Evaluating the Impact of China's Rural Insurance Scheme on Health Using Biomarkers
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I. Introduction

On September 6, 2013 the Chinese government announced that its New Rural Cooperative Medical Scheme (NCMS), a health insurance program begun in 2003 for rural residents, covered 99 percent of rural residents – 800 million people. A decade prior only 8 million rural residents had access to any health insurance.[1] While the program has scaled with remarkable speed, there is little evidence of the program's effectiveness at improving health, one the main goals of this vast undertaking.[2] Considering the significant expense of implementing the program and that several other developing countries, including Colombia, Vietnam, and Mexico, have also recently implemented large public health insurance programs,[3] we seek to better understand how the NCMS affects health.

In this paper, we evaluate the effect of NCMS coverage on objective health measures, including blood pressure and biomarkers. Until now, evaluation of the NCMS's effect on health has been conducted entirely through process measures such as care-seeking, or through self-reported health. We reduce selection bias using intent-to-treat and instrumental variable analysis strategies. We find significant increases in utilization of health services, of about 3.3 percentage points (95% CI: 1.3-5.2). We find no effect of NCMS on biomarkers such as HbA1c, total cholesterol, HDL and LDL cholesterol, triglycerides, or hypertension. Overall we find no pattern of improved health due to exposure to NCMS, but significant increases in utilization of health services. The rest of this paper is organized as follows. Section 2 describes the background of the NCMS program and its context within Chinese history. Section 3 describes previous literature evaluating the NCMS and other public health programs. Section 4 describes the data and provides descriptive statistics. Section 5 describes the empirical analytical strategy. Section 6 gives the results and Section 7 concludes and discusses the results.

II. Background

For over three decades, beginning in 1950, most of China's rural residents were covered by the original Cooperative Medical Scheme (CMS).[4] Each commune member contributed to the commune-based medical fund, and in return typically received benefits like free visits and medicines at village health clinics and co-payments for referred inpatient care.[5] The program was considered fairly successful, with up to 90 percent of rural residents having coverage at its peak,[6] and

[1] The Atlantic (2013)
[2] Lei & Lin (2009)
[3] Wagstaff, et al. (2009)
[4] The Atlantic (2013), Lei & Lin (2009)
[5] Brown, et al. (2009)
[6] Liu & Cao (1992)

some considering it a major contributor to China's fall in mortality rate through the 1960s and 1970s.[7]

In the late 1970s, China introduced economic reforms were and communal farms dissolved. Without the collective welfare funds, the communities instead offered care in a fee-for-service setup, and health insurance coverage quickly plummeted to below 10 percent for over 30 years.[8] There were various attempts to re-introduce a major health insurance system in rural areas, but most rural residents remained uninsured.[9] High out-of-pocket costs for catastrophic illness are estimated to have increased the number of rural households living below the poverty line by 44 percent.[10] Moreover, failure to protect its rural residents from catastrophic health costs likely helps explain why some human development indicators like life expectancy did not improve for decades, despite rapid economic growth.[11]

In order to reduce the large rural-urban disparities in health care coverage, the central government introduced the New Cooperative Medical Scheme (NCMS) in October 2002, with the goal of covering the entire rural population by 2010.[12] By that point, only four percent of rural households had medical insurance, more than a third of the sick did not seek medical care, and many households were so affected by medical debt that they had reduced their food consumption.[13] The program initially began with a small number of pilot counties with local interest, and relatively high managerial capacity, incomes, and quality health facilities.[14] Within a year, over 300 counties had NCMS programs, and by the end of 2007 that number had reached over 2,400 rural counties in China (85% of all rural counties) covering over 700 million people.[15]

The NCMS is administered at the county level, and each county has some leeway in designing its program.[16] As a result there has been a fair amount of experimentation within counties, subject to three basic restrictions established by the central government: (1) voluntary participation, (2) county-level participation, and (3) focus on catastrophic illness.[17]

While the program is administered at the county level, higher levels of government from central to sub-regional contribute about 70 percent of the NCMS's funds on average.[18] Depending on the wealth of the county, regional and sub-regional

