




Medical waste management of village clinics in rural China

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Abstract

Purpose Medical waste is rising on policy agendas as a serious public health and environmental issue. The aim of this study was to assess current practices of medical waste management, which include waste generation, collection, storage, segregation, disposal, and use of protective equipment, in village clinics in rural China.

Methods Based on survey results from 236 randomly selected village clinics in 21 counties from three provinces of China, we used descriptive statistics to determine the medical waste management of village clinics in sample area.

Results We found that the generation rate of medical waste in sampled village clinics was approximately 0.65 kg per day or 0.17 kg/patient per day on average. Given the large number of primary healthcare facilities and population in rural areas of China, the total quantity of medical waste generated in these facilities is noteworthy. However, we also found poor compliance levels with the national regulations regarding medical waste management practices. A large proportion of medical waste was still not packed in required containers, and almost all village clinics did not segregate correctly. Moreover, a significant portion of village clinics used improper disposal methods and lacked the necessary protective equipment. Medical staff in these facilities pointed out four main difficulties in complying with national regulations: a lack of funding, equipment, designated areas, and management personnel specifically delegated for medical waste management.

Conclusion These findings suggest that Chinese policymakers and health administrators should pay more attention to rural areas in addressing potentially hazardous medical waste management practices by investing financial support as well as developing specific guidelines tailored to resource-strained rural primary healthcare facilities.

Keywords China · Medical waste management · Village clinics · Public health

Introduction

Medical waste mismanagement has become an increasingly urgent public health and environmental issue worldwide (Malekahmadi et al. 2014; Reza et al. 2007; Shinee et al. 2008). As one of the largest and fastest-growing developing countries in the world, China is also facing important challenges with respect to the management of medical waste (Geng et al. 2013). Previous studies have found that China

generates around 650,000 tons of medical waste annually—a quantity growing at a rapid rate of 20% each year (Mao 2011; Yan et al. 2011). In response to these challenges, the Chinese government has enacted a number of targeted policies in the past few years. These national regulations detail how to store, handle, dispose, and categorize different types of medical waste (China Department of State 2003; China Ministry of Health 2003). In other words, these regulations standardize how health facilities should manage medical waste.

Although studies show improvements in medical waste management in urban China, numerous obstacles still prevent the rural Chinese healthcare system, especially its primary healthcare facilities (i.e., township health centers and village clinics), from implementing these regulations into standard practice (Gai et al. 2009, 2010; Nie and Wu 2016; Zhang et al. 2009). Existing evidence has shown large gaps in compliance with medical waste management guidelines between urban and rural hospitals, which have been attributed to urban–rural resource disparities (Gai et al. 2009; Geng et al.

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2013). Moreover, within the rural healthcare system, resources at upper-tier county hospitals far exceed those at township health centers and village clinics, which may prevent these lower-tier primary healthcare facilities from being able to reach compliance with waste management regulations (Meng et al. 2009). Given the large number of rural primary healthcare facilities (36,817 township health centers and 640,536 village clinics in 2015), the total amount of medical waste generated and managed by these facilities should not be overlooked (National Health and Family Planning Commission of China 2016).

However, to our knowledge, limited studies have focused on medical waste management in primary healthcare facilities of rural China, especially in the bottom tier of rural health systems—village clinics, which are designed to be the first point of contact for rural patients. The few papers that do exist on this subject suggest low compliance with national regulations in township health centers and village clinics (Gao et al. 2018; Nie and Wu 2016). Only one of these studies explicitly includes village clinics in their quantitative analysis but focuses on only one province in China (Nie and Wu 2016). Considering the limited published evidence surrounding this issue and the heterogeneity of the Chinese government and healthcare system across different areas in China (Geng et al. 2013), a fuller understanding of medical waste management in primary healthcare facilities of rural China, especially in village clinics, is needed.

Therefore, the primary aim of this study was to describe medical waste management practices in village clinics—the frontline of the Chinese rural healthcare system—based on data drawn from three different provinces. In order to meet this goal, we had three specific objectives. First, we assessed the amount of medical waste generated from village clinics in different regions of rural China. Second, we explored their current practices surrounding medical waste management across different regions, which includes the use of necessary protective equipment as well as the collection, storage, segregation, and disposal of waste. Third, we explored explanations for and possible improvements to the current status of medical waste management in rural China.

