Out-of-Pocket Payments for Noncommunicable Disease Care: A Threat and Opportunity for Universal Health Coverage

OUT-OF-POCKET PAYMENTS FOR NONCOMMUNICABLE DISEASE CARE: A THREAT AND OPPORTUNITY FOR UNIVERSAL HEALTH COVERAGE

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Abstract

Noncommunicable diseases (NCDs) are rising as a share of disease burden in low- and middle-income countries where out-of-pocket (OOP) payments are a major source of health financing. To realize universal health coverage (UHC) aims, health systems may need to better protect people from the financial risks of NCDs and ensure OOP costs do not restrict access to NCD health services.

This dissertation aimed to assess: cross-country differences in the catastrophic health expenditure (CHE) caused by NCDs versus other disease areas; how OOP spending and utilization patterns differed for CHE cases caused by NCDs versus other disease areas; and whether the elimination of OOP costs can increase uptake and reduce disparities in coverage of NCD health services. Two cross-country household surveys were used, the World Health Surveys (Chapter II) and the Study on Global Aging and Adult Health (Chapter III), as was high-frequency insurance claims data, the Maine Health Data Organization All Payer Claims Database (Chapter IV). Quantitative methods included cross-sectional regressions (Chapter II), machine learning (Chapter III), and quasi-experimental methods (Chapter IV).

This dissertation showed that NCD OOP spending is both a threat and opportunity for UHC. First, Chapter II showed that the association between heart disease CHE and prevalence

was strong and robust to key controls, suggesting that as NCDs comprise a larger share of disease burden, they could pose a threat to financial risk protection. Chapter III showed that OOP spending per visit was twice as high for NCDs as communicable diseases and CHE caused by NCDs was more likely to be caused by the culmination of spending over many visits, rather than a single health spending shock. Finally, Chapter IV showed that eliminating the OOP costs of preventive colonoscopies increased utilization substantially more in rural areas than in urban areas, reducing disparities significantly.

Overall, these results underscore that the rising share of disease burden caused by NCDs may pose new challenges for financial risk protection, service coverage, and the equity of UHC. Targeting reforms to how OOP spending on NCDs affects populations, and how that differs from other health focus areas, may help countries pursue UHC cost-effectively.

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I dedicate this dissertation to my father, Larry Haakenstad, who passed away in 2015 from a long battle with lung cancer.

Chapter I

Introduction

Universal health coverage (UHC) aims to ensure all people and communities can use the promotive, preventive, curative, rehabilitative and palliative health services they need, of sufficient quality to be effective, while also ensuring that the use of these services does not expose the user to financial hardship (WHO 2019). The UHC agenda is far from realized. Annually, approximately 210 million households incur severe financial hardship – or catastrophic health expenditure (CHE) – due to out-of-pocket (OOP) health spending (Wagstaff et al. 2017a) and an estimated 97 million people are pushed below the poverty line (Wagstaff et al. 2017b). Furthermore, while information about service coverage is far from comprehensive, the global median of an index based on key service coverage tracers is 65 out of a maximum of 100, indicating that many countries fall short of full service coverage (Hogan et al. 2017).

Hypotheses about noncommunicable diseases and universal health coverage

This dissertation was developed based on the hypothesis that noncommunicable diseases (NCDs) pose a unique challenge for the pursuit of UHC. NCDs are rapidly growing as a share of disease burden in low- and middle-income countries, where premature mortality (before age 60) due to NCDs, is higher than in high-income countries (IHME 2016). Across countries, evidence suggests that NCDs have some of the widest gaps in service coverage (Cotlear et al. 2015). Achieving UHC worldwide will thus increasingly require addressing financial risk protection and service coverage for NCDs. Furthermore, there is reason to believe that NCDs are distinct from other disease areas in terms of costs, utilization patterns, and the organization and financing of health systems.

First, some NCD treatment is likely to be more expensive than health care for other diseases and conditions. NCD treatment can entail intensive procedures, such as heart surgery and chemotherapy, that require extensively trained (e.g. expensive) providers. The prices of equipment and medicine for NCDs may also be higher on average than the prices of inputs for other disease areas. For example, in low-income countries, a one-month supply of generic cardiovascular drugs costs on average two days wages in the public sector (van Mourik et al. 2010) and combination therapy for cardiovascular disease was estimated to be unaffordable for 60% of households (Khatib et al. 2016). The prices of key drugs for HIV/AIDS and malaria, in contrast, have been lowered through international negotiations and strategic purchasing (Global Fund 2009, Waning et al. 2009). Treatment and prevention for malaria and HIV/AIDS are also highly subsidized by development assistance for health (DAH) (Haakenstad et al. 2019a, 2019b).

The costs of care are often passed onto patients through OOP payments. In the United States for instance, the costs of procedures are increasingly transferred to patients because a rising share of the insured population is enrolled in high deductible health plans (Cohen et al. 2018). In developing countries, patients may incur high OOP costs even when care is sought in the public sector with low or nonexistent user fees – patients often must purchase drugs, diagnostics and other supplies outside of government health facilities. For instance, in a survey of 36 developing countries, the public sector had much higher rates of stock-outs of cardiovascular medicines than the private sector (van Mourik et al. 2010), indicating many patients would be forced to purchase medicine from private providers.