[7] Sidel (1993)
[8] Brown, et al. (2009)
[9] Yip & Hsiao (2008)
[10] Liu & Cao (1992)
[11] Hsiao (1995)
[12] Brown, et al. (2009), Lei & Lin (2009)
[13] Hsiao (2005)
[14] Lindelow & Wagstaff (2005)
[15] Mao (2005), Lei & Lin (2009)
[16] Brown, et al. (2009)
[17] Wagstaff, et al. (2009), Lei & Lin (2009)
[18] Brown, et al. (2009)

governments are required to contribute 20 to 40 yuan per enrolled person. In the poorest counties in western and central China, the federal government initially contributed 10 yuan, and beginning in 2006 increased its contribution to 20 yuan per enrollee.[19] Since then there have been periodic commitments to further increase the central and regional governments' contributions in these counties.[20]

In most counties, households must pay a fee for every member that participates, but the fee is often dropped for poor families.[21] The central government set a 10 yuan per person minimum fee for enrollees, which most counties maintained, but some wealthier counties set it as high as 40 yuan per person. Given the differences in contributions based on regional wealth, personal payments account for 29 to 41 percent of the overall financing for the program depending on the region.[22] In 2006, the average per capita financing was 51.88 yuan, ranging from 44.44 yuan in the central and western provinces to 61.77 yuan in the eastern provinces.[23]

Altogether, the total pooled funds in most areas are only enough to cover about a quarter of per capita medical costs in most areas,[24] so counties have experimented on many dimensions, including (1) reimbursement rates, (2) what types of illnesses/treatments to cover, (3) deductibles and limits on total reimbursement, and (4) scope of the covered network of providers.[25] Reimbursement is generally fairly transparent and efficient in most counties, particularly when residents seek care at a covered provider in their own county of residence (which is sometimes a requirement for reimbursement).[26] Over time, four main models of reimbursement have emerged; the most common model combines inpatient reimbursement through a formula with a medical savings account for outpatient services, including preventive care.[27] In general, counties in regions with less trust in the local government relied more on medical savings accounts in order to encourage participation (though in practice having these accounts has not been found to increase participation and only seems to reduce outpatient/preventive care seeking).[28] Overall there was a trend over time toward more generous outpatient coverage on top of existing inpatient coverage.[29]

In general participation in the NCMS requires rural "hukou" registration status, and administrators are not allowed to deny any person with this rural registration

[19] Brown, et al. (2009)
[20] Lei & Lin (2009)
[21] Brown, et al. (2009), Lei & Lin (2009)
[22] Mao (2005)
[23] Lei & Lin (2009)
[24] WHO (2004)
[25] Brown, et al. (2009)
[26] Brown, et al. (2009)
[27] See Mao (2005) and Lei & Lin (2009) for a more detailed discussion of the variation in these models.
[28] Mao (2005)
[29] Du & Zhang (2007)

status based on health condition or socioeconomic status.[30] To reduce adverse selection whereby only the unhealthiest members of the county choose to enroll, the central government stipulated that it would only pay its share of the program's funding if coverage reached at least 80 percent of rural residents in the county.[31] Local governments responded in various ways, including by requiring that whole households enroll together, aggressive advertising campaigns, and social pressure.[32] As a result, participation within counties implementing the NCMS increased dramatically over a fairly short period of time.[33]

III. Previous Literature

Many studies have evaluated the NCMS, with outcomes ranging from enrollee satisfaction to out-of-pocket spending and self-reported health. Brown, et al. (2009) measured the performance of the NCMS program through household surveys, evaluating what aspects of the program improve enrollee satisfaction. They found that households value emigrant eligibility and lower spending thresholds for reimbursement eligibility. Moreover, in counties with stricter rules around referrals and covered hospitals, enrollees are less likely to benefit. Most importantly, the schemes developed in most counties for inpatient coverage remained insufficient to properly protect the rural poor from catastrophic illness.

In an impact evaluation more in line with this study, Lei & Lin (2009) used a series of estimation strategies, including individual fixed-effect models and instrumental variable estimation, and found that enrollment in the NCMS does improve care-seeking patterns. Enrollees decreased their use of traditional Chinese folk doctors and increased their use of preventive care. However, they did not find improvements on other important measures, including out-of-pocket expenditures, use of formal medical services, or health status, as measured through self-reported health.

