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A pilot study of changes in physician prescribing practices after Rural Mutual Health Care implementation in China

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ABSTRACT

In 2002, the Chinese government renewed commitment to rural health. One experimental insurance program, Rural Mutual Health Care (RMHC), provides affordable coverage for rural residents where a previous insurance system, Cooperative Medical System (CMS), was poorly functioning. This study examined how RMHC affected physician prescribing in Fengshan Township, Guizhou Province, China. Six village doctors were chosen for study based on prior reviews showing high, average, or low rates of prescribing errors. 858 prescriptions with the single diagnosis of common cold were systematic sampled from insured and uninsured patient visits in March-May 2003 (under CMS) and 2004 (under RMHC). Peer physicians reviewed prescriptions for inappropriate prescribing. X^2, Fisher's exact, and two-tailed t-tests were used to explore demographic and prescription characteristics. Multiple linear and logistic regressions were used to model outcomes of: number of medications, cost, injection use, and inappropriate prescribing with covariates of: patient age and gender, prescribing doctor, year, insurance, and year-insurance interaction. Results show mean cost decreased from 13.09 yuan in 2003 to 7.22 yuan in 2004 ($p<0.001$). Cost increased from 7.12 yuan for the uninsured to 11.19 yuan for the insured ($p<0.001$). After adjusting for other covariates, RMHC had lower drug costs and fewer medications as compared to CMS (respectively, $p=0.025$ and $p=0.001$), but RMHC had no significant effect on injection use or inappropriate prescribing (respectively, $p=0.641$ and $p=0.912$). In conclusion, this study shows RMHC successfully controls medication costs, but likely has little effect on quality of care. A larger, more rigorous study is needed to assess RMHC's impact on quality of care.

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INTRODUCTION

China's economic development since 1978 open policy reforms has led to incredible progress and financial success, however, a large disparity now exists between the rich and poor, especially with regards to health. 800 million out of the total 1.3 billion Chinese currently live in rural areas, but 80% of medical resources are concentrated in urban areas.[1] Fewer than 10% of rural residents have health insurance while roughly half the urban population has employment-based health insurance.[2] Moreover, health outcomes are worse in rural areas: in recent years, infant mortality rates have increased in some poor rural areas while rates in urban areas continue to decline.[2] Realizing this enormous rural health care problem, the Chinese government is now actively supporting various health care reforms throughout the country.

Historically, the communist government has had two approaches to health care. In the 1950s, China created rural Cooperative Medical Systems (CMS) to provide basic preventive and public health services to rural areas. CMS used community-based health insurance and minimally trained "barefoot doctors" to accomplish incredible improvements in health. From 1952 to 1985, life expectancy in rural China nearly doubled, increasing from 35 to 68 years.[3] By comparison, life expectancy in the United States during this time increased just 6 years, from 69 to 75 years.[4] In the 1970s, rural health care coverage reached 90% or higher.[5] However, when China introduced widespread economic reforms in the 1980s, the agriculture sector became decentralized and privatized. CMS was based on agricultural communes, and, with dismantling of this financial structure, the health care sector also became privatized and decentralized. CMS

rapidly declined, and rural health care coverage dropped from 90% in the 1970s to 4.8% in 1984.[5] Rural providers essentially became private practitioners, with strong financial incentives governing their actions. For patients, the decline of CMS led to growing rural-urban inequities in health care financing, access, quality, and ultimately outcomes.

In the past 20 years, total health expenditure in China has risen 40-fold, and in 2005, a total of US$91.8 billion or 5.5% of GDP was spent on health care.[1] Total health spending on average increases 15-22% per year while GDP increases 9% a year.[6] Of total health expenditures, out-of-pocket expenditures increased from 20% in 1980 to 54% in 2005.[6] In fact, the percentage of total health expenditure contributed by the government decreased from 36% in 1980 to 17% in 2004, creating an enormous financial burden on private payers.[1] The relationship between health and ability to pay is well-documented. Average rural incomes in China are much less than urban incomes.[2] Per capita GDP for Beijing province was 25,523 yuan (US $3190) in 2001, nearly 10 times as much as that of Guizhou province, a poor rural province, at only 2,895 yuan (US $361).[7] A 1998 National Health Services Survey found that 10% of the rural Chinese population lived below the poverty line.[8] Of those in poverty, 30-50% become impoverished as a result of illness, with costs for one hospitalization exceeding the annual income for roughly half the rural population.[9,10] Disparities between rich and poor even in rural areas is also quite striking. While the rich tend to spend more absolute money on health care, the relative costs of health care are much higher for the poor. One study estimated that in 2003, one hospitalization equaled 42 months per capita income for the poorest quintile of rural residents as opposed to 9 months per capita income for the richest quintile.[11]

This financial strain is in fact a huge access barrier. Self-medication is a preferred, cheaper mechanism of health care for the rural poor, and many patients also refuse hospitalization even with referrals due to costs. One study found that among patients in the poorest quintile refusing hospitalization, close to 80% listed lack of finances as the main reason for non-admission.[11] Furthermore, even if rural residents are able to afford health care, many are unable to access high-quality care. A 1995 study found that 30% of villages in poor rural areas had no village doctor.[12] Another study estimated that one-third of drugs sold in rural areas are counterfeit.[13] Poor quality health care coupled with lack of financial resources to access care only leads to worse health outcomes for rural residents as compared to urban residents. Under-five mortality in 2002 was 39 per 1000 in rural areas versus 14 per 1000 in urban areas.[2] Maternal mortality in 2002 was 72 per 100,000 in rural areas and 54 per 100,000 in urban areas.[2] These urban-rural differences are quite striking when one considers the public health mission of CMS and the barefoot doctors just 20 years ago.

In response to these problems in rural health care, the Chinese government began to reevaluate CMS and community-based health insurance programs in the 1990s. In 2002, the China National Rural Health Conference developed policies to increase financial support to rural health facilities and expand CMS.[8] The New Rural Cooperative Medical Schemes (NCMS) aim to create a basic financial safety net for rural areas using voluntary community-based health insurance.[2] Under this program, central government, local provincial governments, and individual families each pay 10 yuan (US $1.25) per person for insurance premiums, with additional government subsidies for the poorest people.[13] Local governments have considerable financial and regulatory autonomy over

the specifics of NCMS programs. There are currently over 300 pilot NCMS plans throughout China. Most plans, however, offer mainly catastrophic health insurance, with high deductibles, high co-payments, and coverage limited to inpatient care.[14]

Potential problems in the current NCMS, according to a 2004 World Health Organization (WHO) report, include lack of a "common, rigorous standardized framework" for evaluating NCMS programs, adverse selection, overemphasis on catastrophic illness, and lack of preventive health promotion.[15] In general, community-based health insurance programs (CBHI) have been shown to impact finances but perhaps not quality of care. A systematic review of CBHI literature found some strong evidence that CBHI provided financial protection for patients, but weak or no evidence that CBHI improved quality or efficiency of health care.[16] Similarly, one study in China found that insurance status had significant associations with medications, costs, and quality of care. Insured patients received fewer numbers of prescribed medications, but were prescribed more expensive medications and thus spent more total money on medications per visit.[17] Whether these expensive medications were more or less appropriate treatments was undeterminable.