Method

Sampling

Our study was conducted in 21 counties across Sichuan, Anhui, and Shaanxi provinces. The village clinics included in the study were selected from one prefecture in each of the three provinces. The following procedure was used to ensure that the selected sample was representative of rural village clinics in each of the three chosen prefectures. First, across the three prefectures, we randomly sampled 21 of 24 rural counties and randomly selected ten townships within each county. As one county only had

nine rural townships, in total 209 townships were included. Next, with the same sampling method, one village was randomly included within each township. We included all the village clinics in the selected villages, yielding a sample of 236 village clinics from 21 counties in three provinces. In our sample, there are 97 clinics, 59 clinics and 80 clinics, respectively, from Sichuan, Anhui, and Shaanxi provinces.

Data collection

Data collection was carried out with an in-depth questionnaire and a physical site inspection during June 2015. The questionnaire was designed based on national regulations for medical waste management and the World Health Organization's rapid assessment tool (Chartier et al. 2014; China Department of State 2003). During each site visit, trained enumerators interviewed the staff members mainly responsible for the management of medical waste in the village clinic.

Detailed information was collected using a two-block survey. The first block focused on the basic characteristics and nature of the village clinic. Questions specifically asked about village clinic human resources (e.g., the number of staff and doctors working in the village clinic), physical resources (annual income and value of medical equipment), and patient demand for clinic services (the number of patients seen during a typical month; the number of patients who had received intravenous fluids during a typical month).

The second block of the survey collected information on current practices and barriers of medical waste management in the village clinic. This block assessed the amount of medical waste generated; handling practices of medical waste, such as protective equipment procedures and the collection, storage, segregation, and disposal of medical waste; and possible barriers to optimally managing medical waste in village clinics. Given the somewhat sensitive nature of our questions, enumerators not only collected data from the respondents using the survey instrument, but they also carried out a physical inspection of the village clinic. Through these inspections, enumerators verified survey responses from medical staff by checking where medical waste was collected, stored, segregated, and disposed of.

Results

The summary statistics for the full sample and for our three provincial subsamples are presented in Table 1. According to the survey data, on average, each village clinic had about two staff members, both of whom were most likely doctors (Table 1, rows 1 & 2, column 1). The average annual income was 72,180 RMB, and the average value of medical equipment across village clinics was 8950 RMB (rows 3 & 4, column 1). In general, approximately 232 patients every month were seen at the typical village clinic; more than one-quarter

Table 1 Characteristics of sample village clinics

Variable	Full sample (n = 236) Mean (SD)	Sichuan sample (n = 97) Mean (SD)	Anhui sample (n = 59) Mean (SD)	Shaanxi sample (n = 80) Mean (SD)	F (P) ^b
1. Number of staff ^a	1.77 (1.11)	1.25 (0.69)	3.14 (1.07)	1.39 (0.58)	123.37 (0.000)
2. Number of doctors	1.62 (1.00)	1.19 (0.60)	2.86 (1.01)	1.23 (0.50)	125.35 (0.000)
3. Annual income (thousand yuan)	72.18 (68.78)	58.87 (53.78)	114.31 (75.74)	57.46 (67.65)	16.42 (0.000)
4. Value of medical equipment (thousand yuan)	8.95 (9.94)	6.63 (8.44)	12.91 (13.35)	8.76 (7.55)	7.69 (0.001)
5. Number of patients per month	232.25 (252.13)	230.27 (287.08)	351.41 (227.5)	146.78 (181.53)	12.26 (0.000)
6. Number of patients who had received intravenous fluids per month	64.93 (90.05)	41.49 (57.61)	159.22 (116.13)	23.79 (34.08)	69.67 (0.000)

^a Staff in village clinics include doctors, nurses, and other staff members such as management and custodial staff

^b Testing null hypothesis of no differences among the three sample provinces by F test (one-way ANOVA test) for means comparison

of the patients were patients who had received intravenous fluids (rows 5 & 6, column 1). When looking into the three subsamples, statistical differences in these characteristics exist among different provinces (column 5). Specifically, the number of doctors and patients in the Anhui sample is notably higher than that in Sichuan and Shaanxi samples (columns 2 to 4). This is because village clinics in the Anhui sample have been merged, which leads to larger-scale village clinics and a larger number of residents serviced.