In another impact evaluation, Wagstaff et al. (2009) used difference-in-difference with matching methods to evaluate the effect of NCMS on utilization and out-of-pocket spending. They found that NCMS increased inpatient and outpatient utilization and reduced the cost of deliveries, but these benefits were largely concentrated among relatively wealthy households. NCMS did not, however, reduce out-of-pocket payments per inpatient or outpatient visit or overall out-of-pocket payments.

There has also been literature on the effects of health insurance in other countries on objective biomarkers. Sosa-Rubi et al. (2009) evaluated Mexico's public health insurance scheme, Seguro Popular, and its effect on treatment and blood glucose control (HbA1c levels) among poor adults with diabetes in Mexico. They found that

[30] State Council (2002); Note though that some counties have opened registration up to urban registration holders as well (Brown, et al. 2009).
[31] Brown, et al. (2009)
[32] Brown, et al. (2009)
[33] Yan, et al. (2006)

poor diabetic adults covered under Seguro Popular were both significantly more likely to have appropriately controlled glucose levels (HbA1c $\leq$ 7%) and less likely to have very poor glucose control (HbA1c > 12%) than their uninsured counterparts.

Baicker, et al. (2013) used objective biomarkers to evaluate the impact of Medicaid health insurance coverage on recipients' health in Oregon. They found that Medicaid improves some process measures like the probability of diagnosis for some diseases, but they cannot statistically significantly show any improvements in objective measures of health like biomarkers.

IV. Data

To study the impact of the NCMS on health, we use data from the China Health and Nutrition Survey (CHNS),[34] a nationally representative longitudinal survey in China that spans 36 counties from 9 geographically and economically diverse provinces. We are using data from the four waves of the household- and community-level surveys collected from 2000 to 2009. We restrict our analysis to individuals in rural areas with rural registration, since this is the group that is targeted and eligible for the NCMS. We also restrict to adults age 18 and over. Biomarkers were only collected in the 2009 wave of the CHNS, and we restrict our main analysis to the adults for whom biomarkers were collected.[35] This results in 11,334 observations from 3,753 adult rural registrants over the four waves of the main analysis who have biomarker data. Most other variables were obtained in all waves, except where noted.

Because the individual-level surveys in the CHNS do not distinguish between the old cooperative medical scheme (CMS) and the new CMS that we are interested in analyzing, we cannot obtain an accurate measure of NCMS participation status from the individual-level data. Following Lei & Lin (2009), we instead rely on the confidential community-level CHNS surveys (a community is an area smaller than a county) since virtually all individuals in the data are linked to a community. In each wave of the CHNS, government officials were asked whether the community had cooperative medical insurance, and if so, when the community first obtained it. If the government official gave a year of inception that was prior to 2003, we interpret the community as having the old health insurance system; if the first year was 2003 or later, we designate the community as having NCMS beginning in the year indicated.

The questions about whether the community had cooperative medical insurance and the first year it was obtained were asked in each wave of the CHNS. In some cases, in different waves of the survey government leaders gave different answers

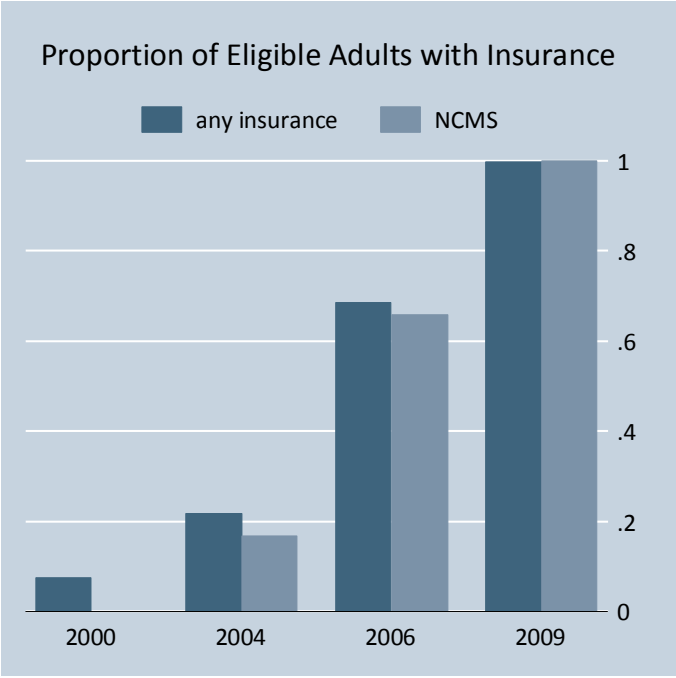
[34] This survey is conducted by the Carolina Population Center at the University of North Carolina-Chapel Hill, the National Institute of Nutrition and Food Safety, and the Chinese Center for Disease.
[35] Results are virtually unchanged if we conduct the non-biomarker analyses with the full sample of adults in rural areas with rural registration.

