

DISTRIBUTION AND DISEASE BURDEN OF CYSTICERCOSIS IN CHINA

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Abstract. Cysticercosis is a common and prevalent parasitic zoonosis in China. In order to understand more about the disease epidemiology, this review emphasizes disease transmission and disease burden of human infection with *T. solium* in China, using a meta-analysis methodology with publications from the 1930s to the 2000s. The results showed that human cases of taeniasis and cysticercosis were found in all 31 provinces, municipalities and autonomous regions in mainland China, with five special epidemic zones. Higher prevalence presented in remote areas than urban areas, with the majority of cases found in minority clusters. The average incidence of taeniasis solium in China was 0.112%, ranging from 0.046-15%. The estimated number of taeniasis patients was 1.26 million. The estimated number of cysticercosis cases was about 3-6 million, and the incidence rate varied from 0.14-3.2% in the endemic areas. The majority of cases occurred in the 20-50 year age group, accounting for 73.06% of total cases. The ratio of male to female cases was 2.4:1. There are still many cases of auto-infection due to unhealthy habits. The serious cases are those with cerebral involvement, often suffering from epilepsy and meningoencephalitis. It was estimated that about 0.2 billion kg of pork discarded due to infection caused a loss of one billion RMB per year in China. A close relationship between incidence of cysticercosis and economic level and education level has been shown. It is imperative to formulate cost-effective strategies to control cysticercosis in China, based on the most recent data derived from the 2nd Nationwide Survey on Important Parasitic Diseases.

INTRODUCTION

Cysticercosis is a common and prevalent parasitic zoonosis in China. A human case of taeniasis was first reported in China by Barnes (1922), and human cases of cerebral cysticercosis were reported by Hu *et al* in 1930 (Li and Mao, 1995). Before those reports, some description of 'white worm' was written in the 'Qingkuang prescription', a famous book in Chinese traditional medicine in AD 217, and the transmission mode was described in the book as 'eating raw meat, especially eating raw beef and pork, causing the presence of white pieces of worm', which indicated that taeniasis (white pieces of worm) was caused by eating raw meat, and human infection with *Taenia solium* has occurred in China for more than 2000 years (Cao, 1983).

According to the records of the first nationwide survey of human parasites (1998-1992) and previous investigations in China, human cases of taeniasis and cysticercosis were found in all 31 provinces, municipalities and autonomous regions of mainland

China (Yu *et al*, 1994). The transmission of taeniasis and cysticercosis is affected by socio-economical status, not only cause human disease but also cause economic loss due to discarded pork that infected with *T. solium*. Therefore, the disease has been paid attention by the society and government, the epidemiological survey of taeniasis and cysticercosis was listed as one of contents in the Second Nationwide Survey for the Important Parasitic Diseases in China from 2001-2003. In order to understand more on the disease epidemiology, this review emphasizes on the disease transmission and disease burden of human infection with *T. solium* in China. The method of meta-analysis was used in the review since a lot of publications have been reported ranging from 1930s to 2000s.

DISTRIBUTION

Geographic distribution

The human cases of taeniasis and cysticercosis were found in all 31 provinces, municipalities and autonomous regions in mainland China, including Beijing, Tianjing, Hebei, Shanxi, Neimeng, Liaoning, Jielling, Heilongjiang, Jiangsu, Anhui, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Sichuan, Gueizhou, Yunnan, Xizang, Sanxi, Gangshu, Qinghai, Ningxia, Xingjiang, Fujian, and Taiwan provinces. The geographic distribution map of cysticercosis was prepared from the collected data presented in local publications in Chinese from the last

