Disease burden and epidemiological characteristics of influenza in Mongolia

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Disease burden and epidemiological characteristics of influenza in Mongolia

(モンゴル国でのインフルエンザの疫学的特徴および疾病負荷に関する研究)

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Contents

List of abbreviations used

CC - Collaborating Center

CDC - Centers for Disease Control and Prevention

CHD - Center for Health Development

GISN - Global Influenza Surveillance Network

HI - Hemagglutination Inhibition

hMPV - human Metapneumovirus

hPIV3 - human Parainfluenza Virus Type 3

ILI - Influenza like illness

ISSSs - Influenza Surveillance Sentinel Sites

MAMS - Mongolian Academy of Medical Sciences

MoH - Ministry of Health

MDCK - Madin-Darby Canine Kidney

NIC - National Influenza Center

NIID - National Institute of Infectious Diseases

PCR - Polymerase Chain Reaction

rt-RT-PCR - real time-Reverse Transcription-Polymerase Chain Reaction

RSV - Respiratory Syncytial Virus

RT-PCR - Reverse Transcription-Polymerase Chain Reaction

RV - Rhinovirus

sARI - severe Acute Respiratory Infection

US - United States

VL - Virology Laboratory

WHO - World Health Organization

1. Summary

The Mongolian influenza surveillance system has gradually improved over the last four decades since its beginning in 1970s. Longitudinal analyses of surveillance data from different perspectives can provide deeper insight in understanding the extent and long term impact of influenza. The current study was aimed to investigate the disease burden and epidemiological characteristics of influenza by analyzing the available data collected from the ongoing national influenza like illness (ILI) and severe acute respiratory infection (sARI) surveillance in Mongolia.

In this study, both the weekly ILI and sARI surveillance data from the 2007/8 to 2013/14 influenza seasons were included. The surveillance data included the number of patients with ILI, total visits to outpatient clinics, the number of patients with sARI, total admissions to hospitals, the number of laboratory-confirmed influenza cases by virus type/subtype, and the number of specimens tested from the sentinel sites located in seven provinces (locally known as *aimags*) and Ulaanbaatar city. For laboratory testing, nasopharyngeal swabs were collected from selected patients with ILI and sARI per site and per week for the entire year and tested using real time-reverse transcription-polymerase chain reaction (rt-RT-PCR). Selected samples negative for influenza were tested for other respiratory pathogens including respiratory syncytial virus (RSV), rhinovirus (RV), parainfluenza virus (hPIV), and human metapneumovirus (hMPV) by multiplex rt-RT-PCR. The spatio-temporal spreads of seasonal and pandemic influenza were mapped for the study periods.

During the seven influenza seasons, ILI cases occupied 1,797,655 (5.1%) out of total 35,572,137 outpatient visits and the average incidence rate was 14.6 per 100 population. The overall ILI incidence rate was highest in the 2009/10 season (22.2 per 100

population) and the lowest incidence rate was in the 2008/9 (8.9 per 100 population). The overall ILI incidence rate for the seven seasons was highest among those aged less than 5 years (86.0 per 100 population) and lowest in the age group of 25–44 years (2.5 per 100 population).

A total of 106,003 sARI patients were recorded. The overall sARI incidence rate for the seven seasons was calculated to be 0.9 per 100 population. The highest rate was in 2013/14 season (1.2 per 100 population), whereas the lowest rate was in 2008/9 season (0.5 per 100 population). The highest rate was observed in those aged less than 5 years for all seasons with the overall rate of 6.9 per 100 population. The rates were much lower in other age groups with the lowest rate of 0.1 per 100 population in those aged 20–49 years.

During the study period, a total of 22,582 (1.3%) specimens from ILI cases were tested and the overall positive rate for influenza viruses was 11.4%. It was highest in children aged 5–9 years (14.4%) and lowest in adults aged 45–64 years (7.5%). Among sARI cases, 14,536 (13.7%) cases were tested and 1,511 (10.4%) were positive for influenza viruses. The highest positive rate was observed in young adults aged 16–24 years (23.1%), and the lowest positive rate in children aged less than 5 years old (7.1%). Of those 16–24 years age group, the positive rates for A (H1N1)pdm09 were accounted for 18.6%. In addition, a ratio of sARI to ILI was high among cases ≥60 years old, although the number of sARI cases in this age group was small.

Predominant strains of influenza virus were varied between the seasons. A (H1N1)pdm09 was a predominant strain in the 2009/10 season, influenza B in the 2007/8, 2011/12, and 2013/14 seasons, influenza A (H3N2) in the 2010/11, and 2012/13 seasons and seasonal A (H1N1) in the 2008/9 season.

Selected samples negative for influenza viruses from ILI and sARI cases from the 2010/11 to 2013/14 seasons were tested for other respiratory viruses. Among sARI cases, RSV was a major causative virus in 2010/11 and 2011/12 whereas RV was in 2012/13 and 2013/14. RSV positive rate was higher in hospitalized children less than 5 years than outpatient cases. Among ILI episodes, RV was the most frequently detected virus.

A plot of weekly number of influenza positives showed a clear seasonal pattern of influenza nationwide. Typically, first influenza cases were detected from late October to early January and reached a peak in February. The temporal trends of sARI cases were slightly different from those of the ILI. Two peaks were generally observed during each season; the first peak occurred in between October and December and the second one between January and March. The first peak was contributed by cases in all age groups, but in the second peak, there was a slight increase of sARI cases in children aged less than 5 years. During the second peak of the 2009/10 season, influenza B was the main influenza virus detected and had more sARI cases than in the first peak of 2009/10 season, in which A (H1N1)pdm09 was a dominant influenza virus.

The distribution of influenza positives in a map showed the synchronization of predominant strains across *aimags* in the seven consecutive seasons except the 2013/14 season. In general, influenza B was the dominantly circulating strain in three seasons: 2007/8, 2011/12 and 2013/14. In 2007/8 an influenza B was the most commonly detected virus and influenza A (H3N2) was co-circulated. In 2011/12 season, influenza B cases were not detected in only one *aimag* out of seven *aimags*. In 2008/9 and in 2010/11 season influenza A (H1N1) (except one *aimag* out of seven) and the dominantly circulating strain was A (H3N2). In 2009/10 influenza A (H1N1)pdm09 was the dominant and influenza A (H3N2) was the predominant strain in 2012/13 season. In 2013/14 influenza B, A (H1N1)pdm09 and A (H3N2) were co-circulated with higher intensity of influenza A (H1N1)pdm09.

In summary, this study highlights that in Mongolia, influenza viruses as well as other respiratory viruses like RSV and RV contributed to a significant burden in both ILI and sARI children aged less than 5 years old.

2. Introduction

Influenza viruses are highly infectious and cause respiratory illness in human. Influenza illness extends from mild disease to serious complications such as pneumonia especially in elderly and young children resulting in substantial disease burden (1-3). Influenza causes seasonal epidemics because of continuous antigenic changes by mutations in the antigenic sites of circulating seasonal influenza viruses, so called antigenic drift. Furthermore, antigenic shift, another mechanism of antigenic change, is also responsible for epidemics of influenza viruses. Antigenic shift occurs through introduction of an antigenically distinct virus in the human population. Those antigenically distinct viruses have a potential to cause a widespread global epidemic with high morbidity and mortality. Seasonal influenza epidemics usually occur during the winter in temperate climates, but influenza can be observed throughout the year in the tropics (4). The epidemiology and impact of influenza are well defined in high income countries in temperate regions. Although more data from countries in different settings including those in tropical and subtropical climate became available in recent years (5-11), the data from developing countries are still limited (12, 13). Influenza control is not prioritized in many developing countries partly because there is no appropriate data to define epidemiology and impact of influenza. Therefore influenza control programs including vaccination are not fully implemented in most developing countries (14, 15).

The seasonality of human influenza varies by region. In temperate region of northern hemisphere, influenza transmission appears in winter. Influenza season could start as early as October, and usually peaks in January or February. The distinct seasonality enables to allocate the resources at appropriate time, thereby facilitating implementation of public health interventions to minimize the impact associated with influenza (10). The influenza activity can be measured by the trend of ILI cases and positive rate for influenza viruses. The peak influenza activity is generally defined as the month with the maximum percentage of respiratory samples positive for influenza viruses (16).

Influenza disease burden is considered to be significant throughout the world as the disease causes high morbidity and significant mortality in humans. Influenza disease burden is usually measured by mortality, morbidity and economic loss. Costs associated with influenza infection due to human suffering are immeasurable, and the economic costs are quite high. For instance, in Germany and France the cost of health care services related to influenza was estimated at US $300 million, and in the United States, the direct cost of influenza was reported at US $1─3 billion per year (17). According to the World Health Organization (WHO), every year 5%–10% of adults and 20%–30% of children become infected with influenza viruses and on average, 250,000 to 500,000 individuals die from complications associated with influenza (18). The importance of defining the disease burden associated with influenza has been recognized (19). The methods to estimate disease burden, especially mortality impact, have been well established in developed countries. The prevalence and burden of influenza have been described for the temperate countries in both northern and southern hemispheres (15, 20-24). In those countries the seasonal peaks of influenza occur distinctly during the cold seasons (22, 25, 26). As aforementioned, typically elderly people and children aged less than 5 years have the highest influenza mortality, therefore vaccination programs mainly focus on these age groups in most countries (21, 23, 27, 28). Monitoring the incidence and clinical characteristics of influenza and hospitalization due to influenza is also critical in understanding the influenza disease burden in the population and guiding prevention and control strategies. However, there remains limited information regarding the impact of influenza including clinical manifestation and outcome of hospitalization of influenza cases in different contexts particularly in developing countries, including Mongolia.

The Mongolian influenza surveillance system has been developed and improved gradually over the last four decades overcoming many obstacles and challenges.

Several studies on epidemiology of influenza in Mongolia have been previously published (6, 29, 30). The study conducted on influenza disease burden in a local Mongolian community showed a significant burden of influenza during the influenza season, and the incidence of ILI was particularly high in children aged less than 5 years (29). However, the study was limited by the scope of the population. Therefore, this study was conducted to define the epidemiological characteristics and disease burden of influenza in whole Mongolia using the more comprehensive national surveillance data and samples collected from patients who visited outpatient clinics with ILI and hospitalized patients with sARI.