Overuse of certain medications is both consumer and provider-driven. Self-medication, patient demand for antibiotics, non-adherence, and cultural preferences for injections all contribute to consumer demand for medications in many developing countries.[18] Providers, in turn, have strong financial incentives for over-prescribing. In Asia, out-of-pocket spending makes up roughly 75% of drug expenditures, with most of this money going to private providers.[19] Many countries have separated medical services from pharmaceutical sales to lower financial incentives for inappropriate prescribing, but

doctors in rural China still both prescribe and sell drugs.[20] A 1999 study in rural China found significant associations between health insurance and prescriptions of antibiotics: uninsured patients received more antibiotics and injections, but physicians prescribed newer, more expensive antibiotics for insured patients.[21] In another study, providers actually admitted to prescribing more expensive antibiotics to patients with health insurance and to those who could afford to pay.[22] In fact, 55% of inpatient and 70% of outpatient revenues in rural Chinese health facilities come from drug sales, as compared to 50% in urban facilities.[21] Moreover, markups for prescription drugs can be as high as 40-80% per a WHO report on rural China.[23]

Inappropriate prescribing not only increases costs for patients, but also has grave public health consequences such as adverse drug events and antibiotic resistance.[18] Adverse drug events cause an estimated 10,000 deaths annually in the UK, and medication errors cause an estimated 7,000 deaths every year in the US.[24, 25] Studies in Hong Kong, Bangkok, and South Korea have found that antibiotics are prescribed for as much as 60-89% of outpatient visits for cold and flu symptoms.[26, 27] A 2000 study in rural China showed that 61% of medications prescribed for influenza were unnecessary.[28] Furthermore, rates of antibiotic resistance are higher in Asia than in other parts of the world.[29] Prevalence of penicillin-resistant *Streptococcus pneumoniae* is as high as 75% in South Korea as compared to 43% in France and a low 7% in Germany.[30,31] Erythromycin-resistant *S. pneumoniae* prevalence is also quite high in Asia: 92.1% in Vietnam, 80.6% in Korea, and 73.9% in China.[32] Thus, inappropriate prescribing by physicians has potential negative impacts on both health care costs and outcomes.

Most of the NCMS pilot programs are catastrophic insurance schemes focusing very little on changing actual health care costs or physician prescribing behavior. One unique pilot NCMS program is Rural Mutual Health Care (RMHC), a rural healthcare insurance experiment led by Harvard and Yale faculty researchers in collaboration with the Chinese government. RMHC is voluntary, subsidized, and locally-managed community-based health insurance, with a strong focus on prevention and primary care.[2,13] RMHC research funds pay 20 yuan per person (the equivalent of the NCMS government share) while enrollees contribute 10 yuan per person, with exemptions for the poor. Local township RMHC offices have board members chosen from the community, and these offices control finances, benefits packages, hiring of selected village doctors, and contracts with local hospitals. RMHC has several cost-control mechanisms to increase financial protection for members and to decrease financial incentives for inappropriate prescribing. Payment to outpatient providers consists of fixed salaries, fee-for-visit reimbursements, and bonuses at the end of the year with any remaining funds. In addition, providers are required to buy drugs from RMHC, follow an essential drug list, and sell drugs at cost to patients. Local RMHC offices periodically evaluate village doctors to ensure proper reimbursements and quality care.

To date, studies on RMHC have looked at baseline poverty and ill health, adverse selection, and unequal distribution of benefits, but none have addressed RMHC's impact on cost to patients or health outcomes.[33, 34, 35]

STATEMENT OF PURPOSE AND HYPOTHESES

This pilot study aims to examine how RMHC affects physician prescribing practices both in terms of costs to patients and quality of care. Health outcomes like mortality or morbidity require long observation times, thus inappropriate prescribing could be a possible proxy for quality of care. This research study tests the feasibility of using inappropriate prescribing for common colds to measure RMHC's impact on quality of care.

There are two sets of hypotheses. First, RMHC reduced medication costs for members as compared to uninsured RMHC patients and compared to the old CMS insurance. Second, RMHC reduced inappropriate prescribing for members as compared to uninsured RMHC patients and compared to the old CMS insurance.

METHODS

Background

Details of RMHC are described in these referenced previous studies.[13, 33, 34, 35] In brief, two of the poorest provinces in China, Guizhou and Shanxi Provinces, were chosen as sites for a voluntary community-based health insurance program, Rural Mutual Health Care. In 2002, RMHC was implemented by a Harvard-Yale research team in conjunction with the local Kaiyang County Public Health Office in Fengshan Township, part of Kaiyang County in Guizhou Province. RMHC used research funds to simulate the government contribution for rural insurance, 20 yuan per capita, and any additional government subsidies for the poorest residents. Enrollees, in turn, contributed 10 yuan. Benefits packages included different levels of co-payments for prescription medications and outpatient visits to the local village doctor as well as reduced rates for inpatient hospitalizations. Several cost-control mechanisms were built into RMHC, as detailed in prior sections.

This study focused specifically on the RMHC site of Fengshan Township. Fengshan is comprised of 26 villages that are served by one township hospital and 56 village doctors. Not all village doctors are hired by RMHC. In 2001, Fengshan had a population of 37,000 and annual income per capita of 2000 yuan (US $275). In 2003, Fengshan's RMHC enrollment was close to 70%, and 11% of the poorest residents were fully subsidized by RMHC.[13, 35]

Prior RMHC evaluation of village doctors in January-February 2004 showed rates of inappropriate prescribing ranging from as low as 1% to as high as 59%. Criteria for inappropriate prescribing used for this evaluation included incorrect medication usage as

well as inaccurate billing. This pilot study had limited resources and time to evaluate all RMHC doctors. Instead, six doctors were chosen based on the prior evaluation as a representative sample of village doctors hired by RMHC. Two doctors had low rates of inappropriate prescriptions, one doctor from Sanhe village at 5% and one from Yongxing village at 4%. Two doctors had average rates of inappropriate prescriptions, one Duoyang village doctor and one Anping village doctor both at 14%. Two doctors had high rates of inappropriate prescriptions, one Guaizhai village doctor and one Xinhua doctor both at 59%.

Sampling of prescriptions

Data collection occurred during July-August 2004. The above-selected doctors in 6 villages – Anping village, Duoyang village, Guaizhai village, Sanhe village, Xinhua village, and Yongxing village – were asked to submit all clinic prescription records for two different time periods. Prescriptions were selected from: March-May 2003 before implementation of RMHC in these villages, and March-May 2004 after RMHC implementation. Choosing the same time period of March-May for each year was intended to reduce confounding from seasonal variability of disease. Within each time period, prescriptions were collected for uninsured and insured patients (under CMS and RMHC for respective time periods). RMHC and the prior CMS insurance programs both required doctors to keep carbon copies of prescriptions for reimbursement. Some, but not all, doctors also kept records of uninsured patient visits.

Out of all the prescriptions collected, only those with the single diagnosis of "gan mao" or "common cold" were selected for this study. Prescription records with multiple

diagnoses were also excluded from this study. The common cold was the chosen diagnosis for this study because it is the most common diagnosis given to patients by village doctors, representing over half of all clinic visits, and because all doctors should be trained to adequately treat the common cold. The original goal was to systematically sample 30-60 common cold prescriptions per physician per insurance group. If the total number of available prescriptions exceeded 60, then one out of every x (x being the total divided by 60) prescriptions were selected. Ultimately, a total of 858 prescriptions with the single diagnosis of "common cold" were sampled for this study.

Each prescription sheet actually functioned more like a clinic visit note because it listed patient diagnosis, symptoms, all medications and dosages, and cost for that visit. The following data were recorded per prescription sheet: prescribing doctor, visit date, patient's age, patient's gender, patient's insurance status, diagnosis, symptoms (if available), each drug prescribed, total number of drugs prescribed, use of any injections, and total price of all drugs.