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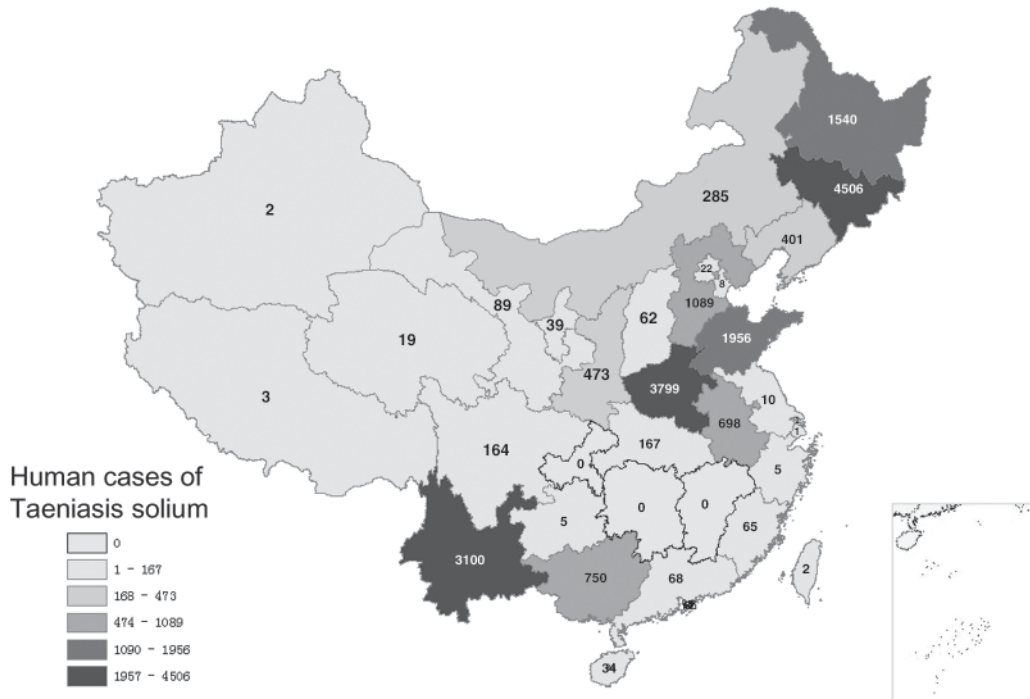


Fig 1- Geographic distribution of human cases infected with *T. solium* in China.

century (Fig 1). Analysis from a total of 19,362 accumulated cases by the author, it was found that 13,004 cases with full local information presented in 682 counties (cities) of 29 provinces (cities, municipalities) in China (Table 1). Five distribution zones are classified, those are three provinces (Jilin, Heilongjiang, Liaoning) in Northeastern China, three provinces (Hebei, Inner Magolian, Shanxi) in Northern China, four provinces (Shaanxi, Gansu, Ningxia, Qinghai) in Northwestern China, four provinces (Shandong, Henan, Anhui, Hubei) in Central China, and six provinces (Guangdong, Guangxi, Hainan, Guizhou, Yunnan, Sichuan) in Southern China.

Population distribution

Based on 4,617 cases with available age information, the age ranged from 8 months to 76 years old, the majority cases occurred in 20 to 50 age group accounting for 73.06% of total cases. While the highest group presented in age group of 30-34 (15.55%), then age group of 35-39 (15.34%) (Table 2). Another report showed that the morbidity of taeniasis and cysticercosis closely related to age ($r_t=0.833$, $r_c=0.762$, $n=8$, $p<0.05$) (Table 3). While data from the current nationwide survey showed that two peaks of taeniasis cases

presented in age 10-15 and age 35-45 of population, which indicated that spectrum of infected cases has been changed due to changes of food types (Fig 2) (Liu *et al*, 2000).

The sexual ratio of male to female cases was 2.4:1 (9,524:4,036), and the occupation distribution showed that 54.48% of cases were farmers, and 26.90% were workers, and 16.45% were cadres based on analysis of 6,312 cases.

Several reports have been demonstrated that higher prevalence presented in remote areas than that in urban areas, with the majority cases found in the minority clusters. For example, in Yunnan Province, the number of taeniasis and cysticercosis distributed in different minority clusters is as follows: Bai minority accounted for 54.38% (824/1,515), Han for 42.05% (637/1,515), Yi minority for 1.72% (26/1,515), Wei minority for 1.72% (26/1,515), Lisu minority for 0.13% (2/1,515), and Zhan minority for 0.04% (1/1,515) (Table 4). While among 3,710 cases of cysticercosis in Henan Province, 3,695 (99.59%) cases presented in Han, 1, 1, 3, and 6 cases appeared in Mongolia, Weiwure, Man, and Hua minority clusters, respectively. Zhou *et al* (1993) reported that in Xide County, Sichuan Province,

Table 1
Distribution of 19,362 cases infected with *T. solium*.