Generation of medical waste

On average, each village clinic generated 0.65 kg of medical waste per day (Table 2, row 1, column 1). Adjusted for patient load, this means that medical waste is generated at a rate of 0.17 kg/patient per day (row 2, column 1). There are statistical differences among these different regions and the generation rate ranged from 0.09 to 0.22 kg/patient per day (row 2, columns 2 & 4).

Outcomes of medical waste management

Collection and storage

We found that less than half (48%) of village clinics had a designated area to store medical waste (Table 3, row 1). The

survey also shows that approximately two-thirds (64%) of village clinics reported packing their hazardous medical waste in containers (row 2). However, less than one-third of hazardous medical waste was packed in sealed containers (31%) or in containers with bio-hazard markings (29%—rows 3 & 4). Village clinics that were packed in sealed containers or containers with bio-hazard markings among these subsamples were equally less than half (rows 3 & 4, columns 2 to 4).

Segregation of medical waste

On average, we found that all medical waste categories, which are recommended by national guidelines, were not used by most village clinics, especially in Anhui and Shaanxi subsamples. In general, the categories that village clinics most frequently segregated into were sharps waste (27%) and infectious waste (26%—Table 3, rows 5 & 6, column 1). The categories that were least frequently segregated into were chemical waste (3%) and pathological waste (2%) types (rows 9 & 10, column 1). Only one-seventh (14%) of village clinics in our sample used the non-hazardous category to segregate medical waste (row 7, column 1), and less than 10% of village clinics used the category of medicine waste (8%—row 8, column 1). In fact, as reported in Table 3, much fewer categories were used by clinics in Anhui and Shaanxi samples (rows 5 to 10, columns 3 & 4).

Further, we also calculated the number of categories (or types of waste) that village clinics used when

Table 2 Medical waste generation in sample village clinics

Variable	Full sample Mean (SD)	Sichuan sample Mean (SD)	Anhui sample Mean (SD)	Shaanxi sample Mean (SD)	F (P) ^a
Total (kg/day)	0.65 (0.90)	0.70 (0.91)	0.87 (1.15)	0.43 (0.61)	4.41 (0.013)
Total (kg/patient per day)	0.17 (0.31)	0.17 (0.34)	0.09 (0.10)	0.22 (0.35)	3.10 (0.047)

^a Testing null hypothesis of no differences among the three sample provinces by F test (one-way ANOVA test) for means comparison

Table 3 Medical waste collection, storage, segregation, disposal, and use of protective equipment in sample village clinics

Variable	Full sample n (%)	Sichuan sample n (%)	Anhui sample n (%)	Shaanxi sample n (%)
Collection and storage				
1. Designated area to store waste (1 = yes)	113 (48)	53 (55)	38 (64)	22 (28)
2. Packed in containers (1 = yes)	152 (64)	75 (77)	41 (69)	36 (45)
3. Packed in sealed containers (1 = yes)	73 (31)	41 (42)	11 (19)	21 (26)
4. Packed in containers with bio-hazard markings (1 = yes)	68 (29)	47 (48)	15 (25)	6 (7)
Segregation categories^a				
5. Sharps waste	63 (27)	49 (51)	13 (22)	1 (1)
6. Infectious waste	62 (26)	51 (53)	4 (7)	7 (9)
7. Non-hazardous waste	33 (14)	19 (20)	4 (7)	10 (12)
8. Medicine waste	18 (8)	13 (13)	1 (2)	4 (5)
9. Chemical waste	7 (3)	7 (7)	0 (0)	0 (0)
10. Pathologic waste	5 (2)	4 (4)	1 (2)	0 (0)
Number of categories segregated into				
11. Segregation into one type	93 (39)	15 (15)	23 (39)	55 (69)
12. Segregation into two types	86 (36)	34 (35)	30 (51)	22 (28)
13. Segregation into three types	44 (19)	35 (36)	6 (10)	3 (4)
14. Segregation into four types	12 (5)	12 (12)	0 (0)	0 (0)
15. Segregation into five types	1 (<1)	1 (1)	0 (0)	0 (0)
16. Segregation done correctly ^b	1 (<1)	1 (1)	0 (0)	0 (0)
Disposal				
17. Centralized disposal (1 = yes)	100 (42)	83 (86)	2 (3)	15 (19)
18. Burned (1 = yes)	95 (40)	32 (33)	37 (63)	26 (33)
19. Burned and then put in landfill (1 = yes)	60 (25)	11 (11)	20 (34)	29 (36)
20. Put in landfill (1 = yes)	49 (21)	7 (7)	23 (39)	19 (24)
21. Sold to recycling vendors (1 = yes)	29 (12)	10 (10)	15 (25)	4 (5)
22. Disposal as household garbage (1 = yes)	25 (11)	12 (12)	3 (5)	10 (12)
Personnel protective equipment				
23. Protective equipment available (1 = yes)	92 (39)	23 (24)	36 (61)	33 (41)
Masks	21 (9)	10 (10)	6 (10)	5 (6)
Gloves	56 (24)	11 (11)	25 (42)	20 (25)
Hats	16 (7)	1 (1)	7 (12)	8 (10)
Protective suits	5 (2)	1 (1)	2 (3)	2 (3)

