DOI:10.1111/j.1750-2659.2011.00286.x
www.influenzajournal.com

Original Article

Influenza transmission during a one-year period (2009–2010) in a Sahelian city: low temperature plays a major role

Jean-François Jusot,[a] Lagaré Adamou,[b] Jean-Marc Collard[b]

[a]Unité d'Epidémiologie, Santé-Environnement-Climat. Centre de Recherches Médicales et Sanitaires (CERMES), Boulevard de la Nation, Niamey, Niger. [b]Unité de Biologie. Centre de Recherches Médicales et Sanitaires (CERMES), Boulevard de la Nation, Niamey, Niger.
Correspondence: Dr Jean-François Jusot, Centre de Recherches Médicales et Sanitaires (CERMES), 634, Boulevard de la Nation, PO Box 10887, Niamey – Niger. E-mail: jfjusot@gmail.com

Accepted 3 August 2011. Published Online 20 September 2011.

This work aimed at studying the link between some climatic factors and the occurrence of influenza in Niamey, Niger. Patients with influenza like illness or severe acute respiratory illness were recruited through a sentinel network. A nasopharyngeal swab was sampled and tested for influenza viruses A and B by RT-PCR. Time series of daily counts of influenza cases and climatic factors were linked using a generalized additive model. Among the 320 patients recruited, 76 were confirmed positive for influenza. Influenza cases increased significantly with minimal temperatures and high visibility. This work brings some valuable explanation to the impact of low temperatures on influenza transmission.

Keywords Climate, influenza, temperature, time series, transmission.

Please cite this paper as: Jusot J-François *et al.* (2012) Influenza transmission during a one-year period (2009–2010) in a Sahelian city: low temperature plays a major role. Influenza and Other Respiratory Viruses 6(2), 87–89.

Background

Influenza data in Africa is scarce, and only 18 countries among the 46 in the WHO-AFRO region are able to perform laboratory diagnosis of influenza as previously reported.[1,2] In April 2009, a sentinel network for influenza surveillance was set up in Niamey, the capital city of Niger. Niger was one of the last countries affected by the recent A/H1N1 (2009) pandemic.

In temperate countries, influenza transmission is influenced by temperature and humidity that explains its seasonality.[3] In tropical countries, seasonality is less marked and the role of climatic factors less obvious.[4]

Contrary to humid tropical countries, Niger is a Sahelian country where dryness predominates over a very short rainy season. The effect of temperature at low values of humidity on influenza transmission is not clearly understood. Better knowledge of the role of climatic factors could help when forecasting the occurrence of influenza epidemics, so as to limit their health impact. This work is therefore aimed at studying the link between some climatic factors, particularly temperature and humidity, and the occurrence of influenza in Niamey.

Methods

A sentinel surveillance network was set up in Niamey in April 2009 and comprised of 10 sentinel sites. Patients with influenza like illness (ILI) or severe acute respiratory illness (SARI) consulting at these sites were recruited between June 1, 2009 and May 31, 2010. WHO clinical case definitions were used for ILI and SARI.[5] A nasopharyngeal swab was sampled from each recruited patient and collected into a standard virus transport medium. RNA was extracted and amplified to detect influenza viruses A and B by RT-PCR. All detected influenza A viruses were subsequently subtyped. Detection and typing were performed according to the procedures of the National Influenza Centre, Unit of Molecular Genetics of Respiratory Viruses, Pasteur Institute, Paris.[6]

In Niger, the rainy season is from June to September, the hot season from October to November, the cold season from December to February and the very hot season from March to May. Time series of daily counts of influenza cases and climatic factors were linked using a generalized additive model. Minimal and maximal temperature, minimal and maximal relative humidity, wind speed and visibility routinely collected were analyzed (visibility is defined as the maximal distance from which a fixed object or light can be clearly seen). Trend, seasonality, day of the week, holidays, religious festivals, and pilgrimage were taken into account in the model. The climatic factors were included in the model with a natural spline. The package mgcv (multifold generalized cross-validation) was used to control seasonal and long-term temporal trends and to minimize autocorrelation in the residuals.[7,8] The quality of the model adjustment was checked using partial autocorrelation function, residuals and predicted data versus observed data. The choice of the final model was based on the Akaike information criteria (AIC).[9] All analyses were performed with the r software (R 2.12.0).[10]