Province	No. cases	No. counties covered	No. cases without location information
Shandong	1,956	90	128
Hebei	1,089	91	626
Tianjin	8	1	
Beijing	22	1	
Henan	3,799	119	6
Shaanxi	473	29	326
Guangxi	750	34	482
Yunnan	3,100	50	
Jiangsu	10	5	5
Shanghai	1	1	
Zhejiang	5	5	
Fujian	65	7	1
Anhui	698	16	305
Guizhou	5	3	
Sichuan	164	7	24
Hubei	167	5	83
Hainan	34	12	
Guangdong	68	4	27
Xinjiang	2	2	
Tibet	3	2	
Qinghai	19	2	
Gansu	89	1	
Ningxia	39	11	
Shanxi	62	9	53
Inner Mongolia	285	10	
Jilin	4,506	48	3,119
Heilongjiang	1,540	79	1,101
Liaoning	401	36	72
Taiwan	2	2	
Total	19,362	682	6,358

the human infection rate of cysticercosis was 8.0% in Yi minority, while 3.0% in Han population. It demonstrated that higher prevalence presented in remote areas than that in urban areas, with the majority cases found in the minority clusters (Ma *et al*, 1990; Zhou *et al*, 1993; Fan *et al*, 1996).

DISEASE BURDEN

Infection rate of taeniasis solium

According to the data obtained from the nationwide surveys on human intestinal parasites in China, the incidence of taeniasis solium was 0.112 %, and the estimated number of patients was 1.26 million.

According to the data reported by authors from different localities, the infection rate varied from 0.046-15 %. In the national survey on human helminthiasis in China carried out in 1992, 2,091 out of 1,475,145 people were infected with taeniasis solium examined by stool examination, the nationwide average rate was 0.096%. The highest infection rate was in Xizang Province (7.99%), then Xingjiang (1.21%), and Yunnan (0.85%) (Yu *et al* 1994).

Incidence of cysticercosis

The estimated number of infected people with *T. solium* was about 3 to 7 million, and the incidence rate varied from 0.14% to 3.2% in the endemic areas (Gong

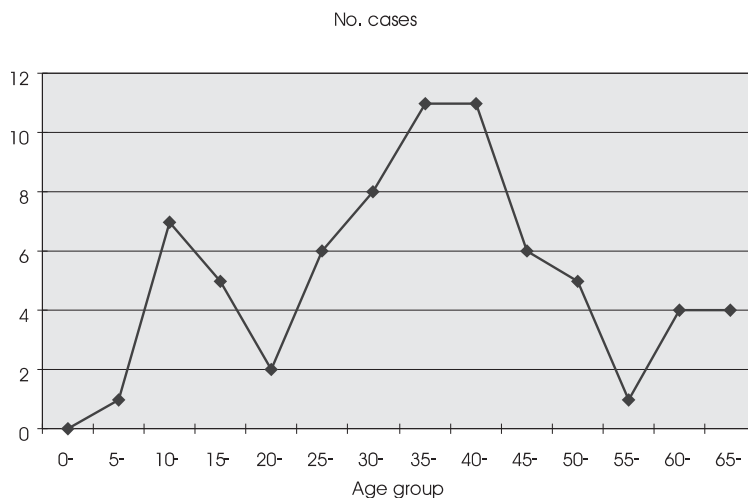


Fig 2- Number of cases in different age groups (Data from Liu X *et al*, 2000).

Table 2
Distribution of cysticercosis by age group.

Age-group (years)	0~	5~	10~	15~	20~	25~	30~	35~	40~	45~	50~	55~	60~	65~	70~	75~
No. cases	37	139	212	242	444	640	718	708	511	352	264	176	111	44	17	2
Rate (%)	0.8	3.01	4.59	5.24	9.62	13.86	15.55	15.34	11.07	7.62	5.72	3.81	2.4	0.95	0.37	0.04

Table 3
Morbidity of taeniasis and cysticercosis in different age groups.

Age group	No. examined	No. taeniasis (%)	No. cysticercosis (%)
<10	6,445	0 (0)	1 (0.016)
10-	5,878	4 (0.068)	3 (0.051)
20-	6,620	4 (0.060)	3 (0.045)
30-	6,421	5 (0.078)	5 (0.078)
40-	5,002	9 (0.179)	15 (0.299)
50-	2,650	5 (0.189)	5 (0.189)
60-	1,808	8 (0.442)	5 (0.277)
>70	688	1 (0.145)	1 (0.145)
Total	35,512	36 (0.101)	38 (0.107)

et al, 1997). For example, a study in Shandong Province in 1995, the incidence of cysticercosis was 0.71%, significantly higher than that of taeniasis (0.30%) (Cao *et al*, 1995). Those cases were determined by using the methods screening by IFAT, and diagnosed by ELISA.

In Xuzhou, Jiangsu Province, the incidence rate of cysticercosis was 1.90% determined by ELISA. Ma *et al* (1990) reported that 34,729,413 inhabitants in 10 cities and districts in Henan were surveyed during 1975 to 1987, 178,037 of them were infected with *T. solium*,

Table 4
Occupational distribution of infection with *T. solium*.

