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This week's issue was organized by Guest Editors Liping Wang and Qiulan Chen.
Cover Photo: Local CDC staff screening for brucellosis in shepherds in Xilin Gol League, Inner Mongolia, 2013.

Preplanned Studies

Serological Prevalence Survey Among the High-Risk Populations of Brucellosis-Endemic Areas — China, 2019−2020

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Summary

What is already known about this topic?

Timely screening of high-risk population is important to improve the early detection of brucellosis among the endemic areas during the high incidence seasons, which is also required by the National Brucellosis Prevention and Control Plan (2016–2020) (NBPCP).

What is added by this report?

Seroepidemiological characteristics of brucellosis in high-risk populations were obtained and special occupational populations were found. The seroprevalence of brucellosis has been decreasing compared with that reported in the recent years due to the ongoing implementation of control measures in endemic areas.

What are the implications for public health practice?

Special occupational populations could be promptly detected using routine screening, which makes it possible to initiate standardized treatment for infected patients as early as possible. It also reminds us to pay attention to special occupational populations to improve their knowledge of brucellosis and reduce the risk of infection.

Brucellosis is a worldwide zoonotic disease with fever and fatigue caused by gram-negative coccobacilli of the genus *Brucella* (*1*). Human brucellosis is usually linked to direct contact with infected livestock or ingestion of unpasteurized dairy products of infected animals (*2*). Human brucellosis is still a severe public health challenge in most low-income and middle-income areas (*1*). Since the 1990s, the incidence of brucellosis has been increasing and reached a peak in 2014 and ranked in the top 10 most prevalent diseases among the Class A and Class B infectious disease from 2008 to 2018 (*3*). To control brucellosis effectively, the National Brucellosis Prevention and Control Plan (2016–2020) (NBPCP) was formulated by the Ministry of Agriculture of China and the National Health Commission (NHC) and has begun being implemented for more than 3 years (*4*). The purpose of this study was to investigate the seroprevalence of different high-risk occupational populations in brucellosis-endemic areas in China from 2019 to 2020 and to understand the seroprevalence of the different seasons. A cross-sectional study using an interviewed-based survey was conducted in 4 total counties including 3 counties (Yanggao County, Zuoyun County, and Hunyuan County) in Datong City of Shanxi Province and 1 county (Huocheng County) in Yili District of Xinjiang Uygur Autonomous Region from December 2019 to July 2020. China CDC designed the protocol and implemented relevant training for local CDCs, including administering questionnaires, sampling, and testing, etc. Written informed consent was obtained with face-to-face interviews before the formal inquiry, and the blood samples were collected by the staff of the county CDCs. The participants were aged 18 years and above and were working in livestock breeding, livestock products production and processing, as veterinarians, etc. The sample size is estimated according to the simple random sampling in the cross-sectional survey, the allowable error is 0.15p (p is the expected infection rate,based on other studies, p was at 7%.), and the non-response rate is 10%. The total sample size is initially determined to be 2,400 people, and the sample size for each county is 600 people.

A questionnaire was used to collect epidemiological data associated with brucellosis, and a blood sample was drawn from each participant. Seropositivity was defined with serum standard tube agglutination test (SAT) approach with titer ≥ 1∶100 (+ +) or ≥1∶50 (+ +) if the course of disease onset lasted more than 1 year according to the Standard for Brucellosis Diagnosis issued by the NHC in 2019 (*5*). Statistical analyses were conducted with R software (version 4.0.2, R Foundation for Statistical Computing, Austria), and χ^2 test with a significance level of α =0.05 was used to test the difference in proportion.

A total of 2,411 participants were surveyed in this study, 2,384 of them completed the questionnaire and participated in blood collection, and the effective response rate was 98.88% (2,384/2,411). Of them, 1,405 were males (58.93%) and 979 were females (41.07%), and the seroprevalence of brucellosis was 3.06% among males and 1.94% among females. The seroprevalence among males (3.73%) was higher than that among females (1.95%) in Shanxi, and the differences were significant (P<0.05). The median age of high-risk populations was 54.5 years (range: 18–91), and the 36–59 age group contained the largest number of participants (49.54%). The seroprevalence in 18–35 age group (4.69%) was higher than that in the 36–59 age group (1.04%) in Xinjiang, and the differences were significant (P<0.05). For education level, only 8.93% of participants had senior high school education or above, and the seroprevalence of brucellosis of this group was 3.76%, among which 2 participants with special occupation were brucellosis seropositive (one was part of a local poverty-alleviation cadre in Shanxi and the other was a rural teacher in Xinjiang) (Table 1).

The 62 participants were seropositive for *Brucella* infection, the crude seroprevalence of brucellosis was 2.60% (62/2,384), and that of Shanxi and Xinjiang was 2.91% (52/1,787) and 1.68% (10/597), respectively. Of the 62 seropositive individuals, 20 had ever been diagnosed with human brucellosis before 2019. However, when screening high-risk groups of brucellosis, they were still seropositive for brucellosis. The seroprevalence in fall-winter and spring-summer seasons were respectively 1.71% (20/1,167) and 3.45% (42/1,217) respectively and the differences were significant (P<0.05). The serological prevalence of high-risk occupational population in the spring-summer season was higher than that in fall-winter, with the same status in Shanxi province and Xinjiang uygur autonomous region (Table 2).

DISCUSSION

This study was conducted in 2 provincial-level administrative divisions (PLADs) with high incidence of brucellosis from 2019 to 2020. Serological characteristics of high-risk populations were obtained and analyzed. In this study, the seroprevalence of brucellosis among people with high-risk occupations in Shanxi from 2019 to 2020 was 2.91%, which was significantly lower than the seroprevalence of brucellosis in Shanxi from 2013 to 2016 (6.15%)(*6*). The seroprevalence of brucellosis among people with high-risk occupations in Xinjiang from 2019 to 2020 was 1.68%, which was significantly lower than the seroprevalence of brucellosis in Xinjiang from 2012 to 2015 (16.86%)(*7*). All these achievements benefitted from early screening of high-risk populations, health education, and behavioral interventions. The agriculture departments also improved livestock vaccination and strengthened animal quarantining. At the same time, the implementation of NBPCP has achieved good results.

The seroprevalence of brucellosis in Shanxi was 2.91%, and that in Xinjiang was 1.68%, but there was no significant difference brtween them (P>0.05). These may be due to 2 reasons: 1) differing methods of livestock breeding between the 2 PLADs; and 2) the poor knowledge of human brucellosis and the lack of utilization of personal protective equipment (PPE), which was concurrently reported by Wang Z et al (*8*). The cohabitation between humans and their livestock was identified among some families during the field survey in Shanxi, which increased the risk of brucellosis transmission.

Screening of high-risk populations can facilitate early disease detection to provide better disease incidence estimates and reduce disease complications. In this study, two special participants were identified among brucellosis patients, including a rural teacher and a member of the poverty-alleviation cadre. There may be two main reasons: 1) they were relatively young and came from areas where brucellosis is not endemic and had no knowledge of human brucellosis; 2) they have low awareness of brucellosis or do not know how to use PPE correctly. The health education and behavior intervention measures are vital to individuals who are undertaking national or local poverty-alleviation missions, including township or village officials and teachers, to properly use PPE when they are exposed to risk environments or engaged in high-risk occupations.

Considering the epidemiological characteristics of human brucellosis, the study was conducted in the fall-winter 2019 and spring-summer 2020. The results indicated that the related occupational populations had a higher risk of infection during spring and summer because this period is the peak lambing periods for cattle, sheep, and other livestock, and 90% of human brucellosis also occurs at this time (*9*). Furthermore, brucellosis incidence was also strongly associated with

TABLE 1. Serological prevalence and comparative analysis of different demographic characteristics of high-risk populations of brucellosis in Shanxi and Xinjiang from 2019 to 2020.

Features	Total					Shanxi				Xinjiang			
	Number of participant	Percentage (%)	Seropositive	Seroprevalence (%)	*P*-value	Number of participant	Seropositive	Seroprevalence (%)	*P*-value	Number of participant	Seropositive	Seroprevalence (%)	*P*-value
Gender					0.091				0.026*				1.000
Male	1,405	58.93	43	3.06		966	36	3.73		439	7	1.59	
Female	979	41.07	19	1.94		821	16	1.95		158	3	1.90	
Age group (years)					0.368				0.447				0.019*
18–35	181	7.59	7	3.87		53	1	1.89		128	6	4.69	
36–59	1,181	49.54	32	2.71		798	28	3.51		383	4	1.04	
≥60	1,022	42.87	23	2.25		936	23	2.46		86	0	0	
Education					0.595				0.793				0.211
Illiteracy	508	21.31	13	2.56		434	12	2.76		75	1	1.33	
Primary school	996	41.78	22	2.21		758	20	2.64		239	2	0.84	
Junior high school	667	27.98	19	2.85		515	17	3.30		153	2	1.31	
Senior high school and above	213	8.93	8	3.76		80	3	3.75		130	5	3.85	
Occupation					0.417				0.456				0.051
Farmer	1,952	81.88	50	2.56		1,689	48	2.84		263	2	0.76	
Herder	260	10.91	6	2.31		75	3	4.00		185	3	1.62	
Livestock processing	7	0.29	0	0		3	0	0		4	0	0	
Teacher	8	0.33	1	12.50		2	0	0		6	1	16.67	
Medical staff	22	0.92	0	0		6	0	0		16	0	0	
Veterinary	72	3.02	4	5.56		2	0	0		70	4	5.71	
Caterer	8	0.34	0	0		0	0	0		4	0	0	
Student	1	0.04	0	0		1	0	0		0	0	0	
Other	54	2.27	1	1.85		9	1[†]	11.11		49	0	0	

Note: Seroprevalence (%)=number of seropositivity/number of participants×100%.
* The different demographic characteristics was statistically significant ($P<0.05$).
[†] The only one case of brucellosis seropositive in other occupations was a local poverty-alleviation cadre.