for the first year that the community had NCMS. We therefore conducted our analysis using two slightly different methods for specifying the community's NCMS participation status. In the first, we use the latest year ever specified as the year of initiation (e.g., if in the 2006 wave the respondent said the community began participating in the NCMS in 2004, but in the 2009 wave the respondent said 2005, we treat the community as participating only beginning in 2005). In the second method, we simply rely on whatever year was given in the last wave of the survey, 2009. The empirical results are nearly identical with each method, which is not surprising considering that in fewer than 9 percent of cases is there any discrepancy, and only in 1 percent of cases is the discrepancy two years rather than one. We therefore only report the results using the first method.

Descriptive Statistics

As described above, NCMS coverage increased dramatically since its inception in 2003. Figure 1 shows the percentage of eligible adults in rural areas with any insurance and with NCMS in our data, broken down by wave. In just six years, coverage was available to nearly all eligible individuals. Generally, NCMS insurance was the only available health insurance for this group during 2000 – 2009.[36]

Figure 1



[36] Note therefore that it does not appear that NCMS is crowding out other insurance. If this was the case, we might be concerned that the effects of the program are reduced because some people are simply switching from another health insurance to NCMS, and their overall insurance status remains the same.

Table 1a shows individual-level demographics and other relevant variables that were collected in all waves, broken up NCMS and non-NCMS communities, pooled across all four waves used in the analysis. P-values reported in the last column represent the test of whether NCMS communities are different from non-NCMS communities while clustering at the community level. NCMS communities tended to have a somewhat higher percentage of people of Han descent, were older, wealthier, and less likely to smoke. They also tend to report poorer health, more sickness, and higher utilization of preventive care services. As expected, coverage of outpatient care is higher, but out-of-pocket spending is also higher, perhaps reflecting Wagstaff, et al.'s (2009) finding that people with insurance tend to ultimately spend more as they may only initiate significant health service utilization once they have health insurance. People in NCMS communities tend to be less healthy overall (e.g., more overweight), but also are more likely to be diagnosed when ill.

Table 1b reports individual-level variables that were generally only collected during the 2009 wave of the CHNS, separated by people living in communities that initiated the NCMS prior to 2007 and those that initiated it in 2007 and later. P-values are again reported for testing whether there are significant differences between the two groups, clustering at the community level. Earlier adopters tended to have somewhat higher total cholesterol and were more likely to have abnormally high total cholesterol.[37] Most other measures suggest that there is not a very large difference in objective health measures between earlier and later adopters of the NCMS in 2009.

[37] Given that people in communities that were earlier adopters tend to look somewhat worse in 2009, as measured by objective biomarkers, it seems likely that there was some selection into the program, with less healthy communities opting into the program earlier than their healthier counterparts. We cannot determine from this information alone, however, whether the NCMS had no beneficial effect on health, or whether the differences between the two sets of groups would have been even higher, but for the NCMS.

Table 1a

Variables	All	NCMS Communities	Non-NCMS Communities	p-value[38]
Female	0.54	0.54	0.55	0.28
Han	0.85	0.87	0.83	0.03
Over 55	0.33	0.37	0.28	0
Gross Household Income	29545.12	36853.4	20697.08	0
Years of Schooling	5.88	5.94	5.78	0.08
Smoker	0.3	0.29	0.31	0.01
Household Size	3.98	3.97	4.05	0.29
Self-Reported Health (1=excellent, 4=poor)	2.34	2.42	2.32	0.02
Sick in the Last 4 Weeks	0.13	0.16	0.1	0
Used Preventive Services in the Last 4 Weeks	0.02	0.03	0.01	0
Money Spent on Illness in the Last 4 Weeks	230.64	160.1	295.8	0.14
% Outpatient Coverage	24.9	30.16	5.88	0
Out of Pocket Spending	102.75	169.67	4.96	0
Any Out of Pocket Spending	0.93	0.92	0.93	0.59
BMI	22.86	23.01	22.67	0
Overweight	0.24	0.26	0.21	0
Obese	0.03	0.03	0.02	0
Systolic Blood Pressure	121.74	123.56	119.53	0
Diastolic Blood Pressure	78.78	79.72	77.76	0
Hypertensive[39]	0.24	0.27	0.21	0
Taking Anti-hypertensive Drugs When Hypertensive	0.16	0.18	0.11	0
Diagnosed Hypertensive When Hypertensive	0.23	0.25	0.19	0
Diagnosed with a Respiratory Disease	0.29	0.31	0.26	0.17
Diagnosed with a Digestive Disease	0.11	0.11	0.12	0.67
Diagnosed with a Myocardial Infarction	0	0.01	0	0.08
N	11,742	5,973	5,769	-