Occupation	No. cases	%
Farmers	3,439	54.48
Factory workers	1,698	26.90
Cadres	1,038	16.44
Students	69	1.09
Pre-school children	20	0.32
Merchants	17	0.27
Cooks	12	0.19
Housewives	11	0.17
Soldiers	4	0.06
Butchers	4	0.06
Total	6,312	100.00

Table 5
Serum-positive rates for cysticercosis in 8 provinces (2003).

Province	No. examined	No. positive	Positive rate (%)
Nienxia	4,492	57	1.2689
Shandong	4,122	13	3.1538
Shanxi	2,940	94	3.1973
Shanghai	1,308	1	0.0765
Jiangsu	2,940	0	0
Fujian	2,940	0	0
Hunan	1,260	0	0
Guangdong	1,260	0	0
Total	21,262	165	0.7760

Table 6
Infection with *T. solium* accompanied by cysticercosis.

Reporting year	Reporters	No. taeniasis	Accompanied by cysticercosis	Mix rate %
1951	Zhong WL	44	1	2.30
1952	Xia ZY	32	7	21.8
1983	Zhen XL	19	17	89.74
1987	Ma YX	208	52	25.00
1993	Ge LY	67	28	41.78
1997	Wang HP	97	43	44.33
Total		467	148	31.69

the incidence rate was 0.55% (Ma *et al*, 1990; Li *et al*, 2000). The data from current nationwide survey showed that the positive rate of cysticercosis in serum varied from 0-3.20% in different provinces (Table 5) based on ELISA results.

Cases of having both taeniasis and cysticercosis

It is very common to see the cases suffered from both taeniasis and cysticercosis. Most of taeniasis infected with *T. solium* who had cysticercosis at the same time is individual having bad habits. A meta-analysis showed that 31.69% (148/467) of cases infected with *T. solium* accompanied by cysticercosis (Table 6). While among 20,371 cases of cysticercosis, 41.63% cases infected with *T. solium* (Table 7). It is indicated that except for the cases infected by other sources, there are still many auto-infection cases due to unhealthy habits.

Clinical aspects

The serious cases are those with cerebral involvement, often suffered from epilepsy and meningoencephalitis several investigations have been conducted in recent two years. It has been shown that the location of cysticerci in human tissue varied from the subcutaneous location to ocular and central nervous system locations, with a malign evolution. Among 3,768 cases examined, 76.28% of cases were cerebral cysticercosis, and 18.8% of cases were vesicular cysticercus, and others were ocular, oral cavity, spinal cord, and cardiac cysticercosis. While in the 4,052 cases of neurocysticercosis, the majority cases with the seizures syndrome (56.23%), and the other syndromes were listed as ventricle (4.87%), meningoencephalitis (3.47%), psychoneurosis (1.51%), mixed syndromes (16.97%), and subclenic syndromes (2.5%) (Table 8,9) (Xu *et al*, 1998).

Infection in pigs

The Infection rate of pigs is also high in endemic areas, it varies from 0.84% to 15%. Occasionally, it may be as high as 40 % in some areas. In Xide County, Sichuan Province, the pigs' infection rate of taeniasis solium was 5.4% among 334 pigs examined while human infection rate was 4.0%. In Inner Mongolia, 75 out of 492 pigs' blood samples were positive as porcine cysticercosis, with the mean serum-positive rate of 15.24%. In Shandong Province (1995), according to

the data provided by county food companies and meat processing factories, the infection rate of cysticercosis of swine ranged from 1-4%. It is estimated that 0.73% to 6.2% of pigs were infected by cysticercus. While among 215 blood samples from pigs collected and examined by ELISA for antibody against cysticercus, 11 showed positive reaction with a positive rate of 5.1%. It was estimated that about 0.2 billion kg of discarded pork due to the infection caused a loss of one billion RMB per year (Zhang *et al*, 2000).

Table 7
Cases of cysticercosis infected with *T. solium*.

