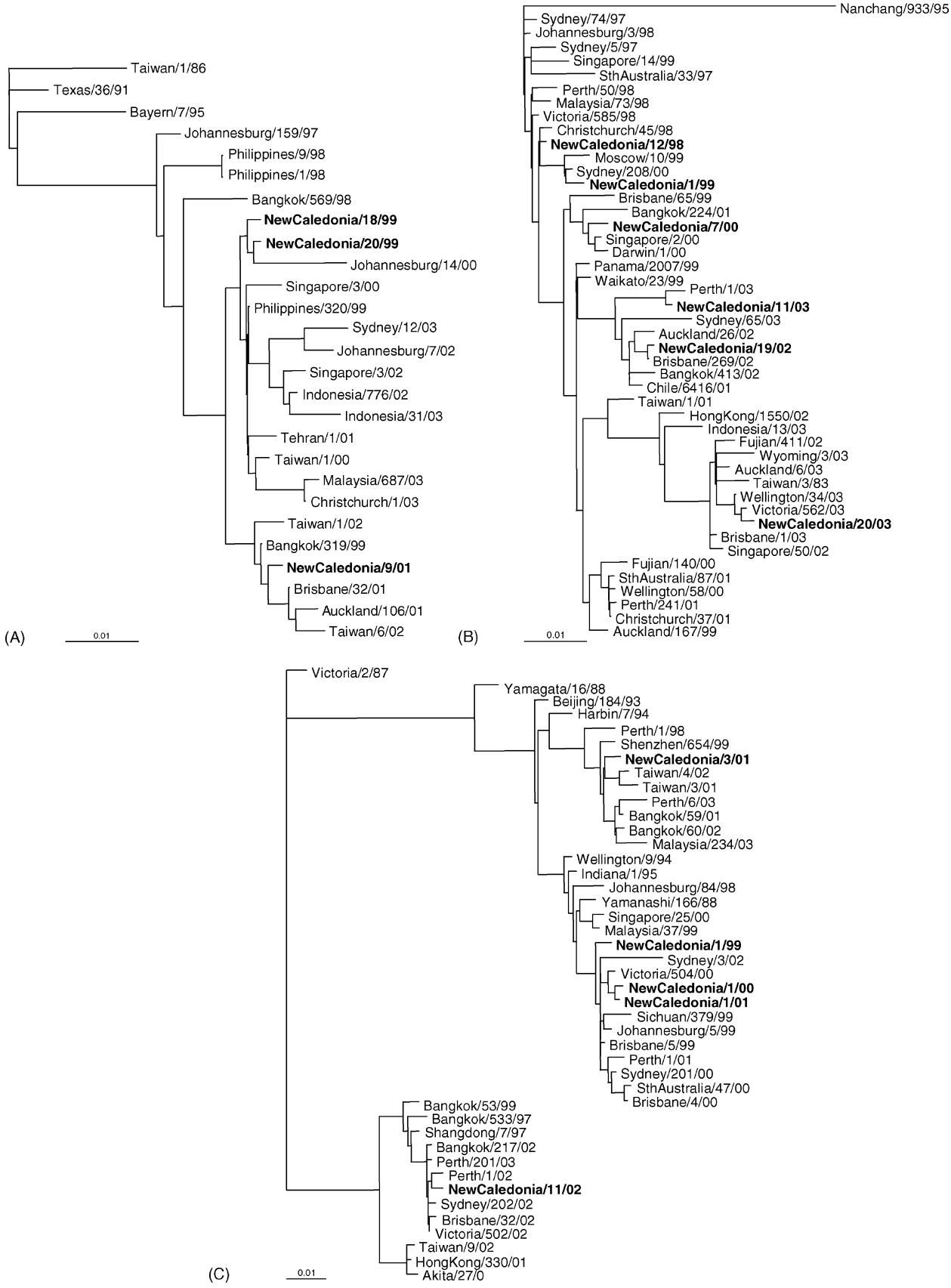
Although delayed, the single peak recorded in 2003 (September and October) was clearly related to the regional outbreak in temperate Oceania, where the circulation of viruses occurred later than has usually been seen (WHO, 2003c).

4.4. Virological aspects

One to three viral types were seen each year in New Caledonia. Generally, these occurred successively with no simultaneous circulation of virus types/subtypes. During the 1999—2003 period, A/H1N1 and B types were always associated with the regional peak, occurring between June and August, whereas A/H3N2 strains were isolated during both risk periods.

