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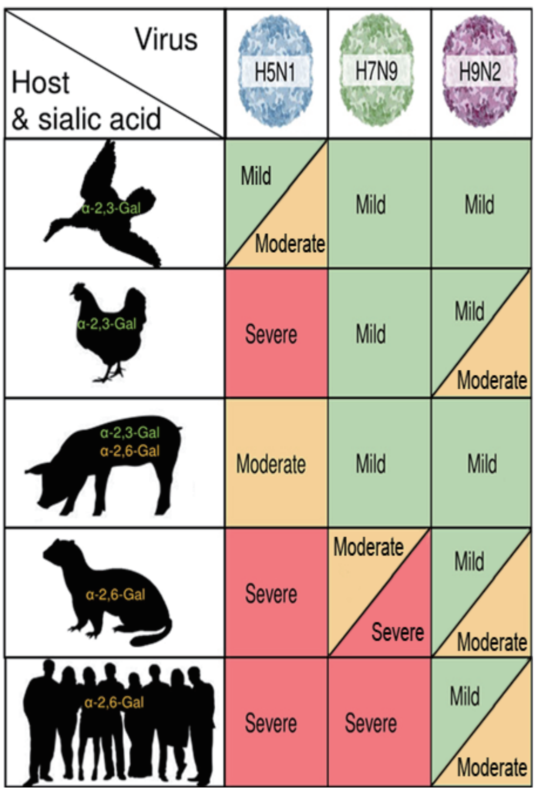

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Cover Image: Zoonotic influenza pathology is linked to host biology. H5N1, H7N9, and H9N2 avian influenza (AI) viruses causing varying degrees of clinical manifestations across different species is shown against different host and their sialic acid properties. (https://www.frontiersin.org/articles/10.3389/fimmu.2018.01812/full)

Vital Surveillances

National Monitoring for Radioactivity in Foods — China, 2012–2019

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ABSTRACT

Introduction: For investigating the potential contaminations from the applications of nuclear energy and techniques, the radioactivity of both natural and artificial radionuclides in foods in China were surveyed during the period of 2012–2019, and the public's exposure to radiation due to the consumption of these foods were estimated.

Methods: The surveillance was conducted using the National Monitoring Network for Radioactivity in Food from 2012 to 2019. Food samples were collected, and radioactivity was determined using HPGe gamma-ray spectrometer by local institutes.

Results: From 2012 to 2019, a total of 6,129 food samples including those collected around nuclear power plants and uranium mines were collected and analyzed, and no samples with activity concentrations of ^{238}U, ^{228}Ra, ^{226}Ra, ^{40}K, or ^{137}Cs were found to exceed Chinese national standards. Among the 7 types of surveyed foods, the natural radionuclide levels of tea and seaweed were relatively high, and the activity concentration of ^{137}Cs in milk and dairy products was higher than that of other foods.

Conclusions and Implications for Public Health Practice: The results of all the surveyed samples were within the scope of Chinese national standards. Different regions should improve monitoring systems, establish corresponding food emergency warning systems, and prepare strategies and measures for handling public health accidents.

INTRODUCTION

With the rapid development and applications of nuclear energy and techniques, the potential radioactive contamination of foods has attracted great public concern. In 2012, the National Monitoring Network for Radioactivity in Food was established by the National Health Commission of the People's Republic of China, and the National Institute for Radiological Protection (NIRP) of China CDC was assigned to operate, maintain, and improve the network. From 2012 to 2019, with the help of provincial institutes, a total of 6,129 food samples that were categorized into 7 types of common foods in China were collected, and both the natural and anthropogenic originating radionuclides in the samples were analyzed.

METHODS

According to the notifications, relevant technical documents, and operating manuals issued by the National Health Commission of the People's Republic of China, the relevant provincial monitoring institutes carried out food sample collection, preparation, processing, and radionuclide measurement every year. The technical principles for the collection and preservation of food samples were also carried out in accordance with the relevant standards (*1*).

Seven categories of foods including milk and dairy products, vegetables, tea, cereals and grains, livestock and poultry meat, fish and seafood, and seaweed were sampled. Foods were selected based on the main diet reported in relevant specification for health survey of residents (*2*). Other considerations such as potential risk for concentrating radionuclides and potential sentinels for specific types of agriculture or aquaculture (e.g. tea) were also considered. All foods were produced or sold locally.

Vegetables were collected in the open vegetable gardens in suburban areas. Fish and seafood as well as seaweed were collected or supplied by assistants of local fisheries. Samples were collected within a radius of 30 kilometers around nuclear power plants and uranium mines. Based on the radionuclide being studied and the laboratory conditions, the processing methods of the food samples could be prepared as fresh, ash, or dry samples before measuring. The dry-fresh ratio or ash-fresh ratio was recorded, and the results was expressed in fresh weight. The radionuclide activity concentration in the sample should be converted to the date of sampling in order to easily compare the results obtained by different processing methods.

All measurements were performed using low background gamma spectroscopy with standard coaxial HPGe detectors housed in Pb shielding with Cu, Cd, and/or plastic linings. Methods for analyzing radionuclides and the risk assessment of radioactive contamination in foods were based primarily on national standards (*3–5*). Measurements were performed in multiple laboratories with the typical relative efficiency of detection system ranging from 30% to 66% [relative to a 3"×3" NaI(Tl) crystal], and the typical energy resolution ranging from 1.60 keV to 2.28 keV at 1,332 keV (^{60}Co).

The nuclear data in Monograph 5 of the Bureau International des Poids et Mesures (*6*) were recommended to be used in the analysis. To determine the background gamma ray spectrum due to naturally occurring radionuclides in the environment around the detector, a similar empty container was usually counted in the same geometry as the samples. Peak detection efficiencies were calculated automatically by computer systems interfaced with multichannel analyzers. The absolute efficiency calibration of the detectors was determined using standard samples from the National Institute of Metrology (NIM) in Beijing, China. All internal and certified reference materials were prepared in the same containers as samples. Density correction was also performed by calculation software for samples where the density and matrix material were different from the standard. The expanded uncertainty μ_{total} (K=2) of the activity concentration was estimated by using the equation from the standard (*5*).

To ensure the accurate and reliable measurements, workloads for quality assurance were strictly implemented. All the instruments involved in the measurements were verified by the NIM, and all laboratories participated in the annual inter-comparison exercises organized by NIRP. NIRP was responsible for drafting the annual monitoring manual, training, and on-site guidance.

RESULTS

From 2012 to 2019, a total of 6,129 food samples were collected and measured. Table 1 lists the mean values of radionuclides in different types of foods during the period of 2012–2019. Among all types of foods, tea had the highest mean concentrations of ^{238}U and ^{228}Ra at 2.88 Bq/kg and 1.75 Bq/kg, respectively, milk and dairy products were found with the highest mean concentrations of ^{226}Ra and ^{137}Cs at 1.13 Bq/kg and 0.79 Bq/kg, respectively, and seaweed had the highest concentration of ^{40}K at 371 Bq/kg.