Second, the impact of OOP spending on household consumption expenditure could differ across disease areas, including how households are able to cope with the OOP costs of health care (Flores et al. 2008). Controlling common NCDs, like hypertension and diabetes, requires frequent, sometimes lifelong contact with the health system. OOP spending on these routine health contacts is thus more predictable, which may be better for households, including by making it easier to plan how to smooth consumption, than highly volatile health spending (Flores & O'Donnell 2016). However, frequent visits also translate into frequent OOP costs. The accumulation of OOP spending over many visits could thus result in CHE, forcing households to reduce consumption to cover health care costs. The ability to anticipate some NCD OOP costs contrasts with many acute infectious diseases and injuries, which can occur suddenly and unpredictably, and may be more likely to result in a single, large, unexpected health spending shock. OOP spending that is difficult to plan for is more difficult for households to absorb and could require households to use funds intended for basic subsistence for health care. The ability for households to tap into informal insurance networks (Townsend 1994), could also differ across disease areas and type of health spending (shock/routine). Stigma, symptom salience, community knowledge about diseases, and other factors distinct across diseases could make community members more or less likely to provide in-kind or financial support to households with major health care costs.

Third, OOP spending on NCDs may be high because health systems in many developing countries have been historically organized and financed to address infectious diseases and maternal and child health conditions (Wilkinson and Wilkinson 2004) not NCDs. Many health systems

may have only recently begun to organize around the needs of NCD patients because NCDs have only recently become a substantial share of disease burden in low- and middle-income countries (IHME 2016). Without government-financed provision of NCD care, patients may be forced to seek care in the private sector, where OOP costs are elevated relative to the public sector. Furthermore, DAH is a major source of funding in some developing countries, but NCDs were the focus of just 2% of global DAH in 2018 (Chang et al. 2019). Examining 106 developing countries, OOP is a smaller share of total health spending on HIV/AIDS (4.7%) and malaria (13.0%) as compared to the all-health OOP portion of health spending (42.9%) (Haakenstad et al. 2019a, 2019b; Chang et al. 2019), implying that other disease areas, including potentially NCDs, are financed more by OOP.

Finally, despite these potential drivers of high NCD OOP spending, NCD CHE could, in fact, be low in low- and middle-income countries because populations are not able to access care. Services could be difficult to access, for example, because care is: i) simply not available, ii) concentrated in urban areas, making travel to health services expensive for rural populations, or iii) provided at such high OOP cost that populations are deterred from taking up services. Existing evidence shows that some but not all populations are accessing NCD services, with substantial inequities across income groups and rural/urban residence (Di Cesare et al. 2013). Lags in service coverage could be viewed as an opportunity: NCDs may be a disease area where major gains toward UHC could be made at a lower cost because countries are only beginning to adopt the most cost-effective strategies for NCD prevention and control (Jamison et al. 2018).

Providing this care may help populations avoid high OOP costs by preventing NCDs' progression to advanced disease states that require expensive care.

Existing literature

Key gaps in knowledge about NCDs and OOP spending, including the implications for CHE, service coverage, and equity, also informed the development of the three studies in this dissertation. First, no existing cross-country studies systematically compare CHE by disease. The cross-country studies that exist extrapolate based on small number of published studies (Essue et al. 2018), and three literature reviews conclude that meta-analysis based on existing research is not possible (Jan et al. 2018; Kankeu et al. 2013; Muka et al. 2015). Most disease-specific CHE studies focus on a single disease area and most are not nationally representative. Contrasting CHE by disease across countries can highlight which countries effectively protect people from financial risks and for which disease areas. Comparing across diseases in a given country can help set national priorities in financial risk protection.

Furthermore, no existing studies systematically compare how cost and utilization distinctions across disease areas relate to CHE in low- and middle-income countries. Such comparisons across diseases can inform further investigations into the programs and policies making a difference and which ones fall short, including for the specific procedures, medicines and supplies threatening household consumption expenditure. This detailed information can support the development of approaches to the diseases threatening financial risk protection and the way they cause financial hardship.

Third, while a substantial number of studies examine the elimination of user fees, few studies assess the response in terms of NCD care (Lagarde & Palmer 2008). Systematic reviews of studies on user fees have determined that much of the existing literature is of low certainty and the equity implications of user fee removals is poorly understood (Wiysonge et al. 2017; Kolasa & Kowalczyk 2016; Lagarde & Palmer 2008; Hatt et al. 2013). Better understanding the policy lever of eliminating OOP costs for NCD service coverage is critical to ensuring such policy changes do not disproportionately benefit better-off populations.

Dissertation overview

This dissertation tackled these hypotheses and gaps in knowledge through empirical analyses. The first two chapters assessed whether OOP payments for NCD care leave people unprotected from the financial risks of health care, and whether NCDs' contribution to CHE differs from other disease areas. Chapter IV examined whether the elimination of OOP costs has the potential to raise NCD service coverage rates. The equity of OOP payments was assessed to varying degrees in all three studies.

In Chapter II, CHE by disease area was estimated, comparing OOP spending to household consumption expenditure for households in 39 low- and middle-income countries using the World Health Surveys (WHS). While dating to 2002-2004, the WHS are the only comparable, nationally representative surveys with detailed information about utilization and OOP spending in more than six countries. In contrast to other existing studies on NCD CHE (Essue et al. 2018), this study estimated all CHE cases and then allocated each to a single disease area (avoiding double

counting), employing the same method across countries with nationally representative surveys. The wide country coverage permitted statistical comparisons of CHE by health focus area with the prevalence of diseases and conditions, while also controlling for macro-fiscal and health financing indicators. Cross-country patterns in CHE by disease, including by poverty status, can also be assessed uniquely with this dataset. In this way, this study shed light on whether differences in CHE by disease reflect differences in health systems versus differences in burden of disease across countries.

