Sentinel surveillance for influenza and other respiratory viruses in Côte d'Ivoire, 2003–2010

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Background Many countries in Africa have lacked sentinel surveillance systems for influenza and are under-represented in data used for global vaccine strain selection.

Objectives We describe 8 years of sentinel surveillance data and the contribution of influenza and other viruses to medically attended influenza-like illness (ILI) in Côte d'Ivoire.

Methods Sentinel surveillance was established in 2003. Nasopharyngeal (NP) specimens and epidemiologic data are collected from persons of all ages presenting with ILI at sentinel sites. Respiratory specimens have been tested for influenza using various viral and molecular diagnostic methods. A subset of 470 specimens collected from children aged 0–5 years were tested for multiple respiratory viruses using RT-PCR.

Results From 2003 to 2010, 5074 NP specimens were collected from patients with ILI. Overall, 969/5074 (19%) of these specimens tested positive for influenza. Seasonal influenza A(H1N1) viruses predominated during 5 years and influenza A(H3N2) viruses predominated during 3 years. Influenza B viruses cocirculated with influenza A viruses during each year from 2004 to 2010. Seasonal peaks in influenza circulation were observed during the months of May, June, and October, with the largest peak corresponding with the primary rainfall season. Of 470 specimens collected from children under aged 5 who were tested for multiple respiratory viruses, a viral respiratory pathogen was detected in 401/470 (85%) of specimens. Commonly detected viruses were RSV (113 of 470 specimens, 24%), rhinoviruses (85/470, 18%), influenza (77/470, 16%), and parainfluenza (75/470, 16%).

Conclusion In Côte d'Ivoire, there is a significant annual contribution of influenza and other respiratory viruses to medically attended ILI.

Keywords Côte d'Ivoire, influenza viruses, respiratory viruses, sentinel surveillance.

Introduction

Influenza is an important cause of annual morbidity and mortality that can be prevented with vaccination and also requires ongoing surveillance because of its pandemic potential.[1–4] As a result of constant genetic mutations in the influenza virus, the effectiveness of vaccination depends on the continuous monitoring of circulating strains globally.[5] Influenza virus infections contribute substantially to the annual burden of respiratory illness in temperate regions of the globe. While there is a growing body of evidence to suggest that this is also the case in tropical regions,[6,7] tropical and developing countries remain under-represented in global surveillance data, and there is limited information available that can be used to inform influenza vaccination and treatment strategies in resource-poor settings, such as Africa. In Côte d'Ivoire, no virological and very limited epidemiological data were available to demon-

strate the patterns of circulation of influenza and other respiratory viruses before 2000,[8] and the etiology of respiratory infections, especially in children, was assumed to be of bacterial origin.[9,10] As a result, sentinel surveillance was established in 2003 to characterize influenza viruses in circulation in Côte d'Ivoire, to determine influenza seasonality and to contribute viruses from Africa into the WHO Global Influenza Surveillance Network. During the surveillance years of 2009–2010, a subset of sentinel respiratory specimens from children under age 5 years were tested for additional respiratory viruses to also evaluate other viral etiologies of pediatric influenza-like illness. In this study, we use 8 years (2003 through 2010) of sentinel surveillance data to describe the circulation and seasonality of influenza in Côte d'Ivoire.

Material and methods

Network set-up

The first seven healthcare centers that were selected to be sentinel surveillance sites were located in the city of Abidjan. These sites were selected in 2003 using the following criteria: geographic representation within Abidjan; adequate throughput of patients consulting at the health facility; the existence of a department of general medicine, a pediatric department, and a laboratory; the accessibility of the site; the availability and the desire of the physicians to participate voluntarily without financial motivation in the surveillance program; and availability of a refrigerator (+4°C) for the storage of specimens. The surveillance system in Abidjan was expanded to 14 sites in 2007. Twelve additional sites were added during 2008 through 2010, of which five were located in Abidjan and nine were located in the interior of the country with an emphasis on the eastern region, which is a focus of local poultry husbandry (Figure 1). General practitioners and pediatricians were trained on respiratory specimen collection, storage, and shipment of specimens to the laboratory. Supervisory visits were conducted quarterly to monitor the performance of each sentinel site, including validation of total respiratory specimens collected against review of medical records to determine the actual number of ILI cases presenting to sentinel facilities.