2.1. Geographic and climatic background

Mongolia is a landlocked country located in Northeast Asia between the latitudes of 41^{0}35”N and 52^{0}09”E and longitudes of 87^{0}44”N and 119^{0}56”E (Figure 2). The country is bordering in the North with the Siberian part of the Russian Federation and in the East, West and South with the People’s Republic of China. Mongolia is the seventh largest country in Asia and the nineteenth largest in the world. Mongolia has a huge landscape of over 150 million hectares. The country is divided into 21 provinces, locally called *aimags*. The climate of Mongolia is extreme with four distinct seasons. Average annual temperatures range between 8.5^{0}C in Gobi and -7.8^{0}C in the high mountainous areas.

The minimum temperature is usually between -31^{0}C and -52.9^{0}C in January, and the maximum temperature ranges from +28.5^{0}C to +42.2^{0}C in July (31).

2.2. Demography and main health indicators of Mongolia

Population growth rate in Mongolia has been gradually increasing in recent years; however, the population density is still one of the lowest in the world. Despite such low population density, influenza transmission has been occurring every year (32). At the end of 2013, the population of Mongolia reached 2 930 300, of which 48.7% were male and 51.3% were female. The percentage of population aged less than 15 years was 27.4%, aged 15–64 years was 68.8% and aged 65 years and older was 3.8%. According to the latest report from the Center for Health Development of the Ministry of Health (CHD, MoH), Mongolia in 2013, the life expectancy at birth is 69.1 years, infant mortality rate is 14.6 per 1000 live births, under 5 mortality rate is 18.0/1,000 live births, and maternal mortality rate has been decreasing steadily since 2000, and it reached the lowest level of 42.6/100,000 live births in 2013 (33). Respiratory diseases including acute respiratory infections are the leading cause of morbidity in general population, especially in children.

2.3. Health Service Delivery in Mongolia

Mongolia has a mix with governmental and private health care system with dominating government health institutions at three levels: primary, secondary and tertiary. Mongolian health care system consists of a total 45,000 employees including 8,911 medical doctors (30.7/10,000 population), and 27,552 middle level health personnel including nurses, doctor’s assistants, laboratory technicians (60/10,000 population) and has relatively good health personnel supply among developing countries (33). Health services in private sector are still limited and expensive. Moreover, private health services are mostly located in urban areas.

2.4. Influenza Surveillance System in Mongolia

Influenza and other acute respiratory infections have been a serious public health concern in Mongolia since the 1970s because of rapidly growing population as well as urbanization. The National Influenza Center (NIC) in Mongolia was established in 1974, and joined the Global Influenza Surveillance Network (GISN) in 1978. The system was hugely affected by economic constraints in 1990s due to political and economic transitions in the country. The influenza surveillance system has begun to restore after the initiation of cooperative agreement between the Centers for Disease Control and Prevention (CDC), the United States (US) and NIC, Mongolia. Since then, the system has gradually improved its quality and coverage to meet the requirements of the WHO for the NIC designation. Influenza surveillance in Mongolia is currently coordinated by the NIC. Until 2004 ILI surveillance was conducted only from October 1 to June 30 and based only on weekly phone reporting of ILI incidences among outpatient visits in Ulaanbaatar, the capital city and 21 *aimag* centers (*provincial capitals*). After introducing the new influenza surveillance system in 2004/5 season, the NIC had increased the number of sentinel surveillance sites to a total of 155 sentinel sites by October 2009 (32). From 2006/7 season, sARI surveillance with 15 sentinel sites was included in the surveillance system, which has been gradually extended to cover all provincial hospitals, district hospitals, the large hospitals, and national centers in Ulaanbaatar consisting of 37 sites, which have been covering the entire country since 2009/10. The Mongolian surveillance sites are divided into three categories by frequencies of specimen collection. The first category of influenza surveillance sentinel sites (ISSSs) reported ILI and sARI cases weekly and required collection of nasopharyngeal swabs from 5–10 patients with ILI and sARI per site and per week for the entire year. During peak influenza seasons, most of these sites collected specimens twice a week. The second category of ISSSs reported ILI and sARI cases weekly, but collected samples from patients only if there was a cluster or an unusual increase in the number of cases. The third category of ISSSs reported ILI and sARI cases weekly, but samples were collected only through consultation with the NIC and when the ILI rates exceeded a particular level. ILI surveillance has been conducted all year round since 2006/7 season including hospital based surveillance of pneumonia and sARI events in response to emergence of serious public health concern such as pandemic influenza in 2009 and other influenza and other respiratory diseases outbreaks.

3. Objectives

3.1. General Objective

To understand the disease burden and epidemiological characteristics of influenza in whole Mongolia

3.2. Specific Objectives

1) To measure the incidence rates for ILI (influenza like illness) and sARI (severe acute respiratory infection) cases in Mongolia;

2) To calculate the positive rates of influenza and other respiratory viruses in Mongolia;

3) To define the seasonality of influenza and other respiratory viruses in Mongolia;

4) To analyze the geographical distribution of influenza cases in Mongolia;

5) To identify strengths and gaps of currently ongoing influenza surveillance system in Mongolia;

4. Materials and Methods_

4.1. Study period

From October 1, 2007 to September 30, 2014, which covered seven influenza seasons

4.2. Study design

This was a prospective longitudinal study by analyzing the data from ongoing national ILI and sARI surveillance in Mongolia.

4.3. Study procedures

In this study, both the weekly ILI and sARI surveillance data from the 2007/8 to 2013/14 influenza seasons were included. The surveillance data consists of number of patients with ILI and total visits to outpatient clinics, the number of patients with sARI and total admissions to hospitals, the number of laboratory confirmed influenza cases by virus type/subtype and the number of specimens tested. The detailed flow chart of study designs including data collection procedure is shown in Figure 1. The epidemiological and laboratory data were entered by ISSSs using a web based online database system. The entire database was centrally maintained by NIC, Mongolia.

In order to analyze the influenza disease burden and spatio-temporal patterns of influenza transmission dynamics, ISSSs were selected based on the following criteria:

1) Ability to collect specimens regularly, usually 1–2 times per week year round;

2) Comprehensive surveillance data collection by the sentinel sites;

3) Representing different geographic regions for better coverage;

4) Regions with high population density;

5) Along main railway route, this represents majority of the population (about 64.2% of total population during the study period);

It is noteworthy to mention that geographically Mongolia lies in a quite interesting setting with only three main entry points into the country: Ulaanbaatar (by air), Selenghe (Russian border, by train), and Dornogobi (Chinese border, by train). The ISSSs included in the analysis were located in the following *aimags*: Dornogobi in the south-eastern region, Dornod in the eastern region, Khovd in the western region, Selenghe in the northern region, and Uvurkhangai, Orkhon, Darkhan-Uul and Ulaanbaatar in the central region (Figure 2). The socio-demographic data including age-stratified population data in each year was obtained from *aimags* to calculate the incidence rates. The summary of such data was reported annually by the CHD, MoH (33).

4.4. Case definitions

ILI and sARI cases were defined based on the WHO standard case definitions recommended before January, 2014. The ILI and sARI case definitions were as follows: ILI case is a person with sudden onset of fever (≥38.0°C), cough, and sore throat in the absence of another diagnosis. sARI case is a patient with ILI and shortness of breath or difficulty breathing, requiring hospitalization.

4.5. Laboratory methods

The most of laboratory tests for influenza viruses were conducted by the Virology Laboratory (VL) of the NIC, Mongolia. About 3% of samples were tested in branches of VL established in Darkhan-Uul and Orkhon *aimags* in 2010. In each sentinel hospital (either out- or in-patient) nasopharyngeal swabs were collected from 5–10 patients with ILI and sARI per site and per week for the entire year. During the peak influenza seasons, most of these sites collected samples twice per week. The collected specimens were immediately immersed into a sterile tube containing virus transport medium and stored in refrigerator at the sentinel sites. The samples were transported to the VL of the NIC or a branch laboratory once per week. Commonly, the frequency of sample collection increased during the winter months. Samples were usually shipped by car from the central region, by plane from the western and eastern regions, and by train from the northern and southeastern regions.

The samples were inoculated on Madin-Darby Canine Kidney (MDCK) cells or embryonated hen's eggs to isolate the influenza viruses during the 2007/8 and 2008/9 seasons. The type/subtype of influenza virus was detected by reverse transcription-polymerase chain reaction (RT-PCR) and the hemagglutination inhibition (HI) test. The reagents for the HI test were provided by WHO Collaborating Centers (CCs); National Institute of Infectious Diseases (NIID), Tokyo, Japan and the CDC, Atlanta, GA, USA.

Real time (rt)-RT-PCR assays were performed to detect influenza viruses in selected samples from August in 2008. This testing procedure was routinely done for all samples received at the NIC since August 2009. All assays were performed following the standard protocol originally developed by the CDC (34), and primers were provided by WHO CCs. Influenza A positive specimens were further subtyped using specific rt-PCR for seasonal A (H1N1), A (H3N2), and A (H1N1)pdm09. For the isolation of viruses, those influenza positive specimens by rt-RT-PCR were inoculated on MDCK cells using a standard protocol (35). To detect other respiratory viruses, multiplex rt-PCR was done for selected samples with influenza negative results started in the 2010/11 season using commercially available multiplex PCR kits (FTD Respiratory Pathogens 21; FTD 2–96/12; Fast-track Diagnostics, Junglinster, Luxembourg). Selected influenza virus isolates were sent to the WHO CC in Tokyo, Japan, for further analyses.

4.6. Statistical analyses

The proportion of specimens positive for influenza virus was calculated for each week. The incidence rates of ILI and sARI were calculated as the proportion of ILI and sARI cases to the total population in the area covered by surveillance. In this study, the peak period of influenza season was defined as the time when the number of ILI cases exceeded a threshold, and the influenza virus positive rates exceeded 15% or more among total tested samples in a week. The threshold was calculated by the cyclic regression model, so called Serfling's method (36) using nationwide data on ILI morbidity per 10,000 population from 2000 to 2011 in Mongolia.

The maps were created with ArcGIS 10.1 (ESRI, CA, US). All calculations were performed using Microsoft Excel 2010 (Microsoft Corp., Redmond, WA) or R 3.1.2 (R foundation, Vienna, Austria).

This study was approved by the Research Ethics Committees of the Mongolian Academy of Medical Sciences (MAMS), and the NIC, Ministry of Health, Ulaanbaatar, Mongolia.

5. Results

5.1. ILI cases

During the seven influenza seasons from 2007/8 to 2013/14, a total of 35,572,137 outpatient visits were recorded and 1,797,655 (5.1%) were diagnosed as ILI (Table 1).