The geographical isolation of New Caledonia results in most of the population not moving outside the territory. This situation, combined with the threat of multiple strains of influenza being introduced from both the southern and northern hemispheres, and the low overall vaccination rates, make New Caledonia susceptible to influenza outbreaks. This may lead to the early introduction of new variants, such as A/H3N2/Moscow/10/99-like strains in 2000 or A/H3N2/Fujian/411/2002-like strains in 2003. This situation probably also allowed the local emergence, in 1999, of the A/H1N1/New Caledonia/20/99 variant, from which similar strains were still circulating worldwide in 2003. Phyloge-

Figure 3 Dendrograms showing the phylogenetic relationships among South East Asia, Oceania and New Caledonia human influenza viruses from the 1999—2003 period based on the HA1 domain of the haemagglutinin gene. (A) Dendrogram for A(H1) viruses, (B) dendrogram for A(H3) viruses, and (C) dendrogram for B viruses. New Caledonia strains are shown in bold. Note there were certain years in which no isolations of particular influenza types/subtypes were made in New Caledonia and were therefore not available for sequence analysis (H1: 2000, 2002 and 2003; H3: 2001; B: 2003). The lengths of the horizontal lines are proportional to the percentage of nucleotide differences as indicated by the bar. The nucleotide sequences were analysed with PHYLIP using the maximum likelihood algorithm and the dendrograms were drawn with Treeview.


Taiwan/1/86
Texas/36/91
Bayern/7/95
Johannesburg/159/97
Philippines/9/98
Philippines/1/98
Bangkok/569/98
NewCaledonia/18/99
NewCaledonia/20/99
Johannesburg/14/00
Singapore/3/00
Philippines/320/99
Sydney/12/03
Johannesburg/7/02
Singapore/3/02
Indonesia/776/02
Indonesia/31/03
Tehran/1/01
Taiwan/1/00
Malaysia/687/03
Christchurch/1/03
Taiwan/1/02
Bangkok/319/99
NewCaledonia/9/01
Brisbane/32/01
Auckland/106/01
Taiwan/6/02
0.01
(A)
Nanchang/933/95
Sydney/74/97
Johannesburg/3/98
Sydney/5/97
Singapore/14/99
SthAustralia/33/97
Perth/50/98
Malaysia/73/98
Victoria/585/98
Christchurch/45/98
NewCaledonia/12/98
Moscow/10/99
Sydney/208/00
NewCaledonia/1/99
Brisbane/65/99
Bangkok/224/01
NewCaledonia/7/00
Singapore/2/00
Darwin/1/00
Panama/2007/99
Waikato/23/99
Perth/1/03
NewCaledonia/11/03
Sydney/65/03
Auckland/26/02
NewCaledonia/19/02
Brisbane/269/02
Bangkok/413/02
Chile/6416/01
Taiwan/1/01
HongKong/1550/02
Indonesia/13/03
Fujian/411/02
Wyoming/3/03
Auckland/6/03
Taiwan/3/83
Wellington/34/03
Victoria/562/03
NewCaledonia/20/03
Brisbane/1/03
Singapore/50/02
Fujian/140/00
SthAustralia/87/01
Wellington/58/00
Perth/241/01
Christchurch/37/01
Auckland/167/99
0.01
(B)
Victoria/2/87
Yamagata/16/88
Beijing/184/93
Harbin/7/94
Perth/1/98
Shenzhen/654/99
NewCaledonia/3/01
Taiwan/4/02
Taiwan/3/01
Perth/6/03
Bangkok/59/01
Bangkok/60/02
Malaysia/234/03
Wellington/9/94
Indiana/1/95
Johannesburg/84/98
Yamanashi/166/88
Singapore/25/00
Malaysia/37/99
NewCaledonia/1/99
Sydney/3/02
Victoria/504/00
NewCaledonia/1/00
NewCaledonia/1/01
Sichuan/379/99
Johannesburg/5/99
Brisbane/5/99
Perth/1/01
Sydney/201/00
SthAustralia/47/00
Brisbane/4/00
Bangkok/53/99
Bangkok/533/97
Shangdong/7/97
Bangkok/217/02
Perth/201/03
Perth/1/02
NewCaledonia/11/02
Sydney/202/02
Brisbane/32/02
Victoria/502/02
Taiwan/9/02
HongKong/330/01
Akita/27/0
0.01
(C)

netic analysis of the HA1 gene of isolates obtained from New Caledonia emphasises their exposure and susceptibility to viruses that were circulating regionally (Barr et al., 2003). During 1999—2003, the New Caledonia A/H3N2 showed similar drift to viruses in Australia, New Zealand and Southeast Asia, as did the B viruses which reflected the emergence of B/Victoria lineage viruses in 2002 displacing the B/Yamagata-like viruses which circulated in 1999—2001. The A/H1N1 viruses showed little change up to 2001 from those that generally circulated in 1999; however, no A/H1N1 isolates were made in New Caledonia in 2000 and 2002—03.