Chapters II and III have complementary strengths and weakness related to scope, methodology and the drivers of CHE. Chapter III used the follow-up to the WHS, the Study on Global Aging and Adult Health (SAGE) surveys, to improve on the methods used in Chapter II, and delve more in depth into distinctions by disease area, all with a more recent dataset (2007-2010). In contrast to Chapter II, Chapter III focused on a limited age group (adults) and set of countries (China, Ghana, India, Mexico, Russia, and South Africa), prohibiting broader cross-country comparison based on statistical methods. Because the SAGE is more detailed than the WHS, it lent itself to more rigorous estimation of CHE by disease. Machine learning and a two-part regression model were deployed to predict utilization and costs, in contrast to the coarser approach deployed in Chapter II. The SAGE also asked about a wider array of disease areas, permitting more general groupings of CHE by disease. Finally, the detailed nature of the data allowed for characterization of disease-specific CHE cases by an array of characteristics: demography; the frequency, location (private/public), and setting (inpatient/outpatient) of care; the magnitude and structure of OOP spending; and whether CHE cases were driven

predominately by a single health care shock or the accumulation of OOP spending over many visits. These detailed analyses contribute to a more specific assessment of which policies and programs would better target NCDs versus other disease areas in pursuit of UHC.

Finally, Chapter IV assessed the elimination of OOP costs and its impact on service coverage rates, focusing on one highly-effective preventive service – colonoscopies – in the United States. While a different setting than Chapters II and III, the availability of high-frequency, comprehensive claims data, the Maine Health Data Organization All Payer Claims Data, and the implementation of a sweeping health reform, the Patient Protection and Affordable Care Act, permitted the deployment of a precisely estimated interrupted times series model that examined the change in both OOP costs and coverage rates. This analysis shed light on the connection between disparities in OOP and disparities in coverage by residence in a rural or urban area. Quasi-experimental intervention studies like Chapter IV provide evidence of what occurs when policies are fully rolled out and constraints to the system come into play. This study complemented the two cross-sectional, cross-country analyses in examining the implications of changes to NCD OOP policies.

All three chapters touched upon the consequences of NCD OOP spending for equity. Chapters II and III assessed a *snapshot* of CHE inequities (O'Donnell et al. 2008), examining the distribution by disease area by rural/urban status and according to whether a household is considered poor according to the multidimensional poverty index (Alkire & Santos 2011). Chapter IV, in contrast, is a *program evaluation*, assessing whether changes in a user fee policy narrowed or widened health inequalities.

Chapter V summarizes the findings from the three analyses and discusses the implications of these findings for research and policy pertaining to the global response to NCDs and global aims to achieve UHC.

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Chapter II

Disaggregating catastrophic health expenditure by disease area: cross-country estimates based on the World Health Surveys

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Abstract

Introduction: Financial risk protection (FRP) is a key objective of national health systems and a core pillar of universal health coverage (UHC). Noncommunicable diseases (NCDs) are increasingly a major share of disease burden among the world's poorest people but have been neglected by health financing, particularly by development assistance for health. NCDs could be a significant cause of catastrophic health expenditure (CHE) in the developing world – cancers and heart disease for instance can entail major treatment costs. Yet, little is known about the distribution of CHE across diseases and conditions at the national level.

Data & Methods: Using the World Health Surveys (WHS) for 39 countries, we quantified CHE, or household health spending that surpasses 40% of capacity-to-pay by key health focus areas. We restricted our analysis to households in which the respondent used health care in the last 30 days and tagged health spending according to the reason care was sought (based on the limited WHS response options available): maternal and child health (MCH); high fever, severe diarrhea, or cough; heart disease; asthma; injury; surgery; and other. We compared CHE by health focus area estimates across income, pooled funding as a share of total health expenditure, share of the population affected by the different diseases and conditions, and poverty status.

Results: Across countries, an average of 45.1% of CHE cases could not be tied to a specific cause; 37.6% (95% UI: 35.4-39.9%) of CHE cases were associated with high fever, severe cough or diarrhea; 3.9% (3.0-4.9%) with MCH; and 4.1% (3.3-4.9%) with heart disease. Injuries constituted 5.2% (4.2-6.4%) of CHE cases. The distribution of CHE across health focus area varied substantially by national income. The share of CHE cases that occurred among the poor was lower

for heart disease than for CHE caused by maternal care (p=.026) and maternal care (p=.055). A ten percent increase in heart disease prevalence was associated with a 1.7% (1.1- 2.3%) increase in heart disease CHE, controlling for macro-fiscal and health system indicators, an association stronger than any other health focus area.

Conclusions: Unlike previously published research, our approach is empirically-based, comprehensively tags all cases of CHE, and allows us to compare the CHE distribution between countries. CHE by health focus area estimates underscore which diseases and conditions health systems should target to improve financial risk protection.

Introduction

Universal health coverage (UHC) aims to ensure that all people have access to quality health services while also providing protection from healthcare-related financial hardship (WHO 2019a). UHC is aspirational and multidimensional. As emphasized by the World Health Organization (WHO) and the World Bank, and included in target 3.8 of the Sustainable Development Goals (SDGs), UHC has become a major global health priority (The Elders 2016).