[38] P-values represent the test of whether NCMS communities are different from non-NCMS communities while clustering at the community level.
[39] Hypertension is defined as blood pressure greater than 140 over 90.

Table 1b

Variables	All	NCMS Pre-2007	NCMS 2007 and later	p-value[40]
Diagnosed with Diabetes	0.01	0.01	0.01	0.89
Taking Anti-diabetes Medicine (if Diabetic)	0.78	0.77	0.79	0.76
Control Diabetes with Non-medical Means	0.47	0.55	0.32	0.05
Taking Medicine or Controlling Diabetes Through Other Means	0.85	0.85	0.85	0.98
Total Cholesterol	187.18	189.25	183.59	0.06
Abnormal Total Cholesterol	0.33	0.36	0.29	0.04
HDL Cholesterol	56.93	57.22	56.44	0.48
Abnormal HDL	0.24	0.24	0.23	0.63
LDL Cholesterol	2.96	3	2.89	0.1
Abnormal LDL	0.1	0.11	0.08	0.15
Triglycerides	136.33	134.99	138.66	0.58
Abnormal Triglycerides	0.18	0.18	0.19	0.48
Glucose	5.3	5.34	5.22	0.1
Abnormal HbA1C	0.14	0.15	0.12	0.25
N	11,742	7,366	4376	-

V. Identification Strategy

As with any health insurance program, adverse selection is an important concern in evaluating the NCMS; specifically, we are concerned that relatively unhealthy people may opt to join the health insurance scheme, which could result in any potential benefits of the program being understated or even to appear negative. Because participation in the program was stipulated to be voluntary by the central government, policymakers were especially concerned about adverse selection and therefore required that entire families join together. It is not immediately clear, however, that this requirement would effectively overcome adverse selection forces, and indeed early surveys around the program suggest there was a fair amount of adverse selection. For example, in one early study of more than 700 people from 200 households split between NCMS participants and non-participants, nearly 100 percent of non-participants ranked themselves as "very healthy" or "healthy", compared to 83 percent of NCMS participants. Moreover, total medical expenditures prior to enrolling in the program were more than 2.5 higher in the households that opted to enroll.[41] In a study of one pilot county, participants

[40] P-values represent the test of whether early NCMS-initiating communities are different from late NCMS-initiating communities while clustering at the community level.
[41] Zhan (2005)

accounted for three-quarters of the population, but 95 percent of hospitalization patients.[42]

Because we are concerned that enrollment in NCMS could be affected by unobserved confounders at the individual level, we implement two strategies to overcome this selection bias. First, we conduct an intention to treat (ITT) analysis, whereby we use an indicator of community-level availability of coverage as the explanatory variable of interest. Community-level coverage is not affected by individual choice.

The second strategy is to exploit the heterogeneity in rollout times of the NCMS program across communities and use this as an instrument for individual-level coverage (the instrumental variable, or IV, strategy). Since rollout is exogenous to the individual, we can predict individual coverage using the community rollout times, and then regress the outcome on the predicted values.