^a Number and proportion of village clinics reporting categories used in the segregation of medical waste. We focus on six categories. In addition to five different categories of hazardous medical waste (including sharps waste, infectious waste, medicine waste, chemical waste, and pathologic waste), the category of non-hazardous waste (typically disposed of with household garbage) is also included in this table

^b The results are calculated based on asking survey respondents to describe the type of materials that were discarded into each of the categories that they reported using. Responses were marked as correct if materials listed corresponded with correct segregation practices (by law); responses were marked as incorrect if not

^c According to the data, 44% of sample village clinics used more than one type of disposal methods

segregating their medical waste (Table 3). More than three-quarters of the surveyed village clinics segregated their medical waste into two or fewer types of wastes (75%—rows 11 & 12, column 1). Few clinics reported that their medical waste was divided into three types (19%—row 13, column 1), and even fewer reported four or five categories (around 6%—rows 14 & 15). When

looking into the subsamples, 36% of clinics in the Sichuan sample segregated medical waste into three types, which is much higher than that in Anhui and Shaanxi provinces (10% and 4%, respectively—rows 13, columns 2 to 4). However, all but one of the sample facilities from the Sichuan sample had segregated medical waste incorrectly as defined by national regulations (row 16).

Disposal of hazardous medical waste

Less than half of village clinics in our sample reported disposing of hazardous medical waste through centralized disposal, which is the practice recommended by national regulations (42%—Table 3, row 17). The majority of village clinics using centralized disposal were from the Sichuan sample and a few clinics reported in Anhui and Shaanxi samples (row 17, columns 2 to 4). The most commonly used method to dispose of hazardous medical waste was burning (65%—rows 18 & 19). Approximately 21% of sample clinics reported dumping hazardous medical waste into landfills (row 20). Further, some clinics indicated that they disposed of hazardous medical waste with household garbage (12%) or by selling it to recycling vendors (11%—rows 21 & 22).

Personnel protective equipment

According to our data, on average, only 39% of medical staff who were mainly responsible for handling medical waste had any protective equipment and the percentage ranged from 24% to 61% across the subsamples, which is mandated by national guidelines (Table 3, row 23). Specifically, in general, only one quarter (24%) of the medical waste handlers wore gloves when exposed to medical waste. Less than 10% of medical waste handlers were equipped with masks (9%) or protective hats (7%). Only a few medical waste handlers (2%) in the surveyed village clinics had protective suits.

Possible reasons for poor medical waste management

To evaluate the awareness of recommended practices for medical waste management, we asked the medical staff about the

best methods of medical waste disposal. As the method suggested by national regulations, centralized disposal in general was mentioned by more than half of medical staff (58%) as one of the best disposal methods for village clinics (Table 4, row 1 & column 1) and identified by 45% as the singular best method (row 2 & column 1). According to our data, 42% of village clinics spent money on medical waste in the past year, with a large proportion in the Sichuan sample (row 3). However, only four clinics in total (2%) had ever received any funding specifically for medical waste management from the upper government (row 4). In the survey, the medical staff were also asked to report at most three main difficulties they confronted regarding medical waste management in the village clinic (row 5). We found that lack of funding and lack of equipment are simultaneously the two main difficulties across these three different samples, as approximately 40% of medical staff in general reported these two factors. Some medical staff also identified inadequate designated areas for storing and disposing of medical waste (25%) and a lack of management personnel specifically hired to manage medical waste (16%) as challenges as well.