Sentinel physicians were asked to screen all outpatients presenting to the sentinel sites for signs and symptoms of influenza-like illness according to the CDC case definition (temperature ≥37·8°C and either cough or sore throat). For each ILI case, a case-based surveillance form including clinical and epidemiological data such as date of illness onset, date of sample collection, patient's name, sex, age, clinical symptoms, and vaccination status was completed. A nasopharyngeal (NP) specimen was collected from each ILI case using virocult swabs (Medical Wire and Equipment, UK) and immediately stored in a
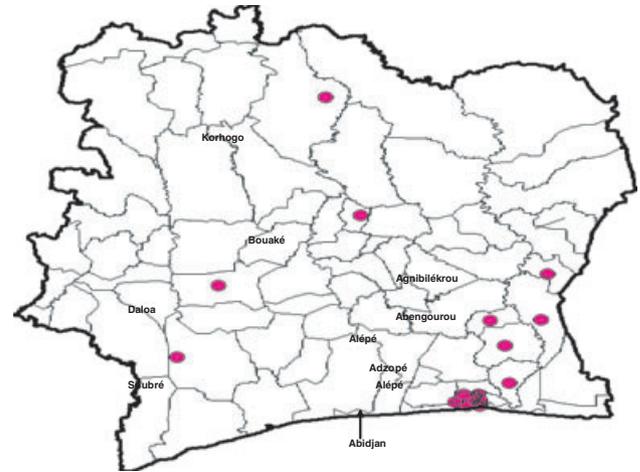

Figure 1. Location of influenza sentinel sites in Côte d'Ivoire.

sterile cryovial containing a viral transport medium (VTM). Specimens were kept at +4°C following collection and during transport. Respiratory specimens were transported during three days per week (Monday, Wednesday, and Friday) from sentinel sites to the National Influenza Center (NIC) located at Pasteur Institute and frozen at −80°C before testing.

Virus testing

All 5074 NP specimens were analyzed for the detection of influenza viruses. During the period 2003–2007, all sentinel specimens ($n = 867$) were tested using viral culture. During the year 2008, molecular detection with conventional reverse transcription polymerase chain reaction (RT-PCR) was used on all sentinel specimens ($n = 425$). During the years 2009–2010, influenza viruses were detected using real-time RT-PCR in all sentinel specimens ($n = 3782$). Following the introduction of molecular diagnostic techniques in 2008, viral culture was additionally performed on a subset ($n = 757$) of RT-PCR-positive cases to have influenza viruses available for antigenic characterization.

During the years 2009–2010, a subset of NP swabs that were collected from children aged 0–5 years were selected for the detection of 12 RNA respiratory viruses [influenza viruses A, B, and C, human respiratory syncytial virus (hRSV), human *metapneumovirus* (hMPV), parainfluenza viruses types 1–4, human *coronaviruses* OC43 and 229E (HCoV), and *rhinovirus* (hRV)]. This subset of respiratory specimens was all collected within 3 days of first symptom onset. Simple random sampling was performed to select specimens for this multipathogen testing, and we selected as many specimens as available reagents would allow us to test. Of the 1782 respiratory specimens collected from patients aged 0–5 years, which were received at the

laboratory within 3 days of NP swab collection, 470 were selected for this multipathogen testing.

Viral isolation

All the 867 respiratory specimens collected during the years 2003–2007, and the 757 specimens selected for virus isolation from 2008 to 2010 were inoculated on Madin Darby Canine Kidney (MDCK) cells in a medium containing trypsin. The cultures were maintained at least 12 days at 35°C in a CO_2 steam room. Until 2007, influenza viruses were detected in culture using the ELISA immunocapture method according to the protocol of the Institut Pasteur Paris.[11] In 2008, a hemmaglutination test with 0·5% red blood cells of chicken was performed on the culture supernatant after 48 hours of incubation. In the case of a positive result, HAI was undertaken using specific antisera for influenza A(H3N2), A(H1N1), pandemic influenza A(H1N1) 2009 (A(H1N1)pdm2009), and influenza B viruses. The reference strains and specific antisera were supplied by the WHO reference center in Lyon (France) and the WHO Collaborating Center at CDC in Atlanta, USA. From 2008, cell culture was performed on only the positive samples in RT-PCR.