TABLE 2. The overall serological prevalence and comparative analysis of high-risk population of brucellosis in different seasons in Shanxi and Xinjiang from 2019 to 2020.

Unit	Total				Fall-Winter season			Spring-Summer season			
	Number of participant	Seropositive	Seroprevalence (%)	*P*-value	Number of participant	Seropositive	Seroprevalence (%)	Number of participant	Seropositive	Seroprevalence (%)	*P*-value
Shanxi	1,787	52	2.91	0.101	871	17	1.95	916	35	3.82	0.019*
Yanggao County	599	3	0.50		271	3	1.11	328	0	0	
Hunyuan County	587	35	5.96		295	11	3.73	292	24	8.23	
Zuoyun County	601	14	2.33		305	3	0.98	296	11	3.72	
Xinjiang	597	10	1.68		296	3	1.01	301	7	2.33	0.352
Huocheng County	597	10	1.68		296	3	1.01	301	7	2.33	
Total	2,384	62	2.60		1,167	20	1.71	1,217	42	3.45	0.008*

Note: Seroprevalence (%)=number of Seropositivity/number of participants×100%. Fall-winter season: December 2019 to January 2020; Spring-summer season: April to July 2020.
* The difference between the two seasons was significantly (P<0.05).

lambing of livestock, handling of aborted products, or improper personal protection behaviors (*3,10–11*).

This study was subject to two limitations. First, China CDC did not review 20% of seropositive samples due to COVID-19 outbreak, which might cause some uncertainties in the results. Second, only 3 counties in Shanxi and 1 county in Xinjiang were investigated, so the results might not be widely generalizable.

In summary, although the seroprevalence of brucellosis in endemic areas of China has decreased, some high-risk occupational populations still have the risk of being infected with brucellosis, especially some special occupational populations, such as rural teachers and poverty-alleviation cadres. It is necessary to expand the scope of brucellosis education, especially to strengthen the health education and behavioral intervention measures, to improve their awareness of brucellosis and their ability to protect against it and reduce the risk of infection. Moreover, the results can provide some evidence for future evaluation work from the NBPCP and can be used to guide the local health departments on brucellosis prevention and control work.

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Ethical Approval and consent to participate: The study design obtained ethical approval following a review by China CDC Institutional Review Board. Written informed consent has been obtained from the patients in accordance with the Declaration of Helsinki. The research group confirmed that the identification information of all participants (including patient names, ID numbers, home addresses and telephone numbers) would not be included in recordings, descriptions, or publications.

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Preplanned Studies

Brucellosis Knowledge and Personal Protective Equipment Usage Among High-Risk Populations in Brucellosis-Endemic Areas — China, 2019–2020

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Summary

What is already known about this topic?

According to the National Brucellosis Prevention and Control Plan (2016–2020) (NBPCP), the awareness rate of high-risk populations in brucellosis-endemic areas should reach 90% by 2020. But the updated results have not been reported.

What is added by this report?

This report determined the awareness rate of brucellosis (17.74%), utilization of personal protective equipment (PPE) (20.13%), and their relationship with seroprevalence, which provides evidence for the effectiveness of the implementation of NBPCP.

What are the implications for public health practice?

The results suggest that health education should be conducted for high-risk populations to improve their brucellosis and protection knowledge.

Brucellosis remains an important public health problem in most low-income and middle-income countries (*1–3*). During the past decade, the incidence rate and the number of reported cases of brucellosis have dramatically increased in China (*4*). To control brucellosis effectively, the National Brucellosis Prevention and Control Plan (2016–2020) (NBPCP) was formulated by the Ministry of Agriculture of China and the National Health Commission. Based on NBPCP, the awareness rate of high-risk populations in brucellosis-endemic areas should reach 90% by 2020 (*5*). This study was designed and conducted to determine the populations at high risk for brucellosis in endemic areas to provide the evidence to evaluate the effects of the NBPCP. From 2019 to 2020, China CDC established a cross-sectional study with an interviewed-based survey in Shanxi Province and Xinjiang Uygur Autonomous Region, that with high incidences of brucellosis in China. Yanggao, Zuoyun, and Hunyuan counties in Shanxi Province and Huocheng county in Xinjiang Uygur Autonomous Region were selected. The local CDCs conducted face-to-face interviews. The results showed that the awareness rate and the utilization rate of personal protective equipment (PPE) in high-risk populations were relatively lower than the goals of the NBPCP. It is necessary to carry out targeted health education for high-risk groups.

The study subjects, sample size estimation, and seropositivity definition were described elsewhere (*6*). Using a questionnaire, data on population knowledge of brucellosis and PPE utilization was collected. Brucellosis knowledge primarily included transmission routes, symptoms, and domestic animal hosts, etc. The variable "Awareness" was scored as "yes" if respondents answered all five questions correctly and "no" if any questions were answered incorrectly. The utilization of PPE primarily included gloves, masks, rubber boots, and overalls, and the variable "Protection" was defined as a respondent who answered "often" or "occasionally" in all four aspects. Statistical analysis were conducted in R software (version 4.0.2, R Foundation for Statistical Computing, Austria) and χ^2 test with a significance level of α=0.05 to test the difference in the proportion.

A total of 2,411 participants from 4 counties responded, and 2,384 of them met the requirements with a response rate of 98.88% (2,384/2,411). The crude awareness rate (i.e. "having awareness") and utilization rate of PPE of brucellosis were 17.74% (423/2,384) and 20.13% (480/2,384), respectively. Figure 1 shows the awareness rate of brucellosis knowledge and utilization rate of PPE in different counties. The awareness rate of brucellosis knowledge and utilization rate of PPE in Huocheng County were the highest among the four counties. Table 1 demonstrated the correlation between the awareness

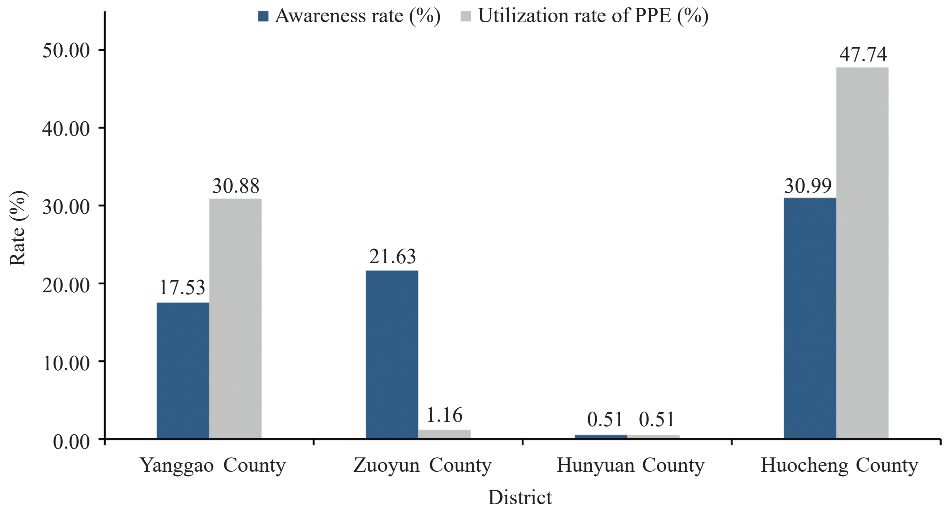

FIGURE 1. The awareness rate of brucellosis knowledge and utilization rate of personal protective equipment (PPE) among high-risk populations in four counties, 2019–2020.

rate of brucellosis knowledge in different aspects and seroprevalence. The proportion of respondents who heard of brucellosis was 96.81%, including those who knew of transmission (50.08%), prevention (69.55%), and symptoms (51.76%). However, only 31.88% of respondents knew about the species of domestic animal hosts that spread brucellosis. Although seroprevalence in the group that had awareness was lower than that in the group did not have awareness, no significant difference was found between them (P=0.312, >0.05) except "Can brucellosis be prevented?" (P=0.023, <0.05). Table 2 illustrated the association between the utilization rate of PPE in different ways and seroprevalence. About a third of the respondents utilized PPE, including gloves (38.26%), facemasks (31.80%), boots (32.01%), and overalls (30.87%), respectively. The seroprevalence of the protected population was lower than that in the unprotected population. However, the difference was not statistically significant (P=0.264, >0.05).

TABLE 1. The awareness of brucellosis knowledge and the relationship between their seroprevalence among high-risk populations in Shanxi and Xinjiang from 2019 to 2020.