The ILI incidence rates per 100 population were calculated for each season. The overall ILI incidence rate was highest in the 2009/10 season (22.2 per 100 population), which was higher than the average incidence rate for the seven influenza seasons (14.6 per 100 population). The incidence rates were similar to the average in the 2010/11, 2011/12 and 2012/13 seasons; 14.7, 14.1 and 14.9 per 100 population, respectively. The ILI incidence rates were highest among those aged less than 5 years in the all seven seasons; the overall incidence rate in this age group was 86.0 per 100 population for the seven seasons, ranging from 60.1 in the 2008/9 season to 112.9 in the 2009/10 season. The rates were lower in adult age groups with the lowest overall rate in the age group of 25–44 years (2.5 per 100 population). In all age groups, the rates were highest in the 2009/10 season, but difference between the 2009/10 season and the average for all seasons were larger in older age groups. The rates in the 2009/10 season were more than twice higher than the average in 16–24 years, 25–44 years, 45–64 years, and 65 years or older.

5.2. Detection of influenza and other viruses in ILI cases

A total of 22,582 (1.3%) ILI cases were tested for influenza viruses and 2,577 were positive, including 228 (8.8%) of A (H1N1), 995 (38.6%) of A (H1N1)pdm09, 682 (26.5%) of A (H3N2) and 672 (26.1%) of influenza B (Table 2).

On average 3,226 specimens (between 2,128 and 5,050) were tested annually for influenza viruses. Among those specimens, the overall positive rate for influenza viruses was 11.4%. The positive rates by season were ranging from 2.6% in the 2007/8 season to 28.4% in the 2009/10 season. Over the seven seasons, the total positive rate for A (H1N1), A (H1N1)pdm09, A (H3N2) and B viruses were 1.0%, 4.4%, 3.0%, and 3.0%, respectively (Table 2).

The predominantly circulating strains varied between seasons. A (H1N1)pdm09 was a predominant strain in the 2009/10 season, during which 726 (76.8%) out of 945 influenza virus positive cases were A (H1N1)pdm09. The A (H1N1)pdm09 positive rate was 21.8% in the 2009/10 season, however, this rate declined to 2.9%, 0.7%, 3.0%, and 4.9% in the 2010/11, 2011/12, 2012/13 and 2013/14 seasons, respectively. Influenza B was the most commonly detected virus in the 2007/8, 2011/12, and 2013/14 seasons, influenza A (H3N2) in the 2010/11, and 2012/13 seasons and seasonal A (H1N1) was in the 2008/9 season (Table 2).

The total influenza positive rates by age group ranged from 7.5% to 14.4%. It was highest in children aged 5–9 years (14.4%) and lowest in adults aged 45–64 years (7.5%) and ≥65 years (7.7%) (Table 3). Positive rates for different age groups differed by virus type/subtype: Positive rates for influenza A (H3N2) were highest (3.6%) among children aged less than 5 years; positive rates for influenza A (H1N1) were highest among children 5–9 and 10–15 years (1.3% for both); and positive rate for influenza B was also highest among children aged 5–9 years (4.9%). However, age distribution of influenza A (H1N1)pdm09 was significantly different, and the highest positive rate (8.4%) was observed among young adult aged 16–24 years.

A total of 1,350 specimens negative for influenza viruses between 2010/11 to 2013/14 seasons were selected and tested for other respiratory viruses. Of those specimens, 563

(41.7%) were positive for at least one virus, including RV (139, 24.7%), hMPV (64, 11.4%), RSV (45, 8.0%), and hPIV3 (31, 5.5%). The positive rate for hMPV was the highest among children aged 1–4 years and 5–9 years (6.5% for both), for hPIV3 it was highest in children aged less than 1 year (3.4%), for RSV higher rates were seen in children aged 10–15 years (5.3%), less than 1 year (5.2%) and 1–4 years (4.1%) and for RV the highest was in adults aged 16–24 years old (25.0%) (Table 4).

Unlike other three respiratory viruses, RV has shown year-round circulation with two peaks before and after the increase in the influenza positive rates during the 2011/12, 2012/13 and 2013/14 seasons (Figure 3). The positive rates of RV, hMPV, RSV, and hPIV3 in ILI cases were 10.3%, 4.7%, 3.3% and 2.3%; respectively. Among ILI episodes, RV was the most frequently detected virus throughout the four seasons (Table 5).

ILI cases started increasing between October and November, peaked between December and February and resumed to baseline between April and May for the study period except the 2009/10 season when there were two peaks; one in October 2009 which was caused by A (H1N1)pdm09 another peak in February 2010, which was caused by influenza B. Typically, the first influenza cases were detected in late October to early January and reached a peak in February (Figure 3).

5.3. sARI cases

During the study period, a total of 106,003 sARI patients were recorded, of which 84,618 (79.8%) were aged less than 5 years and only 2,394 (2.3%) were aged 60 year or older (Table 6). The overall sARI incidence rate for the seven seasons was calculated to be 0.9 per 100 population. The overall sARI incidence rate was highest in the 2013/14 season (1.2 per 100 population). The incidence rates were lower in the 2007/8 and

2008/9; 0.6 and 0.5 per 100 population, respectively. The rates were highest in those aged less than 5 years in all seasons with the overall rate of 6.9 per 100 population (ranging from 4.3 in the 2008/9 season to 9.0 in 2013/14 season). The rates were much lower in other age groups with the lowest rate in those aged 20–49 years. The rate was also generally low in those aged 60 years or older (0.3 per 100 population). Unlike the ILI incidence rate, the sARI incidence rate was not significantly higher in 2009/10 season. The temporal trends of sARI cases showed slightly different patterns from those of the ILI. Two peaks were generally observed during each season; the first peak occurred between October and December and the second one between January and March. The first peak was contributed by cases in all age groups, but in the second peak, there was a slight increase of sARI cases in children aged less than 5 years. During the second peak of the 2009/10 season, influenza B was the main influenza virus detected and had more sARI cases than in the first peak of 2009/10 season in which A (H1N1)pdm09 was a dominant influenza virus (Figure 5).

5.4. Detection of influenza and other viruses in sARI cases

A total of 14,536 (13.7%) sARI cases were tested for influenza viruses, and 1,511 (10.4%) were tested positive, including 61 (4.0%) of A (H1N1), 862 (57.0%) of A (H1N1)pdm09, 291 (19.3%) of A (H3N2) and 297 (19.7%) of influenza B (Table 7). Among a total of 1,511 positive cases, 688 (45.5%) were aged less than 5 years old and only 18 (1.2%) were aged 65 years or older (Table 8). An average of 2,077 specimens (range: 1,569–3,499) were tested annually for influenza viruses. The highest positive rate was observed in the 2009/10 season, during which 802 (22.9%) of 3,499 samples were positive for influenza viruses including 685 (85.4%) of A (H1N1)pdm09 and 117

(14.6%) of influenza B (Table 7). Over the seven seasons, the total positive rates for A (H1N1), A (H1N1)pdm09, A (H3N2) and B viruses in sARI cases were 0.4%, 5.9%, 2.0%, and 2.0% respectively.

Although, number of positives for influenza viruses was highest in children less than 5 years (688), the highest positive rate was observed in young adults aged 16–24 years (23.1%). Positive rates in different age groups varied by virus type/subtype: Positive rate for influenza A (H3N2) was highest among adults aged 65 years or older (2.6%); that for influenza A (H1N1) was highest among children 5–9 years (0.7%); and that for influenza B was also highest among children aged 5–9 years (5.4%). Like ILI cases, the highest positive rate (18.6%) for A (H1N1)pdm09 was observed among young adults aged 16–24 years (Table 8).

A total of 1,682 specimens negative for influenza viruses were selected from the sARI cases from the 2010/11 to 2013/14 seasons to be tested for other respiratory viruses. Of these specimens, 763 (45.4%) were positive for at least one virus, including RV (145, 19.0%), RSV (143, 18.7%), hMPV (85, 11.1%), and hPIV3 (45, 5.9%). A peak in RSV positive rates was observed during the second peak of the 2010/11 and first peak of the 2011/12 season, when extremely low influenza positive rates occurred (Figure 6). The positive rates of RV, hMPV, RSV, and hPIV3 in sARI cases were 8.6%, 5.1%, 8.5% and 2.7%; respectively (Table 9). For hMPV the positive rate was highest among children aged 1–4 years (6.5%); for hPIV3 it was highest in adults aged 45–64 (4.7%); for RSV higher rates were observed in infants and small children; 13.2% in those aged less than 1 year and 8.5% in those aged 1–4 years; and for RV the highest was in adults aged 45–64 years old (11.6%) (Table 9). Among sARI cases RV (8.6%) and RSV (8.5%) were the most commonly identified viruses.

Among sARI cases the highest positive rate of RSV, RV, hMPV and hPIV3 was in 2011/12, 2013/14, 2013/14 and 2010/11 with 12.5%, 10.5%, 6.8%, and 5.2%, respectively (Table 10). RSV positive rate was higher in hospitalized children less than 5 years than outpatient cases.

5.5. Spatio-temporal distribution of influenza positives

Figure 7 shows the spatio-temporal distribution of influenza positives using proportion of positives of each virus type/subtype over total number of positives in the seven seasons. In 2007/8 influenza B virus was a predominant virus in all regions with co-circulation of influenza A (H3N2) in the south-eastern and central regions of the country. In the western, eastern and northern regions influenza A (H3N2) was not observed. In 2008/9 seasonal A (H1N1) was dominated in all regions with the exception of Khovd *aimag* in the western region. In the central region, in Ulaanbaatar, Selenghe and Orkhon *aimags* influenza A (H3N2) was detected, and a few cases of influenza B were also detected in the capital city, Ulaanbaatar. In 2009/10 A (H1N1)pdm09 was introduced in all regions and reached a peak in short period of time, which was followed by spread of influenza B in all regions with the exception of Selenghe *aimag* in the northern region at the Russian border. In the central and in the south-eastern region, at the Chinese border transmission of influenza B was higher than in other regions. In 2010/11 influenza A (H3N2) was a dominant strain in all regions, co-circulating with influenza A (H1N1)pdm09 with more intense spread in Orkhon *aimag*. In the western and the eastern regions influenza A (H1N1)pdm was circulated with low intensity than in others. The epidemic was also contributed by influenza B in the central and in the south-eastern regions at the Chinese border. In 2011/12 influenza B was dominated with co-circulation of influenza A (H3N2). Influenza A (H3N2) spread was higher in Orkhon *aimag* than in others. Influenza A (H1N1)pdm09 was also seen in to Ulaanbaatar, Selenghe and Dornogobi *aimags* along the main Mongolian railway network. In 2012/13 influenza A (H3N2) was a dominant strain throughout the country with co-circulation of influenza A (H1N1)pdm09. Influenza A (H1N1)pdm09 was not seen in the western region and with low intensity in the eastern region. But co-circulation was almost at the same level by intensity in the central and south-eastern regions. In 2013/14 influenza season influenza A (H3N2), A (H1N1)pdm09 and influenza B were co-circulated in the country. Influenza B was predominantly circulated in the south-eastern and central regions, but influenza A (H1N1)pdm09 was a dominant strain in the western, eastern and in the central regions. Influenza B virus dominated in the northern region at the Russian border and in the south-eastern region at the Chinese border.