Molecular detection

RNA extraction from 140 μl of specimen was performed using the QIAmp virus RNA mini kit [Qiagen (QIAGEN S.A.S. 3 avenue du Canada, COURTABOEUF CEDEX, France)], with RNA elution into a final volume of 60 μl and stored at +4°C until RT-PCRs were performed the same day. Longer storage was carried out at −80°C.

From 2008 until early 2009, conventional RT-PCR assays were performed in a final volume of 50 μl with 5 μl RNA, 0·6 μm each primer, 4 U RNase inhibitor (Promega, Parc d'Activités des Verrières, Charbonnieres, France), and 1 μl enzyme mix (SuperScript II OneStep RT-PCR System; Invitrogen, Life Sciences and Research Products, Accesorios para Laboratorios S.A. De C.V., Col Anzures, Mexico). The hemagglutinin (HA) genes of the seasonal A(H1N1), A(H3N2), and A(H5N1) viruses were amplified with specific primers using a protocol developed by Institut Pasteur du Cambodge (primers and protocol available upon request). For the detection of other respiratory viruses, three multiplex hemi-nested RT-PCR assays were carried out as described by Bellau-Pujol S *et al.*,[12] targeting the following 12 RNA respiratory viruses simultaneously: influenza viruses A, B, and C, human respiratory syncytial virus (hRSV), human *metapneumovirus* (hMPV), parainfluenza viruses types 1–4, human *coronaviruses* OC43 and 229E (HCoV), and *rhinovirus* (hRV). All amplified products were visualized after electrophoresis on an ethidium bromide-stained 1·5% agarose gel. Following the purchase of an ABI 7300 RT-PCR Machine in 2009 (Applied Biosystems, Foster City, CA, USA), we performed real-time RT-PCR assays. We used a panel of oligonucleotides primers and dual-labeled hydrolysis (Taqman®) probes according to the CDC real-time RT-PCR (rRT-PCR) protocol for the detection and characterization of influenza A, B, A/H5,[13] and swine influenza virus RNA.[14] Using methods developed by the NIC Nord de France, the rRT-PCR assays targeted the M gene for the detection of type-A influenza virus and the HA gene, for specific detection of pandemic influenza A(H1N1) 2009, seasonal influenza A(H1N1), and influenza A(H3N2) viruses. The primers and probes designed for RT-PCR are available upon request (grippe@pasteur.fr). The rRT-PCR testing was performed at a final volume of 25 μl on the ABI 7300 (Applied Biosystems) platform, using SuperScript III Platinum One-Step Quantitative RT-PCR System (Invitrogen) and optimized with 0·8 μm primer, 0·2 μm probe and 0·5 μl enzyme mix, and 5 μl of RNA. Thermocycling reaction conditions were same as described by Duchamp BM *et al.*,[15] with reverse transcription incubation time of 30 min. Negative controls were included in each run.

During each season, influenza-positive specimens were sent either to the Institute Pasteur in Paris or to the WHO Collaborating Centers in Atlanta and/or London for more advanced analysis, such as antiviral resistance testing and genetic sequencing.

Statistical analysis

The surveillance data were analyzed to evaluate temporal trends in the number of ILI cases and the percent of those cases testing positive for influenza at the sentinel sites. During 2007 through 2010, when influenza surveillance specimens were most consistently collected and submitted throughout the year, we overlayed epidemiological, virological data, and meteorological data (monthly rainfall, relative humidity, and average daily temperature data obtained from the airport authority in Côte d'Ivoire) to make a descriptive assessment of the relationship between the percent of sentinel specimens testing positive for influenza and these meteorological variables. Epidemiological and virological data were also analyzed by age, year, month, and sentinel site. Age was categorized based on the age groups 0–4, 5–19, 20–39, 40–54 and >55 years. Statistical tests comparing the percentage of sentinel specimens testing positive by viral culture versus molecular diagnostic techniques; comparisons of the distribution of viral respiratory pathogens by age groups were undertaken using chi-squared tests. Analyses were performed with the software EPI INFO 2000 and epi info (version 6; Epi Info™, Centers for Disease Control and Prevention, Atlanta, GA, USA).