Main outcome measures used for this pilot study were: total number of medications per prescription/visit, total cost of prescription, use of injections, and inappropriate prescribing for common cold, based on peer physician review. Number of medications and total cost are objective, quantitative measures of physician prescribing behavior, while injection use and inappropriate prescribing are subjective surrogates for assessing quality of care.

Peer review of prescriptions for inappropriateness

Each prescription was reviewed by one of two Kaiyang County Health Department physicians. The reviewers gave each prescription a binary score of appropriate or inappropriate medication usage based on all the information recorded on the prescription sheet: patient diagnosis, symptoms, and age. Criteria for labeling a prescription "inappropriate" were: incorrect use of a prescribed drug, incorrect dose, incorrect drug delivery (oral versus injection/intravenous), drug-drug interactions, and redundant use of drugs. This pilot study, unlike the prior RMHC physician evaluation, did not use incorrect billing or overpricing of medications as criteria for inappropriateness of prescriptions.

There were several limitations to the objectiveness of the peer reviewing process which this pilot study was unable to address due to funding and time constraints. No prescriptions were reviewed by both physicians to check for inter-observer reliability. In addition, the two health department physicians were also involved in overall RMHC management. They thus had prior knowledge and possible biases towards the selected village doctors. It was not possible to blind the two reviewing physicians to prescribing doctor or patient insurance status because that information was written on the prescriptions. Peer reviewers were also not blinded to this study's objectives because soliciting their help required explaining study aims. Similarly, village doctors were told of study aims when prescriptions were collected from their offices.

Statistical Analysis

Prescription data was entered into Microsoft Excel (Microsoft Corp, Seattle, WA) and converted to Intercooled Stata version 9.0 (Stata Corp, College Station, TX) for all subsequent analyses. Age was first analyzed as a continuous variable and then stratified into 3 categories: age ≤ 15, age 16-45, and age > 46. Cost was transformed to logcost. Background characteristics between groups were analyzed using X^2 tests for difference in proportions and Fisher's exact test for categorical variables. Two-tailed t-tests with unequal groups were used for continuous variables. Comparisons were made between 2003 (under CMS insurance, before RMHC implementation) and 2004 (after RMHC implementation); between insured and uninsured patient prescriptions regardless of insurance program; between CMS insured and RMHC insured patient prescriptions; and between uninsured 2003 (not enrolled in CMS) and uninsured 2004 (not enrolled in RMHC) patient prescriptions.

Four multiple regression models were used. First, multiple linear regression was performed on the number of medications as a function of patient age, patient gender, village doctor, use of any injections, year, insurance, and the interaction of year*insurance. Second, multiple linear regression was also performed on logcost using the same covariates as above. Third, multiple logistic regression was performed on use of any injections using covariates of age, gender, village doctor, number of medications, year, insurance, and year*insurance. Fourth, multiple logistic regression was performed on the binary outcome of prescription appropriateness or inappropriateness using the same covariates used with multiple linear regression. Regarding village doctors, the tables show regressions with Anping village as the reference village.

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RESULTS

General Information

A total of 858 prescriptions with single diagnosis of common cold were collected. 414 prescriptions were from 2003 pre-RMHC implementation and, of these, 272 were for insured CMS and 142 for uninsured patients. 444 prescriptions were from 2004 post-RMHC implementation and, of these, 301 were for insured RMHC and 143 for uninsured patients. Table 1 lists numbers of prescriptions collected by village doctor and insurance category. The number of prescriptions collected per category ranges from 0 to 59.

Table 1: Overall Prescription and Demographic Characteristics

Number of prescriptions collected					
Villages	Year 2003 (under CMS)		Year 2004 (under RMHC)		*Total*
	Uninsured	Insured	Uninsured	Insured	
Anping	0	55	42	56	153
Duoyang	29	51	19	52	151
Guaizhai	49	52	34	59	194
Sanhe	36	52	45	49	182
Xinhua	0	28	3	37	68
Yongxing	28	34	0	48	110
Total	142	272	143	301	**858**
Patients					
Age	Mean 33.72 years, Range 0-86 years				
Age ≤ 15	273 (31.8%)				
Age 16-45	262 (30.5%)				
Age > 46	323 (37.7%)				
Gender					
Male	451 (52.6%)				
Female	407 (47.4%)				

Table 1: Overall Prescription and Demographic Characteristics (cont)

Prescriptions	
Total number of drugs per visit	Mean 5.79, Range 1-18
Cost	Mean 9.94 yuan, Range 0.36-52.74 yuan
Injections	
None	213 (24.8%)
≥1 injection	645 (75.2%)
Appropriateness	
Appropriate	625 (72.8%)
Inappropriate	233 (27.2%)

Table 1 also lists the overall demographic characteristics for this data set. Patient age ranged from 0 to 86 years, with a mean age of 33.72. Shapiro-Wilk normality test for age showed a non-normal distribution ($z=8.549$, $p<0.001$). Closer examination of age revealed a tri-modal distribution, with peaked at roughly 5, 35, and 55 years. Three age categories were created for subsequent data analysis – age ≤ 15, age 16-45, and age > 46. These age categories roughly correlate to school-age, young adults/middle-age, and older patients. In this data set, 31.8% of patients were age ≤ 15; 30.5% were age 16-45; and 37.7% were age > 46. Shapiro-Wilk tests showed normal distributions within these categories: age ≤ 15 ($z=0.756$, $p=0.225$), age 16-45 ($z=1.081$, $p=0.140$), age > 46 ($z= -0.921$, $p=0.821$).

Regarding other variables, 52.6% of all prescriptions were for male patients. Total number of medications per prescription ranged from 1 to 18, with a mean of 5.79. Total cost per prescription ranged from 0.36 (US $0.05) to 52.74 yuan (US $6.59), with a mean cost of 9.94 yuan (US $1.24). Cost was the only variable with missing values; 31 prescriptions had no cost listed. All 31 of these prescriptions were for uninsured CMS

patients: 29 of the prescriptions were from Duoyang village, and 2 from Guaizhai village. Use of injections was quite high: 75.2% of all prescriptions had at least one injection or intravenous medication. In terms of prescribing inappropriateness, 27.2% of all prescriptions had at least one inappropriately prescribed medication.

Comparison of 2003 versus 2004 prescriptions

Table 2 compares 2003 (pre-RMHC implementation) with 2004 (post-RMHC implementation) data. As expected by results in Table 1, there is a statistically significant difference between the number of prescriptions collected per village doctor (X^2=16.019, p=0.007). There is also a significant difference in mean age between the two years: 30.05 years in 2003 versus 37.13 years in 2004 (t=-4.574, p<0.001). Significantly more older patients were seen in 2004 than in 2003: 43.2% prescriptions were for age > 46 in 2004 versus 31.6% in 2003; 32.7% were for age 16-45 in 2004 versus 28.3% in 2003; and 24.1% were for age ≤ 15 in 2004 versus 40.1% in 2003 (X^2=26.247, p<0.001).

As for other variables in Table 2, no significant difference existed for gender distribution between 2003 and 2004 data (X^2=0.106, p=0.744). Mean number of medications per prescription was slightly higher in 2003, but this difference was not statistically significant (t=1.708, p=0.088). Mean cost of prescriptions significantly decreased from 13.09 yuan in 2003 (US $1.64) to 7.22 yuan in 2004 (US $ 0.90) (t=8.217, p<0.001). Use of injections significantly decreased from 87.9% in 2003 to 63.3% in 2004 (X^2=69.665, p<0.001). There was actually no significant difference in proportion of inappropriate prescriptions between the two years (X^2=0.975, p=0.324).