In general, transmission of influenza viruses occurs in all regions of the country with different intensity during influenza epidemics.

6. Discussion

This was the first study attempting to define nationwide disease burden and epidemiological characteristics of influenza in Mongolia. To describe epidemiological patterns of influenza and virus circulation for whole Mongolia, ISSSs were selected by considering the proportion of population. Seven provinces and Ulaanbaatar city were selected as ISSSs, which represent majority of the population (about 64.2% of total population) in the country. Despite a huge landscape, the ISSSs were selected from different geographic regions for better coverage and provinces that function as a hub for human traffic including those along main railway route and bordering provinces with Russia and China were also selected. Therefore, it is considered that the data of the study captured epidemiological patters of influenza in whole country.

The overall ILI incidence rate was highest in the 2009/10 season, which was higher than the average rate for the seven influenza seasons. This was partly because more ILI cases intended to seek care at healthcare facilities during the pandemic of A (H1N1)pdm09. The sARI incidence rate in the 2009/10 season was also higher than the average rate although it was lower than that in the 2013/14 season. The impact of A (H1N1)pdm09 was clearly observed in ILI while that in sARI was compatible between A (H1N1)pdm09 and other influenza viruses. The highest incidence rate of sARI in 2013/14 season was likely to be due to combining impact of three types/subtypes of influenza viruses: influenza B, A (H1N1)pdm09 and A (H3N2). This was the first season when the A (H1N1)pdm09 virus circulated predominantly after the 2009/10 pandemic period. This was also observed in other temperate countries (16). Influenza B was considered to cause a milder illness than influenza A viruses however, recent studies in China and Hong Kong indicated a high disease burden of influenza B (37, 38). This study showed a compatible positive rate between A (H3N2) and influenza B among sARI cases, which indicated a potential impact of influenza B in hospitalization.

During the study period dominant influenza virus types/subtypes were varied between seasons, and the same virus type/subtype was not predominant for two consecutive seasons. Higher positive rates of influenza B virus were observed every two season: 2007/8, 2009/10, 2011/12 and 2013/14 seasons. Similar pattern of influenza B virus circulation was reported from other countries, particularly in the northern hemisphere countries (6, 16).

Age is a key determinant for ILI and sARI incidence rates and influenza positive rates. The highest ILI and sARI incidence rates were observed in children less than five years in the all seven seasons which were compatible with results of the population based study in Vietnam (39). However, influenza positive rate was highest among children aged 5–9 years in ILI cases which were similar to study results in China and Bangladesh (40, 41). Generally, 5–9 year age group represents the preschool and school age group and has a high social mixing (30, 42). A community-based study in Mongolia (29, 43) and other countries (44-47) have also reported the highest incidence in young children including infants. The ILI incidence rate among the adult population was low but it was higher in the 2009/10 season. This increase could be explained partly due to the large number of susceptible population to the novel influenza virus in adults and partly due to the change of health seeking behavior because of anxiety among general public during that period.

The influenza virus positive rates for both ILI and sARI were lower for the 2007/8 and 2008/9 seasons because screening for influenza viruses was conducted by viral isolation during these two seasons, which is less sensitive than detection methods used later. After introducing rt-PCR as the initial screening method during the 2009/10 influenza season, the influenza virus positive rates significantly increased, as was also noted in the study in Thailand (48). Among sARI cases, the overall highest influenza positive rate (23.1%) was observed in young adults aged 16–24 years, which was compatible to other study results (49, 50). This highest positive rate was due to A (H1N1)pdm09 since 81% of influenza positives in this age group were that subtype. When excluding A (H1N1)pdm09 positives during the pandemic period, the rate went down to 12.7%. The second highest positive rate was found in children 10–15 years. Although the number and the incidence rate of sARI cases were highest in children aged less than 5 years, influenza positive rate was lowest (7.1%) in this age group.

In addition, a higher ratio of sARI to ILI was found among persons more than 60 years old, although the number of sARI cases in that age group was low. The higher proportion of sARI among the elderly reflects more severe influenza infection in this age group, which is similar to other countries where severe complications are reportedly more common in elderly people (21, 51, 52). But, no apparent excess mortality was estimated in Mongolia by using the Serfling type model with 2004-2007 surveillance data (53). This may partly be because the elderly population, which occupies a major part of influenza excess mortality, is smaller in developing countries, including Mongolia.

ILI and sARI specimens were selected for testing other respiratory pathogens for the 2010/11 to 2013/14 seasons. The results indicated that among ILI episodes, RV was the most frequently detected virus throughout the four seasons, whereas among sARI cases, RV and RSV were more commonly identified viruses. Similar to our data the study in China which tested all samples for other respiratory viruses found that RV was also the most frequently identified virus and followed by hMPV and RSV (54). RSV positive rate was higher in hospitalized children less than 5 years than in outpatient cases. This finding is in line with other studies, which recognized RSV as significant viral etiology of severe acute respiratory infection in infants and young children (55-57). The increase of ILI activity before and after influenza virus circulation may be due to other respiratory viruses, including RSV, hMPV, or hPIV3. Some other study results showed that these three viruses have seasonal epidemic peaks in children (58) which were similar to our results. Also, a recent study reported that PIV, RSV, and hMPV cause outbreaks twice per year (one peak between October and December and another peak between March and May) in Mongolia (59). RSV had a considerably higher positive rate than influenza in sARI cases, as observed in other studies (60). This reflected the facts that most sARI cases in the present study were observed in small children. Unlike RSV, hMPV, and hPIV3, RV has shown year-round circulation with two peaks before and after the peaks of influenza positive rates during the 2011/12, 2012/13 and 2013/14 seasons. According the pathogens testing, other respiratory viruses occurred in all age groups. The observed high rates of other respiratory viruses among children aged less than 5 years, are important for clinical management since the viruses often correlates to severe illness as reported in other studies (29, 30, 43-47, 54).

During the study period, the average number of samples tested for influenza for both ILI and sARI episodes was 5,304 annually with most intense sampling in Ulaanbaatar (3,570 samples per season) and lowest sampling in Dornod *aimag* in Eastern of Mongolia (76 samples per season) and on average, 584 influenza virus positive specimens were identified annually. The existing surveillance is representative and robust in nature as the weekly reporting system, sampling method, year-round surveillance in the inpatients and outpatients, quarterly assessment of ISSSs using the indicators, conducting the monthly audio-conference with ISSSs, timeliness, completeness and consistency of surveillance data.

Influenza epidemics exhibit a distinct seasonality in temperate regions with extensive transmission typically occurring during the colder months; November–March in the northern hemisphere and May–September in the southern hemisphere (61, 62). This study has revealed that Mongolia has a clear seasonal pattern of influenza nationwide. Typically, the first influenza cases were detected in late October to early January and reached a peak in February. The positive rate for influenza viruses declined from late March to April, influenza virus circulation was lasting for average of 10 weeks per season in the seven studied seasons. ILI activities followed a similar seasonal pattern of influenza. Recently, some study results were reported changes in frequency and seasonality of influenza and other respiratory diseases (63, 64). In the study in Tennessee, the United States, when there was an increase in other respiratory viruses such as hMPV, RSV and RV detected, level of influenza virus activity was significantly lower. It is hypothesized that increases in other viruses can interfere with spread of influenza (64). However, opposite explanation may be possible that lower rates of influenza may allow other respiratory viruses to increase. Interaction between influenza and other respiratory viruses might be influenced by factors such as viral antigenicity and specific herd immunity. This year-round influenza surveillance enables to present a clear seasonality of influenza in Mongolia. Despite the comparatively high cost to sustain the existing surveillance system for ensuring year-round surveillance including sample transportation by air and train from different regions, regular laboratory supplies, and training of personnel, this type of surveillance system is useful in obtaining a complete picture of the influenza activity. It also contributes to early detection of outbreaks. As an outcome of this type of surveillance system, it was discovered that other respiratory viruses were predominant during early influenza seasons or after declining influenza activity.

Despite such a sparse population density in a large territory, influenza transmission occurs throughout Mongolia. This study analyzed geographic spread of influenza viruses in the country during influenza epidemics in the seven seasons. In the central, south-eastern and northern regions the proportion of influenza viruses was higher than the western and eastern regions, respectively. During the 2009/10 whole country including the seven *aimags* and Ulaanbaatar city experienced a rapid spread of influenza A (H1N1)pdm09. In 2009/10 as a second peak influenza B circulated in the country with high intensity in the central and south-eastern regions. In south-eastern region influenza viruses were detected in the all seven seasons with higher intensity than those in other regions with the exception of the central region, particularly, Ulaanbaatar city. This result might be due to population density, high social mixing and movement of population in this area using the main railway connected to the China and Russia.

In Mongolia people commonly use coal-stove to keep them warm during winter months. This type of stove emits a large amount of smoke in the surrounding environment. This might be one of environmental factors that may increase the occurrences of respiratory diseases in children as well as in adults (65, 66). On the other hand, to define the association between influenza activity and weather parameters such as absolute humidity, sunshine, and precipitation more data are needed to assess the impact of human behavior and influenza virus transmission in different climates (4, 67, 68). As suggested in some other studies, influenza epidemics can be influenced by factors such as seasonal crowding, and influenza virus survival in respiratory droplets (69). Further studies are therefore needed to figure out the association of influenza disease with the particular climatic factors of Mongolia.