Discussion

The survey results indicated that, while the generation rate of medical waste in village clinics varies across the three samples, the average generation rate is consistent with findings from previous studies conducted in rural primary health facilities in China and comparably higher than those reported by other developing countries. In general, the average generation rate of medical waste in the surveyed village clinics is around 0.17 kg/patient per day, which is similar to the rate in rural

Table 4 Possible reasons for poor medical waste management in sample village clinics

Variable	Full sample n (%)	Sichuan sample n (%)	Anhui sample n (%)	Shaanxi sample n (%)
1. The medical staff believes that one of the best disposal methods to handle hazardous medical waste is the centralized disposal method (1 = yes) ^a	137 (58)	78 (80)	29 (49)	30 (38)
2. The medical staff believes that the singular best disposal method to handle all hazardous medical waste is the centralized disposal method (1 = yes) ^a	106 (45)	55 (57)	25 (42)	26 (33)
4. Had ever received any funding from the upper government (1 = yes)	4 (2)	2 (2)	1 (2)	1 (1)
3. Spent money on medical waste management in the past year (1 = yes)	99 (42)	80 (82)	12 (20)	7 (9)
5. The biggest difficulty in managing medical waste ^b				
Lack of funding	105 (44)	31 (32)	39 (66)	35 (44)
Lack of equipment	87 (37)	24 (25)	32 (54)	31 (39)
Lack of management personnel responsible for medical waste	37 (16)	11 (11)	18 (31)	8 (10)
Lack of designated areas to store and dispose of medical waste	59 (25)	18 (19)	30 (51)	11 (14)

^a The medical staff were asked to suggest the best disposal method for medical waste generated by the village clinic

^b The medical staff were asked to list at most three biggest difficulties toward reaching optimal medical waste management practices in the village clinic

township health centers of the same sample areas (0.15 kg/patient per day) (Gao et al. 2018). Given the relatively smaller size of rural primary health facilities, it is not surprising that their medical waste generation rate in this study is much less than those found in both rural and urban hospitals in China (more than 100 kg per day) (Zhang et al. 2013; Gai et al. 2009; Gai et al. 2010; Zhang et al. 2009). While our generation rate may be slightly overestimated because of poor segregation practices between domestic and medical waste, our generation rate in rural China is much higher than those found in other developing countries, such as the 0.01–0.075 kg/patient per day rate in primary health-care centers in Brazil, Pakistan, and Tanzania (Alves et al. 2014; Chartier et al. 2014).

The high rate of medical waste generation in rural primary health facilities of China can be partly explained by the increasing demand and utilization of healthcare services, which is tied to the country's rapid economic development (Gai et al. 2009). In 2015, rural China had 677,353 primary health facilities that received approximately 2.95 billion patient visits (National Bureau of Statistics of China 2016). Assuming that our sample and medical generation rate (0.15–0.17 kg/patient per day) is representative of rural China, the total quantity of medical waste—estimated to be more than 442 million kilograms per year—generated in these facilities is enormous.

Despite the large amount of medical waste generated in rural primary health facilities, our study also shows consistently low levels of compliance with recommended medical waste practices, which include the proper collection, storage, segregation, disposal, and use of protective equipment. Such poor management practices may have significant public health and environmental consequences, particularly for medical staff who do not use protective measures or equipment while handling and disposing of medical waste. Indeed, the most popular disposal method used in our survey—open burning—produces dioxins and other toxic pollutants that threaten the health of not only medical workers, but also local communities, environments, and ecosystems (Gai et al. 2010; Mato and Kassenga 1997; Soliman and Ahmed 2007). While our finding documented the disparities across different regions, the results in the three sample areas indicated poor medical waste practices in village clinics is a common problem in rural China. As previous studies suggested, many developing countries (such as India, Iran, and Brazil) are still suffering from poor medical waste management, findings in the survey show consistent results in rural China (Ali et al. 2017; Da et al. 2005; Mesdaghinia et al. 2009; Patil and Shekdar 2001). In line with past findings, our study also further confirmed the large gap between rural and urban Chinese health facilities in medical waste management (Gai et al. 2009, 2010; Gao et al. 2018; Nie and Wu 2016). For example, our data show that almost no sample village clinics segregated medical waste correctly, and few staff members used protective equipment when handling medical waste. However, previous studies in urban

hospitals indicate that a large proportion of surveyed hospitals had proper segregation systems and that a majority of them were equipped with gloves, masks, and other protective equipment (Nie et al. 2014; Gai et al. 2009, 2010). Moreover, we also found disparities between the different tiers of rural primary health facilities. In general, village clinics performed worse in medical waste management practices than township health centers in the same sampled areas (Gao et al. 2018).