Table 2: Demographic and Prescription Characteristics by Year

	2003 Pre-RMHC	2004 Post-RMHC	Total	X^2 or T-test	P-value
Villages					
Anping	55 (13.3%)	98 (22.1%)	153 (17.8%)	X^2:	0.007
Duoyang	80 (19.3%)	71 (16.0%)	151 (17.6%)	16.019	
Guaizhai	101 (24.4%)	93 (20.9%)	194 (22.6%)		
Sanhe	88 (21.3%)	94 (21.2%)	182 (21.2%)		
Xinhua	28 (6.8%)	40 (9.0%)	68 (7.9%)		
Yongxing	62 (15.0%)	48 (10.8%)	110 (12.8%)		
Patients					
Mean Age in years (95% CI)	30.05 (27.86, 32.25)	37.13 (35.02, 39.25)	33.72 (32.18, 35.25)	T: -4.574	<0.001
Age ≤ 15	166 (40.1%)	107 (24.1%)	273 (31.8%)	X^2:	<0.001
Age 16-45	117 (28.3%)	145 (32.7%)	262 (30.5%)	26.247	
Age > 46	131 (31.6%)	192 (43.2%)	323 (37.7%)		
Gender					
Male	220 (53.1%)	231 (52.0%)	451 (52.6%)	X^2: 0.106	0.744
Female	194 (46.9%)	213 (48.0%)	407 (47.4%)		
Prescriptions					
Mean number of drugs (95% CI)	5.93 (5.73, 6.14)	5.65 (5.39, 5.90)	5.79 (5.62, 5.95)	T: 1.708	0.088
Mean cost in yuan (95% CI)	13.09 (11.85, 14.32)	7.22 (6.55, 7.89)	9.94 (9.24, 10.64)	T: 8.217	<0.001
Injections					
None	50 (12.1%)	163 (36.7%)	213 (24.8%)	X^2:	<0.001
≥1 injection	364 (87.9%)	281 (63.3%)	645 (75.2%)	69.665	
Appropriateness					
Appropriate	308 (74.4%)	317 (71.4%)	625 (72.8%)	X^2: 0.975	0.324
Inappropriate	106 (25.6%)	127 (28.6%)	233 (27.2%)		
Total number of prescriptions	414	444	858		

Comparison of insured (both RMHC and CMS) versus uninsured patients

Table 3 combines data from both 2003 and 2004, CMS and RMHC, to compare all uninsured (285 prescriptions) versus insured (573 prescriptions). Patient age and gender, village doctor, use of injections, and prescription cost were all statistically

significantly different between insured and uninsured prescriptions. Significant differences existed between the percentage of insured versus uninsured prescriptions collected per village doctor (X^2=49.313, p<0.001). Mean age for the insured was 37.67 years, much older than the uninsured at 25.76 years (t=-7.553, p<0.001). For age > 46, 46.6% were insured versus 19.7% uninsured; for age 16-45, 27.9% were insured versus 35.8% uninsured; and for age ≤ 15, 25.5% were insured versus 44.6% uninsured (X^2=62.352, p<0.001). Gender was also significantly different; for the insured, 51.0% were for female patients and 49.0% for male patients, whereas for uninsured prescriptions, only 40.3% were for female patients and 59.7% for male patients (X^2=8.591, p=0.003).

The average number of medications per prescription did not statistically differ between insured and uninsured groups (t=-1.597, p=0.111). Mean cost for uninsured patients was 7.12 yuan (US $0.89), significantly lower than the mean cost of 11.19 yuan (US $1.40) for insured patients (t=-5.910, p<0.001). As for injections, 84.9% of uninsured patients received injections as compared to 70.3% of insured patients (X^2=21.682, p<0.001). The proportion of inappropriate prescriptions did not significantly differ between insured and uninsured patients (X^2=1.159, p=0.282).

Table 3: Demographic and Prescription Characteristics by Insurance Status

	Uninsured	Insured	Total (%)	X^2 or T-test	P-value
Villages					
Anping	42 (14.7%)	111 (19.4%)	153 (17.8%)	X^2:	<0.001
Duoyang	48 (16.8%)	103 (18.0%)	151 (17.6%)	49.313	
Guaizhai	83 (29.1%)	111 (19.4%)	194 (22.6%)		
Sanhe	81 (28.4%)	101 (17.6%)	182 (21.2%)		
Xinhua	3 (1.1%)	65 (11.3%)	68 (7.9%)		
Yongxing	28 (9.8%)	82 (14.3%)	110 (12.8%)		

Table 3: Demographic and Prescription Characteristics by Insurance Status (cont)

	Uninsured	Insured	Total (%)	X^2 or T	P-value
Patients					
Mean Age in years (95% CI)	25.76 (23.29, 28.24)	37.67 (35.81, 39.54)	33.72 (32.18, 35.25)	T: -7.553	<0.001
Age ≤ 15	127 (44.6%)	146 (25.5%)	273 (31.8%)	X^2:	<0.001
Age 16-45	102 (35.8%)	160 (27.9%)	262 (30.5%)	62.352	
Age > 46	56 (19.7%)	267 (46.6%)	323 (37.7%)		
Gender					
Male	170 (59.7%)	281 (49.0%)	451 (52.6%)	X^2: 8.591	0.003
Female	115 (40.3%)	292 (51.0%)	407 (47.4%)		
Prescriptions					
Mean number of drugs (95% CI)	5.60 (5.33, 5.87)	5.88 (5.67, 6.09)	5.79 (5.62, 5.95)	T: -1.597	0.111
Mean cost in yuan (95% CI)	7.12 (6.09, 8.14)	11.19 (10.30, 12.08)	9.94 (9.24, 10.64)	T: -5.910	<0.001
Injections					
None	43 (15.1%)	170 (29.7%)	213 (24.8%)	X^2:	<0.001
≥1 injection	242 (84.9%)	403 (70.3%)	645 (75.2%)	21.682	
Appropriateness					
Appropriate	201 (70.5%)	424 (74.0%)	625 (72.8%)	X^2: 1.159	0.282
Inappropriate	84 (29.5%)	149 (26.0%)	233 (27.2%)		
Total number of prescriptions	285	573	858		

Comparison of CMS insured versus RMHC insured prescriptions

Of the 858 prescriptions collected, 272 were for CMS insured (2003, pre-RMHC implementation) patients and 301 for RMHC (2004) patients. Table 4 shows that age, use of injections, mean number of medications per prescription, and mean cost were significantly differ between the two insurance groups. There was no significant difference between the numbers of CMS versus RMHC insured prescriptions collected by village doctor (X^2=2.725, p=0.742). Mean age of RMHC insured prescriptions was significantly higher, 41.25 years, than for CMS insured prescriptions, 33.71 years

(t=-4.025, p<0.001). 54.1% of RMHC prescriptions were for patients age > 46 versus 38.2% of CMS; 25.3% of RMHC were for age 16-45 versus 30.9% of CMS; and 20.6% of RMHC were for age ≤ 15 versus 30.9% of CMS (X^2=15.324, p<0.001). There was no significant difference in gender distribution for RMHC versus CMS insured prescriptions (X^2=1.143, p=0.285).

In terms of prescription characteristics, significantly fewer drugs were used for RMHC than CMS insured patients, mean of 5.54 versus 6.25 medicines per prescription (t=3.392, p<0.001). Also, RMHC prescriptions had significantly lower costs than CMS prescriptions, 7.95 yuan versus 14.78 yuan (t=7.761, p<0.001). Use of injections also significantly decreased under RMHC as opposed to CMS, 56.5% of RMHC versus 85.7% of CMS (X^2=58.319, p<0.001). However, proportion of inappropriate prescriptions did not significantly differ between the two insurance categories; overall, 26.0% of insured prescriptions had one inappropriately prescribed medication (X^2=0.271, p=0.603).