In order for the IV method to be valid, the instrument should be as good as random conditional on covariates, and the exclusion restriction must hold, in that the instrument must predict the individual insurance status but not affect the outcome directly. To test that the instrument is as good as random, we regress the year the community adopted NCMS on community characteristics as well as an binary indicator of being a late adopter, which is adopting NCMS on or after 2006 (Table 2). In the first column, we find that wages significantly predict the year the community adopted NCMS, with communities with higher average wages adopting earlier. In the second column, we find that average household size predicts being a late adopting community. In addition, both analyses find that having a clinic in the community significantly predicts earlier adoption. Communities with clinics and higher income levels were able to implement NCMS faster. However, no health markers including hypertension, overweight, or average smoking status in 2000 (before NCMS was rolled out) predicts adoption year, which strengthens the evidence for our identification strategy. Although we cannot exclude that other unobservables may violate the validity of the instrument, by controlling for wealth as well as other community-level observables we greatly reduce any bias.

[42] He (2005)

Table 2: Regression of community-level observables on year of adoption

	(1) Year community adopted	(2) Late Adopter[1]
Average age	0.0327	0.0156
	(0.0533)	(0.0162)
Fraction female	-2.053	-0.184
	(2.793)	(0.985)
Fraction smoker	-2.686	0.394
	(2.122)	(0.626)
Fraction had hypertension in 2000	-3.913	-1.422
	(2.463)	(0.873)
Fraction overweight in 2000	1.335	0.796
	(1.792)	(0.618)
Average urbanicity score	-0.000225	0.00586
	(0.0171)	(0.00547)
Average years of schooling	0.362	0.0377
	(0.183)	(0.0560)
Fraction married	-2.078	0.451
	(2.180)	(0.763)
Fraction Han	-0.801	-0.0536
	(0.550)	(0.169)
Average household size	0.120	0.165**
	(0.190)	(0.0589)
Average log wages	-0.867**	-0.0497
	(0.318)	(0.0907)
Fraction agriculture land	0.966	0.369
	(0.671)	(0.231)
Has clinic in community	-0.873*	-0.296*
	(0.374)	(0.119)
Has hospital in community	0.606	0.251
	(0.570)	(0.213)
N	104	104

[1] Late adopter began NCMS $\geq$ 2006
Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

VI. Results

Cross-sectional Analysis

Outcomes such as blood pressure and self-reported doctor visits are available for all waves, but biomarker measures are only available in 2009. As a result, we conduct

both cross-sectional and panel specifications. We begin with the cross-sectional specifications.

The model specification for the ITT cross-sectional analysis is shown in equation (1).

$$Y_{ij} = \delta CommunityNCMSduration_j + X'_{ij}\beta + Z'_j\alpha + \epsilon_{ij} \quad (1)$$

where Y_{ij} is an outcome variable such as blood pressure, for individual *i* in community *j*, $CommunityNCMSduration_j$ is the number of years that community *j* had NCMS, and *X* and *Z* are vectors of individual and community level controls, respectively. The individual level covariates include age, sex, an indicator of whether the individual was overweight in 2000, an indicator of whether the individual had self-reported hypertension in 2000, education, marital status, an indicator of Han nationality, household size, household wealth quintile, and province fixed effects. Household wealth is based on detailed measures of all income-earning activities of all household members.

The community-level controls include a measure of urbanicity and community-level averages of all of the individual level covariates. Urbanicity is defined using a multidimensional 12 component urbanization index that captures the community-level physical, social, cultural, and economic environment and which represents the heterogeneity that would be otherwise missed in a measure based only on an urban/rural indicator of population density.[43] The overall mean (standard deviation) of the urbanicity score in our sample was 54.3 (12.8) and ranged from 30.4 to 103.1. A high urbanization index represents a large population living closely together in a physical environment providing an efficient transport system, a good communication network, high-quality health care, higher-level education, and water, sewer, and electric lines. We cluster the standard errors at the community level to adjust for the within community correlation structure.

The model specification for the IV cross-sectional analysis is shown in equations (2a) and (2b).

$$IndivNCMSduration_{ij} = \gamma \underset{NCMSduration_j}{Community} + X'_{ij}\theta + Z'_j\,\delta + \sigma_{ij} \quad (2a)$$

$$Y_{ij} = \delta Indiv\widehat{NCMSduration}_{ij} + X'_{ij}\beta + Z'_j\alpha + \epsilon_{ij} \quad (2b)$$

where $Indiv\widehat{NCMSduration}_{ij}$ is the predicted individual NCMS duration based on the community-level duration in (2a). The same controls are used as in the ITT specification described in equation (1).

[43] Yan et al. (2010)

The results of the cross-sectional analysis using ITT and IV specifications are presented in Table 3.