This is an analysis of routinely collected public health surveillance data. As such, it is a non-research study and did not require approval from an institutional review board.

Results

Description of sentinel specimens

During 2003 through 2010, a total of 5074 respiratory specimens were collected from 26 sentinel health centers. Five sentinel sites including four in Abidjan and one in the interior of the country collected 55·4% (2809/5074) of all specimens, and 82·9% (4207/5074) of specimens were collected during 2008–2010 (Table 1 and Figure 2). Of the 26 sentinel ILI sites, six were also 'pediatric-only' sites that officially served persons under 15 years of age and which contributed 45·9% (2331/5074) of all sentinel specimens.

The age of the population enrolled in the sentinel surveillance system ranged from 1 month to 89 years. The 0–4-year age group represented 52% (2524/4848) of 4848 ILI cases with known age. The sex ratio was 1·4:1·0 (male/female). Of the 4238/5074 specimens for which the date of onset of symptoms was recorded, 83% (3533/4238) had respiratory specimens collected within four days of symptom onset. Of the 4217/5074 ILI specimens with valid data on date of specimen collection, 75·7% (3191/4217) of sentinel specimens were received by the NIC within three or fewer days from specimen collection. Of the 4317 of 5074 ILI cases who reported a known influenza vaccination status, only 11 (0·25%) reported influenza vaccination during the year prior to onset of symptoms during the 8 years of surveillance.

Influenza virus detection

Of the 5074 specimens tested, 969 (19·1%) tested positive for influenza viruses. Of the 969 positive specimens, 126/969 (13·0%) were initially confirmed using virus isolation techniques; 92/969 (9·5%) by conventional RT-PCR; and 751/969 (77·5%) by real-time RT-PCR. Of the 843 specimens that were confirmed by molecular diagnostic techniques, viral culture was attempted on 89·8% (757/843) of specimens, of which 18·1% (137/757) produced viral isolates. During 2003–2010, the percentage of sentinel specimens testing positive for influenza was 14·5% (126/867) in

specimens initially confirmed using viral culture and 20% (843/4207) in specimens initially confirmed using molecular diagnostic techniques ($P < 0·001$). During 2007–2010, when sentinel ILI cases were most comprehensively detected and tested every month, we observed peaks in the percent of sentinel specimens testing positive for influenza during May, June, and October, and the primary peaks in May and June appear to correlate with the rainy season (Figure 3). Among sentinel ILI specimens tested by RT-PCR during the peak months of influenza activity (May, June, and October) during 2007 through 2010, 38·9% (293/753) specimens tested positive for influenza viruses.

The age-group-specific percentages of sentinel specimens testing positive for influenza were similar and ranged from 18% to 22%. Of the 4848 of 5074 ILI specimens with valid data on the age of the patient, 18·7% (473/2524) of respiratory specimens tested positive for influenza among 0–4-year-olds; 22·1% (143/646) among 5–19-year-olds; 18·3% (227/1239) among 20–39-year-olds; 18·8% (64/340) among 40–54-year-olds; and 19·2% (19/99) among persons aged 55 years and older.

Of the 969 persons with confirmed influenza virus infections during 2003–2010, 702 (72·4%) persons had influenza A virus infections, and 267 (27·6%) had influenza B virus infections. Nine of these persons (0·9%) had co-infections with influenza A and B viruses. Of the 620 subtyped influenza A viruses, 176 (28·4%) were subtyped as seasonal influenza A(H1N1), 382 (61·6%) as influenza A(H3N2), and 62 (10·0%) as pandemic (H1N1)2009 viruses (Table 1).