There are several limitations in the current study. Firstly, even though the weekly ILI and sARI data from seven provinces together with Ulaanbaatar city were included, sample collection was conducted in selected sentinel sites and frequencies of sampling were varied both by places and the timing of influenza activity. However, I believe that the study results represent influenza circulation patterns in whole country. Secondly, the current surveillance system targeted selected healthcare facilities that might not reflect an entire picture of influenza activity in the community because some patients, especially adult patients with ILI or sARI may not seek care at healthcare facilities. Thirdly, tests for other than influenza viruses were conducted with selected samples negative to influenza virus. This potentially led a selection bias of samples tested as well as failed to detect co-infections. Lastly, a rather longer duration between sample collection and test led to a false negative result when samples were collected in a later course of the illnesses and transferred to the laboratory, however I believe this was surely minimal partly because samples were not collected if that duration was over 7 days and there was a chance to select more fresh samples among many cases. Despite of those limitations, a systematic surveillance study with eight sentinel sites over Mongolian territory was established to provide a comprehensive data of ILI and sARI with testing influenza and other respiratory viruses in this study.

7. Conclusion

My study results showed as follows:

First, the study shows the substantial disease burden due to influenza in ILI and sARI cases reported from sentinel sites throughout the study period. Like other previous studies, age was the key determinant, and the highest ILI and sARI incidence rates were observed in children less than five years in the all seven seasons.

Second, despite the differences in frequencies of sample collection, sample size, and non-strict standardized criteria on sampling from patients with ILI and sARI in different regions, the study result shows the impact of not only influenza viruses but also that of other respiratory viruses, which also contributed significant disease burden. Among ILI cases, RV was the most frequently detected virus, affecting mainly adult population, whereas among sARI cases higher RSV positive rates were observed in infants and small children. Co-circulation of other respiratory viruses with influenza viruses was seen only when influenza positive rates were lower or before or after the decreasing the influenza positives. The study also indicates the clear seasonality of influenza in Mongolia. Samples were collected from seven geographically distinct *aimags* and the highest populated capital city Ulaanbaatar, in which around 64.2% of total population of Mongolia live. Therefore my data generally represents the whole Mongolia.

Third, my study attempted to analyze the spatio-temporal distribution of influenza positives using the geographical method which also suggests the transmission of influenza virus occurs in all regions with different intensities during the annual epidemics. To date, there have already been several published studies focusing on the epidemiology of influenza in Mongolia (6, 29, 30), however, these studies were limited by the few study sites as well as by the small number of collected samples.

As aforementioned, understanding the disease burden and epidemiology of influenza is important and the detection of epidemics is crucial in order to make proper decisions by policy makers and public health specialists, which include vaccination strategies. In this regard, my study will contribute in formulating the national vaccination policies. The study results suggest interventions targeting young children may be important to reduce influenza associated burden. On the other hand, to reveal a precise disease burden of influenza in Mongolia there is a need to improve the data quality including collection of detail information related to clinical manifestation and outcome of patients in the sentinel sites.

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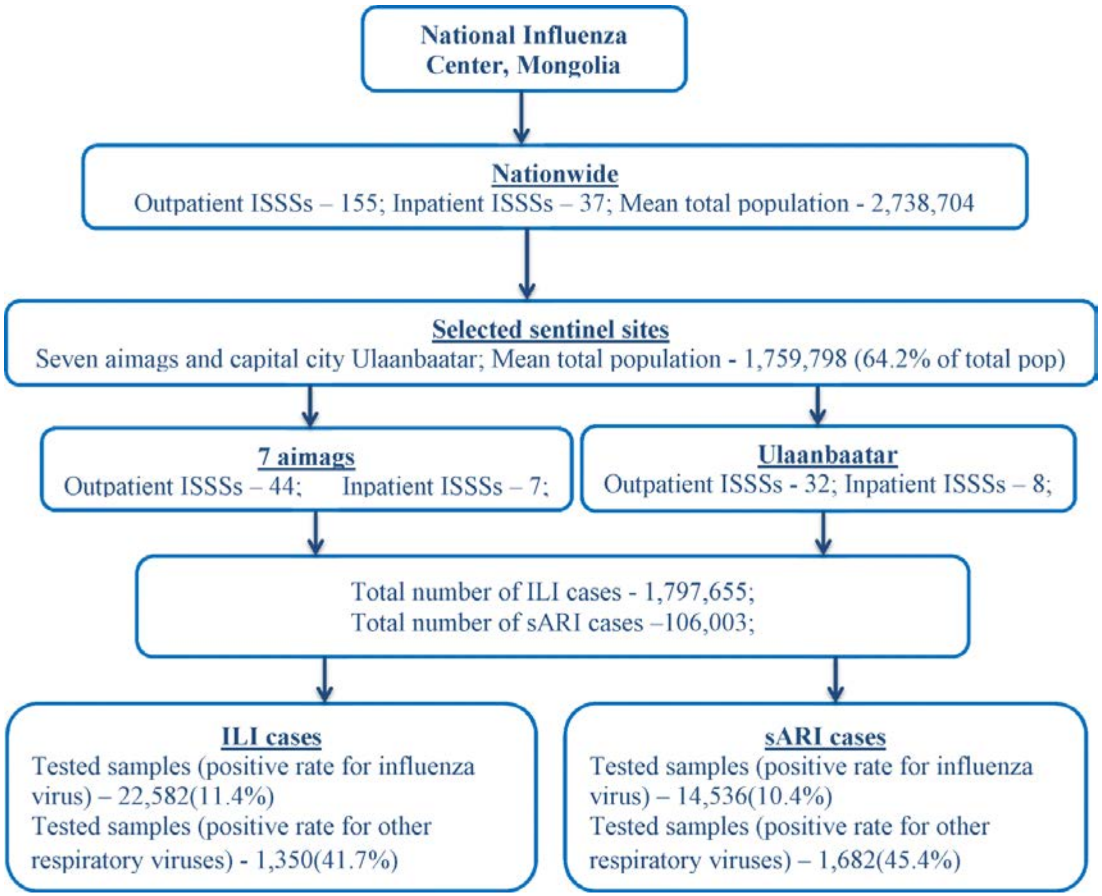
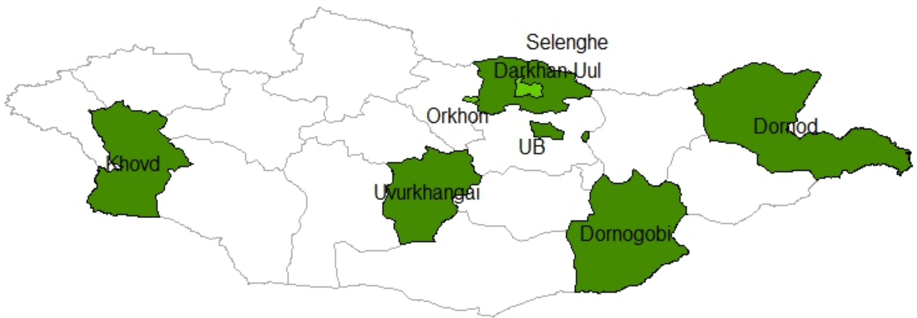
9. Figures

Figure 1. Flow chart of study steps including data collection procedure*



*ISSSs; Influenza Surveillance Sentinel Sites, ILI; Influenza-like Illness, sARI; severe Acute Respiratory Infection

Figure 2. Map of Mongolia and location of sentinel sites for influenza surveillance *



*UB; Ulaanbaatar

Figure 3. Temporal distribution of (A) ILI cases and influenza-positive rates for ILI cases and (B) detected influenza viruses from ILI cases during the 2007/8–2013/14 seasons in Mongolia

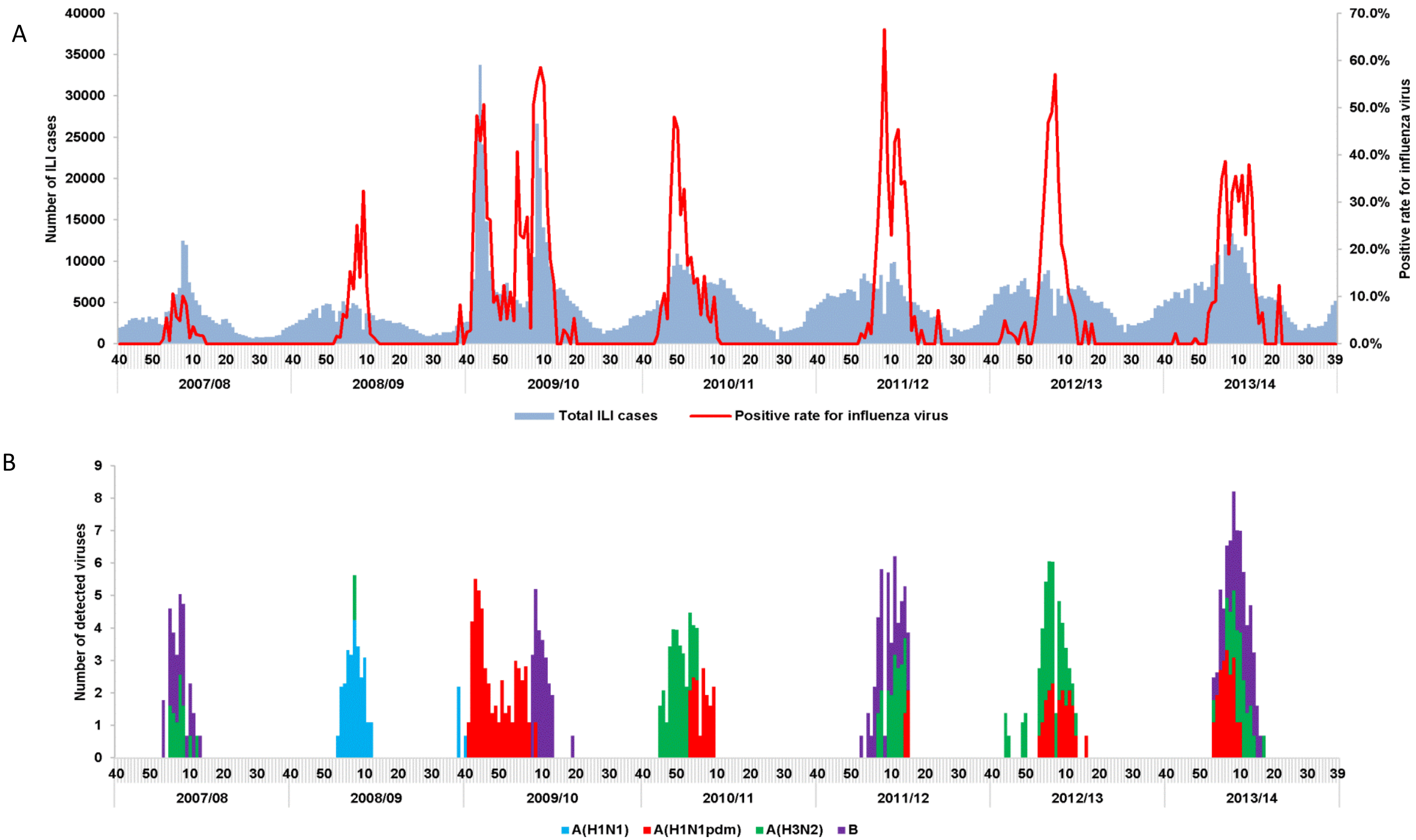


Figure 4. Temporal distribution of ILI cases and positive rates for (A) influenza, and (B) hMPV, hPIV3, RSV and RV during the 2010/11–2013/14 seasons in Mongolia