Financial risk protection (FRP) is a core pillar of UHC and a major aim of health systems (Murray & Frenk 2000; Roberts et al. 2008). In 2010, an estimated 210 million people incurred catastrophic health expenditure (CHE), a key measure of FRP, defined as out-of-pocket (OOP) health expenditure that surpasses 40% of non-food expenditure (Wagstaff et al. 2017). OOP health spending can push households into poverty and further impoverish households already below the poverty line; it can also act as a deterrent to accessing health services (Wagstaff et al. 2017a; Saksena et al. 2014; WHO & World Bank 2015).

Noncommunicable diseases (NCDs) are increasingly an important cause of disease burden among the world's poorest people (Bukhman et al. 2015), but have been neglected by health financing, notably by development assistance for health (IHME 2017). NCDs could be a significant cause of impoverishment and CHE in the developing world: cancers and heart disease can entail major treatment costs and NCDs have been shown to be a major cause of disease even among the poor (Kankeu et al. 2013; Coates et al. 2019). If NCDs cause substantial CHE in low- and middle-income countries, they may become an urgent priority for financial risk protection reforms. However, without knowing how rates of NCD CHE compare to other disease areas, it is

unclear whether to prioritize NCDs over financial risk protection reforms aimed at other health focus areas. Thus, comparing NCD CHE to the CHE caused by maternal and child health care, injuries and infectious diseases can help policymakers decide how to design health reforms intended to improve financial risk protection, including whether the targeting of specific health focus areas would accelerate progress toward UHC.

There is a robust body of literature estimating CHE globally and examining the relationship between CHE rates and macro-fiscal and health system indicators (Wagstaff et al. 2017a, 2017b; Xu et al. 2003, 2007). CHE rates tend to rise with income, which is posited to reflect better service availability, use of expensive technology, and higher prices. Declines in CHE are associated with increases in publicly-pooled financing, emphasizing the important role of public financial arrangements in ensuring financial risk protection. Rigorous theoretical and empirical work also examines the best way to conceptualize and measure CHE (Flores et al. 2008; Flores & O'Donnell 2016; O'Donnell 2007; Moreno-Serra 2011; Saksena et al. 2014; Wagstaff & van Doorslaer 2004; Wagstaff et al. 2007; Wagstaff & Eozenou 2014; Wagstaff et al. 2018).

However, only a few studies have assessed the prevalence of CHE associated with NCDs and, to our knowledge, no research to date has systematically contrasted CHE driven by NCDs to CHE driven by other health focus areas across countries in a comparable and comprehensive manner. Essue et al. (2018) summarized the small number of studies estimating CHE for select NCDs and generated global NCD CHE estimates by extrapolating from these few studies, assuming the same utilization and cost patterns applied to disparate country contexts. Jan et al. (2018) conducted a systematic review of existing NCD CHE literature and were unable to

standardize CHE across studies. Often, existing studies capture health expenditure and CHE for one specific disease at a time and do not conduct comparisons between diseases. Furthermore, many analyses are characterized by methodological idiosyncrasies, such as convenience- or episode-based sampling or are otherwise not nationally representative, making them of limited use for comparison across studies and countries (Engelgau et al. 2012; Kankeu et al. 2013).

We address this gap in knowledge by using the World Health Surveys (WHS) to characterize the distribution of CHE across key health focus areas in 39 low- and middle-income countries. We report CHE by health focus area according to World Bank income group, the share of total health expenditure that is pooled, the share of the population affected by specific diseases and conditions, and poverty status. Finally, we test whether variation in CHE by health focus area is associated with income and pooled health financing, controlling for the share of the population afflicted by the different diseases and conditions.

Data & Methods

We used the WHS as our primary source of data. The WHS was implemented over 2002-2004 in 39 low- and middle-income countries (listed in the appendix) and surveyed more than 238,000 respondents. It deployed a multistage sampling design to capture a nationally representative population. The WHS was selected because it is the only survey implemented to date that captures the reason for seeking care and associates care-seeking with spending in more than six developing countries. Thus, the WHS serves as one of the only existing data sources that

can be used to empirically compare CHE by health focus area across countries and against the underlying share of the population affected by different conditions and diseases.

The WHS collected household expenditure for a range of items. We focused our analysis on health, food and total consumption expenditure. First, households were asked to report expenditure on a number of items over the last four weeks, which we summed and used as our measure of household consumption expenditure. Second, households reported monthly spending on food: we used the mean of the 45-55th percentiles of these expenditures as our subsistence expenditure threshold, adjusted for household size, consistent with previous CHE studies (Xu et al. 2003, 2007). Third, to calculate monthly health spending, we summed households' 30-day expenditure on inpatient care, outpatient care, care from traditional providers, medicines, diagnostics and other health care costs.

Subsequently, we paired total household expenditure with spending on food and health to calculate CHE. We defined capacity-to-pay as the difference between total household expenditure and the subsistence expenditure threshold, calculated as the mean of 45th-55th percentile of food expenditure for each country (Xu et al. 2003, 2007). This was adjusted for the number of household members by using an exponent of 1/2 to scale the subsistence expenditure threshold, following the established literature. For households spending less than the subsistence threshold, we represented capacity-to-pay with reported non-food spending. Thirty-day health expenditure was deemed catastrophic if it comprised more than 40% of capacity-to-pay. We chose this measure of CHE because it is (slightly) more commonly used in the literature (appendix of Wagstaff et al. 2017a) and is more sensitive to CHE among the poor.