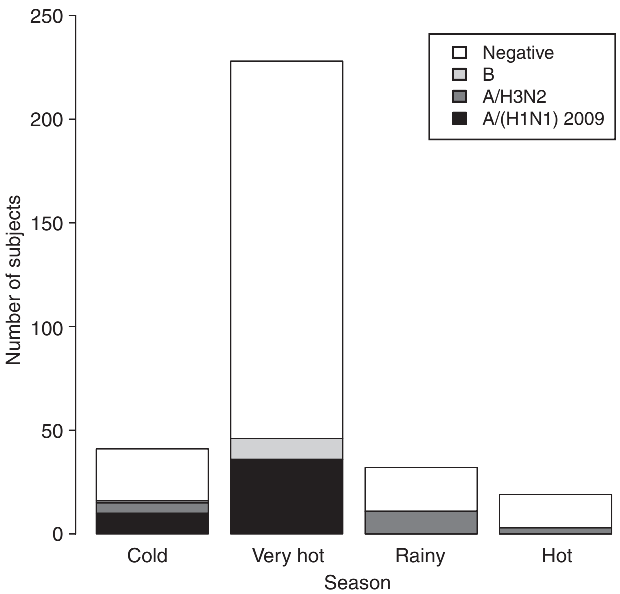

Figure 1. Distribution of the different influenza viruses by season in Niamey, Niger (2009–2010).

Results

A total of 320 patients consulting at the sentinel sites were recruited. Among them, 76 (23.8%) were confirmed positive for influenza and consisted of 46 A/H1N1(2009), 19 A/H3N2 and 11 influenza B, with the median age of 7 (interquartile range = 2–16 years), 6 (interquartile range = 2–14.5 years) and 7 years (interquartile range = 4.5–8 years), respectively. The 244 negative patients had a median of age of 5.5 years (interquartile range = 1.8–27.3 years). Thirty-nine per cent (39%) of the patients recruited during the cold season were confirmed positive for influenza as well as for 34.4%, 20.2%, and 15.8% during the rainy, the very hot, and the hot seasons respectively (Figure 1). All the A/H1N1 (2009) cases were detected between February 2 and April 8, 2010. Climatic factors are depicted in Table 1.

Influenza cases increased significantly with minimal temperatures between 13 and 22°C ($\beta = 3.99$, SE = 1.74, $P = 0.022$). These values were retrieved mainly during the cold and rainy seasons. Increase in influenza cases occurred with visibility ≥9500 m, values encountered during the rainy season ($\beta = 3.30$, SE = 1.34, $P = 0.014$). Relative humidity and wind speed showed no significant impact.

Discussion

The preliminary results indicated that temperature and visibility were significantly correlated with the occurrence of influenza in Niamey. The majority of influenza cases were detected at low minimal temperatures during the cold season and the rainy season. Lack of aerosol transmission at

Table 1. Proportion of positive cases for influenza and description of climatic factors according to the seasons

Variable	Hot*	Cold**	Very hot***	Rainy†
Number of subjects recruited	19	41	228	32
Number of influenza positive (%)	3 (15.8)	16 (39)	46 (20.2)	11 (34.4)
Maximal temperature (°C): Median (Q1²–Q3²)	36 (34–39)	35 (34–36)	41 (39.5–42)	35 (33–37)
Minimal temperature (°C): Median (Q1–Q3)	23 (19–26)	17 (16–19)	27 (25–30)	25 (23–26)
Maximal humidity (%): Median (Q1–Q3)	57 (39–70)	27 (24–31)	30 (15–52)	83 (74–94)
Minimal humidity (%): Median (Q1–Q3)	11 (9–21)	4 (4–6)	6 (4–15)	36 (27.3–44)
Wind speed (ms^{-1}): Median (Q1–Q3)	8 (7–9)	8 (7–11)	10 (7–13)	11 (8–13)
Visibility (km): Median (Q1–Q3)	9.3 (7.9–10)	7.6 (7–9.1)	6.7 (4.6–7.8)	9.95 (8.6–10.4)

Q1, first quartile; Q3, third quartile.
*Hot season: 1st October to 14 December 2009.
**Cold season: 15 December 2009 to 13 February 2010.
***Very hot season: 14 February to 31 May 2010.
†Rainy season: 1st June to 30 September 2009.