Our findings also suggest that rural primary facilities are consistently unable to comply with medical waste management practices in part because of the decentralized Chinese healthcare system. Because the Chinese health sector is institutionally fragmented and prioritizes local autonomy and governance, numerous healthcare reform policies—including those on medical waste management—unevenly impact the country's diverse communities (World Bank et al. 2016). Under the decentralized health system, primary healthcare facilities are left largely dependent on their local governments, which—especially in rural areas—lack adequate financial and institutional resources (Han et al. 2016; Hipgrave et al. 2012; Shen et al. 2014). As previous studies reported, in the bottom tier of the health system, rural village clinics receive the fewest resources and support, despite being the first point and often the only source of healthcare for a vast number of rural patients (Gai et al. 2010; Liu et al. 1995; Nie et al. 2014).

Notably, our data confirmed that poor compliance with medical waste regulations may not be due to a lack of awareness but rather a lack of financial and institutional support as well as specialized labor and technology. For example, as our data suggested, although a large number of medical staff in sampled village clinics had realized centralized disposal should be the best disposal method as the national regulations recommend, improper disposal methods and handling practices were still used by a large number of resource-constrained clinics. In fact, almost all surveyed village clinics had not received any funding from the upper government to manage medical waste. Moreover, village clinics seem to lack the specialized labor needed to adequately manage medical waste. The number of staff members in each sample village clinic ranged from two to four doctors, both of whom were most likely doctors and not medical waste handlers. In contrast, some studies suggested that the majority of urban Chinese hospitals have designated personnel for handling medical waste (Nie and Wu 2016). Medical staff independently confirmed our survey findings and identified the greatest difficulties to proper medical waste management to be lack of funding, equipment, designated areas, and management personnel for medical waste management—difficulties that could not be overcome by the limited capacity of rural facilities to comply with national regulations.

While the Chinese health system is institutionally and fiscally decentralized, our results indicate opportunities to improve medical waste management in rural primary healthcare

facilities. First, findings of this study suggest that providing funding specifically for medical waste management is necessary and needed for village clinics to reach compliance with national regulations. Setting up these funds would be feasible and similar to previous industry-specific policies in China, such as those that have provided subsidies to offset the losses of drug revenues after the national zero-mark-up drug policy (Wei et al. 2017). Second, to improve medical waste management, detailed medical waste management policies and regulations that are appropriate for and tailored to the resource-constrained primary healthcare facilities in rural China should be developed. As previous studies suggested, because village clinics must operate flexibly with their limited infrastructure and staff, blanket national regulations for medical waste management may be ineffective or irrelevant to rural primary care facilities, making monitoring and enforcement of these regulations difficult and ineffective (Nie and Wu 2016). Thus, guidelines specific to these clinical environments and accounting for their limited human resources and funding could result in higher compliance with these regulations.

Conclusion

The generation rate of medical waste in the surveyed village clinics in rural China was approximately 0.17 kg/patient per day on average. When compared to national regulations, rural village clinics had poor medical waste management practices, which include collection, storage, segregation, disposal, and use of protective equipment across three different regions. Lack of funding, equipment, designated areas, and management personnel were reported as the main difficulties for village clinics to manage medical waste. Our findings suggest that policy initiatives should be tailored to these facilities, such as through greater financial support from upper tiers of government and waste management guidelines specific to their resource-strained clinical operations.

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Compliance with ethical standards

Competing interests The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical and informed consent Approval from the institutional review board of Sichuan University, China (protocol number: K2015025) was obtained for this study. Informed consent from local authorities and sample village clinics was obtained through direct communications with them.

Data availability statement All replication files are available from the Harvard Dataverse: <https://doi.org/10.7910/DVN/EXWUYI>.

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