We then used unique WHS questions about the causes of health care utilization to identify the diseases and conditions associated with health expenditure. The WHS asked randomly-selected respondents detailed questions about their most recent health care encounter. Specifically, respondents were asked: "Which reason best describes why you [your child] last needed health care?" Respondents could select among 12 response options. We grouped four of these options into a maternal and child health (MCH) category: "antenatal consultation," "family planning," "immunizations," and "child birth." We also created a maternal care only category (excluding immunizations). We reported separately each of the following response options: "high fever, severe diarrhea, or cough", "heart disease," "asthma", "injury," and "minor surgery". We grouped "other" and "arthritis" into the "other" category because we assumed arthritis was interpreted by respondents as pain in joints or other generalized pain that would unlikely truly be arthritis.

We restricted our analysis only to households in which the randomly-selected respondent used health care in the last 30 days, in order to match the utilization time frame with the spending recall period: households were asked to report total health expenditure over the same time period (30 days). We categorized CHE according to the cause of utilization selected by the respondent.

We used bootstrap to estimate the uncertainty of CHE by disease (Kovar et al. 1988). We designated the different strata used to select clusters and resampled at the strata level, allowing us to maintain the national representativeness of the survey while also integrating the unique survey design implemented in each country. We took n=1000 draws of the underlying data to calculate bootstrapped uncertainty intervals (UIs) (5^{th} and 95^{th} percentiles, respectively) for estimating CHE

prevalence. Finally, to scale up to a global level, we used the population of each country at the time of the WHS to weight estimates.

We also calculated a modified version of the multidimensional poverty index (MPI) (Alkire & Sanos 2011), which we called the poverty index (PI). The MPI measures poverty according to the number of deprivations a household experiences in health, education and living standards. Because our focus was health, we omitted the health deprivation in the PI, avoiding concerns about confounding. The WHS did not capture whether household members of the appropriate age were attending primary school and thus the education portion of the PI was based on whether adults in the household had completed primary school. Table A2.1 in the appendix lists each indicator and its definition. Under the PI, households were considered poor when deprived in four or more areas. Using this classification, we compared CHE by disease between poor and non-poor households.

To understand the association between disease-specific CHE and the share of the population affected by the specific diseases and conditions captured in the WHS, we used 2016 Global Burden of Disease (GBD 2016) estimates for the incidence of injuries and the prevalence of cardiovascular disease (CVD) for the years 2002-2004 (GBD 2016). Because spending on maternal care captured all deliveries, we compared maternal care CHE with the crude birth rate as a share of the population, as estimated by the United Nations Population Division (UN 2016). These cross-sectional comparisons highlight how the share of the population affected by CHE differed by disease area and how well health systems have adapted their financial risk protection measures to the most prominent areas of disease nationally.

We depict the distribution of CHE by disease according to two defining features of health systems: income and the pooling of health financing. First, we define income using World Bank income groups. Income is highly correlated with how much a country can spend on health, and thus invest in financial risk protection (Musgrove 1996). Income is also correlated with the share of the population living below the poverty line and thus most susceptible to CHE. Second, we use the share of health expenditure that is pooled (sourced from governments and prepaid private contributions) as estimated by the Institute for Health Metrics and Evaluation (Dieleman et al. 2018). Pooled financing represents how well the health system is organized to protect people financially from health care costs.

Finally, we examined the relationship between the share of the population affected by each of the highlighted disease areas and key health system features. We regressed each of the disease-specific CHE measures on corresponding measures of the share of the population affected and, in multivariate regressions, controlled for the natural log of gross domestic product (GDP) per capita, pooled funding as a share of total health expenditure (Pooled/THE) and the natural log of government health expenditure as a source (GHES) per capita, all in 2017 purchasing-power-parity-adjusted dollars, in order to assess whether the relationship between the share of the population afflicted by the disease and disease-specific CHE, respectively, could be explained by underlying features of the health system, including its organization and financing, rather than burden of disease (Dieleman et al. 2018). A positive relationship would suggest that as the share of the population afflicted rises, more people incur CHE. The lack of a relationship is more

ambiguous and could suggest that as disease burden increases, health systems have focused on protecting people from that cause of financial risk protection, or populations forego health care.

To examine whether there was any evidence that the other category was associated with one health focus area more than another, we assessed the association between the "other" CHE category and measures of the prevalence of NCDs and communicable causes not otherwise captured in the WHS, standardized by subtracting mean prevalence and dividing by the standard deviation across countries. Section A2.2 of the appendix presents the causes included and how prevalence estimates were computed. All analyses were conducted in Stata 14.0.

Results

Table 2.1 depicts select indicators for each World Bank income group. On average, 5,603 households were surveyed in each country, ranging from 1,028 in Bosnia and Herzegovina to 38,746 in Mexico. The share of households incurring CHE ranged from 30% in low-income countries to 17% in upper-middle income countries. These estimates are similar to other CHE estimates using the WHS, but slightly higher than estimates that do not use these surveys (Wagstaff et al. 2017a; Raban et al. 2013).

Table 2.1: Summary indicators, across the different country income groups included in the analysis.