Questions	Having awareness	Infected	Uninfected	Total	Awareness rate (%)	Seroprevalence (%)	*P*-value
All		62	2,322	2,384		2.60	
Have you heard of brucellosis?	Yes	60	2,248	2,308	96.81	2.60	1.000 ¶
	No	2	74	76		2.63	
What behaviors may cause a person to contract brucellosis? *,†	Yes	29	1,165	1,194	50.08	2.43	0.597
	No	33	1,157	1,190		2.77	
Can brucellosis be prevented? *	Yes	35	1,623	1,658	69.55	2.11	0.023 **
	No	27	699	726		3.72	
What are the symptoms of brucellosis? *,†	Yes	27	1,207	1,234	51.76	2.19	0.190
	No	35	1,115	1,150		3.04	
Which domestic animals can transmit brucellosis? *,†	Yes	13	747	760	31.88	1.71	0.062
	No	49	1,575	1,624		3.02	
Awareness §	Yes	8	415	423	17.74	1.89	0.312
	No	54	1,907	1,961		2.75	

* The response was depended on those who answered "yes" for the first question.
† These were multiple-choice questions. The "yes" means who answered more than 70% of the questions correctly.
§ The "yes" means who answered all five questions correctly.
¶ Results from Fisher's exact test.
** The seroprevalence difference was statistically significant (P<0.05).

TABLE 2. The utilization of PPE and the relationship between their seroprevalence among high-risk populations in Shanxi and Xinjiang from 2019 to 2020.

Questions	Utilization	Infected	Uninfected	Total	Utilization Rate (%)	Seroprevalence (%)	*P*-value
All		62	2,322	2,384		2.60	
Do you wear gloves when you work? *	Yes	17	895	912	38.26	1.86	0.075
	No	45	1,427	1,472		3.06	
Do you wear a facemask when you work? *	Yes	17	741	758	31.80	2.24	0.453
	No	45	1,581	1,626		2.77	
Do you wear boots when you work? *	Yes	14	749	763	32.01	1.83	0.107
	No	48	1,573	1,621		2.96	
Do you wear overalls when you work? *	Yes	13	723	736	30.87	1.77	0.087
	No	49	1,599	1,648		2.97	
Protection †	Yes	9	471	480	20.13	1.88	0.264
	No	53	1,851	1,904		2.78	

* The "yes" means who answered "often" or "occasionally".

† The "yes" means who answered "often" or "occasionally" in all four aspects.

DISCUSSION

Since the 1990s, the incidence of brucellosis has been increasing and reaching a peak in 2014 and ranked among the top 10 Class A and Class B infectious diseases from 2008 to 2018 (*4*). The research group conducted a cross-sectional study in four counties in two provincial-level administrative divisions (PLADs) to acquire the awareness rate of brucellosis knowledge and utilization rate of PPE. This study showed evidence that awareness of brucellosis and utilization of PPE was insufficient. Since people who answered all awareness questions correctly were regarded as aware, the crude awareness rate of brucellosis knowledge was significantly lower than that of other studies (*7*). Most of the high-risk populations had heard of brucellosis. Nevertheless, most people did not know the animal hosts of brucellosis. The utilization of PPE was low with only about one-third of people in protection. Improving awareness of brucellosis knowledge and utilization of PPE are still vital to reduce the infection rate of brucellosis, but the methods may need to be improved through further research onto changing behaviors. According to other research, education level and household income were negatively correlated with brucellosis awareness, and elderly populations had lower brucellosis awareness than younger populations (*8*–*9*). Health education that focuses on high-risk and historically high prevalence PLADs need to be strengthened. The utilization of PPE needs to be further promoted. Different districts should communicate and exchange practical prevention and control experiences.

This study was subject to some limitations. First, there was a possibility of recall bias because of the retrospective nature of the questionnaire survey method. Second, due to the influence of COVID-19, China CDC only conducted project training but did not carry out field quality control. The quality of the questionnaires was limited by the inability of the team to hand-check every survey while in the field.

In summary, the results indicated that the awareness rate of brucellosis knowledge and the utilization rate of PPE were low in brucellosis-endemic areas in China. The goals set in the NBPCP are still far from being achieved. More effective health education should be carried out for high-risk populations to improve their knowledge of brucellosis and protection to reduce their risk of infection.

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Conflicts of interest: The authors who have taken part in this study declared that they did not have any other potential conflicts of interest.

Ethical approval and consent to participate: The study design obtained ethical approval following a review by China CDC Institutional Review Board.

Written informed consent has been obtained from the patients in accordance with the Declaration of Helsinki. The research group confirmed that the identification information of all participants (including patient names, ID numbers, home addresses and telephone numbers) would not be included in recordings, written descriptions or publications.

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Preplanned Studies

Evaluation of the Integrated Information System for Brucellosis Case Diagnosis and Management — Inner Mongolia Autonomous Region, China, 2019

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Summary

What is already known about this topic?

Wulanchabu City Center for Endemic Disease Prevention and Control had established and used a Brucellosis Integrated Information System (BIIS) since 2013. However, it had not been systematically evaluated and promoted so far.

What is added by this report?

The BIIS had significantly improved the efficiency of brucellosis reporting and provided convenience for follow-up management of cases, which was valuable for finishing completely routine therapy. However, the stability of the system needs to be improved.

What are the implications for public health practice?

The results of the BIIS assessment demonstrated its advantages and disadvantages, which could provide some evidence for its implementation in other areas of China.

Efficient surveillance information systems are essential for the prevention and control of infectious diseases. Wulanchabu City Center for Endemic Disease Prevention and Control (WCEDC) established the Brucellosis Integrated Information System (BIIS) in 2013 to make case diagnosis, treatment, and management more effective and reduce the workload of clinicians for inputting data. This was the first time an integrated information system management for brucellosis diagnosis, treatment, and follow-up was developed and implemented. However, the system had not been systematically evaluated and promoted so far. The aim of this study was to evaluate the BIIS using the framework and index of surveillance information system evaluation issued by World Health Organization (WHO). The results indicated that the implementation of the BIIS had significantly improved the efficiency of brucellosis reporting and follow-up management. However, the stability and completeness of the BIIS needs to be further improved. The study demonstrated the pros and cons of this BIIS that could provide evidence for further improvements.

Brucellosis is an infectious-allergic zoonosis caused by *Brucella* bacteria (*1*). Brucellosis incidence has been increasing over the past decade with a peak in 2014, especially in the northern China, such as Inner Mongolia, Shanxi, Xinjiang, etc. (*2*). The surveillance system of brucellosis now primarily consists of National Notifiable Disease Report System (NNDRS) and active surveillance based on the National Brucellosis Surveillance Work Program (NBSWP) in 19 key endemic areas (*3–4*). The data collecting primarily relied on manual input by medical staff in hospitals or local CDCs, and an effective information network with the Hospital Information System (HIS) or Laboratory Information System (LIS) had not been established. WCEDC was the main medical institute, responsible for local brucellosis case diagnosis and treatment with about 5,000 cases reported per year in Wulanchabu City, Inner Mongolia. The BIIS has been developed and put into use in WCEDC since 2013, which integrated the data of every patient in the HIS and LIS and made the case follow-up management more efficient (Figure 1). The WHO proposed that the surveillance information system needed to be evaluated comprehensively on a regular basis (*5*). Therefore, this study aimed to evaluate the BIIS by using the framework and index of surveillance information system evaluation released by WHO to detect the pros and cons of the system and provide evidence for further improvement.

The project was carried out in WCEDC and the data was collected and reported to the BIIS and the NNDRS from March 18 to December 18, 2019. The promptness of reporting was analyzed by comparing the time interval between case diagnosis and reporting in 2019 and that in 2016–2018, and promptness was

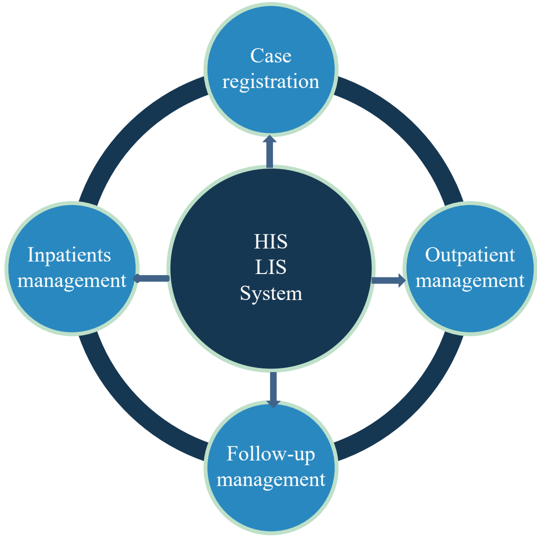

FIGURE 1. Function chart of Brucellosis Integrated Information System in Wulanchabu City Center for Endemic Disease Prevention and Control in 2019.
Abbreviations: HIS=Hospital information system; LIS= Laboratory information system.

defined as the interval being less than 24 hours. It was also assessed by comparing cases reported from WCEDC using BIIS with the other nearby institutes, including Tongliao City Center for Endemic Disease Prevention and Control (TCEDC) and Wulanchabu Central Hospital (WCH), both reporting cases without BIIS during the same period. Completeness and accuracy were tested by 12 indicators in the case records. Usefulness was defined as BIIS assisting with the diagnosis, treatment, and management of brucellosis. To evaluate the usefulness of BIIS, it was necessary to evaluate the function of BIIS to determine whether it could meet the actual needs of brucellosis management. The attribute indexes involving simplicity, stability, and acceptability was assessed through a questionnaire, and all the medical staff who operated the BIIS in WCEDC were interviewed at the end of the evaluation project.

