Seasonal pattern of influenza and the association with meteorological factors based on wavelet analysis in Jinan City, eastern China, 2013-2016

Wei Su [Corresp., Equal first author, 1], **Ti Liu** [Equal first author, 2], **Xingyi Geng** [3], **Guoliang Yang** [3]

[1] Shandong University of Finance and Economics, Jinan, Shandong Province, China

[2] Shandong Center for disease control and prevention, Jinan, Shandong Province, China

[3] Jinan Center for disease control and prevention, Jinan, Shandong Province, China

Corresponding Author: Wei Su
Email address: suwei@sdufe.edu.cn

Background: Influenza is a worldwide surveillance disease which has different characteristics of seasonality in temperate and tropical regions. Previous studies have illustrated that the seasonality of influenza was modeled by climate variables. Hence, we aim to study the potential meteorological drivers of influenza seasonality in Jinan, China.

Methods: The raw data of three influenza sentinel hospitals and relative climatic factors (minimum, mean temperature, relative humidity, sunshine, rainfall and speed of wind), from 2013-2016, were collected. The statistical analysis and wavelet analysis were used to explore the epidemiological characteristics of influenza and the potential association between influenza virus and climatic factors.

Results: We found the dynamics of influenza characterized by annual cycle with remarkable winter epidemic peak from December to February. Weekly mean atmosphere pressure, the weekly temperature (mean and minimum) and the weekly humidity (relative and absolute) were potential climatic drivers to shape the influenza seasonality. During the epidemic season, the temperature and the relative humidity preceded the onset of influenza epidemic for approximately 6-8 weeks and 3-4 weeks, respectively.

Conclusion: Climatic factors were significantly associated with influenza seasonality in Jinan at the influenza epidemic season, which provided the scientific support for the influenza control and prevention.

Introduction

Influenza remains a global public health concern ~~that the~~ annual epidemics may cause 10-20% of ~~the population~~ infection, 3-5 million severe illness and 29.1-64.6 deaths worldwide (Iuliano AD et al.,2018). The influenza epidemics show obvious seasonality in winter in temperate areas ~~in developed countries~~ and more diverse in tropical and subtropical areas, where influenza displays semi-annual or annual epidemic cycles, and year-round activity (Tamerius JD, et al., 2013). However, difference exists between regions ~~and~~ durations ~~as well as in~~ magnitude of transmission periods (Onozuka D et al., 2015). Azziz Baumgartner et al ~~illustrated~~ 7 of 47 (15%) temperate countries ~~occurring~~ two or three influenza epidemic period every year, and year-round activity in 3 of 43 (7%) temperate countries ~~(Azziz BE et al., 2012).~~ Thus, accurately documenting dynamics of influenza epidemic and understanding ~~the~~ epidemic patterns ~~of them~~, are of great important from the viewpoint of not only scientific interest, but also of public health (Thai PQ et al., 2015).

The seasonal ~~epidemic~~ of influenza is associated with many factors, ~~e.g.~~ virus variation, climate, environmental changes, etc., among which the climatic ~~factors~~ play the most important role (Lofgren E et al., 2007; Tamerius J, et al.,2011; Lowen AC et al.,2014; Tamerius J, et al.,2011). The experimental and epidemiological studies ~~illustrated~~ that decreases of temperature and absolute humidity (AH) increased influenza virus survival and transmission in temperate regions (Shaman J et al., 2011; Shaman J et al., 2009; Shaman J et al., 2010). Tamerius JD et al showed that the onset of influenza epidemics was associated with the cold-dry and humid-rainy condition in temperate and tropical areas, respectively (~~Tamerius JD, et al., 2013;~~ Bloom-Feshbach K et al.,

* Specify the areas you are talking about. Is it temperate X tropical? Do you have examples? In the next phrases you cite a study just about temperate regions.

2013). Although ~~relative results~~ had been well described in developed temperate regions, the data is scare in ~~the~~ temperate areas ~~with low or middle income~~. Yu HJ et al has described that minimum temperature, the hours of sunshine and maximum rainfall were closely related with influenza seasonality in China, but absolute humidity was not taken into consideration and the influenza surveillance data ~~in~~ April-September in northern China ~~were lack (Yu H, et al., 2013).~~ Therefore, ~~being~~ difference in the climate, latitude, etc., ~~the~~ local ~~information~~ plays a vital role in understanding the pattern ~~of influenza~~ transmission and the implementation of prevention and control strategies.

In this study, we ~~investigated~~ the seasonality of influenza and explored ~~the~~ climatic factors including absolute humidity, relative humidity, temperature ~~that explained~~ the seasonality of laboratory-confirmed influenza cases in Jinan City, the capital of Shandong Province, eastern China from 2013 to 2016, which is a temperate city with 7 million people and 3 sentinel hospitals for the surveillance of influenza. This detailed analysis of influenza pattern will provide evidence to ~~targeted~~ strategies to prevent and control influenza in different years. ? *

Methods

Influenza surveillance ~~dataset~~

The weekly and annual reported data was collected from Jinan CDC for the study period of 2013-2016, including the number of influenza-like illness cases and laboratory-confirmed influenza cases from sentinel hospitals in Jinan. Jinan has built the influenza surveillance system in 2008, which is an online reporting system providing weekly reports from 3 sentinel hospitals.

Climate data

~~The~~ daily meteorological data from 2013-2016 ~~in~~ Jinan were obtained from China

*) Please cite studies from China, even if it is about other areas.
?) Why? What do you mean by "different years"? Do you mean "in the next years?

Meteorological Science Data Sharing Service System (http://data.cma.gov.cn),including temperature (~~mean~~, minimum,°C), ~~mean~~ atmospheric pressure (Pa), ~~mean~~ relative humidity (%), ~~mean~~ wind speed (m/s), rainfall (mm) and ~~mean~~ sunshine duration (h). The weekly ~~mean~~ absolute humidity (g/m^3) was calculated based on the ~~data of~~ temperature and relative humidity using the formula described ~~in the literature (Xiao H, et al., 2012)~~.

Statistical analysis

A descriptive analysis was used to reveal the characteristics of influenza epidemics and climatic factors. ~~To illustrate the seasonality of influenza,~~ we choose the weekly positive rate as influenza virus proxy (positive rate=number of positive specimens/total number of specimens tested per week ×100%) according to Tameriu J et al and Liu XX et al ~~(Tamerius J, et al., 2011; Liu XX, et al., 2017)~~. Spearman's correlation was conducted to show the association between positive rate and climatic factors after normal distribution test.

Wavelet analysis

Wavelet analysis has been used to ~~effectively~~ reveal the time-frequency structure features of non-stationary time series, and ~~was~~ utilized to explore the temporal and spatial variations of various infectious diseases including influenza (Xiao H, et al., 2012; Liu XX, et al., 2017). Wavelet analyses can divide time series data into small time-frequency ~~spaces~~ to identify the key frequencies in different time periods.

~~Continuous wavelet transform~~

Continuous wavelet transform (CWT) which divides the time series into a family of wavelets, translates and scales copies of a generally oscillating and decaying function known as the mother wavelet, which is capable of building a time-frequency representation of a signal that offers very good time and frequency localizations. In this study, a complex wavelet, the Morlet wavelet, was