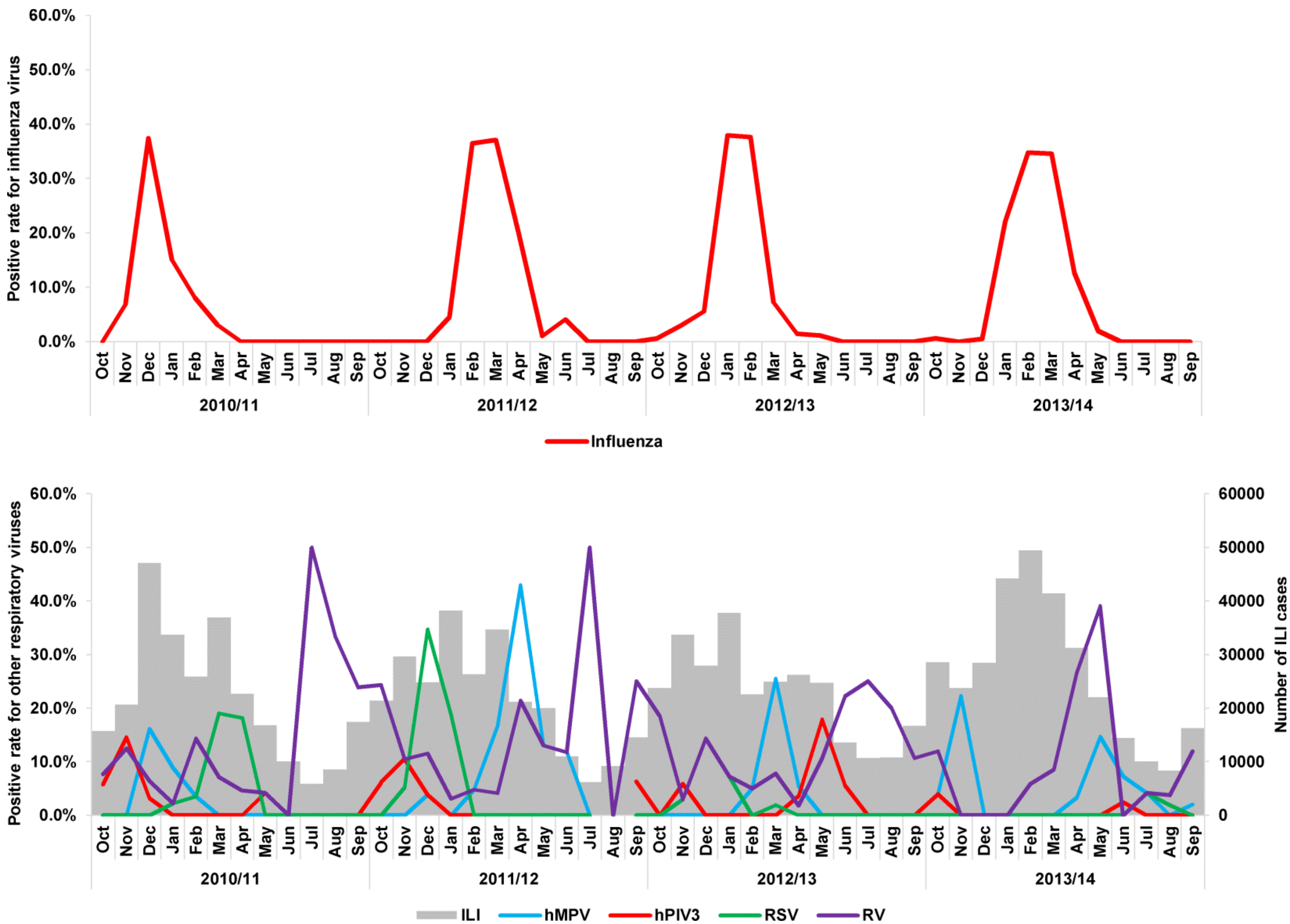


Figure 5. Temporal distribution of (A) sARI cases and influenza-positive rates for sARI cases and (B) detected influenza viruses from sARI cases during the 2007/8–2013/14 seasons in Mongolia

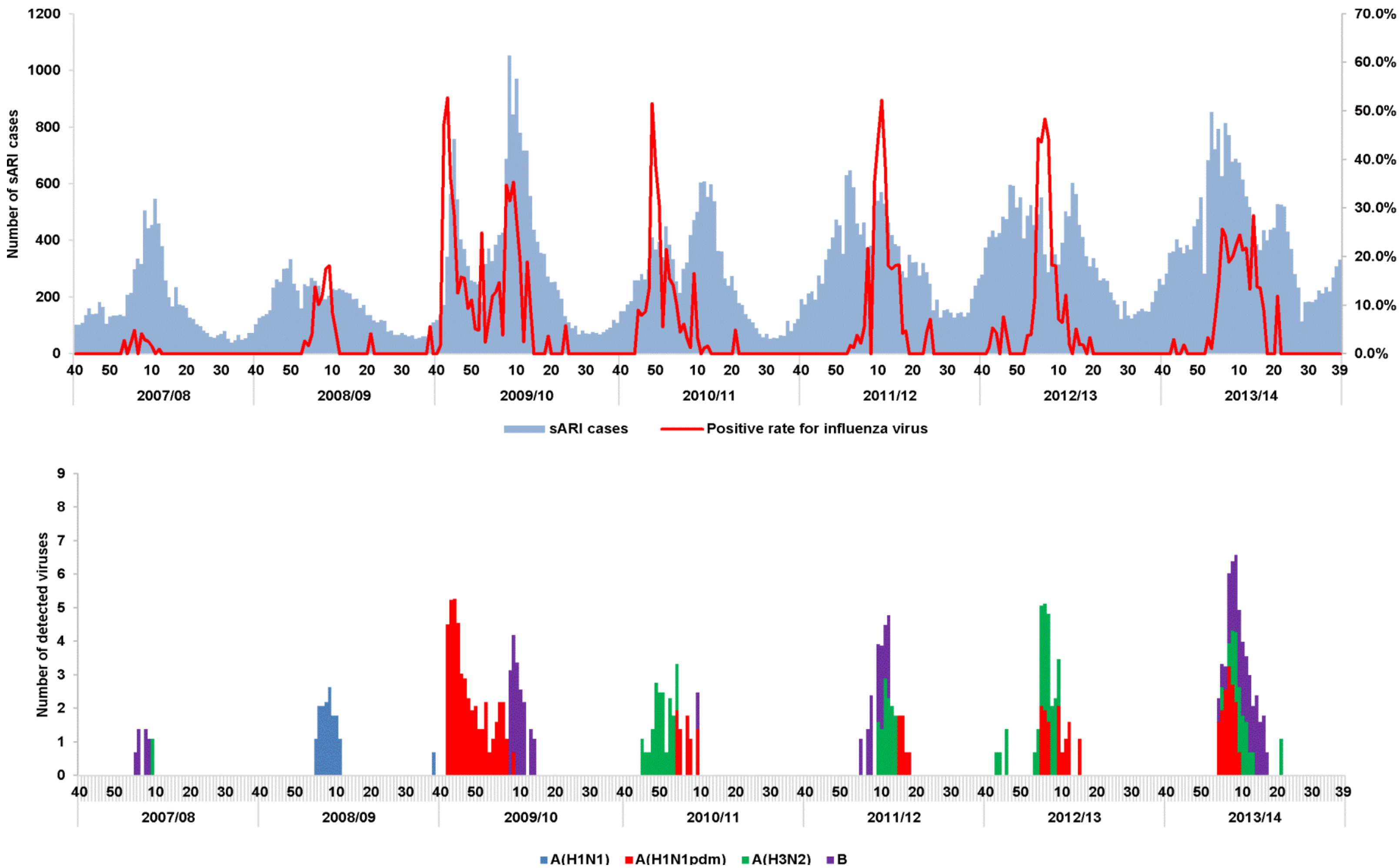


Figure 6. Temporal distribution of sARI cases and positive rates for (A) influenza, and (B) hMPV, hPIV3, RSV and RV during the 2010/11–2013/14 seasons in Mongolia