Table 4: Demographic and Prescription Characteristics comparing CMS insured versus RMHC insured

	CMS insured	RMHC insured	Total (%)	X^2 or T-test	P-value
Villages					
Anping	55 (20.2%)	56 (18.6%)	111 (19.4%)	X^2: 2.725	0.742
Duoyang	51 (18.7%)	52 (17.3%)	103 (18.0%)		
Guaizhai	52 (19.1%)	59 (19.6%)	111 (19.4%)		
Sanhe	52 (19.1%)	49 (16.3%)	101 (17.6%)		
Xinhua	28 (10.3%)	37 (12.3%)	65 (11.3%)		
Yongxing	34 (12.5%)	48 (15.9%)	82 (14.3%)		

Table 4: Demographic and Prescription Characteristics comparing CMS insured versus RMHC insured (cont)

	CMS insured	RMHC insured	Total (%)	X^2 or T	P-value
Patients					
Mean Age in years (95% CI)	33.71 (31.07, 36.36)	41.25 (38.68, 43.82)	37.67 (35.81, 39.54)	T: -4.025	<0.001
Age ≤ 15	84 (30.9%)	62 (20.6%)	146 (25.5%)	X^2: 15.324	<0.001
Age 16-45	84 (30.9%)	76 (25.3%)	160 (27.9%)		
Age > 46	104 (38.2%)	163 (54.1%)	267 (46.6%)		
Gender					
Male	127 (46.7%)	154 (51.2%)	281 (49.0%)	X^2: 1.143	0.285
Female	145 (53.3%)	147 (48.8%)	292 (51.0%)		
Prescriptions					
Mean number of drugs (95% CI)	6.25 (6.00, 6.51)	5.54 (5.21, 5.87)	5.88 (5.67, 6.09)	T: 3.392	<0.001
Mean cost in yuan (95% CI)	14.78 (13.29, 16.27)	7.95 (7.07, 8.83)	11.19 (10.30, 12.08)	T: 7.761	<0.001
Injections					
None	39 (14.3%)	131 (43.5%)	170 (29.7%)	X^2: 58.319	<0.001
≥1 injection	233 (85.7%)	170 (56.5%)	403 (70.3%)		
Appropriateness					
Appropriate	204 (75.0%)	220 (73.1%)	424 (74.0%)	X^2: 0.271	0.603
Inappropriate	68 (25.0%)	81 (26.9%)	149 (26.0%)		
Total number of prescriptions	272	301	573		

Comparison of 2003 uninsured versus 2004 uninsured patients

Table 5 shows demographic and prescription characteristics for 2003 uninsured (not enrolled in CMS) and 2004 uninsured (not enrolled in RMHC) data. A total of 142 prescriptions were collected for uninsured patients in 2003 and 143 for uninsured patients in 2004. The number of uninsured 2003 and 2004 prescriptions available for analysis significantly differed by village doctor: Anping and Xinhua had no records for 2003 uninsured patient visits; Xinhua only had 3 records for 2004 uninsured patients; and

Yongxing had no records for 2004 uninsured patient visits (X^2=78.792, p<0.001). Age of uninsured patients was significantly older in 2004 than in 2003; mean age in 2004 uninsured was 28.47 years versus 23.04 years in 2003 (t=-2.167, p=0.031); 20.3% were age > 46 in 2004 versus 19.0% in 2003; 48.3% were age 16-45 in 2004 versus 23.2% in 2003; and 31.5% were age ≤ 15 in 2004 versus 57.7% in 2003 (X^2=23.554, p<0.001). As for gender, 2004 uninsured prescriptions were composed of 46.1% female and 53.9% male patients as compared to 2003 uninsured prescriptions, where 34.5% were female and 65.5% were male patients (X^2=4.015, p=0.045).

Mean number of drugs significantly increased from 2003 to 2004 for uninsured patients, but mean costs of prescriptions significantly decreased overall. In 2003, mean number of medications per patient visit was 5.32, which increased to 5.87 in 2004 (t=-2.027, p=0.044). However, while number of medications increased from 2003 to 2004, mean costs decreased. Mean costs of prescriptions for 2003 uninsured was 8.94 yuan, which significantly decreased to 5.70 yuan in 2004 (t=2.919, p=0.004). Use of injections significantly decreased from 2003, where 92.3% of all prescriptions had at least one injection, to 2004 with 77.6% (X^2=11.905, p=0.001). The only variable not statistically significantly different between the two groups was proportion of inappropriate prescribing, which was 29.5% overall (X^2=1.002, p=0.317).

Table 5: Demographic and Prescription Characteristics comparing 2003 uninsured versus 2004 uninsured

	2003 uninsured	2004 uninsured	Total (%)	X^2 or T-test	P-value
Villages					
Anping	0 (0%)	42 (29.4%)	42 (14.7%)	X^2:	<0.001
Duoyang	29 (20.4%)	19 (13.3%)	48 (16.8%)	78.792	
Guaizhai	49 (34.5%)	34 (23.8%)	83 (29.1%)		
Sanhe	36 (25.3%)	45 (31.5%)	81 (28.4%)		
Xinhua	0 (0%)	3 (2.1%)	3 (1.1%)		
Yongxing	28 (19.7%)	0 (0%)	28 (9.8%)		
Patients					
Mean Age in years (95% CI)	23.04 (19.37, 26.71)	28.47 (25.15, 31.79)	25.76 (23.29, 28.24)	T: -2.167	0.031
Age ≤ 15	82 (57.7%)	45 (31.5%)	127 (44.6%)	X^2:	<0.001
Age 16-45	33 (23.2%)	69 (48.3%)	102 (35.8%)	23.554	
Age > 46	27 (19.0%)	29 (20.3%)	56 (19.7%)		
Gender					
Male	93 (65.5%)	77 (53.9%)	170 (59.7%)	X^2: 4.015	0.045
Female	49 (34.5%)	66 (46.1%)	115 (40.3%)		
Prescriptions					
Mean number of drugs (95% CI)	5.32 (4.98, 5.67)	5.87 (5.46, 6.29)	5.60 (5.33, 5.87)	T: -2.027	0.044
Mean cost in yuan (95% CI)	8.94 (6.93, 10.95)	5.70 (4.80, 6.60)	7.12 (6.09, 8.14)	T: 2.919	0.004
Injections					
None	11 (7.7%)	32 (22.4%)	43 (15.1%)	X^2:	0.001
≥1 injection	131 (92.3%)	111 (77.6%)	242 (84.9%)	11.905	
Appropriateness					
Appropriate	104 (73.2%)	97 (67.8%)	201 (70.5%)	X^2: 1.002	0.317
Inappropriate	38 (26.8%)	46 (32.2%)	84 (29.5%)		
Total number of prescriptions	142	143	285		

Multiple Linear Regression of Number of Medications

Table 6 shows multiple linear regression of the number of medications prescribed per patient visit with covariates of age, gender, village doctor, use of injections, insurance status, and interaction between year and insurance. The adjusted correlation coefficient for this model is 0.365. Analysis of village doctor reveals that Guaizhai, Sanhe, and Yongxing prescribed significantly more medicines than Anping ($\beta_{Duoyang}$=0.189, p=0.421; $\beta_{Guaizhai}$=0.691, p=0.002; β_{Sanhe}=1.099, p<0.001; β_{Xinhua}=0.476, p=0.112; $\beta_{Yongxing}$=1.688, p<0.001).