Reporting year	Reporters	No. cysticercosis	Accompanied by taeniasis	Mix rate %
1933	Zhong WL	10	4	(4/10)
1952	Xia ZY	17	7	(7/17)
1953	Pan RS	52	35	67.30
1955	Yu QH <i>et al</i>	16	8	50.00
1958	Ge MZ	66	19	28.78
1981	Ge LY <i>et al</i>	226	136	60.20
1982	Yi NC	201	89	44.20
1983	Ni AO	44	11	25.00
1987	Hu JQ	121	83	69.00
1987	Wang GX <i>et al</i>	52	40	76.92
1989	Xu ZJ <i>et al</i>	233	96	41.20
1989	Ni SM <i>et al</i>	1,682	876	52.08
1990	Ge LY <i>et al</i>	1,878	974	51.86
1990	Liu G <i>et al</i>	147	25	17.01
1990	Zhang ZY <i>et al</i>	110	21	19.09
1992	Ni YF <i>et al</i>	250	112	44.80
1993	Wu FX	3,710	1,692	45.63
1993	Wang CY	272	144	52.94
1993	Liu YQ <i>et al</i>	40	18	40.00
1993	Xia SP <i>et al</i>	3,650	1,251	34.27
1994	Ma YX <i>et al</i>	2,764	1,457	52.71
1994	Qi ZC <i>et al</i>	243	11	4.53
1994	Ma JJ <i>et al</i>	1,200	360	30.00
1995	Lu GH	303	97	32.01
1996	Tai YF <i>et al</i>	119	35	29.41
1996	Liu QP <i>et al</i>	78	10	12.82
1997	Wang HP <i>et al</i>	186	43	23.12
1997	Yu ZH <i>et al</i>	100	38	38.00
1998	Lu TP <i>et al</i>	1,086	613	56.45
1998	Chen XZ <i>et al</i>	224	4	1.79
1999	Tian JL <i>et al</i>	100	23	23.00
2000	Zhang WH <i>et al</i>	65	6	9.23
2000	Zhang SD	1,062	138	12.99
2002	Geng L	64	4	6.25
Total		20,371	8,480	41.63

TRANSMISSION

Infection patterns

The patterns for the dissemination of the disease are: 1) Non-hygienic dietary habits with eating raw or uncooked pork. 2) Non-hygienic personal habitats. 3) Free herding of pigs in endemic areas. 4) Use of untreated night soil for fertilizer. 5) Piggpens connected with human latrines in endemic areas. 6) Incomplete pork inspection system in rural areas. It has been found in Guizhou, Yunnan, Heilongjiang, Jilin, and Liaoning, the minorities have habits to eating raw pork or barbecue pork, or eating the raw vegetables. In the countryside of Shandong, the 88.2% of families cut both raw and cooked meat in a same chopping board. Sixty percent of people have habits to eat raw vegetables. And 92.3% of families' latrines connected with the hogpen (Zhao *et al*, 1999).

Transmission factors

The socio-economic factors play important roles in the transmission of *T. solium*. It has been noticed

that a close relationship between incidence of cysticercosis and economic level and education level (Table 8) (Zhang *et al*, 2000). The positive correlation shown relationships between human positive rate and annual capital income, between human positive rate and number of people eating cysts pork. The negative correlation showed in relationships between human positive rate and ratio of the unlettered, between human positive rate and ratio of pig raised inside, between human positive rate and number of the closed latrine. In another investigation in Dongsheng, Jiangsu Province, 88% (829/937) of residents did not have the knowledge of taeniasis and cysticercosis, 51% of people drink the raw water, and 82% of families prepare both cooked and uncooked food in the same chopping board.

CONCLUSIONS

This review showed that cysticercosis is still common in China, which has a great impact on human health, due to its serious morbidity and mortality. The prevalence varied from regions to regions mainly

Table 8
Clinical patterns of cysticercosis.

Investigations	Subcutaneous and intramuscular cysticercosis	Cerebral cysticercosis	Spinal cord cysticercosis	Ocular cysticercosis	Oral cavity cysticercosis	Cardiac cysticercosis	In other sites ^a	Total
National survey								
2001	2,919	9,223	29	767	113	46	11	13,108
Yudan, Shandong								
2002	0	64	0	0	0	0	0	64
Jinin, Shandong								
2002	0	67	0	0	0	0	0	67
Huanan, Anhui								
2002	0	142	0	0	0	0	0	142
Shengyang, Liannin								
2002	0	45	0	0	0	0	0	45
Changchun, Jilin								
2002	0	60	0	0	0	0	0	60
Tonglian, Inner Mongolia								
2002	849	5,607	0	14	8	2	0	6,480
Dali, Yunnan								
2002	0	76	0	0	0	0	0	76
Total	3,768	15,284	29	781	121	48	11	20,042
Rate (%)	18.8	76.26	0.15	3.9	0.6	0.24	0.05	100

^aincluding cases whose *Cysticercus cellulosae* appeared in long, mastic, bone, appendix and neural sheath.