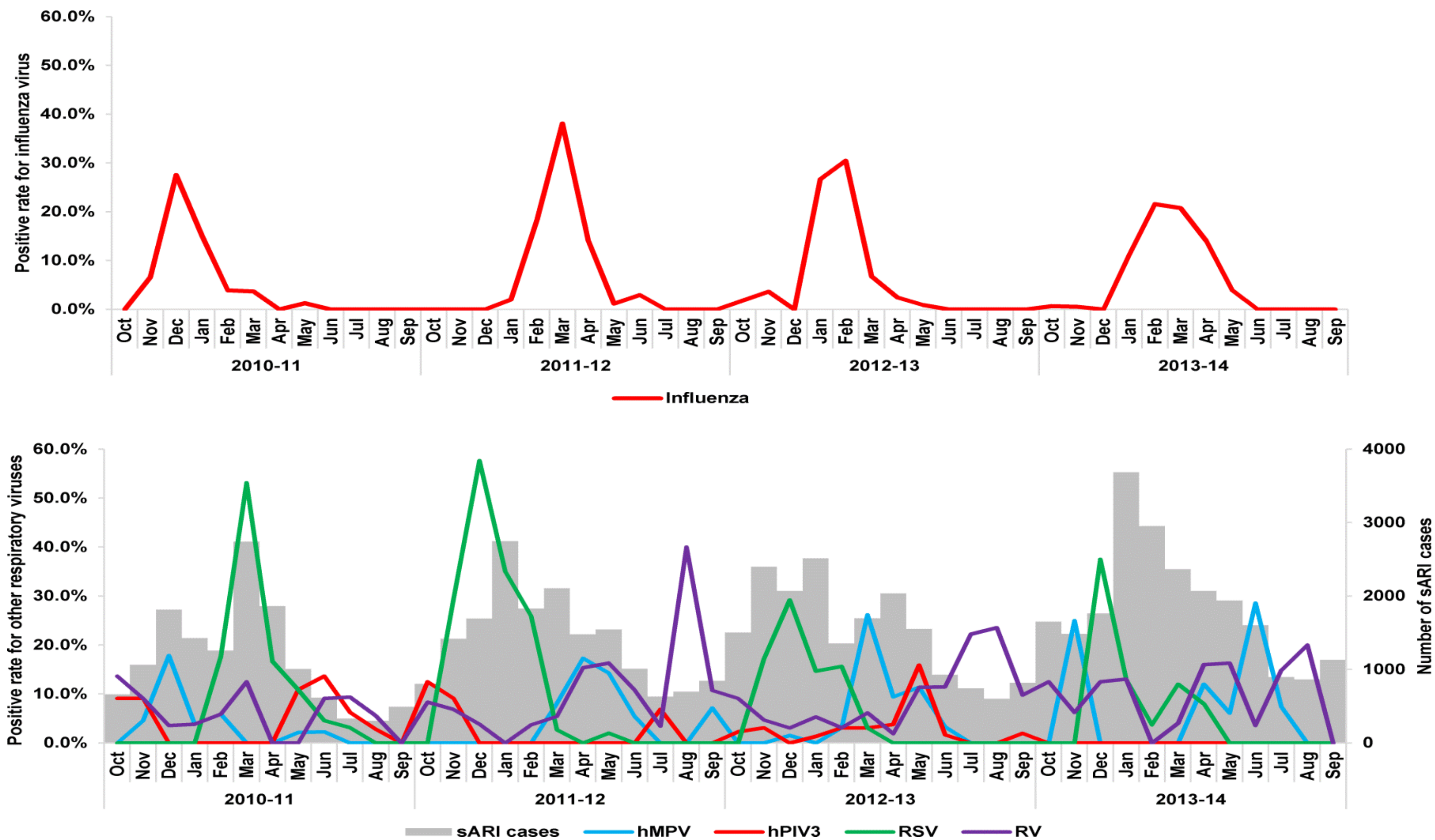
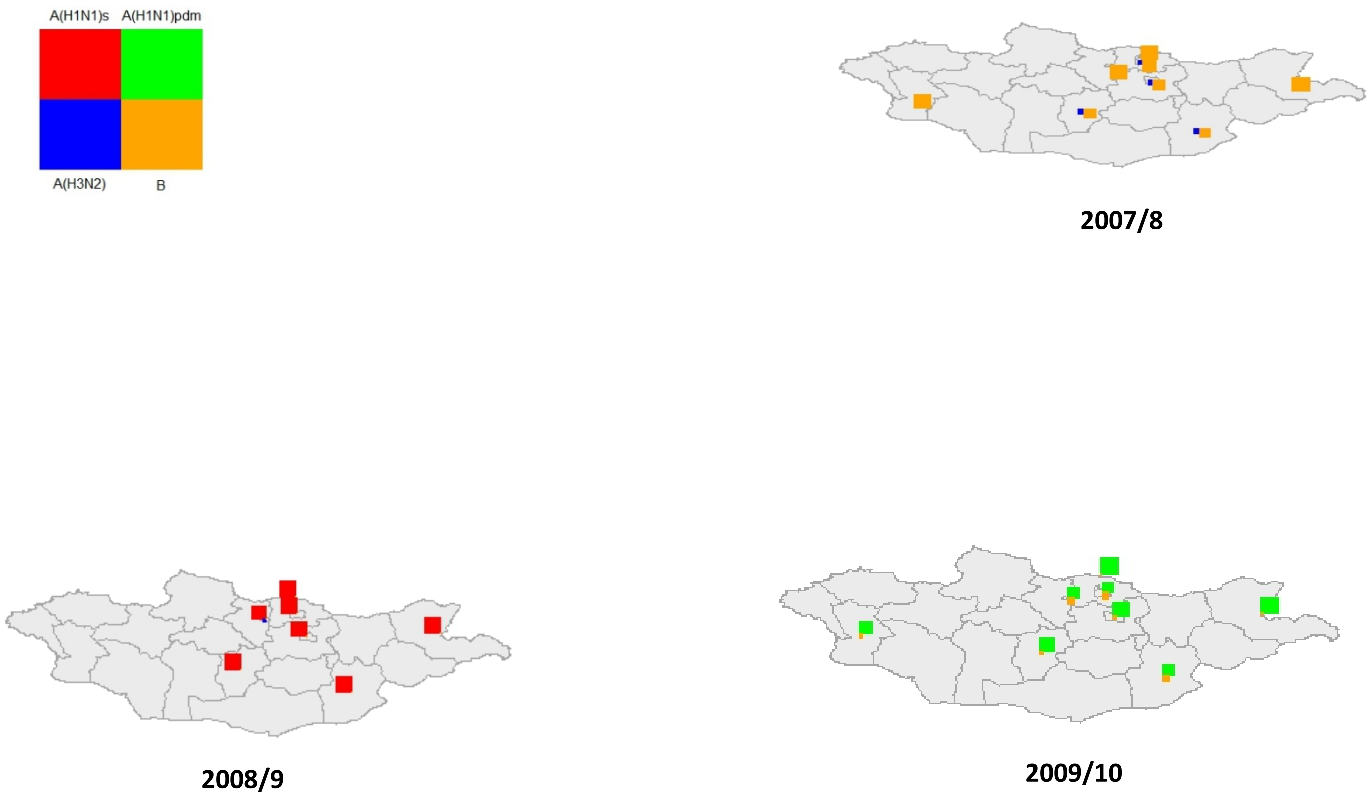
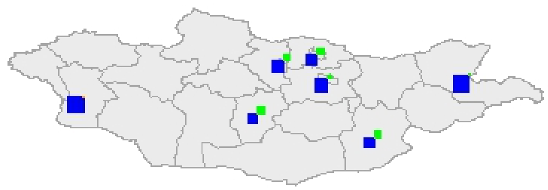
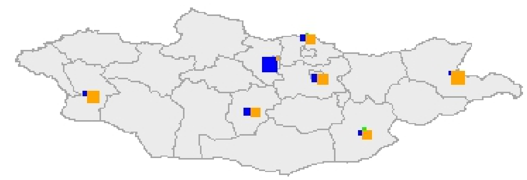


Figure 7. Proportion of each influenza type/subtype over total positives in 7 seasons in Mongolia

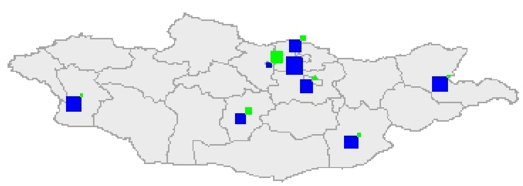




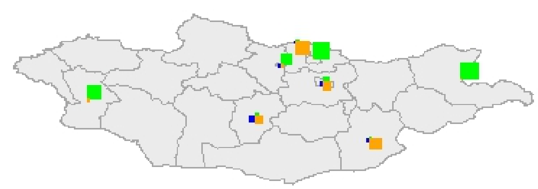
2010/11



2011/12



2012/13



2013/14

10. Tables

Table 1. Number of influenza like illness (ILI) cases and incidence rates by influenza season and age group during the 2007/8–2013/14 seasons in Mongolia

Season	<5y		5-9y		10-15y		16-24y		25-44y		45-64y		≥65y		Total	
	No. of ILI	per 100	No. of ILI	per 100	No. of ILI	per 100	No. of ILI	per 100	No. of ILI	per 100	No. of ILI	per 100	No. of ILI	per 100	No. of ILI	per 100
2007/8	90,627	63.9	26,681	18.6	18,152	9.3	9,979	3.2	7,331	1.4	4,451	1.8	2,226	3.4	159,447	9.8
2008/9	91,785	60.1	23,434	16.5	14,298	7.7	8,139	2.5	6,112	1.1	3,043	1.2	1,473	2.1	148,284	8.9
2009/10	182,546	112.9	59,808	43.1	46,263	25.6	37,608	11.2	31,584	5.6	15,582	5.9	6,790	10.7	380,181	22.2
2010/11	156,706	90.3	40,041	28.9	24,935	13.9	15,462	4.5	13,422	2.3	7,236	2.6	3,550	5.2	261,352	14.7
2011/12	154,585	82.5	40,829	29.0	24,649	14.0	14,202	4.3	12,383	2.0	7,057	2.4	3,354	4.7	257,059	14.1
2012/13	174,906	88.3	40,245	27.4	21,608	12.4	12,849	4.1	13,430	2.2	7,079	2.3	3,034	4.2	273,151	14.9
2013/14	202,431	96.5	48,268	30.3	25,200	14.6	13,843	4.5	16,448	2.6	8,564	2.7	3,427	4.7	318,181	16.9
Total	**1,053,586**	**86.0**	**279,306**	**27.7**	**175,105**	**13.9**	**112,082**	**4.9**	**100,710**	**2.5**	**53,012**	**2.7**	**23,854**	**4.9**	**1,797,655**	**14.6**

Table 2. Number of influenza positives, positive rates and proportion of influenza virus positive samples among total influenza positives by season for influenza like illness (ILI) cases in Mongolia during the 2007/8–2013/14 seasons