Age was first analyzed as a continuous variable in this regression model, which revealed a highly significant association between age and number of medications after adjusting for other covariates (data not shown: β=0.009, p=0.004, overall model adjusted R^2=0.357). Subsequent age stratification, as shown in Table 6, reveals that for patients below age 45, more medications are prescribed as age increases (age ≤ 15 β=0.067, p=0.005; age 16-45 β=-0.062, p=0.048). However, for patients above age 46, there is no significant correlation between age and number of medications (β=-0.016, p=0.375). As for patient gender, it is not significantly associated with number of medications (β=0.265, p=0.058).

Looking at other prescription characteristics in the regression reveals that number of medications is significantly associated with injection use, year, insurance, and year-insurance interaction. Use of injections is significantly positively associated with number of medications (β=3.461, p<0.001). As hypothesized, there are significant associations between number of medications and year and insurance category. After adjusting for other factors, prescriptions in 2004 had more medications per visit than prescriptions in

2003 (β=1.239, p<0.001). Insured patients also had more medications per visit than uninsured patients, regardless of CMS or RMHC insurance type (β=1.227, p<0.001). The interaction between year and insurance was also significantly negatively associated with number of medications (β=-1.011, p=0.001), indicating that the increase in number of medications for insured patients as compared to uninsured patients was less for RMHC than for CMS.

Table 6: Multiple Linear Regression of Number of Medications

	Adjusted β	P-value	95% CI
Village			
(Anping as reference)			
Duoyang	0.189	0.421	-0.272, 0.651
Guaizhai	0.691	0.002	0.250, 1.131
Sanhe	1.099	<0.001	0.659, 1.539
Xinhua	0.476	0.112	-0.111, 1.064
Yongxing	1.688	<0.001	1.177, 2.120
Age ≤ 15	0.067	0.005	0.020, 0.113
Age 16-45	-0.062	0.048	-0.125, -0.001
Age > 46	-0.016	0.375	-0.051, 0.019
Gender	0.265	0.058	-0.009, 0.540
Injection	3.461	<0.001	3.123, 3.800
Year	1.239	<0.001	0.753, 1.725
If insurance	1.227	<0.001	0.800, 1.653
Year * insurance	-1.011	0.001	-1.601, -0.422
Adjusted R^2 = 0.365			

Multiple Linear Regression Analyses of Costs

Cost was log10 transformed to more closely approximate a normal distribution. However, the Shapiro-Wilk test showed that neither cost nor log(cost) were normally distributed (cost: z=12.158, p<0.001 and logcost: z=6.803, p<0.001). Table 7 shows

multiple linear regression of logcost with covariates of age, gender, village doctor, use of injections, year, insurance status, and year-insurance interaction. The adjusted correlation coefficient for this model is 0.442. Regarding village doctors, Guaizhai had significantly lower costs than Anping, while Xinhua and Yongxing had higher costs ($\beta_{Duoyang}$=0.112, p=0.172; $\beta_{Guaizhai}$=-0.177, p=0.020; β_{Sanhe}=-0.004, p=0.953; β_{Xinhua}=0.470, p<0.001; $\beta_{Yongxing}$=0.528, p<0.001).

Cost was not significantly associated with age when age was analyzed as a continuous variable (data not shown: β=0.001, p=0.147, overall model adjusted R^2=0.437). As shown in Table 7, cost also was not significantly associated with any stratified age group ($\beta_{age\leq 15}$=0.013, p=0.101; $\beta_{age16\text{-}45}$=-0.011, p=0.312; $\beta_{age>46}$=-0.008, p=0.169). Gender was not significantly associated with logcost (β=0.023, p=0.622).

Cost statistically significantly increased as the number of medications increased (β=0.158, p<0.001). Cost, however, was not significantly associated with use of injections (β=0.053, p=0.452).

As hypothesized, cost was significantly associated with year (β=-0.272, p=0.003); 2004 post-RMHC mean costs were 0.53 yuan lower than 2003 pre-RMHC mean costs after adjusting for all other factors. As for insurance, mean costs of prescriptions were on average 3.01 yuan higher for insured patients than uninsured patients (β=0.478, p<0.001). The interaction term for year and insurance also showed statistical significance with logcost (β=-0.239, p=0.025), indicating that the increase in costs for insured patients as compared to uninsured patients is less for RMHC than for CMS.

Table 7: Multiple Linear Regression of Logcost

	Adjusted β	P-value	95% CI
Village			
(Anping as reference)			
Duoyang	0.112	0.172	-0.049, 0.274
Guaizhai	-0.177	0.020	-0.327, -0.028
Sanhe	-0.004	0.953	-0.154, 0.145
Xinhua	0.470	<0.001	0.273, 0.666
Yongxing	0.528	<0.001	0.352, 0.703
Age ≤ 15	0.013	0.101	-0.003, 0.029
Age 16-45	-0.011	0.312	-0.032, 0.010
Age > 46	-0.008	0.169	-0.020, 0.003
Gender	0.023	0.622	-0.070, 0.117
Number of medications	0.158	<0.001	0.135, 0.181
Injection	0.053	0.452	-0.085, 0.191
Year	-0.272	0.003	-0.449, -0.095
If insurance	0.478	<0.001	0.318, 0.637
Year * insurance	-0.239	0.025	-0.447, -0.030
Adjusted R^2 = 0.442			

Logistic Regression Analyses of Injection Use

Injection use is a binary variable dependent on whether any of the medications written on a prescription sheet was injected as a shot or given intravenously. Table 8 shows logistic regression of injection use by covariates of age, gender, village doctor, number of medications, year, insurance status, and interaction between year and insurance. Adjusted odds ratios are listed. The Hosmer-Lemeshow goodness of fit test was X^2_8=9.61, p=0.294. Regarding village doctor, Xinhua had significantly higher odds of injection use than Anping, while Yongxing had significantly lower odds of injection

($OR_{Duoyang}$=1.711, p=0.162; $OR_{Guaizhai}$=0.992, p=0.981; OR_{Sanhe}=0.758, p=0.462; OR_{Xinhua}=3.392, p=0.007; $OR_{Yongxing}$=0.180, p<0.001).

Age as a continuous variable was significantly associated with injection use (data not shown: OR=0.988, p=0.020, overall model X^2_8=9.36, p=0.313). With analysis using stratified age groups, older age, age > 46, was positively associated with injection use (OR=1.077, p=0.015), but younger ages were not significantly associated with injection use ($OR_{age\leq 15}$=0.950, p=0.215; $OR_{age16\text{-}45}$=1.019, p=0.732). Gender was not associated with injections (OR=0.994, p=0.981).

As expected, use of injections significantly increased as number of medications increased (OR=2.861, p<0.001). Use of injections significantly decreased from 2003 to 2004 after RMHC implementation (OR=0.139, p<0.001). Use of injections also significantly decreased for insured patients as compared to uninsured patients (OR=0.239, p=0.001). The interaction between year and insurance, however, is insignificant, indicating that RMHC insurance did not have any more impact on injection use than CMS insurance did (OR=1.290, p=0.641).