During the 8 years of surveillance, seasonal influenza A(H1N1) virus was the dominant influenza A virus detected during 5 years (2003, 2004, 2005, 2007, and 2008) and influenza A(H3N2) virus during 3 years (2006, 2009, and 2010). Influenza B viruses co-circulated with influenza A viruses during each year from 2004 to 2010. The first case of pandemic influenza A(H1N1) 2009 virus infection was detected in June 2009. In 2010, the influenza A (H1N1)pdm09 virus

Table 1. Distribution of types and subtypes of influenza viruses, Côte d'Ivoire, 2003–2010

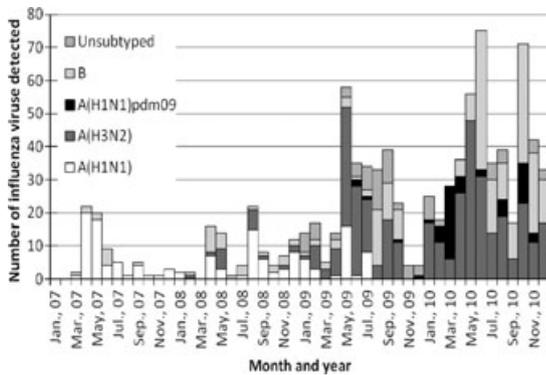|	2003	2004	2005	2006	2007	2008	2009	2010
Specimens tested	95	116	120	111	425	890	1550	1767
Positive cases	8	23	7	9	79	92	274	477
% Positive	8·4	19·8	5·8	8·1	18·6	10·3	17·7	27
A(H1N1)	8	9	5	5	68	47	34	0
A(H3N2)	0	3	0	4	0	18	128	229
B	0	11	2	0	11	27	50	166
A(H1N1)pdm2009	0	0	0	0	0	0	5	57
Unsubtyped	0	0	0	0	0	0	57	25

Figure 2. Distribution of influenza types and subtypes by month, Côte d'Ivoire 2007–2010.

represented 12·0% of all influenza viruses detected and no seasonal influenza A(H1N1) viruses were detected (Table 1 and Figure 2). During the years of surveillance, the strains antigenically characterized were generally good matches to the viruses included in the northern hemisphere vaccine for the same year (Table 2).

Detection of other respiratory viruses

In addition to testing for influenza viruses, screening for other respiratory viruses was carried out on 470 respiratory specimens that were collected during 2009 and 2010 from children aged 0–5 years and sent within 3 days of first symptom onset to the laboratory. The median age of these cases was 3·1 years with a range of 2 months to 5 years. Of these 470 children, 401 (85·3%) tested positive for one or more respiratory viruses. Seventy-seven of the 470 children (16·4%) tested positive for influenza viruses. HRSV was the most common respiratory virus detected in these samples followed by hRV, influenza viruses, parainfluenza viruses, coronavirus OC43, coronavirus 229E, and hMPV. Among children testing positive for a respiratory virus, a greater percentage of infants (aged 0–1 years) tested positive for

HRSV than children aged 2–5 years. However, children aged 2–5 years that tested positive for a respiratory virus were significantly more likely than infants to test positive for influenza and coronavirus infections (Table 3).

Discussion

Sentinel surveillance for influenza viruses expanded substantially in Côte d'Ivoire during recent years, contributing data on the seasonality of influenza, influenza viruses in circulation, and their contribution to ILI in outpatients in this tropical region of Africa. Between 2003 and 2010, 19% of over 5000 NP specimens collected from sentinel patients with ILI tested positive for influenza. Among sentinel ILI specimens tested by RT-PCR during the peak months of influenza activity (May, June, and October) during 2007 through 2010, 39% tested positive for influenza viruses a percentage that is similar to that which may be observed during the winter season in northern hemisphere temperate climates. This percent of sentinel specimens testing p that which may be observed during the winter season in northern hemisphere temperate climates.[16] This system has also highlighted the contribution of influenza viruses relative to other respiratory viruses in children with fever and respiratory symptoms and, indeed, has identified a viral respiratory pathogen to be associated with 85% of ILI cases among a sample of children aged 0–5 years.