Table 2 shows the mean activity concentrations of different radionuclides in samples around the nuclear power plants during 2012–2019. Among the samples, the mean activity concentrations of ^{238}U and ^{40}K in seaweed were the highest, the mean activity concentrations of ^{228}Ra and ^{226}Ra in tea were the highest, and high activity concentration of ^{137}Cs was found both in milk and tea.

Table 3 shows the mean activity concentrations in samples around the uranium mines during 2012–2019. The mean activity concentrations of ^{238}U, ^{40}K, and ^{226}Ra in tea were the highest, the mean activity concentration of ^{228}Ra in seaweed was the highest, and the mean activity concentration of ^{137}Cs in milk and dairy products was the highest.

In 2 independent sample *t*-tests that were performed on data in Tables 2–3, differences in the radionuclide contents of fish and seafood were found between the two regions that were not statistically significant (α =0.05), and the content of ^{226}Ra in milk and dairy products, ^{40}K in vegetables, and ^{226}Ra and ^{228}Ra in

TABLE 1. Mean concentration (Bq/kg, wet weight) of radionuclides in different foods of China, 2012−2019.

Food	No. of samples	^{238}U mean (95%CI)	^{228}Ra mean (95%CI)	^{226}Ra mean (95%CI)	^{40}K mean (95%CI)	^{137}Cs mean (95%CI)
Milk and dairy products	646	2.15 (1.95−2.35)	0.57 (0.51−0.63)	1.13 (1.00−1.26)	228.00 (218.90−237.10)	0.79 (0.64−0.94)
Vegetables	2,203	0.55 (0.51−0.59)	0.29 (0.27−0.31)	0.39 (0.29−0.49)	102.00 (98.30−105.70)	0.08 (0.07−0.09)
Tea	430	2.88 (2.49−3.27)	1.75 (1.52−1.98)	1.09 (0.98−1.20)	305.00 (282.60−327.40)	0.33 (0.29−0.37)
Cereal	1,264	1.76 (1.63−1.89)	0.50 (0.46−0.54)	0.62 (0.57−0.67)	105.00 (98.00−112.00)	0.20 (0.17−0.23)
Livestock and poultry meat	653	0.94 (0.77−1.11)	0.43 (0.36−0.50)	0.46 (0.40−0.52)	96.90 (82.63−111.17)	0.23 (0.18−0.28)
Fish and seafood	802	0.95 (0.84−1.06)	0.94 (0.82−1.06)	0.55 (0.47−0.63)	67.50 (63.97−71.03)	0.04 (0.037−0.042)
Seaweed	131	2.47 (1.56−3.38)	1.11 (0.90−1.32)	0.56 (0.44−0.68)	371.00 (265.68−476.32)	0.03 (0.027−0.033)

TABLE 2. Mean concentration (Bq/kg, wet weight) of radionuclides around nuclear power plants in China, 2012−2019.

Food	No. of samples	^{238}U mean (95%CI)	^{228}Ra mean (95%CI)	^{226}Ra mean (95%CI)	^{40}K mean (95%CI)	^{137}Cs mean (95%CI)
Milk and dairy products	202	1.09 (0.91−1.27)	0.30 (0.27−0.33)	1.20 (0.78−1.62)	185.00 (169.00−201.00)	0.32 (0.27−0.37)
Vegetables	1,023	0.34(0.31−0.37)	0.31 (0.28−0.34)	0.23 (0.20−0.26)	99.80 (96.24−103.36)	0.05 (0.04−0.06)
Tea	90	2.07(1.50−2.64)	2.67 (1.98−3.36)	1.51 (1.19−1.83)	335.00 (282.11−387.89)	0.32 (0.25−0.39)
Cereal	336	0.95(0.85−1.05)	0.60 (0.50−0.70)	0.40 (0.36−0.44)	92.90 (81.78−104.02)	0.09 (0.08−0.10)
Livestock and poultry meat	369	0.63 (0.42−0.84)	0.31 (0.24−0.38)	0.34 (0.25−0.43)	68.30 (64.75−71.85)	0.06 (0.04−0.08)
Fish and seafood	768	0.96 (0.85−1.07)	0.95 (0.82−1.08)	0.55 (0.47−0.63)	67.50(63.85−71.15)	0.04 (0.038−0.042)
Seaweed	109	2.49 (1.47−3.51)	1.07 (0.84−1.30)	0.57 (0.43−0.71)	382.00 (257.90−506.09)	0.03 (0.026−0.034)

TABLE 3. Mean concentration (Bq/kg, wet weight) of radionuclides around the uranium mines in China, 2012−2019.

Food	No. of samples	^{238}U mean (95%CI)	^{228}Ra mean (95%CI)	^{226}Ra mean (95%CI)	^{40}K mean (95%CI)	^{137}Cs mean (95%CI)
Milk and dairy products	250	2.99 (2.60−3.38)	0.55 (0.49−0.61)	1.22 (1.00−1.44)	268.00 (253.74−282.26)	1.18 (0.87−1.49)
Vegetables	590	0.99 (0.86−1.12)	0.25 (0.22−0.28)	0.76 (0.39−1.13)	94.60 (85.08−104.12)	0.17 (0.13−0.21)
Tea	156	4.18 (3.37−4.99)	2.22 (1.80−2.64)	1.30 (1.10−1.50)	405.00 (369.38−440.62)	0.46 (0.38−0.54)
Cereal	447	1.88 (1.62−2.14)	0.45 (0.39−0.51)	0.70 (0.60−0.80)	143.00 (126.68−159.32)	0.40 (0.33−0.47)
Livestock and poultry meat	280	1.39 (1.09−1.67)	0.65 (0.50−0.80)	0.60 (0.53−0.67)	137.00 (104.09−169.91)	0.47 (0.36−0.58)
Fish and seafood	27	0.58 (0.38−0.78)	0.65 (0.30−1.00)	0.58 (0.36−0.80)	71.40 (59.00−83.81)	0.05 (0.04−0.06)
Seaweed	2	1.91	2.38 (1.26−3.50)	0.78 (0.41−1.15)	15.0	–

Note: "–" means not detected.

tea between the two regions were also not statistically significant (α =0.05). However, the differences of radionuclides in the remaining foods between the 2 regions were statistically significant (α =0.05).

DISCUSSION

Assessing radionuclide contamination in food is an important consideration for food safety as understanding the levels of radionuclide content in food and their ranges are helpful for quantifying the risk of public exposure. This study presented the latest and most comprehensive national survey results in food from 2012 to 2019, which can be used as baseline data for food safety risk assessments. The radioactive survey also covered food around nuclear power plants and uranium mines, which is conducive to improving the ability and level of nuclear accident emergency monitoring.