Table 9
Syndromes of neurocysticercosis.

Investigations	Seizures	Intracranial hypertension	Encephalitis	Psycho-neurosis	Ventricle	Mixed	Subclinic	Total
National survey								
2001	3,937	996	249	109	346	1,213	180	7,030
Yudan, Shandong								
2002	48	0	1	0	5	10	0	64
Jinin, Shandong								
2002	67	0	0	0	0	0	0	67
Shengyang, Liannin 2002	0	45	0	0	0	0	0	45
Total	4,052	1,041	250	109	351	1,223	180	7,206
Rate (%)	56.23	14.45	3.47	1.51	4.87	16.97	2.5	100

Table 10
Transmission factors related to socio-economic features in Inner Mongolia.

Villages	Population	No. families	No. people serum-examined	No. positive	Positive rate (%)	Annual capital income (RMB)	Ratio of the unlettered (%)	No. of people eating pork	No. pigs raised	No. pigs raised inside	Ratio of pig raised inside (%)	No. closed toilets
Village A	3,450	750	528	31	5.87	1,500	8.38	30	2,000	98	4.9	100
Village B	1,112	261	397	20	5.04	1,483	15	15	891	70	7.86	30
Village C	702	212	405	11	2.72	950	20	20	420	10	2.38	3
Village D	1,572	367	378	17	4.5	655	27	27	260	0	0	0
Village E	2,340	584	393	74	18.83	1,650	30.1	34	1,285	18	1.40	6
Village F	1,338	352	387	102	26.36	1,110	16.2	36	256	15	5.86	4
Village G	3,500	540	401	33	8.23	1,900	20.1	14	1,080	20	1.85	4
Village H	2,195	458	396	40	10.1	1,700	27.4	16	916	22	2.40	3
Village I	4,200	960	399	66	16.54	1,100	32	20	1,920	21	1.09	1
Village J	2,649	698	408	47	11.52	1,300	33.2	27	1,100	26	2.36	2
Total	23,058	5,182	4,092	441	10.7771	1,401.3	23.72	239	10,128	300	2.96	153

contributed by the cultural background, unhealthy human behavior and customs, except for environmental and ecological features in the endemic areas. Therefore, it is imperative to formulate the cost-effective strategy in control of cysticercosis in China, based on the most recent data derived from 2nd Nationwide Survey on Important Parasitic Diseases.

The new transmission characteristics have been noticed recently as follows: 1) More clinical cases were reported from urban areas, and the difference of incident rate between city and countryside has been declined. For example, among 505 taeniasis cases

diagnosed in Jilin Province from 1984 to 1997, 57.65% of them came from the towns or cities and 42.35% from countryside. 2) The occupation distribution of cysticercosis cases has been changed due to the food spectrum is changing in urban areas. Reported in Shandong Province, infection rates with *T. solium* in cadres, teachers, and workers were 2.24%, 2.10%, and 1.45%, respectively, while in farmer, purple, and children are 0.72%, 0.21%, and 0.13%. 3) The number of infected children is increasing. In one of hospital of Jilin, the ratio of 0-15 age group was 4.21% among all of taeniasis cases from 1984 to 1990, while it was

10.17% from 1991 to 1996. 4) The endemic areas have been extended to all provinces, with mainly distributed in five zones. People acquire cysticercosis after accidentally ingesting *T. solium* eggs, or even whole proglottids. Three infection ways are identified as follows: self-infection inside body, self-infection from outside body, and infected by other sources. Those closely related to the level of economic development and social activities (Ma *et al.*, 1986).

The factors responsible for the dissemination of the disease are: 1) Non-hygienic dietary habits with eating raw or uncooked pork. 2) Non-hygienic personal habitats. 3) Free herding of pigs in endemic areas. 4) Use of untreated night soil for fertilizer. 5) Piggens connected with human latrines in endemic areas. 6) Incomplete pork inspection system in rural areas. The meat inspection needs to be strengthened and to be integrated into control strategies for the national control program. To interrupt the transmission chain of the disease, it is urgent to formulate a comprehensive strategy to control taeniasis and cysticercosis in China with following countermeasures: strengthening the management of animals and vaccination, giving chemotherapy to both human cases and animal cases, strengthening capacity of the disease surveillance, changing the living habits and improving the sanitation in countryside, improving meat inspection in markets, and health education and promotion, etc. It is expected to issue a special law or regulation for meat inspection to prevent food-borne parasitic diseases.

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