The scaled up point estimates for the IV analysis are larger in magnitude than the ITT analysis, but the standard errors are also larger due to the additional uncertainty in the first stage equation. In the IV analysis, we find a significant increase in use of a preventative health service in the past 4 weeks of .023 percentage points, and a significant increase in LDL cholesterol. However, no other biomarkers are significant at the .05 level.

Table 3: Cross-sectional results for ITT and IV specifications

	ITT	IV 2SLS
Systolic BP (mmHg)	-0.224	-0.740
	(0.328)	(1.033)
Diastolic BP (mmHg)	-0.0942	-0.311
	(0.235)	(0.755)
Hypertensive (%)	-0.00625	-0.0207
	(0.00553)	(0.0182)
Used Prevent service (%)	0.00697*	0.0230*
	(0.00305)	(0.0101)
Abnormal Total Cholesterol (%)	0.0108	0.0356
	(0.00796)	(0.0262)
Abnormal HbA1c (%)	0.00732	0.0242
	(0.00623)	(0.0191)
Abnormal HDL	-0.00718	-0.0237
	(0.00611)	(0.0201)
Abnormal LDL	0.00789*	0.0261*
	(0.00381)	(0.0125)
Abnormal Triglycerides	-0.00777+	-0.0257
	(0.00461)	(0.0159)
FRS 10 year risk score[44]	0.0455	0.150
	(0.0712)	(0.234)
N	3753	3753
Number of clusters	103	103
First stage F-stat		22.07
Errors clustered at community level. *p<.10, **p<.05		

[44] The Framingham Risk Score (FRS) uses an individual's age, gender, total cholesterol, HDL cholesterol, smoking status, and systolic blood pressure to produce an indicator for the risk of having a heart attack in the next ten years. The score can range from 0 to 17.

Panel Analysis

For blood pressure and 'used a preventative health service' outcomes, we have individual-level panel data. Thus we investigate whether the panel data can give us more precise estimates of the impact of NCMS than the cross-sectional analysis. The model specification for the ITT panel analysis is shown in equation (3).

$$Y_{ijt} = \delta CommunityNCMS_{jt} + X'_{ijt}\beta + Z'_{jt}\alpha + \lambda_t + \epsilon_{ijt} \quad (3)$$

where Y_{ijt} is an outcome variable such as blood pressure, for individual *i* in community *j* at time *t*, $CommunityNCMS_{jt}$ is an indicator of whether the community *j* had NCMS at time *t*, X'_{ijt} and Z'_{jt} are vectors of individual- and community-level controls, respectively, and λ_t are year fixed effects. The individual-level covariates are the same as before, but also include individual averages of covariates. The community-level controls are the same as before. Standard errors are again clustered at the community level.

The model specification for the IV panel analysis is shown in equations (4a) and (4b).

$$IndivNCMS_{ijt} = \gamma CommunityNCMS_{jt} + X'_{ijt}\theta + Z'_{jt}\delta + \nu_t + \sigma_{ijt} \quad (4a)$$

$$Y_{ijt} = \delta \widehat{IndivNCMS}_{ijt} + X'_{ijt}\beta + Z'_{jt}\alpha + \lambda_t + \epsilon_{ijt} \quad (4b)$$

Finally, we conduct the IV analysis and include individual-level random effects in our specification. Random effects have been shown to have better statistical properties than individual fixed effects because of the additional benefit of partial pooling. We remove correlation between the random effect and the covariates by including the individual-level averages as a group-level predictor.[45]

The results are shown in Table 4.

[45] Bafumi and Gelman (2006).

Table 4: Panel Results for ITT and IV analyses

	ITT	IV 2SLS	IV RE
Systolic BP (mmHg)	-0.189	-0.442	0.274
	(0.904)	(2.104)	(1.019)
Diastolic BP (mmHg)	0.318	0.744	0.800
	(0.641)	(1.492)	(0.692)
Hypertensive (%)[46]	-0.00819	-0.0191	-0.0238
	(0.0170)	(0.0393)	(0.0191)
Used Prevent service (%)	0.0154*	0.0360*	0.0330***
	(0.00683)	(0.0166)	(0.00978)
N	11334	11334	11334
Number of clusters	111	111	111
1st stage F stat		83.06	48.66

Errors clustered SE at community level. *p<.10, **p<.05

We find no significant change in diastolic blood pressure, systolic blood pressure, or likelihood of being hypertensive. We do find a significant increase in the use of a preventative health service in the last 4 weeks ranging from 1.5 to 3.6 percentage points for the three specifications.