The original data from the BIIS and NNDRS was sorted using Microsoft Excel software (version 2010, Microsoft Office, CA, USA) and analyzed usingIBM SPSS Statistics 22.0 (IBM Corp; Armonk NY, USA). Wilcoxon Rank Sum Test was used to compare the medians of the interval between diagnosis and reporting, and chi-squared test was used to compare the promptness proportion. *P*-value less than 0.05 was considered as statistically significant.

A total of 342 cases were reported in 2019 with a promptness rate of 100% in WCEDC, whereas 210 cases were reported during the same period in 2016–2018 with a promptness rate of 99.05%. The maximum, median, and minimum values of the interval between case diagnosis and reporting in 2019 were 83.36%, 50.00%, and 63.29% less than that in 2016–2018, respectively (Table 1). The comparison analysis of the promptness rate of brucellosis reported in WCEDC, TCEDC, and WCH showed that the median of interval in WCEDC (1.15 h) was significantly lower than that in WCH (17.12 h) and TCEDC (5.17 h). The proportion of cases reported within 2 hours by WCEDC was 69.30%, whereas that by WCH and TCEDC were 33.33% and 1.88%, respectively. The implementation of BIIS had significantly improved the efficiency of brucellosis reporting (Table 2).

The results showed that the completeness rate of NNDRS in BIIS was 100% (1,345/1,345), and the accuracy rate was 98.36% (1,323/1,345). However, the completeness rate of the NBSWP in the BIIS was only 33.90% (456/1,345) and accuracy rate was 99.56% (454/456).

Overall, 90.91% (20/22) of local medical staff in WCEDC participated in the questionnaire survey;

TABLE 1. Promptness of brucellosis reporting during 2019 and during 2016–2018 in Wulanchabu City Center for Endemic Disease Prevention and Control.

Time interval from diagnosis to reporting	2019 (N=342)	Average of 2016–2018 (N=210)	Change (%)
Median (h)	1.15	2.30	−50.00
IQR (h)	4.39	0.85	416.47
Minimum (h)	0.29	0.79	−63.29
Maximum (h)	7.42	44.59	−83.36
<2 h	237 (69.30%*)	108 (51.43%)	34.75†
2–24 h	105 (30.70%)	100 (47.62%)	−35.53†
≥24 h	0 (0%)	2 (0.95%)	−100.00†

Abbreviation: IQR=Inter quartile rang.
* The value in the bracket means the correspondent proportion.
† The percentage of changes for the correspondent proportion.

TABLE 2. Promptness of brucellosis reporting during the projects of WCEDC, WCH, and TCEDC in 2019.

Time interval from diagnosis to reporting	WCEDC (N=342)	WCH (N=333)	TCEDC (N=1,062)	*P*
Median (h)	1.15	17.12	5.17	<0.01†
IQR (h)	4.39	16.88	0.62	
Minimum (h)	0.29	0.20	1.15	
Maximum (h)	7.42	22.23	29.27	
<2 h	237 (69.30%*)	111 (33.33%)	20 (1.88%)	<0.01
2–24 h	105 (30.70%)	222 (66.67%)	1,041 (98.03%)	<0.01
≥24 h	0 (0%)	0 (0%)	1 (0.09%)	

Abbreviations: WCEDC=Wulanchabu City Center for Endemic Disease Prevention and Control; TCEDC=Tongliao City Center for Endemic Disease Prevention and Control; WCH=Wulanchabu Central Hospital.

* The value in the bracket means the correspondent proportion.

† The difference statistically significant.

100% (20/20) thought that the BIIS was easy to use while 35% (7/20) thought it was unstable. All medical staff were willing to use it in future works.

DISCUSSION

This study was the first to evaluate the BIIS. The implementation of BIIS had significantly shortened the delays of brucellosis reporting; made the case diagnosis, treatment, and management more effective; and reduced the workload of data input. It was an effective information connection hub with the HIS and LIS.

The stability of BIIS needs to be further improved. The main reason for the instability of the system was that after the BIIS was connected with the HIS and LIS, the heterogeneous systems were complex and the compatibility was insufficient, which was a problem encountered by most connected hospitals (*5–6*). It was also necessary to upgrade the integration of the BIIS with HIS and LIS to clearly monitor the process of exchange among the systems (*7*). Meanwhile, the completeness of BIIS also needs to be improved, which was primarily affected by the lack of epidemiological exposure history of patients. That is, medical staff focused more on diagnosis and treatment according to the clinical symptoms and laboratory results of patients but paid no attention to the epidemiological characteristics. In order to improve the completeness of the system, patient epidemiological history should be set as mandatory check.

This study has subject to some limitations. The BIIS currently only is applied by one hospital in WCEDC. There was needed for more medical institution and for further evaluation of the system.

In summary, the BIIS was evaluated for the first time and demonstrated its advantages and disadvantages, which could provide some evidence for further improvement of the system. The results of the BIIS assessment gave us certain understandings for the future application in other districts in China.

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Conflicts of interest: The authors who have taken part in this study declared that they did not have any other potential conflicts of interest.

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Ethical Approval and consent to participate: The ethics committee approved the study. Written informed consent has been obtained from the patients in accordance with the Declaration of Helsinki. We confirmed that the identification information of all participants (including patient names, ID numbers, home addresses and telephone numbers) would not be included in recordings, written descriptions or publications.

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Vital Surveillances

Epidemiological Characteristics of Human Brucellosis — China, 2016–2019

Zhongfa Tao[1,2,3]; Qiulan Chen[1,#]; Yishan Chen[1,4]; Yu Li[1]; Di Mu[1]; Huimin Yang[1]; Wenwu Yin[1]

ABSTRACT

Introduction: Brucellosis is an important zoonotic infectious disease with its main mode of transmission from livestock to humans. The study analyzed epidemiological characteristics of human brucellosis from 2016 to 2019 in China, aiming to understand progress of the National Program of Brucellosis Prevention and Control.

Methods: The research obtained data on human brucellosis cases reported through China's National Notifiable Disease Reporting System (NNDRS) from January 1, 2016 to December 31, 2019 and described brucellosis epidemiological patterns by region, seasonality, age, sex, and occupation.

Results: The number of cases reported nationwide in China decreased from 47,139 (3.4/100,000) in 2016 to 37,947 (2.7/100,000) in 2018, and then increased to 44,036 (3.2/100,000) in 2019, with an average annual incidence of 3.0/100,000 during the four study years. Brucellosis in Xinjiang declined from 35.6/100,000 in 2016 to 16.3/100,000 in 2019 — an average annual decrease of 22.9%. Brucellosis in Inner Mongolia increased from 23.8/100,000 in 2016 to 54.4/100,000 in 2019 — an average increase of 31.8% per year and accounting for 22% of all reported cases. Northern China reported 95.2% of cases during this period and still had an incidence of 7.2/100,000 and 87.0% of counties being affected by brucellosis in 2019. In this region in 2019, males aged 45-64 years old had an incidence of over 15.9/100,000, compared with over 7.0/100,000 among females aged 45-64 years old.

Conclusions: Although there was progress in prevention and control of human brucellosis in some provincial-level administrative divisions (PLADs) in 2016 through 2019, progress was limited nationwide and there was an overall resurgence of brucellosis in 2019. The resurgence was primarily in Inner Mongolia. An One Health approach should be strengthened to ensure successful and sustainable brucellosis prevention and control in China.

INTRODUCTIONS

Brucellosis is a zoonotic disease caused by various *Brucella* species (*1*). Humans are infected most often though contact with sick animals, especially goats, sheep, and cattle, and through consumption of contaminated milk and milk products such as fresh cheese (*1*–*2*). In China, the main mode of transmission is contact with sick livestock such as sheep, goats, and cattle (*3*). Clinical features during the acute phase of human brucellosis are fever, hyperhidrosis, fatigue, and joint and muscle pain. If timely and effective treatment is not available during the acute phase, the infection can become chronic, which causes great suffering (*4*–*5*).

More than 170 countries and regions in the world have reported human and animal brucellosis (*6*). In the 1950s, brucellosis was widespread in China, with infection rates of human and animal brucellosis as high as 50% in severely affected areas. Following strengthened prevention and control measures based on the One Health approach, the brucellosis epidemic declined (*7*). However, at the beginning of the 21st century, human brucellosis had a resurgence in China, with sharply increasing incidences and widely expanded affected areas in the north and the south (*8*–*9*). In 2014 and 2015, the number of reported cases exceeded 50,000 per year, and the annual incidence rates were 4.22/100,000 and 4.18/100,000, which were historically high levels (*8*,*10*). To prevent and control human brucellosis, China's Ministry of Agriculture and the National Commission of Health and Family Planning in 2016 co-issued a National Brucellosis Prevention and Control Plan (2016–2020) (*11*). The study analyzed the epidemiological characteristics of human brucellosis from 2016 to 2019 in China to evaluate progress of the national plan.