Table 8: Logistic Regression of Use of Injections

	Adjusted OR	P-value	95% CI
Village			
(Anping as reference)			
Duoyang	1.711	0.162	0.806, 3.632
Guaizhai	0.992	0.981	0.493, 1.995
Sanhe	0.758	0.462	0.363, 1.583
Xinhua	3.932	0.007	1.458, 10.603
Yongxing	0.180	<0.001	0.077, 0.423
Age ≤ 15	0.950	0.215	0.877, 1.030
Age 16-45	1.019	0.732	0.914, 1.136
Age > 46	1.077	0.015	1.015, 1.144

Table 8: Logistic Regression of Use of Injections (cont)

	Adjusted OR	P-value	95% CI
Gender	0.994	0.981	0.617, 1.601
Number of medications	2.861	<0.001	2.415, 3.390
Year	0.139	<0.001	0.055, 0.349
If insurance	0.239	0.001	0.101, 0.570
Year * insurance	1.290	0.641	0.442, 3.769
Hosmer-Lemeshow X^2(df 8) = 9.61, p = 0.294			

Logistic Regression Analyses of Inappropriate Prescriptions

Inappropriate prescribing is a binary variable representing the presence of any inappropriately prescribed medications on a prescription sheet. Table 9 shows logistic regression of inappropriate prescribing as a function of age, gender, village doctor, injection use, number of medications, year, insurance status, and interaction between year and insurance. Adjusted odds ratios are listed. The Hosmer-Lemeshow goodness of fit test was X^2_8=4.02, p=0.855. Analysis of village doctor reveals that Duoyang and Sanhe had significantly higher odds of inappropriate prescriptions than Anping ($OR_{Duoyang}$=2.593, p=0.001; $OR_{Guaizhai}$=1.039, p=0.897; OR_{Sanhe}=2.077, p=0.009; OR_{Xinhua}=0.890, p=0.772; $OR_{Yongxing}$=1.311, p=0.430).

Age as a continuous variable was not significantly associated with inappropriate prescribing (data not shown: OR=0.995, p=0.233, overall model X^2_8=5.52, p=0.701). By contrast, analysis with stratified age groups show that age ≤ 15 and age 16-45 are both significantly associated with inappropriate prescribing, but age > 46 is not ($OR_{age>46}$=0.981, p=0.376). For age ≤ 15, as age increased, the proportion of inappropriate prescriptions actually decreased ($OR_{age\leq 15}$=0.937, p=0.023), which was the

opposite for age 16-45 ($OR_{age16-45}$=1.082, p=0.041). Gender was also significantly associated with inappropriate prescribing; inappropriate prescribing was lower for female patients (OR=0.657, p=0.013).

Injection use was not associated with inappropriate prescribing (OR=0.917, p=0.743). As expected, inappropriate prescribing was significantly and positively associated with number of medications (OR=1.253, p=<0.001). Contrary to hypothesis, however, year, insurance status, and the interaction between the two were all not significantly associated with inappropriate prescribing (OR_{Year}=1.328, p=0.331; $OR_{If\ insurance}$=0.869, p=0.589; $OR_{Year*insurance}$=0.962, p=0.912).

Table 9: Logistic Regression of Inappropriate Prescribing

	Adjusted OR	P-value	95% CI
Village			
(Anping as reference)			
Duoyang	2.593	0.001	1.481, 4.539
Guaizhai	1.039	0.897	0.582, 1.854
Sanhe	2.077	0.009	1.120, 3.598
Xinhua	0.890	0.772	0.406, 1.953
Yongxing	1.311	0.430	0.669, 2.569
Age ≤ 15	0.937	0.023	0.886, 0.991
Age 16-45	1.082	0.041	1.003, 1.167
Age > 46	0.981	0.376	0.940, 1.023
Gender	0.657	0.013	0.473, 0.915
Number of medications	1.253	<0.001	1.154, 1.361
Injection	0.917	0.743	0.545, 1.542
Year	1.328	0.331	0.750, 2.351
If insurance	0.869	0.589	0.523, 1.445
Year * insurance	0.962	0.912	0.481, 1.924
Hosmer-Lemeshow X^2(df 8) = 4.02, p = 0.855			

DISCUSSION

Study Findings

This pilot study's purpose was to evaluate RMHC's impact on physician prescribing behavior. In this study, we analyzed 858 prescriptions from 6 village doctors, with diagnoses limited to only "common cold". Results show that RMHC significantly lowered number of medications prescribed per visit and lowered prescription costs, but RMHC did not change inappropriate prescribing or injection use.

Analysis of baseline demographic and patient characteristics revealed that patient age, use of injections, and prescription costs were all significantly different between 2003 and 2004 (Table 2), between insured and uninsured patients (Table 3), between RMHC and CMS enrolled patients (Table 4), and between uninsured patients during 2003 and 2004 (Table 5). The difference in age between groups is likely due to adverse selection in enrollment, with more older patients enrolling in RMHC.[35] The differences in injection use and costs may be caused by stricter drug controls and standards created by RMHC. Proportion of inappropriate prescriptions, however, did not significantly differ between years and insurance categories.

Average costs after RMHC implementation, 7.22 yuan (US $0.90), were nearly half of costs before RMHC implementation, 13.09 yuan (US $1.64). Under both insurance systems, insured patients spent more on prescriptions than uninsured patients. This likely reflects adverse selection seen in previous RMHC studies, where older and sicker patients are more likely to enroll in RMHC.[35] Also, insured patients are more likely to use and overuse health services because of increased affordability. In addition, doctors may prescribe more medications for insured patients to keep patients satisfied and

returning because doctors are partly reimbursed fee-for-visit by RMHC. One study of Hong Kong doctors in 2003 found that many doctors, when asked about their own behavior, thought they overused antibiotics: common reasons for overusing antibiotics were patient satisfaction, fear of malpractice suits, and saving time.[36] In particular, older doctors, private practice doctors, and more senior doctors were more likely to report this.[36] Perhaps insured patients have more purchasing power and thus more influence on doctors to prescribe newer, more expensive, or better medications.

As hypothesized, the regression model for cost showed a significant interaction between year and insurance, a negative value, indicating that the cost difference between insured and uninsured patients was less for RMHC. In addition, the regression model for number of medications also showed a significant negative association between number of medication and the year-insurance interaction term. Thus, RMHC seems better than CMS in regulating overall costs and number of medications for insured patients as compared to uninsured patients even with adverse selection. This finding agrees with this study's original hypothesis. These differences in mean costs are statistically associated with number of medications and prescribing doctor. The strong relationship between prescription costs and number of medications is expected, as is the fact that certain doctors tend to have higher costs: Xinhua village and Yongxing village in particular. After adjusting for all other factors, costs were still significantly associated with year and with insurance status.

Contrary to original hypotheses, this study found no significant difference in the proportion of inappropriate prescriptions by year or by insurance status. Even after controlling for all other factors, there was no significant difference between effects of

RMHC versus CMS insurance on inappropriate prescribing (Table 9: $OR_{Year*insurance}$=0.962, p=0.912). As expected, increased number of medications is strongly associated with increased odds of inappropriate prescriptions, roughly 1.25 times higher odds per additional drug.

Logistic regression results show that number of medications, prescribing doctor, patient age, and patient gender are all significantly associated with inappropriate prescribing. In Table 9, the adjusted OR for gender was 0.657 (p=0.013), indicating that female patients had lower odds of inappropriate prescriptions, which is quite interesting. One possible explanation is that all village doctors were male and perhaps preferentially over-prescribed for male patients. Alternatively, perhaps this study's data sample was too small and skewed. As for age, analysis with age as a continuous variable showed no association with inappropriate prescriptions. However, analysis with stratified age groups revealed a significant negative association between inappropriate prescribing and age ≤ 15; a significant positive association between inappropriate prescribing and age 16-45; but no significant association with inappropriate prescribing and age > 46. This could once again be due to small sample size. Another possible explanation is that physicians may be more cautious and careful in prescribing for pediatric patients whereas prescribing for adult patients may be more influenced by patient finances or preference.