Influenza viruses circulate throughout the year in Côte d'Ivoire with peaks observed during the months of May/-June and October. The months of May and June correspond with the primary rainy season. October occurs during the secondary rainy season.[17] Although descriptive, these findings suggest some association between influenza activity and rainfall, and appear consistent with those of the study carried out by Dosseh A *et al.*,[18] in Senegal. However, it is less clear what factors may be associated with the secondary peaks in influenza activity observed
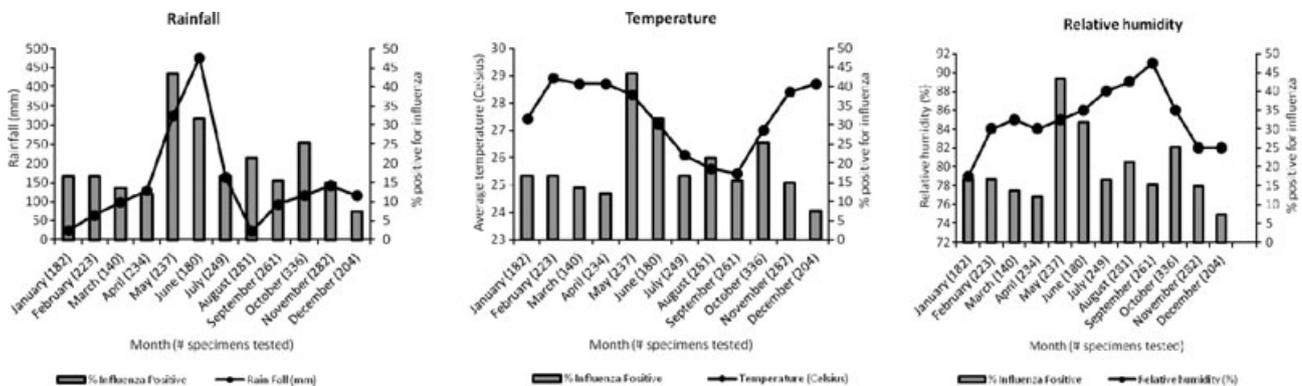

Figure 3. Monthly percentage of sentinel ILI cases testing positive for influenza viruses, by average rainfall (mm), temperature (C) and relative humidity (%), Côte d'Ivoire, 2007–2010.

Table 2. Summary of influenza viruses circulating in Côte d'Ivoire, 2003–2010

Years	Number of Isolates	A(H1N1) Strains	A(H3N2) Strains	A(H1N1)pdm 09 Strains	B strains	Vaccine strains included in the northern. hemisphere formulation
2003	8	A/Chili/6416/01	0	0	0	A/New Caledonia/20/99 (H1N1)-like virus
2004	23	A/New Caledonia/20/99 (H1N1)-like virus*	A/Wyoming/3/2003*; A/Fujian/411/2002-like viruses*	0	B/Sichuan/379/99; B/Hong Kong/330/2001*	A/New Caledonia/20/99 (H1N1)-like virus A/Fujian/411/2002(H3N2)-like virus B/Hong Kong/330/2001-like virus
2005	7	A/New Caledonia/20/99 (H1N1)-like virus*	0	0	B/Hong Kong/330/2001	A/New Caledonia/20/99 (H1N1)-like virus B/Shanghai/361/2002-like virus
2006	9	A/New Caledonia/20/99 (H1N1)-like virus*	A/Hong Kong/4443/2005. A/Wisconsin/67/2005	0	–	A/New Caledonia/20/99 (H1N1)-like virus A/California/7/2004(H3N2)-like virus
2007	79	A/New Caledonia/20/99 (H1N1)-like virus*	0	0	B/Malaysia/2506/2004-like virus*	A/New Caledonia/20/99 (H1N1)-like virus B/Malaysia/2506/2004-like virus
2008	63	A/Brisbane/59/2007 (H1N1)-like virus	A/Brisbane/10/2007 (H3N2)-like virus*	0	B/Florida/4/2006-like virus*	A/Solomon Islands/3/2006 (H1N1)-like virus A/Brisbane/10/2007 (H3N2)-like virus| B/Florida/4/2006-like virus
2009	28	A/Brisbane/59/2007 (H1N1)-like virus*	A/Brisbane/10/2007 (H3N2)-like virus*	A/California/7/2009 (H1N1)-like virus	B/Florida/4/2006-like virus*	A/Brisbane/59/2007 (H1N1)-like virus A/Brisbane/10/2007 (H3N2)-like virus B/Florida/4/2006-like virus
2010	46	0	A/Perth/16/2009 (H3N2)-like virus*	A/California/7/2009 (H1N1)-like virus*	B/Brisbane/60/2008-like virus*	A/California/7/2009 (H1N1)-like virus A/Perth/16/2009 (H3N2)-like virus B/Brisbane/60/2008-like virus