4.5. Local vaccine policy

Yearly immunization is usually recommended to patients who are likely to be at risk from complicated presentations: mainly people aged more than 60 years and chronically ill patients. To date, the vaccine coverage in this targeted population is not precisely known, but has been estimated to be around 70%. This has been calculated using the average number of vaccine doses imported annually (16 000) and the targeted group, which comprises 25 000 people.

As most of the confirmed cases were seen in infants, the option of childhood immunization in New Caledonia could also be considered. In Japan, where this practise was mandatory from 1962 to 1987, this resulted in a significant reduction in the spread of viruses in the community and prevented about one death for every 420 children vaccinated (Reichert et al., 2001). The protection is said to be maintained for at least eight months (Manuguerra, 2002). In temperate countries of the northern hemisphere, the optimal time for vaccination is October, in order to cover the main risk period, between November and March (Bridges et al., 2002).

As shown in this study, in New Caledonia, the influenza season can begin at any time between February and September. For the optimal protection of patients, vaccination should therefore take place in January. As this period of the year corresponds to summer holidays in New Caledonia, it was decided, for logistic reasons, to have the annual vaccination campaign in December. Under these conditions, protection can be regarded as most effective at least until the end of August. Moreover, the numerous people going to Metropolitan France at the end of the year should be protected if these viruses are circulating in Europe during this period. On the other hand, protection may be declining below the protective threshold by September, a possible explanation of sporadic vaccine failures. Another option could be to have a second yearly shot, but this has been reported as not being significantly better in some studies (Buxton et al., 2001) and would substantially increase the costs.

The vaccine used in New Caledonia comes from France and thus follows the previous northern hemisphere formulation, according to the latest recommendations that are available there at the time. In certain circumstances, this may have some disadvantages. As an example, it was noted that the only available vaccine at the end of 1999 in New Caledonia conferred poor protection against type A/H1N1 viruses identified locally. On the other hand, the southern hemisphere formulation, as defined in September 1999, was well matched. Thus, it would have been logical to use this vaccine in New Caledonia during the 1999 campaign, if it had been available.

Over the 1999—2003 period, two apparent vaccine failures were reported. The first occurred in a 62-year-old patient, with chronic respiratory illness. He was correctly vaccinated in November 2002 and became infected in September 2003, i.e. nine months later. A possible explanation for this is that during this extended period the post-vaccination antibody levels had fallen below the level required for protection. The second case was reported in a 60-year-old patient, immunized in May 2003, and also infected in September. The laboratory confirmation was only based on direct immunofluorescence; therefore, the strain was not characterized. However, it is likely that the dominant new A/H3N2/Fujian strain was involved, and the vaccine administered (which included the A/H3N2/Panama strain) might have conferred a lower level of protection against this new variant.

5. Conclusions

Surveillance of influenza in New Caledonia shows a regular circulation of viruses occurring during the cool season, from May to August. As shown in 1999 and 2002, other risk periods may exist, undoubtedly related to the numerous holiday and tourist migratory flows occurring in the territory throughout the year with France (family or business travel), Asia (including Japanese tourists and visits by New Caledonians of Vietnamese or Indonesian origin) and other countries of the Pacific area, such as Australia, New Zealand or French Polyne-

sia. This complex situation justifies the existence of the New Caledonia Sentinel Network, which participates efficiently in the WHO global monitoring of influenza, as shown by the local detection, in 1999, of the current A/H1N1 reference strain, A/New Caledonia/20/99. Significant outbreaks of influenza were described in 1999, 2002 and 2003, whereas 2000 and 2001 seasons had very low levels of influenza. Even in years of low influenza incidence, the presence of a sentinel network, by its role in actively investigating and confirming cases, has allowed the annual assessment of the epidemiological and virological aspects of influenza in New Caledonia. It was found to be important to include paediatric wards in sentinel sites in order to have year round recruitment and allow the early detection of first cases. Geriatric sites may also be added to the Sentinel Network in future years to increase the number of elderly participants being monitored.

Potential exposure of New Caledonia to both annual flu seasons (from the northern and southern hemispheres) requires a carefully timed vaccine program. Local surveillance suggests that January each year is the optimal time for influenza vaccination in New Caledonia to obtain both the maximum level of protection and for ease of delivery.

Conflicts of interest statement
The authors have no conflicts of interest concerning the work reported in this paper.

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