Income group (N)	Average number of respondents	Mean age (years) (min/ max)	Average share of female respondents (min/max)	Average share Rural (min/ max)	Average share of population with an outpatient visit in the last year (min/max)	Share with catastrophic health expenditure (min/max)
LICs (8)	4,596	38 (36 to 42)	54% (43 to 63)	77% (53 to 91)	29% (4 to 50)	15% (8 to 34)
LMICs (18)	4,906	40 (35 to 48)	51% (42 to 66)	81% (10 to 89)	58% (15 to 80)	30% (8 to 42)
UMICs (13)	7,124	45 (38 to 54)	54% (51 to 69)	53% (13 to 67)	46% (22 to 70)	17% (4 to 22)

Notes: LICs: Low-income countries; LMICs: Lower-middle-income countries; UMICs: Upper-middle-income countries; according to 2002-2004 World Bank income classifications. Survey weights used at the national level; population size used to weight at the income level. No population weights used for average number of respondents.

Across all 39 countries, 37.6% (95% UI: 35.4-39.9%) of CHE cases were associated with fever, cough or diarrhea. The largest category was "other": we were unable to associate 45.1% (42.6-47.6%) of CHE cases with a specific disease area. MCH and heart disease were associated with 3.9% (3.0-4.9%) and 4.1% (3.3-4.9%) of CHE cases, respectively. Injuries constituted a slightly higher share of all CHE cases, at 5.2% (4.2-6.4%), while asthma CHE was slightly lower, at 3.0% (2.2-3.9%). Although "minor surgery" was associated with less than 2% of cases, some surgical spending would likely be associated with the other categories and thus the "minor surgery" estimates should be interpreted as a lower bound of CHE associated with surgical care.

Much more variation was observed with respect to heart disease CHE than any other area. The standard deviation for heart disease CHE was 4.5 per 1,000, larger than the standard

deviations of maternal-, injury- and asthma-associated CHE, at 1.9, 1.8 and 1.4 per 1,000, respectively.

We also report on the distribution of CHE by disease area disaggregated by three groupings (Figure 2.1). First, we depict the distribution of CHE by disease across World Bank income groups (Figure 2.1a). Distinct patterns in the distribution of CHE by income group emerged: as income rises, a smaller share of CHE was related to fever, diarrhea and cough, and a larger share of CHE was associated with heart disease and the other category.

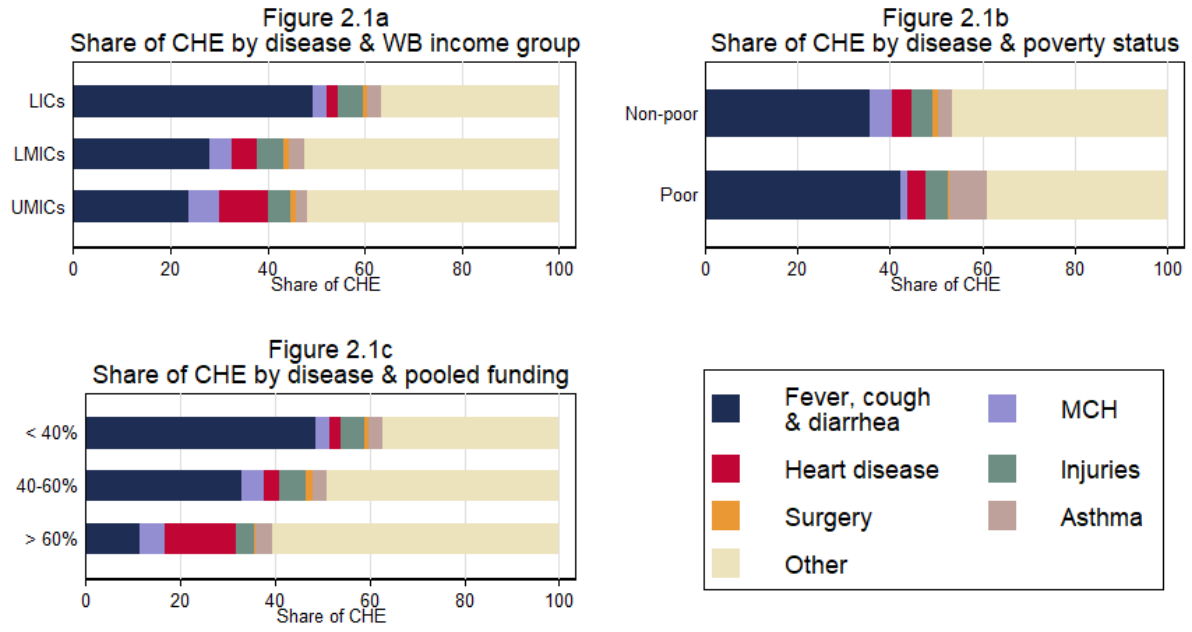

Figure 2.1: Share of catastrophic health expenditure (CHE) by disease area grouped by World Bank income group, poverty status, and pooled funding.

Notes: Among households with a respondent that used health care in the last 30 days. LICs: Low-income countries; LMICs: Lower-middle-income countries; UMICs: Upper-middle-income countries; according to 2002-2004 World Bank income classifications. Households considered poor according to the multidimensional poverty index. Pooled funding: share of prepaid private and government spending as a share of total health expenditure, countries grouped by the interquartile range of: less than the 25th percentile (<40% pooled), 25th-75th percentile (40-60% pooled), and more than the 75th percentile (>60% pooled). Survey weights used at the national level and population size used to weight across countries.