*Virus strains from Côte d'Ivoire that appear consistent with northern hemisphere vaccine formulations for each year.

during October–November, although this is a period of lower temperature and relative humidity in Côte d'Ivoire.

Importantly, antigenic characterizations of a limited subset of influenza strains circulating in Côte d'Ivoire generally suggest a good match to those included in the northern hemisphere influenza vaccine compositions during 2003 through 2010, although we did not carry out specific antigenic analyses of strain match. However, during this time frame only 0·25% of persons with ILI reported having received an influenza vaccination during the past year. In Côte d'Ivoire, seasonal influenza vaccination is currently recommended for parents of young children and also for pilgrims to Mecca. In addition, the only marketed formulation is a northern hemisphere vaccine produced by Sanofi-Pasteur. While current levels of vaccine uptake are low, the apparently high degree of match during recent seasons between circulating viruses and those included in the northern hemisphere vaccines would seem to suggest that currently licensed vaccines are suitable for use in Côte d'Ivoire.

Children aged 0–4 years of age comprised one-half of the sentinel ILI cases. This is owing to the participation of a relatively larger number of pediatricians in the sentinel surveillance system. However, the proportion of ILI specimens testing positive for influenza viruses was similar across age groups, suggesting the circulation of influenza viruses throughout the general population. Additional work to highlight the burden of influenza among persons with more severe illness by age (e.g. hospitalized illness), and the impact of influenza in persons with underlying and

Table 3. The relative contribution of influenza and other respiratory viruses to sentinel influenza-like illness cases in Côte d'Ivoire, by age, 2009–2010

	0–1 years (*n* = 191) *n* (%)	2–5 years (*n* = 279) *n* (%)	Total (*n* = 470) *n* (%)	*P*-value*
Hrsv	63 (40·9)	50 (20·2)	113 (28·2)	<0·001
Hrv	34 (22·1)	51(20·6)	85 (21·2)	0·733
Influenza viruses	17 (11·0)	60 (24·3)	77 (19·2)	0·001
Parainfluenza viruses	28 (18·2)	47 (19·0)	75 (18·7)	0·832
Hcov (OC43 and 229E)	9 (5·8)	33 (13·4)	42 (10·5)	0·016
Hmpv	3 (1·9)	6 (2·4)	9 (2·2)	0·975
Positive for any virus	154 (80·6)	247 (88·5)	401 (85·3)	
Negative for all viruses	37 (19·4)	32 (11·5)	69 (14·7)	
Coinfections involving influenza and another virus	0	0	0	
Non-influenza viral coinfections	0	6	6	

Chi-square tests of association.

chronic conditions, is needed to highlight subpopulations that might be prioritized for vaccination and antiviral treatment. For this reason in 2009, Côte d'Ivoire expanded the sentinel system to include hospitalized patients with severe acute respiratory infections (SARI). Over time, this system, in combination with the existing ILI surveillance, will help to further identify persons at risk of complications of influenza. However, these surveillance data provide initial support for the potential public health benefit of influenza vaccination programmes in Côte d'Ivoire.[19]