METHODS

The study obtained data on human brucellosis cases reported through China's National Notifiable Disease Reporting System (NNDRS) from January 1, 2016 to December 31, 2019. NNDRS is an Internet-based national passive surveillance system that covers all township health centers and all levels of hospitals across the country. The research compared numbers of annual cases and incidences by region, age, gender, and occupation. This study evaluated the time trend of human brucellosis of all the provincial-level administrative divisions (PLADs) with average annual growth of annual incidence. The average annual growth rate of annual incidence from 2016 to 2019 was defined as: $\sqrt[3]{\frac{annual\ incidence\ in\ 2019}{annual\ incidence\ in\ 2016}} - 1) \times 100\%$. The research compared the number and percent of affected counties, number of reported cases, incidence, and median number of cases at the county level between southern and northern China. Southern PLADs including Jiangsu, Shanghai, Zhejiang, Anhui, Hunan, Hubei, Sichuan, Chongqing, Guizhou, Yunnan, Guangxi, Guangdong, Hainan, Fujian, and Jiangxi; northern PLADs included Heilongjiang, Jilin, Liaoning, Beijing, Tianjin, Inner Mongolia, Shaanxi, Hebei, Henan, Ningxia, Shanxi, Shandong, Gansu, Qinghai, Xinjiang, and Tibet. All statistical analyses were performed using SAS (version 9.4, SAS Institute Inc., Cary, USA) and the figures was drawn using Microsoft Excel (version 2007).

RESULTS

From 2016 to 2019, a total of 167,676 cases of human brucellosis was reported to NNDRS in the mainland of China, for an average annual incidence of 3.02/100,000 population. The annual number of cases reported nationwide was 47,139 (3.43/100,000) in 2016 and decreased to 38,554 (2.79/100,000) in 2017 and 37,947 (2.73/100,000) in 2018. Reported cases increased to 44,036 (3.15/100,000) in 2019. The peak season for human infections (by date of illness onset) was from March to August, accounting for 64.5% of cases in 2016–2019. The north and south had similar seasonal distributions (Figure 1).

Human brucellosis was reported in all 31 PLADs of the mainland of China; 95.2% (159,667) were reported from northern PLADs. Inner Mongolia reported the most cases (36,805 cases; 22.0% of all reports) and had an average annual incidence of

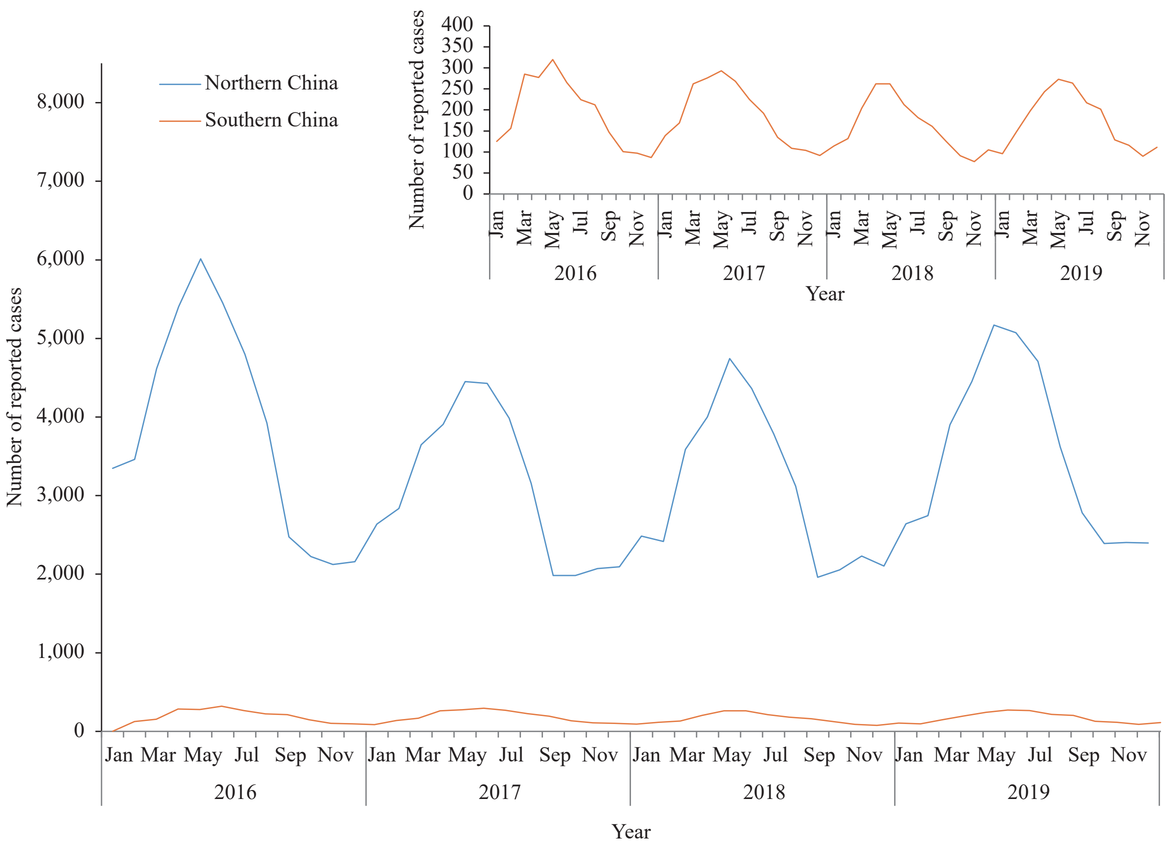

FIGURE 1. Monthly distribution of human brucellosis in northern and southern China, 2016–2019.

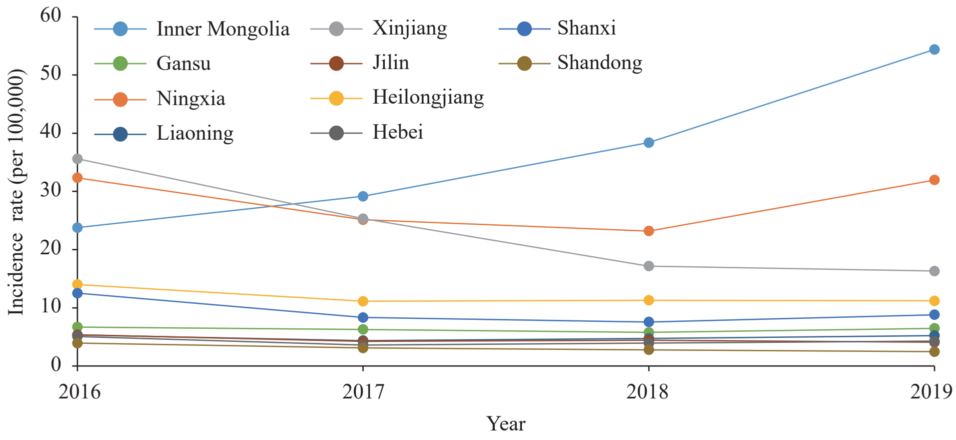

FIGURE 2. Human brucellosis in the ten provincial-level administrative divisions (PLADs) with the highest incidence rate of cases reported from 2016 to 2019.

36.5/100,000. The other 10 PLADs with the highest number of cases were located in northern PLADs — Ningxia, Heilongjiang, Shanxi, Gansu, Liaoning, Jilin, Hebei, Henan, and Shandong (Figure 2), with average annual incidences ranging from 3.1/100,000 to 28.2/100,000. The incidence of human brucellosis was less than 1.0/100,000 in all southern PLADs; in Shanghai, the incidence was less than 0.1/100,000.

High-burden PLADs differed in annual incidence patterns (Figure 2). Inner Mongolia had an upward trend with an annual incidence increasing from 23.8/100,000 in 2016 to 54.4/100,000 in 2019 — an average annual increase of 31.8%. Ningxia, Shanxi, Gansu, Shaanxi, Liaoning, and Hebei's annual incidences declined and then increased. In Ningxia, brucellosis increased more than 8/100,000 from 2018 to 2019. In Heilongjiang, Jilin, and Henan, incidences declined in 2017 and remained relatively stable in 2018 and 2019. Xinjiang's annual incidence decreased from 35.6/100,000 in 2016 to 16.3/100,000 in 2019 — an average annual decrease of 22.9% (Figure 2, Supplementary Table S1 available in http://weekly.chinacdc.cn/). Several provinces in southern China had significant annual increases in incidence, including Hainan (39.7%), Fujian (23.8%), Anhui (19.2%), and Hunan (7.5%) (Supplementary Table S1).