Second, we compare CHE between poor and non-poor households across all countries (Figure 2.1b). The fraction of CHE due to fever, diarrhea and cough was somewhat higher among the poor (42.3%, 95% UI: 34.6-50.4%) as compared to the non-poor (35.8%, 33.1-38.8%). The distribution of CHE cases by PI status was overlapped for all other causes (Table A2.3 in the appendix). However, when we examine the portion of each of the disease-specific CHE groupings that occurred among the poor versus the non-poor within countries, CHE patterns by disease area are more distinct. The portion of heart disease CHE cases that were among the poor (16.9%) was lower than the share of maternal CHE cases among the poor (23.6%, p=.026) and injury CHE cases among the poor (25.6%, p=.055). This underscores that, despite the lack of broad cross-country distinctions, within countries, maternal and injury CHE is more concentrated among the poor than heart disease CHE.

Third, we represent the distribution of CHE by disease across pooled financing as a share of THE, grouped by the 25th percentile (<40% pooled), the 25th-75th percentile (40-60% pooled) and the 75th percentile (>60% pooled). In countries with the greatest pooling, a larger share of CHE was associated with heart disease and the other category.

Figure 2.2 captures the association between disease-specific CHE and the share of the population affected by each disease, using different metrics based on the disease or condition. The slope of the association of CVD prevalence and heart disease CHE was the highest. The slope of the association between maternal care CHE and live births per person was less pronounced; and the slope for the relationship between injuries and CHE was effectively zero. The visualization was confirmed by our univariate and multivariate regressions (Table 2): the coefficient for CVD

prevalence was positive (0.17, 95% UI: 0.11 to 0.23) – a result that is robust to controlling for log GDP per capita, log GHES per capita and the share of health expenditure that is pooled. The coefficients for live births per person (0.07, -0.02 to 0.16) and injuries incidence (0.02, -0.13 to 0.18) were smaller and not statistically significant.

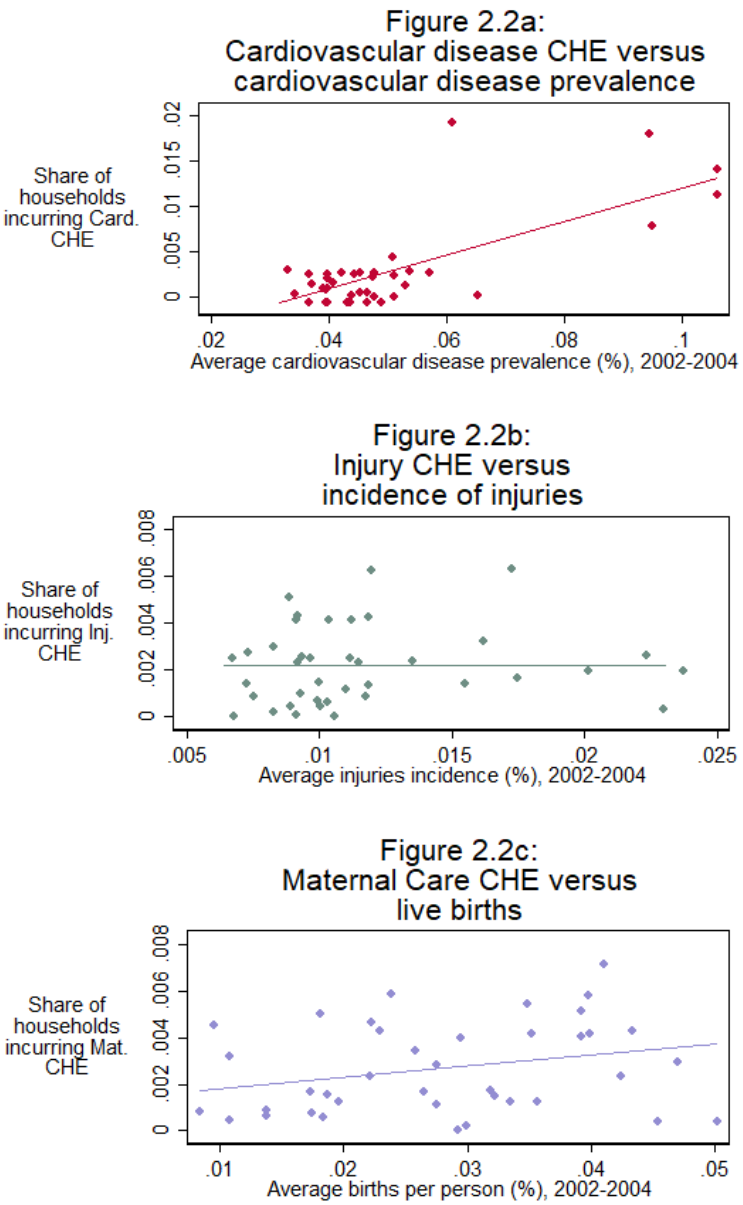

Figure 2.2: Comparing catastrophic health expenditure (CHE) to the share of the population affected by disease area.

Notes: Among households with a respondent that used health care in the last 30 days. CHE: Catastrophic health expenditure defined as 40% of capacity-to-pay. Source of prevalence of cardiovascular disease and incidence of injuries from Global Burden of Disease Study 2016. Source of live births from United Nations Population Division.

Table 2.2: Results from regressing catastrophic health expenditure (CHE) on the share of the population affected, by disease area.