Based on survey results and combining the food consumption data (*7*) and the dose coefficients given by ICPR (*8*), the annual committed effective dose of ^{238}U, ^{228}Ra, ^{226}Ra, ^{40}K, and ^{137}Cs from ingestion were estimated to be 20.03, 110.24, 54.70, 242.72, and 0.84 μSv, respectively. The results were all below the limit values of the national standard. National monitoring results showed relatively higher levels of natural radionuclides in tea and seaweed than in other types of foods. This suggested that more attention should be paid to analyze the radioactivity levels in these foods, and the radiation doses due to the public consumption of these foods.

Cesium is an artificial radionuclide that researchers are usually concerned about. Similar to international studies, milk remains a suitable sentinel for artificial radioactivity Cesium in Chinese terrestrial agriculture (*9–10*). The results of milk and dairy products can serve as an indicator of artificial radionuclides like ^{137}Cs, which is of great significance in emergency food monitoring. The contents of ^{137}Cs in milk and tea in this survey were far lower than the national limit concentration standard (*11*) and complied with the detected activity concentrations in foods with the Codex Alimentarius guideline levels (*12*). This indicated they did not represent a radiological risk.

Data from nuclear power plants and uranium mines showed that the measured radionuclide concentrations were below national standards and did not pose a threat to public health. The differences in the radionuclides content of fish and seafood between the two places were not statistically significant, possibly due to the fluidity of the water and the wide range of activities of fish and seafood. The numbers of some food samples were small in these areas, and an appropriate increase in sample size will be considered in future surveillance.

Radionuclides in foods are an invaluable source of data for undertaking risk assessments for public health. The result of such surveys should be promptly released to the public, so that the public can understand the status of food safety. The National Monitoring Network for Radioactivity in Food can continue to provide a scientific basis for the health administrative department or disease control and prevention's decision making and improve early warning and control capabilities.

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Outbreak Reports

Poisonings Caused by Wild Mushroom Containing Amanitin Toxins — Shaoxing City, Zhejiang Province, China, 2019

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Summary

What is already known about this topic?

Among all food poisoning, poisonings caused by wild mushrooms containing amanitin toxins have the highest case fatality rate. Amanitin toxins can cause acute liver function damage, and symptoms of the poisoning can include vomiting and diarrhea in early stages and progressive liver damage 2–3 days later.

What is added by this report?

Before 2019, there were about 1–2 cases of wild mushroom containing amanitin toxins poisoning each year in Zhejiang Province. In 2019, 10 cases were identified through disease investigation and toxin detection and biological identification in Shaoxing City, Zhejiang Province. All patients had a history of wild mushroom consumption.

What are the implications for public health practice?

In the summer, some people collect the wild mushrooms for consumption. In China, about 20 species of mushrooms can cause death, and most people lack the ability to identify which mushrooms are edible. To combat this, effective science popularization and prevention and control work will be able to reduce the occurrence of related poisoning events.

BACKGROUND

From June 28 to July 15, 2019, 3 suspected poisoning events continuously occurred in Shaoxing City, Zhejiang Province, China. A total of 10 patients with different degrees of liver damage were found, and 1 patient died so the case fatality rate was 10%. The agencies for disease control and prevention formed a team to investigate this incident. Using a combination of epidemiological investigations, laboratory toxin analysis, and biological identification results of poisonous samples, the poisoning events were determined to be caused by the ingestion of a wild mushroom (*Amanita rimosa*) containing amanitin toxins. Through popular science publicity and education on wild mushroom poisonings and the prohibition of wild mushroom collection/consumption, similar poisoning events were reduced until the middle of August.

INVESTIGATION AND RESULTS

The Xinchang County CDC of Shaoxing City, Zhejiang Province, received an event report from a local hospital that 6 patients in a family went to a doctor with suspected food poisoning on June 29, 2019. The local CDC in Shaoxing immediately carried out an epidemiological investigation and found that the patients had the gastrointestinal irritation symptoms including nausea, vomiting, and diarrhea in the early stages. The patients then developed different degrees of liver function damage with symptoms including abnormal increase of glutamic pyruvic transaminase and glutamic oxaloacetic transaminase between 40–72 hours following consumption. One patient was found to be in severe condition upon rescuing and died. All other patients had improved conditions after medical treatments and were discharged from the hospital one week later. On July 11, the Shaoxing City CDC received a report from that local hospital of another 2 patients with similar symptoms. The national, provincial, and local CDC organized a joint survey team to carry out an epidemiological investigation.

From June 22 to July 25, 2019 in Shaoxing City, Zhejiang Province, case searching was carried out. The criteria included patients with symptoms of gastrointestinal irritation such as nausea, vomiting, and diarrhea appearing in early stages and then progressing to acute liver function damage within 12–72 hours with no obvious fever in the course of the disease.

The professionals of the local CDC carried out case searching in medical institutions within their jurisdiction by interviewing the patients that met the case definition, their families, and the medical staff involved in the treatment of the patients, collecting their medical records, and making household hygiene survey in the villages where the incidents occurred. The plasma/urine samples of the patients were collected and detected with α-amanitin by the Zhejiang Provincial CDC. Wild mushrooms were collected and detected as poisonous by the Zhejiang Provincial CDC and was identified with molecular biology by China CDC.

Until July 25, a total of 10 patients meeting the case definition were found including 6 patients in Xinchang County, 2 patients in Keqiao District, and 2 patients in Zhuji County.

All patients came from three families in Shaoxing City, which lived tens of kilometers apart. The members of the three families did not know each other, nor did they have any other common exposure factors. All patients became sick 10–22 hours after their family dinners. The consumption dates for three families were on June 27–28, July 10, and July 15. Family members who did not participate in the dinner did not become sick.

Field investigations revealed that the meals of the three families were relatively simple and mainly included fried vegetables, soups, and staple foods such as rice. All foods were cooked and eaten as soon as possible, and no individuals were in contact with raw or cold foods. The wild mushrooms were collected on mountains near their residence and were one of the main foods. From June 27 to 28, 7 people had dinner together in Xinchang County, 1 person ate noodles cooked with wild mushrooms, 6 persons (including the aforementioned individual) ate wild mushroom soup containing bamboo, and these 6 persons became sick; the remaining individual was a child who did not consume the wild mushroom and developed no disease. On July 10, 2 individuals in Keqiao District picked and ate a variety of cooked wild mushrooms for dinner. On the morning of July 11, both became sick. On July 15, 2 persons in Zhuji County ate wild mushroom soup collected by themselves for lunch and dinner, and both presented poisoning symptoms. Besides wild mushroom consumption, there were no other shared risk factor exposures between the patients. Therefore, wild mushroom consumption was identified as the exposure risk factor.