The percent of counties affected by brucellosis increased from 63.7% in 2016 to 65.9% in 2017 and decreased to 64.3% in 2019. Most affected counties were in northern PLADs. The percent of affected counties in southern PLADs increased from 40.4% in 2016 to 41.2% in 2019. The annual incidence of human brucellosis varied by county, with median incidences (interquartile range [IQR]) of 2.0 (0.5, 7.3)/100,000 in 2016 and 1.7 (0.5, 5.7)/100,000 in 2019. Counties in northern PLADs had higher median incidences than counties in southern PLADs: 4.4 (IQR: 1.6, 13.1)/100,000 *vs.* 0.4 (0.2, 0.7)/100,000 in 2016, and 3.4 (1.4, 10.9)/100,000 *vs.* 0.3 (0.2, 0.6)/100,000 in 2019. The 10 counties with the highest average annual incidence had incidences ranging from 124.5/100,000 to 265.0/100,000; among these, 6 were in Inner Mongolia, 3 in Xinjiang, and 1 in Ningxia. In 2019, the median of cases reported by county was 7 and was higher in northern China than in southern China (13 *vs.* 2) (Table 1, Supplementary Table S2 available in http://weekly.chinacdc.cn/).

Farming and herding were the most common occupations of reported cases, accounting for 83.8% of reports. Houseworkers and unemployed individuals, students, and migrating individuals and kindergarten children accounted for 4.5%, 1.9%, and 1.1% of cases, respectively. The incidence among males was higher than that among females in all age groups and in the south and north, except for those aged 0–4 years and 5–9 (Figure 3 and Supplementary Table S3 available in http://weekly.chinacdc.cn/). People aged 45-64 years old had higher risk of infection than younger people. Those aged 45-64 years old had an incidence over 15.9/100,000 in the north in 2019, compared with over 7.0/100,000 among females (Figure 3 and Supplementary Table S3).

DISCUSSION

Our study found that human brucellosis had a resurgence in 2019 in China, although the overall epidemic level was nearly 30% lower in 2019 than in the peak year of 2014. Inner Mongolia had a rapid

TABLE 1. Comparison of human brucellosis between northern and southern China PLADs by numbers of affected counties and incidence (1/100,000), 2016–2019.

Year	Region	Affected counties		Incidence* (per 100,000)
		Number	Percentage (%)	
2016	South	591	40.4 (591/1,463)	0.3
	North	1,286	86.8 (1,286/1,482)	7.8
	Total	1,877	63.7 (1,877/2,945)	3.4
2017	South	657	44.9 (657/1,462)	0.3
	North	1,286	86.6 (1,286/1,485)	6.3
	Total	1,943	65.9 (1,943/2,947)	2.8
2018	South	597	40.9 (597/1,461)	0.2
	North	1,298	87.3 (1,298/1,487)	6.2
	Total	1,895	64.3 (1,895/2,948)	2.7
2019	South	603	41.2 (603/1,462)	0.2
	North	1,294	87.0 (1,294/1,488)	7.2
	Total	1,897	64.3 (1,897/2,950)	3.2

* Incidence was calculated as the total number of cases in each region divided by the total population in the same region.

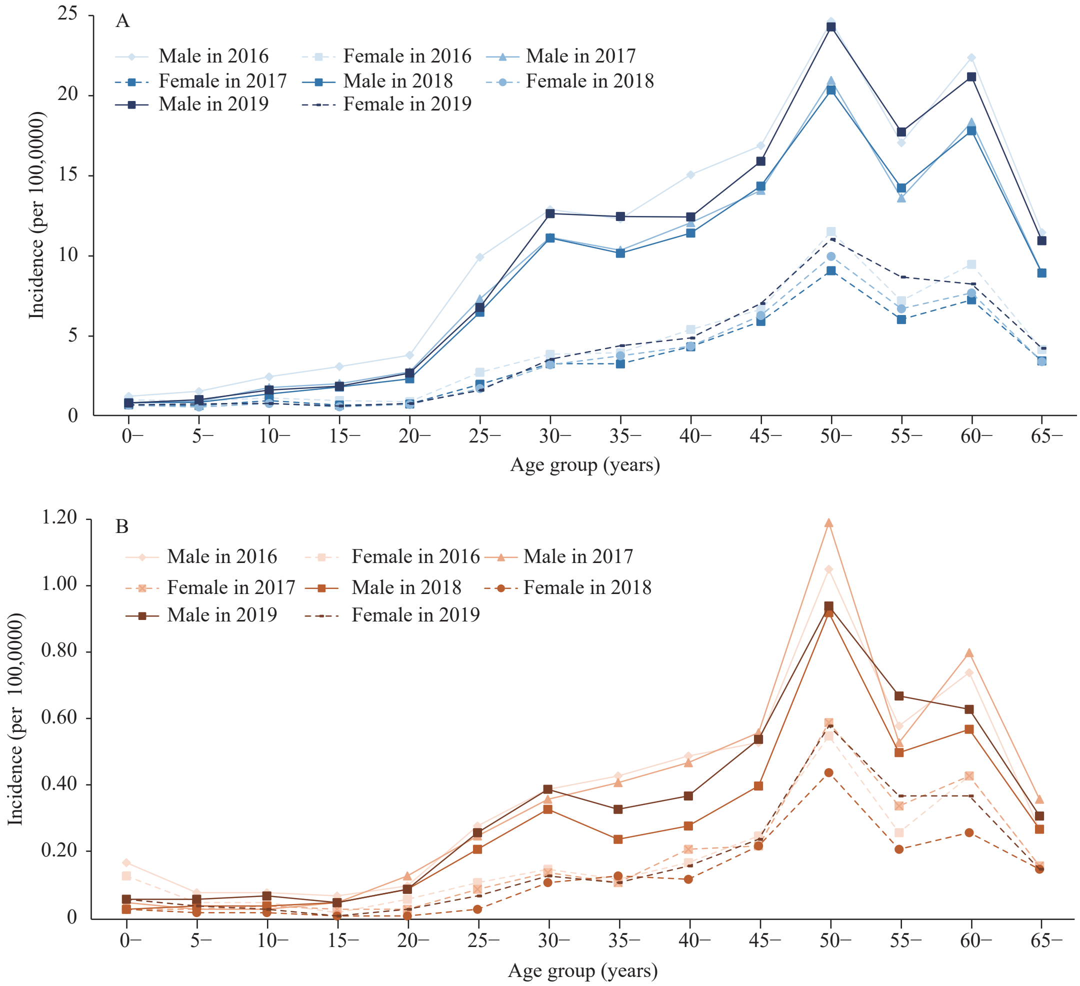

FIGURE 3. Age and sex distribution of annual incidence (1/100,000) of human brucellosis by north and south from 2016 to 2019 in China. (A) Age and sex distribution of human brucellosis in northern China, 2016−2019. (B) Age and sex distribution of human brucellosis in southern China, 2016−2019.

increase that started in 2017, and its surrounding provinces experienced a subsequent resurgence. Northern China reported the vast majority of cases and had a much higher incidence than did southern China. Older male farmers and herders were the highest risk populations.

According to the National Brucellosis Prevention and Control Plan (2016–2020), the targets of brucellosis control by the end of 2020 include: 1) counties in 11 PLADs including Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, should have reached and maintained control standards (an indicator is that new human cases decrease compare with the previous year); 2) counties in Hainan Province should have reached the elimination standard (an indicator is that there should be no new confirmed human cases for 3 consecutive years); and 3) counties in the other PLADs should have reached near-elimination standard (an indicator is that there were no new confirmed human cases for 2 consecutive years). Our study showed that in 2019, all PLADs in the mainland of China, including Hainan, still had reported human brucellosis cases, and that nearly 90% of northern counties and more than 40% of southern counties were affected. We found that the national program had limited progress and did not achieve these objectives by the end of 2019.

Animal brucellosis control is the most effective strategy for human brucellosis control (*1*). In addition to health education, early detection, and proper treatment for high-risk populations, the national program required highly endemic areas to implement a mass animal vaccination strategy and used a "quarantine-vaccination-slaughter" policy in the less-affected areas (i.e. to vaccinate the negatives and safely slaughter the animals testing positive based on quarantine results). Some areas succeeded, with Xinjiang as a good example. As one of the endemic regions in China, Xinjiang implemented a mass animal vaccination campaign against brucellosis starting in 2016 (*12*) and has seen a dramatical decrease in the incidence of human brucellosis. A study in Hami Prefecture of Xinjiang showed that the brucellosis infection rate among local cattle and sheep dropped significantly from 2017 to 2019 (*13*).

There are several possible reasons for the increasing incidence in Inner Mongolia and the subsequent rebound in the surrounding provinces. First, the market price of beef and lamb has been rising since 2016 and the number of people engaged in breeding, purchasing, selling, and trading has increased. Second, the movement of livestock increased with the growing demand and has led to spread of brucellosis via sick animals due to the lack of proper quarantine and inspection. For example, a genotype study showed that *Brucella* strains in Inner Mongolia were related to those in neighboring provinces (*14*). Third, the investment of resources for controlling brucellosis might have been reduced, and activities based on One Health principles decreased after consecutive declines in previous years — a possible reason based on impressions during field visits to endemic areas.

Northern China had a more severe epidemic, which is consistent with previous studies (*8–9*). This may be because husbandry of goats, sheep, and cattle is more common in rural areas in northern China. The main pastoral areas and the historically epidemic zone of brucellosis are both located in northern China. Although the southern PLADs had a small proportion of cases, the affected areas in the south expanded and some had rapid increases in incidence. This expansion may be related to trading and movement of livestock from north to south, which is a phenomenon deserving more attention.