30°C showed by Lowen *et al.*[11] with guinea pig model infected by A/H3N2 virus (influenza A/Panama/2007/99 virus) supports this result. Indeed, high values for maximal temperatures (>30°C) are observed almost all year around in Niamey. David-West and Cook observed that in Nigeria, major outbreaks of ILI and SARI occurred at the lowest temperatures when the dry and dusty Harmattan winds blow from November to March.[12] In this study, the transmission was efficient even at very low values of relative humidity observed during the cold season. However, a study by Hanley and Borup showed that below 20% of relative humidity and irrespective of temperature, influenza transmission remains poorly known.[3]

Influenza was predominant during the rainy season when visibility was observed at its highest values and in climatic conditions closer to those which are observed in humid tropical countries. Visibility was found to be correlated with occurrence of influenza cases but was in fact probably more of a surrogate factor. Indeed during rainy days, close contact favors virus transmission likely because people stay home for longer periods of time. In this work, relative humidity was not retrieved as a significant climatic factor contrary to studies on the incidence of influenza A virus in Argentina and Hong Kong.[13,14] The role of humidity on influenza transmission efficiency is not well established in the tropics.

This study, however, had some limitations. First, the number of influenza cases was limited. Indeed, influenza generally leads to symptoms similar to malaria, and patients frequently treat themselves or consult the healthcare facilities only in case of serious disease. Second, the results of this analysis concerned only the main healthcare facilities within Niamey, the capital city of Niger. The patients recruited in the study, however, came from different quarters of Niamey and concerned all socioeconomic classes (data not shown).

These results are in favor of a predominant seasonality of influenza during the cold and rainy seasons. During these seasons, positive patients were more frequently detected even though the influenza virus could circulate all year round in Niamey. This work provides a new insight into higher influenza transmission during low temperatures, even at the lowest values of relative humidity. It also quantifies the risk of occurrence of influenza cases. Further work is ongoing in Niger to provide more information regarding the link between climatic factors and influenza, as well as its seasonality. It will need a strengthened and continued surveillance of influenza.

Acknowledgements

Authors are indebted to all the doctors and the healthcare workers in charge of Niamey sentinel sites who sent swabs and questionnaires to the CERMES. We thank Bibata Sidikou (CERMES) for database management and Bassira Issaka (CERMES) for technical support.

References

1 Yazdanbakhsh M, Kremsner PG. Influenza in Africa. PLoS Med 2009; 6:e1000182.
2 Schoub BD. Surveillance and management of influenza on the African continent. Expert Rev Respir Med 2010; 4:167–169.
3 Hanley BP, Borup B. Aerosol influenza transmission risk contours: a study of humid tropics versus winter temperate zone. Virol J 2010; 7:98.
4 Lofgren E, Fefferman NH, Naumov YN, Gorski J, Naumova EN. Influenza seasonality: underlying causes and modeling theories. J Virol 2007; 81:5429–5436.
5 Ortiz JR, Sotomayor V, Uez OC *et al.* Strategy to enhance influenza surveillance worldwide. Emerg Infect Dis 2009; 15:1271–1278.
6 WHO information for laboratory diagnosis of pandemic (H1N1) 2009 virus in humans – revised. Group protocol No.120 pp 36-41. Available at http://www.who.int/csr/resources/publications/swineflu/diagnostic_recommendations/en/index.html (Accessed 23 March 2011).
7 Wood SN. Stable and efficient multiple smoothing parameter estimation for generalized additive models. J Amer Statist Ass 2004; 99:673–686.
8 Wood SN. Fast stable direct fitting and smoothness selection for generalized additive models. J R Statist Soc B 2008; 70:495–518.
9 Akaike H, Petrov BN, Csaki F, eds. Information theory as an extension of the maximum likelihood principle. Second international symposium on information theory. Akademiai Kiado, Budapest, Hungary. 1973: 267–281.
10 R Development Core Team, 2010. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing, 2010. ISBN 3-900051-07-0, Available at: http://www.R-project.org/URL http://www.R-project.org/ (Accessed 21 February 2010).
11 Lowen AC, Steel J, Mubareka S, Palese P. High temperature (30 degrees C) blocks aerosol but not contact transmission of influenza virus. J Virol 2008; 82:5650–5652.
12 David-West TS, Cooke AR. Laboratory and clinical investigation of the 1974 influenza epidemic in Nigeria. Bull World Health Organ 1974; 51:103–105.
13 Viegas M, Barrero PR, Maffey AF, Mistchenko AS. Respiratory viruses seasonality in children under five years of age in Buenos Aires, Argentina: a five-year analysis. J Infect 2004; 49:222–228.
14 Tang JW, Lai FY, Wong F, Hon KL. Incidence of common respiratory viral infections related to climate factors in hospitalized children in Hong Kong. Epidemiol Infect 2010; 138:226–235.