The morbidity timeline, place, and population distribution of poisoning patients are shown in Table 1.

Through interviewing the patients and their family members in three families, we found that all the wild mushrooms eaten by the patients were picked in the mountains near their residence and were white mushrooms with similar biological morphology. The investigation team immediately collected mushroom samples in the fields the patients identified. The mushrooms were confirmed by the patients and were sent to the laboratory for toxin detection and biological identification.

The clinical characteristics of all patients were as follows: 1) The latent period was between 10 hours and 22 hours; 2) the initial symptoms were gastrointestinal irritation including nausea, vomiting, abdominal pain, diarrhea, etc.; 3) 36–72 hours post-consumption of wild mushroom, liver function damage appeared and a death occurred as a result of acute liver failure; 4) about a week after of symptomatic support treatment, the liver function of the patients gradually recovered; and 5) there were no fever symptoms in the course of disease. The development of clinical symptom was consistent with the characteristics of acute toxic liver damage (*1*–*3*).

The clinical manifestations of poisoning patients are shown in Table 2.

The patients' plasma samples from their first day in the hospital were collected. The mushroom toxin α-amanitin in samples were detected by liquid chromatography with tandem mass spectrometry (LC-MS/MS). The toxins were found in 8 patients' plasma samples. The contents of α-amanitin in plasma were between 0.016–1.11 ng/mL. The toxins could not be

TABLE 1. The morbidity time, place, and population distribution of the poisoned patients

Meal events	Total number at meal	Number of consuming wild mushrooms	Poisoned patients	Poisoning sites	Time of consumption	Time of first case	Time of last case	Latent period (hours)
Xinchang 1	1*	1	1	Home	Jun 27, 7:00	Jun 27, 17:00	–	10
Xinchang 2	7	6	6	Home	Jun 28, 18:00	Jun 29, 5:00	Jun 29, 16:00	11−22
Keqiao 1	2	2	2	Home	Jul 10, 17:00	Jul 11, 8:00	Jul 11, 8:00	15
Zhuji 1	2	2	2	Home	Jul 15, 12:00	Jul 15, 22:00	–	10
Zhuji 2	2	2	2	Home	Jul 15, 18:00	Jul 15, 22:00	Jul 16, 4:00	10

* This patient consumed the poisonous mushroom twice and died.

TABLE 2. The clinical manifestations of the poisoned patients in the 3 areas.

Clinical characteristics	Xinchang	Zhuji	Keqiao	Total
Patients with gastrointestinal irritation				
Nausea and vomiting	5	2	2	9
Abdominal pain	6	2	2	10
Diarrhea	6	2	1	9
Patients with liver function damage				
Glutamic-pyruvic transaminase (GPT/ALT) and glutamic-oxaloacetic transaminase (GOT/AST)	6 (Up to 55 times higher)	2 (Up to 110 times higher)	2 (Up to 25 times higher)	10

detected in 2 patients' plasma samples 30 hours and 50 hours post-consumption of the mushrooms. The toxins were found in 2 patients' urine samples 62 hours and 51 hours post-consumption and the contents were 0.069 ng/mL and 1.24 ng/mL, respectively.

The wild mushroom samples were found to have α-Amanitin and β-amanitin, and the average contents in the dried samples were 8.63 mg/g and 2.57 mg/g, respectively.

Molecular identification was based on internal transcribed spacer (ITS) sequences. Based on morphological and molecular studies, the suspected mushroom was identified as *Amanita rimosa* (*4–5*) Figure 1. The contents of α-amanitin and β-amanitin in the sampled mushroom specimens were similar to those in previously reported *Amanita rimosa* (*6*).

PUBLIC HEALTH RESPONSE

After the cause of poisoning was determined, the CDCs in Shaoxing city immediately carried out the popular science publicity and education about wild mushroom poisonings and prohibited residents from

FIGURE 1. Basidioma of *Amanita rimosa* (white bar= 1 cm). *Amanita rimosa* grows on the ground in broad-leaved forest dominated by the Fagaceae family of trees. Basidiocarp: small; pileus: 3–5 cm in diameter, white to whitish, middle white to slightly darker; stipe: white to whitish; volva: white; limbate annulus: subapical, white.

picking and eating wild mushrooms. No similar poisoning incidents occurred until August 15, 2019.

The local CDC also suggested regularly carrying out the popular science publicity and education of toxic mushroom poisonings before the rainy season (from the middle of June to the middle of July) in the future. They also decided to set up warning signs prohibiting the picking and eating of wild mushroom in mountain areas to prevent such incidents.

DISCUSSION

The rainy season in Zhejiang Province is from the middle of June to the middle of July every year and the average temperature is between 20 °C–30 °C, which are suitable temperatures and humidity for the growth of wild mushrooms (*7*). Some local mountain residents often consume wild mushrooms, but it is difficult to distinguish edible or toxic wild mushrooms for most residents. There is the possibility of poisoning in the collection and ingestion of toxic wild mushrooms.

The case fatality rate of wild mushroom poisonings with amanitin toxin is reportedly about 20% (*2*). The increase in transaminase levels of poisoning patients generally occurs 48–72 hours following consumption and the optimal treatment period is before 36 hours (*8*). Toxin detection should occur as early as possible to determine the cause of the disease and carry out effective interventions and treatment in time.

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Notes from the Field

First Human Infection with Avian Influenza H9N2 — Guangdong Province, China, 2020

Qianfang Guo[1]; Lirong Zou[1]; Jianxiang Yu[1]; Yingchao Song[1]; Lijun Liang[1]; Xue Zhuang[1]; Tie Song[1]; Jie Wu[1,2,#]

A case of avian influenza H9N2 was detected in a human in Zhuhai City, Guangdong Province through routine influenza surveillance on March 30, 2020. The patient was a 3-year-old child who developed fever and cough on March 22. A pharyngeal swab was collected on March 23, and the novel coronavirus nucleic acid test was negative. On March 26, the pharyngeal swab was sent to Zhuhai CDC for influenza virus tests and was found to be H9 influenza A positive, and on March 30, Guangdong Provincial CDC reexamined the pharyngeal swabs as positive for influenza A (H9N2). On March 28, the patient was hospitalized for isolation treatment, and oseltamivir and other antiviral drugs were given in the hospital. A pharyngeal swab was collected again for reexamination on March 28, and the H9 test was negative. Epidemiological investigation found that the patient had been exposed to chickens and ducks raised by her grandparents before onset of illness. Samples taken from 5 close contacts and the environment of her grandparents' home all tested negative for the H9 nucleic acid.