These analyses are also subject to several limitations. Of the 28 sentinel sites involved in the surveillance, only one sentinel site (the Clinique du Grand Centre of Yopougon) was able to provide specimens throughout the 8-year surveillance period. During 2007–2010, four sentinel sites provided 50% of the respiratory specimens. This highlights the challenges of establishing sentinel site surveillance and demonstrates that the feasibility of a sentinel site to participate in a surveillance system in terms of administrative and clinical staff commitment, political willingness, and logistics of data collection and specimen transfer is critical to consider when selecting sentinel sites. It is also therefore possible that specific populations, and pockets of influenza activity, may not have been captured by this sentinel system—especially during the early years of surveillance prior to the implementation of molecular diagnostic techniques in Côte d'Ivoire.

Only nine percent of the samples were collected between 2003 and 2006. During this period, the sentinel surveillance for influenza was involved in the general microbial surveillance activities of the Institut Pasteur of Côte d'Ivoire and was limited to Abidjan city. Although this surveillance permitted us to collect our first data on the circulation of influenza viruses in Côte d'Ivoire, during this period there was limited motivation among medical doctors to sustain the activity. This could be explained by increased workload,

and perceptions of influenza as a benign or 'mild' disease, which was not seen at the time as a priority in terms of public health. For these reasons, our assessment of influenza seasonality was limited to the years 2007–2010 when data were consistently reported from multiple sentinel sites. A critical line of work for the sub-Saharan African Region is to identify better ways to provide incentives to over-extended clinicians to participate in sentinel surveillance. In this regard, the development of sensitive rapid diagnostic tests that may be used in the clinic and hospital setting could better allow surveillance to inform clinical management and increase its relevance to participating clinicians.

Following the occurrence of outbreaks of highly pathogenic avian influenza A (H5N1) in 2006 among poultry in Côte d'Ivoire, clinician perceptions of influenza began to change, and a national pandemic influenza preparedness plan was developed and supported by the Centers for Disease Control and Prevention through a Cooperative Agreement with the Ministry of Health of Côte d'Ivoire. This plan called for the reinforcement of influenza surveillance capacities in the country and the strengthening of influenza diagnostic techniques within the Institut Pasteur of Côte d'Ivoire. Consequently, from 2007 to 2010, the annual average number of respiratory specimens collected was 10 times higher than during the 2003–2006 period. This demonstrates the ancillary benefit of pandemic preparedness activities to the strengthening of routine surveillance infrastructures, which in turn will be available to monitor circulation during future epidemics and pandemics.

An added value of this surveillance system has been to demonstrate the relative contribution of influenza and other respiratory viruses to influenza-like illnesses. Our study confirmed the presence of other respiratory viruses in addition to influenza viruses as important contributors to outpatient ILI morbidity. This has also been demonstrated by other studies in

Africa.[20,21] A large majority of ILI cases in children under age 5 were associated with respiratory virus infections, with RSV, rhinoviruses, influenza viruses, and parainfluenza viruses contributing to medically attended ILI. The finding that influenza is also an important relative contributor to ILI across all ages also supports the notion that, if available, timely use of neuraminidase inhibitors could help to further reduce the burden of febrile respiratory disease in this setting.

Particularly during recent years, data collection using a standard case definition from several sentinel facilities has made it possible to interpret trends in influenza activity over time and to interpret patterns of seasonality and disease intensity. The introduction of the first cases of influenza associated with influenza A(H1N1)pdm09 in Côte d'Ivoire further increased awareness and mobilization of resources during the surveillance period and strengthened the capacity of the national monitoring system. However, the question of sustainability arises today in a context of economic austerity and scarcity of funding. It is possible that limiting ILI surveillance to a representative subset of efficiently functioning sentinel sites, while continuing to establish sentinel surveillance for SARI in a few well-chosen hospitals, will allow the surveillance system to effectively monitor influenza virus circulation and seasonality and additionally provide data on persons at risk of more severe complications of influenza. Taken together, such data may also be able to provide a more comprehensive understanding of the burden of influenza in Côte d'Ivoire and effectively inform future influenza vaccination and antiviral treatment policy.

Acknowledgements

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