Season	Tested ILI samples	A(H1N1)			A(H1N1pdm)			A(H3N2)			B			Total influenza positives	
		Number of positives	Positive rate	% of positives among total influenza positives	Number of positives	Positive rate	% of positives among total influenza positives	Number of positives	Positive rate	% of positives among total influenza positives	Number of positives	Positive rate	% of positives among total influenza positives	Number of positives	Positive rate
2007/8	5,050	1	0.0%	0.8%	0	0.0%	0.0%	35	0.7%	26.3%	97	1.9%	72.9%	133	2.6%
2008/9	5,027	225	4.5%	98.3%	0	0.0%	0.0%	4	0.1%	1.7%	0	0.0%	0.0%	229	4.6%
2009/10	3,329	2	0.1%	0.2%	726	21.8%	76.8%	0	0.0%	0.0%	217	6.5%	23.0%	945	28.4%
2010/11	2,484	0	0.0%	0.0%	72	2.9%	23.0%	240	9.7%	76.7%	1	0.0%	0.3%	313	12.6%
2011/12	2,128	0	0.0%	0.0%	15	0.7%	5.3%	98	4.6%	34.9%	168	7.9%	59.8%	281	13.2%
2012/13	2,199	0	0.0%	0.0%	66	3.0%	22.8%	222	10.1%	76.8%	1	0.0%	0.3%	289	13.1%
2013/14	2,365	0	0.0%	0.0%	116	4.9%	30.0%	83	3.5%	21.4%	188	7.9%	48.6%	387	16.4%
Total	**22,582**	**228**	**1.0%**	**8.8%**	**995**	**4.4%**	**38.6%**	**682**	**3.0%**	**26.5%**	**672**	**3.0%**	**26.1%**	**2,577**	**11.4%**

Table 3. Number of influenza positives and positive rates for influenza by age group for influenza like illness (ILI) cases in Mongolia during the 2007/8–2013/14 seasons

Age group	Tested ILI samples	A(H1N1)		A(H1N1pdm)		A(H3N2)		B		Total influenza positives	
		Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate
<5y	9,164	95	1.0%	259	2.8%	331	3.6%	246	2.7%	931	10.2%
5-9y	3,559	46	1.3%	180	5.1%	112	3.1%	174	4.9%	512	14.4%
10-15y	2,945	37	1.3%	170	5.8%	72	2.4%	106	3.6%	385	13.1%
16-24y	2,083	17	0.8%	174	8.4%	45	2.2%	39	1.9%	275	13.2%
25-44y	2,896	25	0.9%	157	5.4%	72	2.5%	71	2.5%	325	11.2%
45-64y	1,537	6	0.4%	44	2.9%	35	2.3%	30	2.0%	115	7.5%
≥65y	326	2	0.6%	7	2.1%	11	3.4%	5	1.5%	25	7.7%
Total	**22,582**	**228**	**1.0%**	**995**	**4.4%**	**682**	**3.0%**	**672**	**3.0%**	**2,577**	**11.4%**

Table 4. Number of hMPV, hPIV3, RSV and RV positives and positive rates for influenza like illness (ILI) cases by age group during the 2010/11–2013/14 seasons in Mongolia

Age group	Tested ILI samples	hMPV		hPIV3		RSV		RV	
		Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate
0-11m	116	2	1.7%	4	3.4%	6	5.2%	10	8.6%
1-4y	659	43	6.5%	18	2.7%	27	4.1%	61	9.3%
5-9y	169	11	6.5%	4	2.4%	5	3.0%	12	7.1%
10-15y	114	5	4.4%	1	0.9%	6	5.3%	15	13.2%
16-24y	80	1	1.3%	1	1.3%	1	1.3%	20	25.0%
25-44y	123	2	1.6%	1	0.8%	0	0.0%	19	15.4%
45-64y	69	0	0.0%	2	2.9%	0	0.0%	2	2.9%
≥65y	20	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Total	**1,350**	**64**	**4.7%**	**31**	**2.3%**	**45**	**3.3%**	**139**	**10.3%**

Table 5. Number of hMPV, hPIV3, RSV and RV positives and positive rates for influenza like illness (ILI) cases by season during the 2010/11–2013/14 seasons in Mongolia

Season	Tested ILI samples	hMPV		hPIV3		RSV		RV	
		Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate
2010/11	379	15	4.0%	13	3.4%	18	4.7%	34	9.0%
2011/12	227	17	7.5%	6	2.6%	16	7.0%	29	12.8%
2012/13	352	17	4.8%	10	2.8%	9	2.6%	34	9.7%
2013/14	392	15	3.8%	2	0.5%	2	0.5%	42	10.7%
Total	**1,350**	**64**	**4.7%**	**31**	**2.3%**	**45**	**3.3%**	**139**	**10.3%**

Table 6. Number of severe acute respiratory infection (sARI) cases and incidence rates by influenza season and age group during the 2007/8–2013/14 seasons in Mongolia

Season	<5y		5-9y		10-19y		20-49y		50-59y		≥60y		Total	
	No. of sARI	per 100	No. of sARI	per 100	No. of sARI	per 100	No. of sARI	per 100	No. of sARI	per 100	No. of sARI	per 100	No. of sARI	per 100
2007/8	6,775	4.8	448	0.3	625	0.2	602	0.1	223	0.2	288	0.3	8,961	0.6
2008/9	6,522	4.3	527	0.4	631	0.2	550	0.1	169	0.1	237	0.2	8,636	0.5
2009/10	12,206	7.6	935	0.7	1,174	0.4	2,196	0.3	410	0.3	505	0.5	17,426	1.0
2010/11	11,051	6.4	527	0.4	584	0.2	792	0.1	261	0.2	356	0.3	13,571	0.8
2011/12	13,831	7.4	778	0.6	877	0.3	726	0.1	249	0.2	337	0.3	16,798	0.9
2012/13	15,326	7.7	842	0.6	851	0.3	716	0.1	197	0.1	279	0.3	18,211	1.0
2013/14	18,907	9.0	1,073	0.7	909	0.3	814	0.1	305	0.2	392	0.3	22,400	1.2
Total	**84,618**	**6.9**	**5,130**	**0.5**	**5,651**	**0.3**	**6,396**	**0.1**	**1,814**	**0.2**	**2,394**	**0.3**	**106,003**	**0.9**

Table 7. Number of influenza positives, positive rates and proportion of influenza virus positive samples among total influenza positives by season for severe acute respiratory infection (sARI) cases in Mongolia during the 2007/8–2013/14 seasons

Season	Tested sARI samples	A(H1N1)			A(H1N1pdm)			A(H3N2)			B			Total influenza positives	
		Number of positives	Positive rate	% of positives among total influenza positives	Number of positives	Positive rate	% of positives among total influenza positives	Number of positives	Positive rate	% of positives among total influenza positives	Number of positives	Positive rate	% of positives among total influenza positives	Number of positives	Positive rate
2007/8	2,073	0	0.0%	0.0%	0	0.0%	0.0%	5	0.2%	23.8%	16	0.8%	76.2%	21	1.0%
2008/9	1,941	61	3.1%	96.8%	0	0.0%	0.0%	1	0.1%	1.6%	1	0.1%	1.6%	63	3.2%
2009/10	3,499	0	0.0%	0.0%	685	19.6%	85.4%	0	0.0%	0.0%	117	3.3%	14.6%	802	22.9%
2010/11	1,569	0	0.0%	0.0%	31	2.0%	28.2%	74	4.7%	67.3%	5	0.3%	4.5%	110	7.0%
2011/12	1,606	0	0.0%	0.0%	18	1.1%	13.4%	55	3.4%	41.0%	61	3.8%	45.5%	134	8.3%
2012/13	1,641	0	0.0%	0.0%	47	2.9%	29.9%	110	6.7%	70.1%	0	0.0%	0.0%	157	9.6%
2013/14	2,207	0	0.0%	0.0%	81	3.7%	36.2%	46	2.1%	20.5%	97	4.4%	43.3%	224	10.1%
Total	**14,536**	**61**	**0.4%**	**4.0%**	**862**	**5.9%**	**57.0%**	**291**	**2.0%**	**19.3%**	**297**	**2.0%**	**19.7%**	**1,511**	**10.4%**

Table 8. Number of influenza positives and positive rates for influenza by age group for severe acute respiratory infection (sARI) cases in Mongolia during the 2007/8–2013/14 seasons

Age group	Tested sARI samples	A(H1N1)		A(H1N1pdm)		A(H3N2)		B		Total influenza positives	
		Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate
<5y	9,721	43	0.4%	270	2.8%	213	2.2%	162	1.7%	688	7.1%
5-9y	816	6	0.7%	83	10.2%	17	2.1%	44	5.4%	150	18.4%
10-15y	538	3	0.6%	70	13.0%	11	2.0%	16	3.0%	100	18.6%
16-24y	950	4	0.4%	177	18.6%	13	1.4%	25	2.6%	219	23.1%
25-44y	1,584	2	0.1%	192	12.1%	21	1.3%	35	2.2%	250	15.8%
45-64y	663	3	0.5%	55	8.3%	10	1.5%	11	1.7%	79	11.9%
≥65y	191	0	0.0%	9	4.7%	5	2.6%	4	2.1%	18	9.4%
Total	**14,536**	**61**	**0.4%**	**862**	**5.9%**	**291**	**2.0%**	**297**	**2.0%**	**1,511**	**10.4%**

Table 9. Number of hMPV, hPIV3, RSV and RV positives and positive rates for severe acute respiratory infection (sARI) cases by age group during the 2010/11─2013/14 seasons in Mongolia

Age group	Tested sARI samples	hMPV		hPIV3		RSV		RV	
		Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate
0-11m	372	12	3.2%	9	2.4%	49	13.2%	35	9.4%
1-4y	999	65	6.5%	33	3.3%	85	8.5%	80	8.0%
5-9y	85	3	3.5%	0	0.0%	5	5.9%	9	10.6%
10-15y	61	0	0.0%	0	0.0%	2	3.3%	5	8.2%
16-24y	30	1	3.3%	1	3.3%	1	3.3%	2	6.7%
25-44y	61	2	3.3%	0	0.0%	0	0.0%	7	11.5%
45-64y	43	2	4.7%	2	4.7%	1	2.3%	5	11.6%
≥65y	31	0	0.0%	0	0.0%	0	0.0%	2	6.5%
Total	**1,682**	**85**	**5.1%**	**45**	**2.7%**	**143**	**8.5%**	**145**	**8.6%**

Table 10. Number of hMPV, hPIV3, RSV and RV positives and positive rates for severe acute respiratory infection (sARI) cases by season during the 2010/11–2013/14 seasons in Mongolia

Season	Tested sARI samples	hMPV		hPIV3		RSV		RV	
		Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate	Number of positives	Positive rate
2010/11	346	10	2.9%	18	5.2%	32	9.2%	21	6.1%
2011/12	408	23	5.6%	9	2.2%	51	12.5%	39	9.6%
2012/13	633	32	5.1%	18	2.8%	48	7.6%	54	8.5%
2013/14	295	20	6.8%	0	0.0%	12	4.1%	31	10.5%
Total	**1,682**	**85**	**5.1%**	**45**	**2.7%**	**143**	**8.5%**	**145**	**8.6%**