The pharyngeal swab samples collected on March 23 were inoculated into an 11-day-old specific pathogen free (SPF) chicken embryo in Guangdong Provincial CDC. On April 7, the chicken embryo's allantoic fluid was collected and identified as A(H9N2) positive, with the strain named A/Guangdong/Zhuhai/20SF8034/2020(H9N2). The isolated strain was sequenced and all 8 virus sequences of A(H9N2) were obtained. The 8 gene sequences have been uploaded to GISAID (GISAID accession numbers: EPI1738873-EPI1738880). Basic local alignment search tool (BLAST) in GenBank showed that the hemagglutinin (HA) gene of this virus was most similar with A/duck/China/d4/2018(H9N2) that was isolated from Guangdong Province, China, with a sequence similarity of 99.06%. When compared with the HA genes of 36 H9N2 virus isolates from human infection cases (searched from GISAID), the sequence similarity with A/Hunan/34179/2018 was the highest (98.4%). BLAST in GenBank showed that the NA gene of this virus was most similar with A/chicken/Shanghai/07/2018(H9N2) at 99.06%. Comparison with the NA genes of 36 H9N2 virus isolates from human infection cases, sequence similarity was highest at 98.4% with A/Fujian-Sanyuan/2881/2019(H9N2).

Phylogenetic analysis of HA and NA was carried with reference strains including the World Health Organization (WHO) recommended pre-pandemic vaccine strains (*1*), similar H9N2 strain sequences from GenBank, and all human avian influenza virus sequences from GISAID. HA phylogenetic tree analysis showed the virus belong to the Y280/G9 clade and shared the same branch with A/duck/China/D4/2018(H9N2) from ducks and A/Hunan/34179/2018(H9N2) from humans (Figure 1). NA Phylogenetic tree analysis showed the virus belongs to the Y280/G9 clade and was clustered with A/chicken/Shanghai/07/2018(H9N2), A/chicken/China/1103/2019(H9N2), and A/chicken/China/71/2019(H9N2) (*2*) (Figure 2). BLAST analysis of the internal gene segments (MP, NP, NS, PA, PB1, PB2) of the isolated strain found that these 6 segments all had the highest similarity with avian-derived A (H9N2) with molecular markers of avian-like viruses, suggesting that the risk of human infection was not higher than that of previous H9N2 avian influenza viruses.

H9N2 is the most common subtype of avian influenza in poultry, and human infection is relatively rare (*3–4*). A total of 11 cases of H9N2 have been reported since 2010 in Guangdong Province, all of which were mild cases and have recovered. The case of H9N2 detected this time is an occasional case of human infection with H9N2 avian influenza virus. We should continue to strengthen the risk monitoring and early warning of avian influenza on the basis of the existing surveillance of avian influenza.

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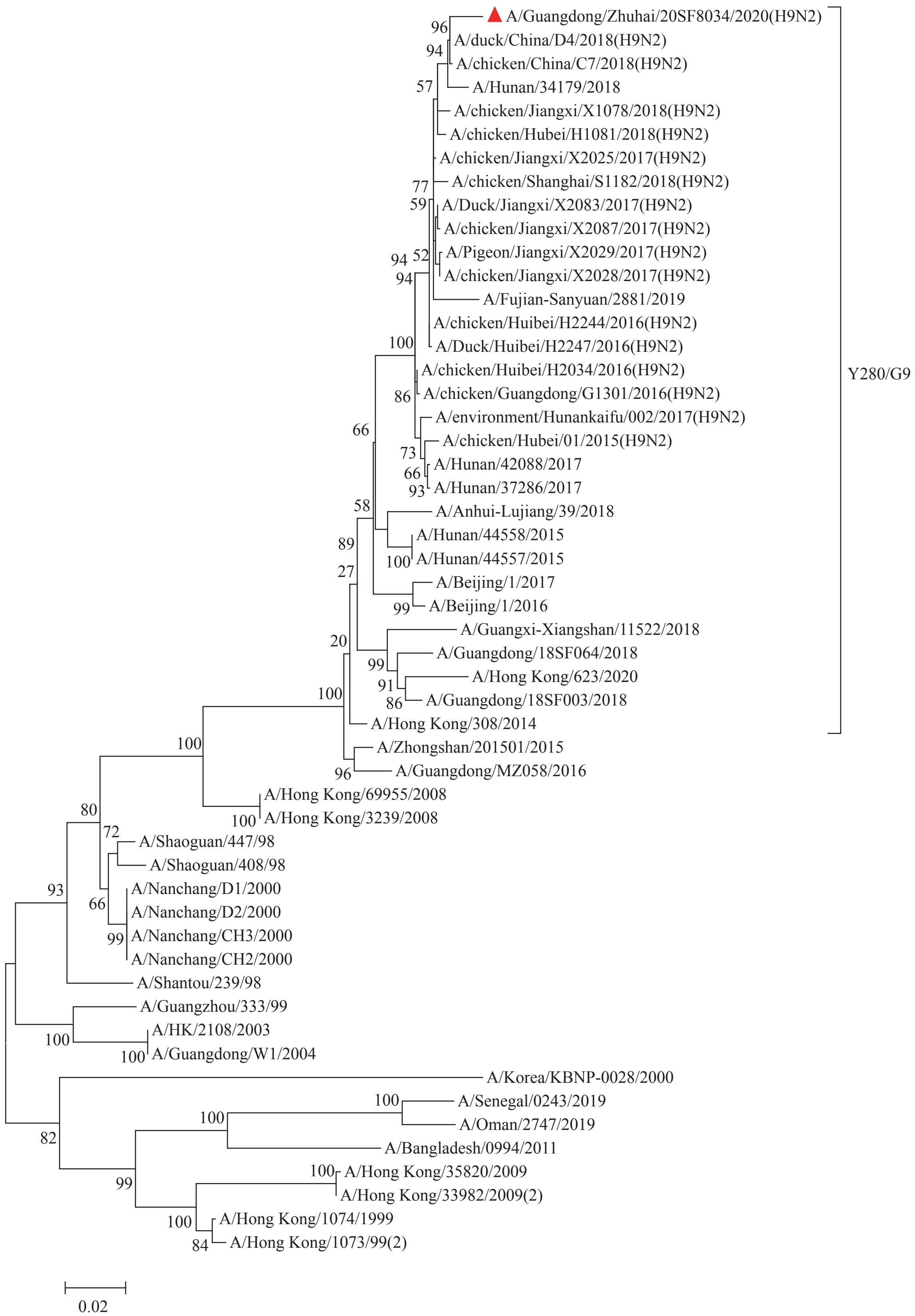

FIGURE 1. Phylogenetic tree based on HA gene sequences of the isolated virus strain A/Guangdong/Zhuhai/20SF8034/2020(H9N2) and the reference strains using the maximum likelihood method. A red solid triangle marks the location of A/Guangdong/Zhuhai/20SF8034/2020(H9N2).