The incidence of brucellosis has clear seasonal characteristics with peaks in the late spring and summer, which was consistent with previous studies (*8–9*). Farmers and herders remain high-risk occupations. Continuous effort is needed to promote proper use of personal protection equipment to prevent infection. The incidence among males was higher than among females, which was also found in previous research (*8–10*,*15*), but the incidence of males under 10 years of age was similar to the incidence of same-age females. This may represent lower exposure risk of brucellosis in children under 10 years old, while older-age men are more likely to have occupational exposures through breeding livestock.

Our study has limitations. The data were obtained from NNDRS and may be impacted by the case finding ability of different areas. Our incidence estimates may underestimate the true incidence of brucellosis, as it is a globally underreported disease due to its typical symptoms and signs at the early stage. However, surveillance data can still reflect trends of the epidemic, something that is supported by the stability and even quality of NNDRS in China. NNDRS has the highest quality and most complete data that are currently available for evaluation of the epidemiological characteristics and progress towards national program goals.

In conclusion, from 2016 to 2019, although human brucellosis prevention and control showed progress in some PLADs, progress was limited nationwide and brucellosis had a resurgence in 2019. The resurgence was most prominent in Inner Mongolia. An One Health approach should be strengthened to ensure successful and sustainable brucellosis prevention and control in China. Health education campaigns should be focus on middle- and older-age groups of farmers and herders in northern China.

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SUPPLEMENTARY TABLE S1. The annual incidence (1/100,000) and average annual growth rate of human brucellosis by provincial-level administrative divisions (PLADs) in the mainland of China from 2016 to 2019.

PLADs	2016	2017	2018	2019	Average annual incidence	Average annual growth rate (%)
North						
Inner Mongolia	23.78	29.15	38.39	54.38	36.46	31.76
Ningxia	32.34	25.13	23.19	31.96	28.15	−0.39
Xinjiang	35.60	25.33	17.17	16.32	23.46	−22.89
Heilongjiang	14.01	11.14	11.30	11.21	11.92	−7.17
Shanxi	12.52	8.34	7.56	8.82	9.30	−11.02
Gansu	6.71	6.29	5.77	6.49	6.32	−1.13
Liaoning	5.34	4.37	4.73	5.24	4.92	−0.61
Jilin	5.38	4.24	4.44	4.09	4.54	−8.71
Hebei	5.08	3.61	3.93	4.28	4.22	−5.55
Shandong	3.95	3.11	2.79	2.47	3.07	−14.49
Henan	4.21	2.57	2.11	2.30	2.79	−18.23
Shaanxi	2.50	1.92	1.74	2.85	2.25	4.43
Qinghai	0.25	0.40	1.27	2.12	1.02	102.67
Tianjin	1.18	0.95	0.80	0.85	0.94	−10.40
Tibet	0.31	0.54	0.68	1.45	0.76	67.61
Beijing	0.88	0.70	0.57	0.40	0.64	−23.30
South						
Yunnan	0.59	0.46	0.49	0.64	0.55	2.57
Guangxi	0.60	0.40	0.28	0.31	0.40	−19.90
Guangdong	0.35	0.35	0.37	0.38	0.36	3.14
Hubei	0.45	0.40	0.19	0.12	0.29	−35.17
Hunan	0.24	0.26	0.26	0.30	0.26	7.52
Fujian	0.20	0.24	0.24	0.37	0.26	23.77
Anhui	0.13	0.24	0.24	0.22	0.20	19.20
Guizhou	0.32	0.29	0.13	0.07	0.20	−39.93
Zhejiang	0.17	0.26	0.19	0.19	0.20	3.90
Jiangsu	0.18	0.23	0.20	0.17	0.20	−1.24
Jiangxi	0.14	0.16	0.20	0.13	0.16	−2.67
Hainan	0.05	0.32	0.06	0.15	0.14	39.74
Chongqing	0.14	0.14	0.07	0.15	0.13	0.60
Sichuan	0.14	0.09	0.08	0.14	0.11	0.05
Shanghai	0.05	0.02	0.03	0.01	0.03	−44.93

SUPPLEMENTARY TABLE S2. Comparison of human brucellosis between northern and southern China by reported cases at regional and county level, 2016–2019.

Year	Region	Reported cases		Median (IQR) at county level	
		No	Percentage (%)	Case number	Incidence rate
2016	South	2,115	4.5	2 (1, 4)	0.4 (0.2, 0.7)
	North	45,024	95.5	16 (6, 40)	4.4 (1.6, 13.1)
	Total	47,139	100.0	8 (2, 26)	2.0 (0.5, 7.3)
2017	South	2,110	5.5	2 (1, 4)	0.4 (0.2, 0.7)
	North	36,444	94.5	13 (5, 32)	3.4 (1.3, 10.3)
	Total	38,554	100.0	6 (2, 20)	1.6 (0.5, 5.3)
2018	South	1,818	4.8	2 (1, 3)	0.3 (0.2, 0.6)
	North	36,129	95.2	12 (5, 28)	3.2 (1.3, 9.5)
	Total	37,947	100.0	6 (2, 20)	1.6 (0.5, 5.4)
2019	South	1,966	4.5	2 (1, 4)	0.3 (0.2, 0.6)
	North	42,070	95.5	13 (5, 33)	3.4 (1.4, 10.9)
	Total	44,036	100.0	7 (2, 20)	1.7 (0.5, 5.7)

Abbreviation: IQR=Interquartile range.

SUPPLEMENTARY TABLE S3. Age and sex distribution of annual incidence (1/100,000) of human brucellosis by north and south from 2016 to 2019 in China.

Age group (years)	2016				2017				2018				2019			
	Male		Female		Male		Female		Male		Female		Male		Female	
	North	South	North	South	North	South	North	South	North	South	North	South	North	South	North	South
0–	1.20	0.17	0.98	0.13	0.80	0.05	0.67	0.03	0.80	0.03	0.64	0.03	0.78	0.06	0.66	0.06
5–	1.51	0.08	0.91	0.05	0.88	0.03	0.62	0.03	0.82	0.04	0.53	0.02	0.99	0.06	0.72	0.04
10–	2.42	0.08	1.09	0.05	1.74	0.03	0.93	0.04	1.35	0.04	0.75	0.02	1.59	0.07	0.75	0.03
15–	3.06	0.07	0.93	0.02	1.99	0.05	0.65	0.03	1.78	0.05	0.54	0.01	1.83	0.05	0.59	0.01
20–	3.77	0.10	0.86	0.06	2.73	0.13	0.72	0.03	2.29	0.09	0.69	0.01	2.65	0.09	0.75	0.03
25–	9.89	0.28	2.70	0.11	7.28	0.25	1.95	0.09	6.45	0.21	1.68	0.03	6.75	0.26	1.57	0.07
30–	12.87	0.39	3.82	0.15	11.13	0.36	3.24	0.14	11.09	0.33	3.17	0.11	12.62	0.39	3.51	0.13
35–	12.29	0.43	3.92	0.12	10.33	0.41	3.23	0.11	10.14	0.24	3.73	0.13	12.44	0.33	4.36	0.11
40–	15.05	0.49	5.37	0.17	12.05	0.47	4.30	0.21	11.40	0.28	4.33	0.12	12.41	0.37	4.84	0.16
45–	16.87	0.53	6.63	0.25	14.07	0.56	5.88	0.22	14.34	0.40	6.25	0.22	15.89	0.54	7.00	0.24
50–	24.64	1.05	11.5	0.55	20.95	1.19	9.05	0.59	20.34	0.92	9.94	0.44	24.29	0.94	11.01	0.58
55–	17.05	0.58	7.17	0.26	13.60	0.53	6.00	0.34	14.22	0.50	6.67	0.21	17.72	0.67	8.65	0.37
60–	22.37	0.74	9.45	0.43	18.34	0.80	7.23	0.43	17.80	0.57	7.66	0.26	21.17	0.63	8.22	0.37
65–	11.44	0.27	4.12	0.16	8.93	0.36	3.41	0.16	8.90	0.27	3.36	0.15	10.92	0.31	4.20	0.15

Commentary

Human Brucellosis: An Ongoing Global Health Challenge

Shengjie Lai[1,#]; Qiulan Chen[2]; Zhongjie Li[2]

Brucellosis is one of the most common zoonotic diseases, caused by species of the genus *Brucella*, that affects domestic and farm livestock and a wide range of wild mammals (*1–2*). Endemic areas are primarily located in the low- and middle-income countries across the Mediterranean region, the Arabian Peninsula, Africa, Asia, and Central and South America, with major regional differences (*3–5*). The highest prevalence in animals was observed in countries of the Middle East and sub-Saharan Africa, China, India, Peru, and Mexico (*3*,*6–7*). Only a few countries in the world are free from the infectious agent and are mainly in developed regions in Western and Northern Europe, Canada, Japan, Australia, and New Zealand (*1*).