In order to better understand how access issues influence the results we see here, we extend this longitudinal ITT analysis to include an indicator C_{jt} for whether the community had a clinic that enters separately and as an interaction with the treatment variable in equation, presented here as equation 5.

$$Y_{ijt} = \delta CommunityNCMS_{jt} + CommunityNCMS_{jt} * C_{jt} + X'_{ijt}\beta + Z'_{jt}\alpha + C_{jt} + \lambda_t + \epsilon_{ijt} \quad (5)$$

Table 5: Longitudinal ITT Results With Interaction for Clinic in the Community

	(1) Systolic BP (mmHg)	(2) Diastolic BP (mmHg)	(3) Used Prevent Service (%)	(4) Hypertensive (%)
Community had NCMS	-1.285	0.698	-0.00679	0.0143
	(1.292)	(0.824)	(0.00933)	(0.0183)
Clinic in community	-1.486	-0.717	-0.0227***	0.0134
	(1.073)	(0.847)	(0.00650)	(0.0139)
Community had NCMS x Clinic in community	1.348	-0.467	0.0273***	-0.0277
	(1.288)	(0.812)	(0.00800)	(0.0170)

This suggests that for those communities that had a clinic, access to NCMS increased utilization more than for those communities that did not.

[46] Hypertension is defined as blood pressure greater than 140 over 90.

VII. Discussion

We use intent-to-treat and instrumental variable strategies to overcome selection bias in estimating the effect of NCMS insurance on health outcomes. We consistently find an increase in utilization of health services for those with access to NCMS, measured by use of a preventative health service in the past 4 weeks, of 3.3 percentage points (95%CI 1.3-5.2). However, we find no indication of improved health for those with access to NCMS, measured by blood pressure, biomarkers including total cholesterol, HbA1c, LDL, HDL, and triglycerides, or the Framingham Risk Score.

This analysis has some limitations. Although we reduce selection bias by using an ITT analysis and with instrumentation, the study is not a randomized trial. We may have unmeasured confounding in unobservable factors. Additionally, the community rollout instrument was not completely random. Some communities implemented the insurance program earlier because they were administratively ready to comply with the new regulations surrounding the insurance and with the potential increase in demand for health care, as can be seen from the predictiveness of NCMS adoption year by proximity to a clinic and the income levels of the community.

The panel specification is a more robust analysis than the cross-sectional specification. However, we only have one wave of biomarkers so we have no baseline for individual biomarker levels. Finally, we are underpowered due to the relatively small sample size and also due to the small number of communities, which substantially increases clustered standard errors.

There are several domains for evaluating the NCMS that we have not been able to explore here, but that could yield some interesting results. This analysis is likely hindered by the limited information on how different counties actually implemented their insurance program. For example, it is possible that in counties explicitly covering preventive care, rather than relying on enrollees to use medical savings accounts, the health outcomes we analyze here do significantly improve. It would also be interesting to explore the impact of the NCMS on children. Delivery care was frequently generously covered, and it would be interesting to see how this has influenced maternal and infant health outcomes.

Explanations for why the NCMS does not appear to have influenced objective measures of health could come from a variety of dimensions. For example, it may simply be that the NCMS does not go far enough to protect households in the case of catastrophic health costs. In over a third of counties surveyed by Brown, et al. (2009), households are required to pay out of pocket for over half of a 15,000 yuan bill for eligible inpatient care at a county-level hospital. Perhaps households still cannot afford to seek care for serious illness, even with NCMS coverage. It could also easily be the case that there is an insufficient supply of (high quality) health care providers, and having insurance coverage does not result in greater access to quality health care. Yet another potential explanation is that because of pressure

from the central government to enroll community members, local governments coerced many people to participate, and as a result they did not fully embrace the program and make use of its benefits. One final potential explanation is that the program is crowding out some other means for providing access to health care, resulting in little to no net improvements in participating counties. We are unable to disentangle which of these explanations – if any – is the most likely explanation for our results, but it is worth further exploring these questions in the future.

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