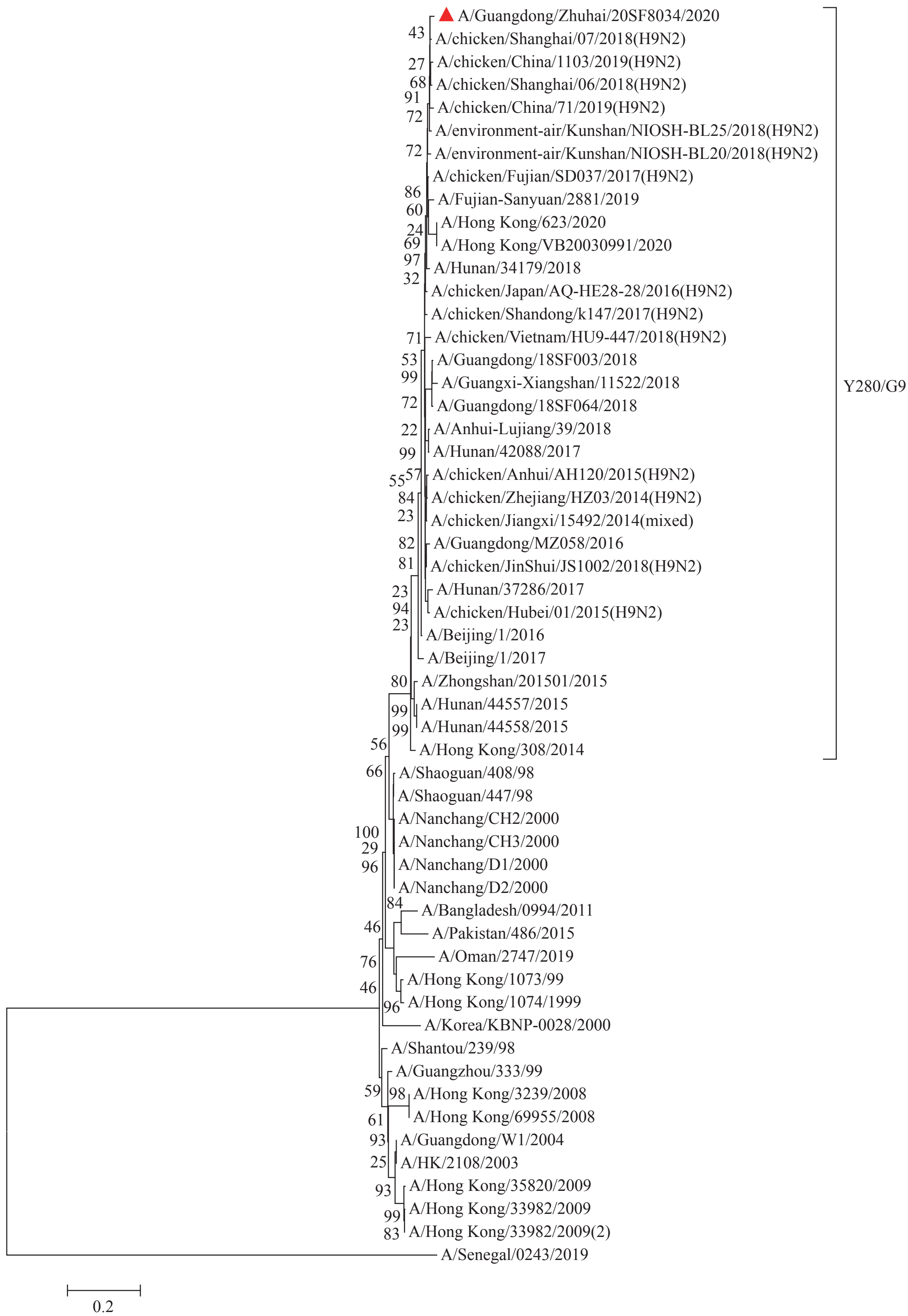

FIGURE 2. Phylogenetic tree based on neuraminidase (NA) gene sequences of the isolated virus strain A/Guangdong/Zhuhai/20SF8034/2020 (H9N2) and the reference strains using the maximum likelihood method. A red solid triangle marked the location of A/Guangdong/Zhuhai/20SF8034/2020(H9N2).

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Notes from the Field

A Reemergent Case of Bubonic Plague-Inner Mongolia Autonomous Region, China, July, 2020

Xiaona Shen[1,&]; Jianyun Li[2,&]; Mengguang Fan[2]; Lianxu Xia[1]; Wei Li[1,#]

On July 5, 2020, a confirmed case of bubonic plague was reported in Urat Middle Banner of Inner Mongolia Autonomous Region, China, which belongs to the *Meriones unguiculatus* plague focus in the Inner Mongolia Plateau. This was the same natural plague focus that reported 2 pneumonic plague patients and 2 bubonic plague patients in Inner Mongolia in late 2019 (*1*). The 2 pneumonic plague patients were once transferred into Beijing Municipality in November 2019 for comprehensive treatment; however, one patient still died.

The case of bubonic plague occurred in Inner Mongolia in a 47-year-old female shepherd that experienced fever, chills, and some symptoms of physical discomfort on July 2. On July 3, she sought treatment in the Urat Middle Banner People's Hospital because of high body temperature (40 ℃) with the swollen and painful right inguinal lymph nodes. A polymerase chain reaction (PCR) test for *Yersinia pestis* specific genes (*caf1* and YPO0392 gene) was performed in the Urat Middle Banner (county-level) CDC, and positive results were detected in the lymph node aspirate. Subsequently, the patient was suspected of having a case of bubonic plague and notified to the local public health agency on the same day. On July 4, Inner Mongolia Autonomous Region CDC reviewed the PCR test and the reverse indirect hemagglutination assay (RIHA) test. The lymph node aspirate sample was positive for the PCR and RIHA tests, while specimens of blood and pharyngeal swab were negative. According to the "plague diagnostic criteria" of China, the case was identified as a confirmed case of bubonic plague. As of July 10, 2020, the patient is being treated in a local general hospital and her condition is stable.

When the bubonic plague patient was initially identified as a suspected case, a series of prevention and control measures were adopted by the local government including the medical observation of 15 close contacts, the establishment of a isolation zone to prevent other residents from entering the patient's home and the surrounding neighborhood areas, and the implementation of rodent and flea control measures in the corresponding epizootic focus. As of July 10, no additional cases were reported.

As early as March 2020, animal plagues had been detected in the Urat Middle Banner with a total of eight *Yersinia pestis* strains having been isolated from local reservoirs (*2*). In June, four dead *M. unguiculatus* rodents were found in the region neighboring where the patient lived, and four *Y. pestis* strains were isolated from these dead hosts. This observation indicated that serious *M. unguiculatus* plague epizootics existed in that area. Epidemiological investigations suggested that the patient might have been infected from a flea bite that transmitted the disease through local epizootic rodents. This was suspected because the patient was a shepherd and suffered right inguinal bubonic plague when herding sheep on an *M. unguiculatus* plague natural focus, where *Nosopsyllus laeviceps kuzenkovi* is the main vector of plague (*3*).