The fact that this study shows RMHC was successful in reducing number of medications but not in reducing inappropriate prescribing is inconsistent. One would assume that reducing the number of medications per visit would lower overprescribing of unnecessary and/or redundant medications. This calls into question the accuracy of the methods used to determine inappropriate prescribing. Insufficient sample size and study

design may be limiting factors to see the true association between RMHC and inappropriate prescribing. One major limitation to this study is that peer reviewers were not blinded to village doctor. Prescriptions were also only judged by one peer reviewer, and inter-observer scoring was not checked. A defined set of criteria for "inappropriate" prescriptions was used by the 2 peer reviewers. The list of criteria should have been straightforward and logical (incorrect use, dose, drug delivery method, drug interactions, redundancy), but interpretation of the criteria was likely variable. Perhaps the peer reviewers were unable to correctly judge the village doctors' prescribing quality due to similar levels of medical training. A more likely answer, however, is that the peer reviewers had limited information about the clinical picture to correctly judge medication appropriateness. For instance, insured RMHC records were required to have both diagnoses and presenting symptoms, but uninsured records often only had diagnoses listed. Village doctors may also have documented a higher severity of symptoms in order to get fully reimbursed by RMHC. Furthermore, proper, systematic sampling of prescriptions was quite difficult given inadequate record-keeping of certain village doctors.

Fundamentally, a binary variable of inappropriate versus appropriate is a very crude way of simplifying a complex process of diagnosis and treatment. Vitamin shots, for example, could be judged as unnecessary but not inappropriate by one physician or judged as unnecessary plus inappropriate by another physician. Using traditional Chinese medicine and Western medicine for the same symptoms could also be seen as redundant or complimentary. Other studies have found that physicians who provide more expensive therapy out of financial incentives are not necessarily providing *inappropriate*

treatment.[37] Thus, the "inappropriate prescribing" variable encompasses a large gray area of decision-making that cannot be easily reduced to a binary variable.

On the other hand, another possible explanation is that RMHC actually does not affect physician prescribing behavior. RMHC is structured around financial protection for patients and not necessarily quality control. Thus, RMHC has an essential drug list to decrease use of counterfeit, expired, and inappropriate drugs. However, few utilization management measures are in place to change physician prescribing behavior. Perhaps the decreased number of overall medications prescribed under RMHC represents a decrease in appropriate as well as inappropriate medications. Furthermore, RMHC does not focus on changing patient demand for medications, which can be a strong factor in inappropriate prescribing of antibiotics and injections.

Study Strengths

The strengths of this pilot study are its focus on the impact of rural health insurance on physician prescribing behavior and its findings regarding prescription costs for common colds. Previous studies on RMHC have focused on insurance-specific topics such as adverse selection,[35] but none have examined the impact of RMHC on physician prescribing behavior. This study showed the importance and feasibility of measuring quantitative and qualitative changes in physician prescribing behavior under RMHC. Results from this pilot study show that RMHC had dramatic effects on lowering the number of medications prescribed per visit and decreasing prescription drug costs for rural residents in Guizhou, the poorest province in China. Prescription drugs constitute the largest portion of out-of-pocket medical expenses. Lowered drug costs should thus

greatly increase access to and affordability of health care. Although this study found no change in inappropriate prescribing with RMHC, it demonstrates that evaluating physician prescribing behavior is quite important. Not only does physician prescribing behavior greatly influence the quality of patient care, but behavior also widely varies depending on individual village doctor.

Study Limitations

In addition to those mentioned above, study limitations include poor data quality, peer reviewer bias, and study design. Sample sizes were quite variable depending on individual doctor and insurance category. Record-keeping for uninsured patients was also quite poor: total number of prescriptions for uninsured patients was half that for insured patients, and some village doctors had no prescriptions for the uninsured. In addition, among the uninsured prescriptions, 31 were missing costs and 62 were missing symptoms (likely used by peer reviewers to evaluate inappropriate prescribing). Copies of these prescriptions were obtained directly from village doctors, who could have lost or withheld prescriptions for this study. Small sample size and poor data quality might also explain the lack of normal distribution for age and logcost. Percentages of inappropriate prescribing per village doctor are strikingly different for this pilot study as compared to the prior January-February 2004 RMHC evaluation. This difference could be due to small sample sizes in this pilot study, flawed study design, and peer reviewer bias.

Peer reviewer bias may strongly affect study results. There were two physicians reviewing all prescriptions for inappropriateness. Both worked at the local health department in charge of the RMHC insurance program. Because these peer reviewers

oversaw and evaluated village doctors on a regular basis, they could have had strong personal biases regarding specific doctors. Peer reviewers were also not blinded to study aims or patient insurance status.

In the future, study design should be optimized. First, a larger study should be done evaluating more than just 6 village doctors. The prior RMHC evaluation in January-February 2004 reviewed 21 village health posts and 31 village doctors. Second, physicians behave independently from each other, but all patients treated by the same physician likely receive similar care. Given this, cluster analysis is the most appropriate approach for evaluating village doctors. This study had only 6 clusters, which made cluster analysis a poor choice for this study. Furthermore, cluster analysis should also take into account multiple visits by the same patient. Insured patients and sick patients who can afford care may visit doctors multiple times in a month, and these visits likely result in similar prescriptions. Moreover, providers may encourage multiple visits to increase RMHC reimbursements for fee-for-service. Thus, future studies should cluster by individual doctors and individual patients. Lack of cluster analysis in this study probably leads to underestimating the differences between village doctors and overestimating the impact of RMHC on physician prescribing practices.

Lastly, this study attempted to evaluate the RMHC insurance program in 2004 by comparing it to the old CMS insurance program in 2003. This method was akin to using a retrospective control for RMHC insurance. A better way to evaluate RMHC would be to compare and match villages currently with RMHC to villages currently without RMHC to control for time, season, local disease patterns, and patient demographics.

Future Studies

Analysis of cost and quality of care is essential to evaluating the overall success of RMHC. Cost is a quantitative and easily obtained measure. Quality, however, as seen in this study, is quite difficult to measure accurately. This pilot study found encouraging results regarding RMHC's ability to lower prescription drug costs for poor rural residents in China. Future studies should explore the distribution of benefits and see if financial protection favors the poor or the rich. Other diagnoses in addition to "common cold" should be studied to see if costs and prescription error rates differ by disease. Analyses with larger sample sizes, more clusters of village doctors and individual patient clusters would be useful. Future studies could also study several other quality of care variables such as antibiotic usage or appropriate tuberculosis treatment. Other considerations are specific village doctor characteristics such as doctor age, years of training, years of practice, satisfaction with reimbursement policies, and overall satisfaction with RMHC. These could be significant confounders in any cost or quality analysis.

CONCLUSION

RMHC is an experimental health insurance program in rural China that focuses on primary care. Its unique focus on outpatient and preventive services makes RMHC an appealing alternative to other NCMS programs focused solely on catastrophic inpatient coverage. If RMHC succeeds, it will become an important example for NCMS development in rural China. Determinants of success include sustainability, financial protection for patients, improved access to health care, and, ultimately, improved health outcomes. This pilot study shows that RMHC does indeed lower drug costs for patients and thus increases financial protection for poor, rural residents. RMHC's cost-control success in even the poorest province of China, Guizhou, bodes well for RMHC feasibility and success in other, less poor rural areas. Access and quality of care, however, need to be studied in greater detail. Rural Mutual Health Care seems to be a viable option for the rest of rural China, provided that its short-term success in controlling costs can be sustained and its quality control measures can be expanded.

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