The human brucellosis, also known as undulant fever or Malta fever, was first recognized in Malta during the 1850s. The infection in humans is primarily caused by direct contact with infected cattle (*Brucella abortus*), sheep and goats (*B. melitensis*), pigs (*B. suis*), dogs (*B. canis*), or by ingesting unpasteurized and contaminated animal products. *B. melitensis* is the most common cause of reported human brucellosis cases and the most severe form of the disease (*4*). Human infections caused by inhaling airborne agents were also reported (*8*). In addition, because brucellosis is one of the most common laboratory-acquired infections, strict safety precautions should be followed when handling cultures and infected samples.

Human brucellosis affects humans of all ages and sex and typically manifests as a variety of symptoms and signs including intermittent or irregular fever, headache, weakness, profuse sweating, chills, weight loss, and general aching. These non-specific clinical manifestations make it difficult to distinguish from other febrile conditions. However, if the disease is not diagnosed properly and treated promptly, it may become chronic and persist for years, leading to complications such as osteoarticular, hepatobiliary, cardiovascular, and central nervous system diseases (*9*). In addition, the disease is regarded as an important occupational hazard to livestock workers. Veterinarians, farmers, and slaughterhouse workers are vulnerable as they handle infected animals and aborted fetuses or placentae.

Human brucellosis has been greatly controlled in many countries, and its epidemiological features have changed drastically over the past few decades due to the various improvements in sanitary conditions, socioeconomic development, political reasons, and the increasing domestic and international human mobility (*4–6*,*10*). However, considering the large number of cases reported across the world each year and its serious health consequences and socioeconomic impacts, human brucellosis remains a global public health challenge, especially in regions where animal infections are common.

Fox example, brucellosis is considered endemic in most Middle Eastern countries with a high number of human cases reported in Yemen, Iran, Syria, Turkey, and Saudi Arabia in recent years (*6*,*11*). The highest annual incidence rate was recorded in Yemen (88.6 cases/100,000 person-years), Syria (40.6/100,000), and Iran (18.6/100,000) in 2014–2017 (*6*). McDermott JJ et al. (*2*) found a high average prevalence (11%) among high-risk human populations in Africa and Asia, such as veterinarians, livestock handlers, and slaughterhouse workers, suggesting that brucellosis is an ongoing epidemic in African and Asian continents. Data on incidence of brucellosis are often underreported because the surveillance system relies on passive reports that collect information from hospitals and diagnostic laboratories, especially in areas with low capacities of healthcare and diagnosis. Therefore, the real burden of human brucellosis in low-income countries may be far greater than figures reported.

However, human brucellosis is also reported in some high-income countries where brucellosis has been eliminated or transmitted at a relative low level. For instance, 381 confirmed cases of brucellosis were reported by 28 European Union countries in 2017 with an overall rate of 0.09 cases/100,000 person-years (*12*). Greece, Italy, and Spain reported the highest numbers of confirmed cases, accounting for 67.2% of all cases. Greece had reported the highest incidence rate, followed by Italy and Portugal, as well as Spain and Sweden. In Sweden, all cases occurred in travelers from countries with ongoing epidemics.

In China, the epidemiological features of human brucellosis have significantly changed in the past 7 decades, especially during the period of dramatic socioeconomic changes since 1980 (*10*,*13*). Before 1950, brucellosis in both animals and humans was highly prevalent across the country. Since 1950, the activities for brucellosis prevention and control were gradually introduced in the mainland of China. During 1955–1979, human brucellosis was relatively steady with an incidence rate of 0.4–1.0 cases/100,000 person-years and peaked during 1957–1963 and 1969–1971 (*13*–*14*). After the implementation of a national control program (*14*), the incidence rate of human brucellosis decreased gradually since 1979 and reached its lowest level in 1994 (interquartile range: 0.05–0.10/100,000) (*13*).

Nevertheless, human brucellosis has reemerged in mainland China since the mid-1990s (*10*,*13*), with the incidence increasing from 1995 and peaking at 57,222 cases in 2014 (4.2 cases/100,000 person-years) (Figure 1). Following the resurgence, this disease has also expanded geographically from northwestern to southeastern China (*15*). The affected regions gradually shifted from northwestern pasturing provincial-level administrative divisions (PLADs), including Inner Mongolia, Xinjiang, Xizang (Tibet), Qinghai, and Ningxia, through adjacent grasslands and agricultural areas with a high density of sheep and goats (*16*), to coastal PLADs and southeast China. In addition, seasonal patterns in human brucellosis were also found as most cases were reported between February and July (Figure 1), which were coincided with the peak period for abortions and parturitions among livestock in the spring and summer (*17*). This reemergence across China might be attributed to a variety of factors, such as the increasing demand for meat consumption, the expansion of animal industries, urbanization, the lack of hygienic measures and vaccination in animal husbandry, and the failure to remove infected animals.

The National Brucellosis Prevention and Control Plan (NBPCP) was implemented in 2016–2020, aiming to contain this disease in animals and humans across China (*18*). In this issue of the *China CDC Weekly*, four important studies about brucellosis have been published to understand the changing epidemiology and control progress of human brucellosis across China (*19*–*22*). Lin S et al. (*19*) investigated the serological prevalence among the high-risk population in brucellosis endemic areas in China in 2019–2020. They found that the seroprevalence decreased following the implementation of NBPCP in endemic areas compared to the reported rates in the previous years. However, an analysis conducted by Tao Z et al. (*20*) revealed that the number of human cases in China had decreased from 47,139 in 2016 to 37,947 in 2018, but then rebounded in 2019. The rebound was mainly related to the resurgence in Inner Mongolia, and most counties failed to meet the control targets of NBPCP, which is calling for improved strategies and more resources to ensure a sustainable brucellosis control program in China.

The reasons for recent rebound in China, especially in Inner Mongolia, might include: 1) the circulation and expanded transmission of *Brucella* among livestock led to an increase in human infections; 2) the improvement of active monitoring, diagnosis, and reporting of human brucellosis also contributed to the

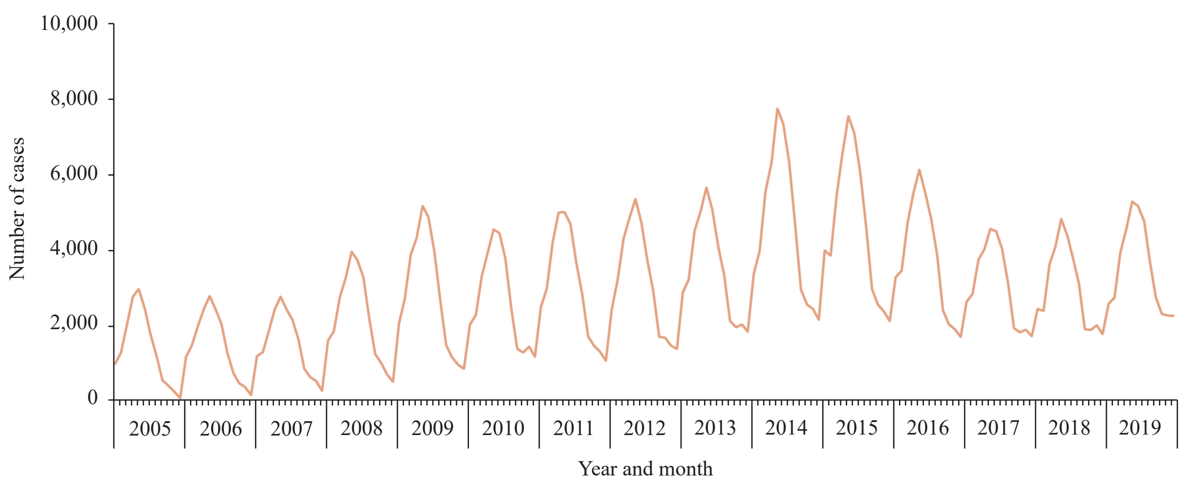

FIGURE 1. The number of human brucellosis cases reported in China, 2005–2019.

increasing number of detected cases; and 3) with recent increases in the price of beef and lamb, the number of people engaged in husbandry might have increased, whereas the awareness of brucellosis prevention still remained substandard, resulting in a surge of infected people. For example, the results of survey published by Wang Z et al. (*21*) revealed that the awareness of brucellosis knowledge and the utilization efficiency of personal protective equipment among the high-risk population remained relatively low compared to the target set in the NBPCP. More effective health education about brucellosis should be carried out to reduce the infection risk in high-risk population, and an efficient surveillance information system could provide timely data for assessing the effectiveness of control program and case management and follow-up. As part of the effort, Wulanchabu City in Inner Mongolia had been establishing a Brucellosis Integrated Information System (BIIS) since the year of 2013, the first human brucellosis-specific reporting system in China, and Dong S et al. (*22*) have evaluated the performance of BIIS on case report and management, providing important evidence for continuously improving the system.

Brucellosis remains a significant health threat in many countries including China (*7*). As there is no human vaccine against brucellosis, the most effective prevention strategy is the elimination of infections in animal hosts in combination with raising protections, food-safety measures, occupational hygiene, and laboratory safety (*23*). Vaccinating cattle, goats, and sheep are also recommended in areas with high prevalence. Most importantly, the One Health approach (*24*), involving collaborative efforts for health in humans, animals, and the environment as well as multiple other sectors, is vital to monitor disease transmission and to mitigate health and socioeconomic impacts of brucellosis, eventually eliminating the disease in human and animal populations across the world.

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