Continuous animal plague have occurred in previous years (in 2018 and 2019) in the *Meriones unguiculatus* plague focus of Inner Mongolia, and in 2020, a total of 14 counties of 5 leagues (cities) had found animal plague in Inner Mongolia with 69 positive rodents been detected (*2*). These surveillance results indicated that animal plague epizootics in the *M. unguiculatus* plague focus were still active.

In the *Meriones unguiculatus* plague focus of the Inner Mongolian Plateau, most cases in humans were caused by flea bites and characterized as bubonic plague. Therefore, a key measure for human plague prevention and control was to carry out health education about rodent and flea control and to avoid flea bites in the epizootic areas. In addition, local residents needed to be educated to avoid hunting in or being in contact with wild reservoirs of plague.

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Commentary

A Prepandemic Warning!

Robert G. Webster[#]

The goal of scientists is to provide knowledge that will benefit humankind. The scientific paper (*1*) published in the *Proceedings of the National Academy of Sciences* (online on June 29, 2020) has the potential of warning the global community of a future pandemic of disease. While the current focus on the coronavirus disease 2019 (COVID-19) pandemic caused by the COVID-19 virus is fully merited because of its catastrophic impact on public health and global economics, it is important not to forget that an influenza pandemic can be even more debilitating.

It has been just over 100 years since Mother Nature unleashed the devastating 1918 Spanish influenza virus that killed between 24.7 and 39.3 million persons worldwide. It is uncertain where this virus came from, but it was first reported on farms in the state of Kansas, USA and may well have come from swine. Each of the subsequent influenza pandemics of 1957, 1968, and 1977 had gene segments from the 1918 virus and the majority spread to or from swine. We do know that the H1N1 pandemic of 2009 (pdm/09 H1N1) was first detected in swine in Mexico with gene segments from Eurasian avian swine influenza viruses and the triple reassortant swine influenza virus from the Americas. The triple reassortant virus contained gene segments from the classical swine influenza virus (HA, NP, NS), human H3 influenza virus (PB1), and North American avian influenza viruses (PB2, PA). Each of these gene segments could be traced phylogenetically to avian influenza viruses from Eurasia or the Americas. Thus, the ultimate source of the pandemic influenza viruses of humans are the avian influenza viruses of the world and swine may serve as both the mixing vessel for the genesis of these viruses and the intermediate hosts in facilitating spread to humans.

The above paper establishes that another reassortant influenza virus containing the Eurasian avian swine hemagglutinin (HA) and neuraminidase (NA) with the majority of internal gene segments from the pdm/09 H1N1 virus became dominant in pigs in China in 2016. The following properties of this Eurasian avian reassortant influenza virus that are of concern for transmission to humans include:

1) Extensive diversity of the sequence of each of the gene segments is occurring, which indicates continued evolution.

2) Reassortment between the different swine influenza virus lineages has generated multiple different genotypes that all retain the Eurasian avian-like hemagglutinin and neuraminidase.

3) The dominant Eurasian avian-like reassortant preferentially bound to sialic acid α 2,6 Gal receptors found in human cells.

4) These Eurasian avian-like reassortant viruses replicated to high titers in human airway epithelial cells.

5) The Eurasian avian-like reassortants caused severe disease signs in ferrets and transmitted efficiently by direct contact and by respiratory droplet spread to contact ferrets.

6) The reassortant Eurasian avian viruses were antigenically distinct from the pdm/09 H1N1 circulating in humans.

7) The current seasonal influenza vaccines to pdm/09 H1N1 do not provide protection against the Eurasian avian reassortant.

8) Serological surveillance of humans working in the swine industry showed that 10% had evidence of infection with the Eurasian avian reassortant influenza virus.

9) To date, there have been three reported cases of infection of humans with the Eurasian avian-like reassortant and one death.

10) The paper is extremely well illustrated with extensive referencing of earlier studies of influenza in swine in China.

The above findings indicate that the Eurasian avian-like reassortant influenza viruses have the ability to replicate in humans. Serological studies in humans indicate that pig to human transmission does occur. The key question is will these viruses acquire the ability to transmit human to human and initiate a pandemic? Integral to this question is understanding the factors that are currently limiting their spread. These Eurasian-avian viruses seem to tick many of the boxes we think necessary for a pandemic virus as detailed above; they bind human receptors, transmit in ferrets, and the human population seems mostly naïve to their HAs. What exactly is holding them back? Could it be that the virus is a mutation or two away from being optimally fit? Could it be that human immunity to the NA is important? Or could it just be good luck that these viruses haven't had more sustained human spread? Continued surveillance at the human-swine interface is clearly an important need. While we know some of the viral gene sequences associated with pathogenicity including PB2, PA-X, and NS we do not know the combination of gene segments and mutations that will allow predictions of human to human transmission.

Since China has the highest density of swine of any country in the world and also the continued circulation of all influenza virus lineages known to infect them, it would be extremely beneficial to continue surveillance at the human-swine interface (*2–3*). Pandemic preparedness resulting from surveillance at the human-swine interface would increase our knowledge of the molecular requirements for human to human transmission and facilitate early control and containment. Continued surveillance of humans working with swine is recommended by the authors of the paper and strongly supported by this author. It has the potential to provide new knowledge and benefit humankind globally.

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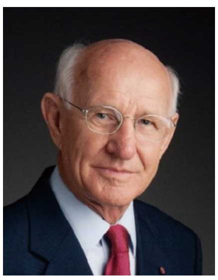

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Profiles

Xu Su, China CDC's Chief Expert of Radiation Protection

Peter Hao[1,&]; Yu Chen[2,&]; Zhenjun Li[1]; Jingjing Xi[1,#]; Feng Tan[1,#]

Xu Su is the major leader of radiation protection in China and has been honored and awarded several times, has published more than 280 research papers, and has been the Director of the National Institute for Radiological Protection (NIRP) of China CDC and the Professor and Executive Director of the Chinese Center for Medical Response to Radiation Emergency from 2002 to 2017. Having been born in 1959 and, following the restoration of the National Unified Examination for Admissions to General Universities and Colleges, testing into Lanzhou University with high honors in 1977 to pursue studies in nuclear physics, Xu Su's entire career has been closely linked to radiological health. Following a desire to engage in radiation medicine teaching and scientific research, Xu Su then applied to the School of Public Health at Norman Bethune Medical University in Jilin Province, but due to external factors, his pursuit resulted in work in the field of nuclear radiation physics and radiation dosimetry instead of radiation medicine.

To change this situation, Xu Su participated in the National Entrance Examination for Postgraduates in 1986 and was admitted to Norman Bethune University for radiation toxicology and was able to continue at the university to pursue a PhD in radiation medicine in 1993. His PhD supervisor was Shuzheng Liu, the president of the university and one of the most famous radiobiologists in the world, whose mentorship and instruction critically influenced Xu Su's career directions that involved researching the biological effects of low dose radiation at Toho University and at the National Institute of Radiological Sciences in Japan. Shuzheng Liu had mentioned to Xu Su that many internationally renowned radiobiologists have a background in nuclear physics, and that his own educational background will be helpful to his career development in radiobiology. Xu Su took this advice seriously, and developed into a productive researcher that was promoted to research professor in 1998.

In 1999, he was transferred to the Laboratory of Industrial Hygiene of the Ministry of Health via the talent introduction program and organized and established the Department of Radiation Biology. After China CDC was founded in 2002, the Laboratory of Industrial Hygiene of the Ministry of Health was merged into China CDC and changed its name to its current form, NIRP. During his 15 years in NIRP, Xu Su was devoted to the disciplined construction of NIRP, and with his impetus and effort, NIRP obtained approval to confer PhD and master degrees in radiation medicine. In addition, he established many subdiscipline departments and research laboratories in NIRP, such as Radiobiology, Radiation Epidemiology, Radiotoxicology, Radiation Chemistry, Radioecology, Radiation Protection, etc. In addition to his 280 published research papers, Xu Su has presided over and undertaken 26 national and ministry-level scientific research projects, edited 15 monographs, and has supervised more than 30 postdoctoral, doctoral, and postgraduate students. Since 1996, Xu Su has been awarded 6 national and provincial-level science and technology achievement awards. He has also been included in the first wave of New Century Ten Million Talents Project National Candidate selected by the 7 Ministries of Chinese Government in 2004, recognized as the Outstanding Mid-Aged Expert of the Ministry of Health in 2004, granted Special Government Allowances approved by the Ministry of Personnel in 2005, and awarded the Award for Outstanding Contribution to Public Health and Preventive Medicine by the China Preventive Medicine Association in 2008, "Contribution Award for Radiation Research" by Asia Association for Radiation Research in 2009, and the 13th Wu Jieping- Paul Janssen Medical & Pharmaceutical Research Award in 2012.

As the Director of NIRP of China CDC, Xu Su led the scientific and technical personnel to conduct a large number of investigations and studies, discovered weak links in the country's radiation protection, and provided recommendations to address these issues. Under his active promotion and effort, many major projects, including the "National Medical Radiation Protection Monitoring," "National Food and Drinking Water Radiation Monitoring," "National Occupational Health Monitoring and Occupational Disease Monitoring for Radiation Workers," and

"National Examination of Technical Ability of Radiological Health Institutions" have been successively launched, which has positively contributed to protect the health rights of workers and the public.

Xu Su attaches great importance to international cooperation and exchanges. As chairman of the conferences, he has held many international conferences in China, such as the "International Seminar on Health Emergency in Nuclear Accidents in 2009," "3rd Asian Congress of Radiation Research in 2013," "First Global Chinese Radiation Research Conference in 2011," "Second Global Chinese Radiation Research Conference in 2014," and "Third Global Chinese Radiation Research Conference in 2018". During the first Asian Congress of Radiation Research in Japan in 2005, Xu Su was elected vice-president of the Asian Radiation Research Association, and by 2013, he was elected president. From 2001 to 2014, he also participated in several meetings of the United Nations Scientific Committee on the Effects of Atomic Radiation as a member of the Chinese delegation.

Since 2002, Xu Su has organized, guided, and participated in the emergency management of many radiation emergencies. Especially during the Fukushima Daiichi Nuclear Power Plant accident in Japan in 2011 when China's public expressed panic, Xu Su carried out more than 40 information releases, expert interpretations, and responses to public questions on CCTV and other mainstream media to effectively eliminate public panic. Especially on March 17, 2011, when the public began panic buying iodized salt wrongfully believing that it could prevent absorption of radioactive iodine and that there would be a shortage of iodized salt, Xu Su appeared on CCTV and provided a detailed and vivid explanation to calm the public and resolve the incident.

Xu Su is now working to improve China's radiation protection capabilities as the chief expert in radiation protection at China CDC.

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Notifiable Infectious Diseases Reports

Reported Cases and Deaths of National Notifiable Infectious Diseases — China, May, 2020

Diseases	Cases	Deaths
Plague	0	0
Cholera	1	0
SARS-CoV	0	0
Acquired immune deficiency syndrome	5,484	1,596
Hepatitis	120,921	43
Hepatitis A	1,100	0
Hepatitis B	97,651	35
Hepatitis C	19,821	8
Hepatitis D	11	0
Hepatitis E	1,585	0
Other hepatitis	753	0
Poliomyelitis	0	0
Human infection with H5N1 virus	0	0
Measles	74	0
Epidemic hemorrhagic fever	686	2
Rabies	14	9
Japanese encephalitis	0	0
Dengue	4	0
Anthrax	16	0
Dysentery	5,664	0
Tuberculosis	83,385	123
Typhoid fever and paratyphoid fever	607	0
Meningococcal meningitis	4	0
Pertussis	277	0
Diphtheria	0	0
Neonatal tetanus	2	0
Scarlet fever	562	0
Brucellosis	5,264	0
Gonorrhea	8,104	1
Syphilis	46,753	6
Leptospirosis	5	0
Schistosomiasis	5	0
Malaria	40	0
Human infection with H7N9 virus	0	0
COVID-19*	143	1
Influenza	16,974	2
Mumps	9,273	0

Continued

Diseases	Cases	Deaths
Rubella	90	0
Acute hemorrhagic conjunctivitis	2,468	0
Leprosy	48	0
Typhus	67	0
Kala azar	26	0
Echinococcosis	266	0
Filariasis	0	0
Infectious diarrhea[†]	87,151	0
Hand, foot and mouth disease	3,919	0
Total	**398,297**	**1,783**

[*] The data were from the website of the National Health Commission of the People's Republic of China.

[†] Infectious diarrhea excludes cholera, dysentery, typhoid fever and paratyphoid fever.

The number of cases and cause-specific deaths refer to data recorded in National Notifiable Disease Reporting System in China, which includes both clinically-diagnosed cases and laboratory-confirmed cases. Only reported cases of the 31 provincial-level administrative divisions in the mainland of China are included in the table, whereas data of Hong Kong Special Administrative Region, Macau Special Administrative Region, and Taiwan are not included. Monthly statistics are calculated without annual verification, which were usually conducted in February of the next year for de-duplication and verification of reported cases in annual statistics. Therefore, 12-month cases could not be added together directly to calculate the cumulative cases because the individual information might be verified via National Notifiable Disease Reporting System according to information verification or field investigations by local CDCs.

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