	Heart disease CHE	**Heart disease CHE**	**Heart disease CHE**	**Injuries CHE**	**Injuries CHE**	**Injuries CHE**	**Maternal CHE**	**Maternal CHE**	**Maternal CHE**
Heart disease prevalence	0.185***	0.168***	0.166***						
	(0.131 to 0.238)	(0.110 to 0.226)	(0.105 to 0.227)						
Injuries incidence				0.002	0.014	0.022			
				(-0.138 to .142)	(-.134 to .163)	(-.132 to .176)			
Crude birth rate (percent)							0.048	0.058	0.072
							(-0.007 to .102)	(-.022 to .137)	(-.015 to .158)
Log GDP pc		0.0010	0.0008		-0.0002	0.0005		0.0002	0.001
		(-0.0003 to 0.0023)	(-0.002 to .004)		(-.001 to .001)	(-.001 to .002)		(-.001 to .001)	(-.001 to .003)
Log GHES pc			0.0002			-0.0004			-0.0005
			(-.002 to .002)			(-.002 to .001)			(-.002 to .001)
Pooled/THE			-0.002			-0.001			-0.001
			(-.009 to .006)			(-.006 to .003)			(-.006 to .004)
N	39	39	39	39	39	39	39	39	39

Notes: Log GDP pc: Natural log of gross domestic product per capita. Log GHES pc: Natural log of government health expenditure as source per capita. Pooled/THE: government and prepaid private spending as a share of total health expenditure. GDP pc and GHES pc are average over 2002-2004 and reported in 2017 purchasing power parity international dollars.

Across income groups, a considerable fraction of households experienced CHE associated with a disease category not provided as a response option ("other"). This fraction increased with rising income. We could not unpack the reasons for spending based on the WHS data. However, in an effort to understand which areas of disease burden could be most associated with this category, we examined the linear association between other CHE and standardized and adjusted NCD and communicable disease prevalence. Other CHE declined as adjusted communicable prevalence increased (coefficient value: -.003, p = .372; Figure 2.3). In contrast, other CHE rose with adjusted NCD prevalence and was statistically significant (.006, p=.043), and remains statistically significant when controlling for log GDP per capita, log GHES per capita and pooled/THE (Table A2.4 in the Appendix) at the .1 level (.005, p=.062). This suggests that the other category could include a substantial amount of NCD CHE.

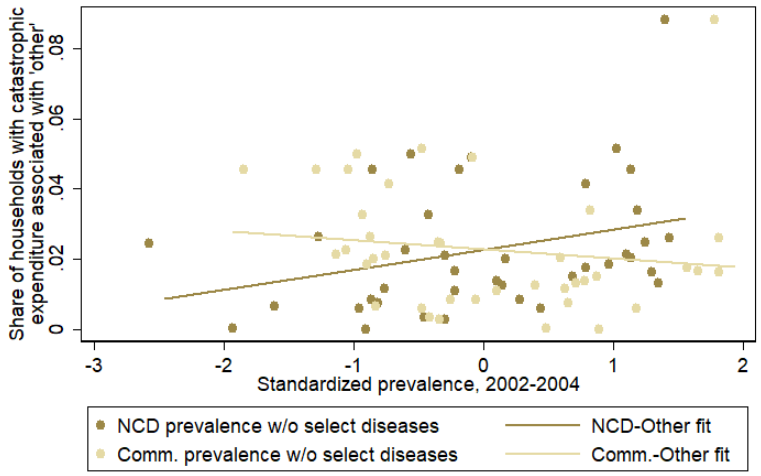

Figure 2.3: Catastrophic health expenditure (CHE) rates associated with 'other' versus standardized prevalence.

Notes: Catastrophic health expenditure rates in 39 countries among households with a respondent that used health care in the last 30 days in the World Health Survey. Noncommunicable disease (NCD) prevalence without selected diseases and communicable prevalence without selected diseases capture disease prevalence omitting the NCDs and communicable causes captured in the other disease-specific catastrophic health expenditure estimates. The full list of causes included in each category can be found in the appendix.

Discussion

Our study characterized the distribution of CHE across health focus areas in a comparable, comprehensive and empirically-based manner. The CHE distribution was associated with income levels: CHE cases associated with communicable diseases and maternal and child health declined with income whereas the portion of CHE cases attributed to heart disease and the "other" category rose with income. In countries with more pooling and higher income, fever, cough, diarrhea and MCH comprised a smaller share of CHE, suggesting that these countries might do a better job at protecting people from these conditions but was also connected to lower prevalence rates of these conditions. In countries with more pooling and higher income, the CHE associated with heart disease was a higher share of total CHE. This is consistent with the higher prevalence of heart disease in countries with higher GDP per capita (GBD 2016). Furthermore, because heart disease can entail intensive and expensive treatments, this finding is consistent with existing literature that emphasizes the role of expensive technology and prices as potential drivers of higher CHE as income increases (Wagstaff et al. 2017a; Xu et al. 2003).

The distribution of CHE by disease was similar when comparing the poor to the non-poor across countries, but, within countries, heart disease CHE occurred less frequently among the poor than maternal and injuries CHE. This suggests that the epidemiologic profile of a country and context-specific health system features (e.g. costs, availability and access to specific health services) are substantial drivers of disease-specific CHE but also that CHE for NCDs like heart disease is skewed toward non-poor populations as compared to communicable diseases.

Across the disease areas that could be examined in depth, the CHE associated with heart disease exhibited the strongest relationship with the share of the population afflicted. However, this relationship varied widely across countries, with much larger dispersion (standard deviation) for CVD CHE than for other areas – countries with similar rates of heart disease exhibited widely different proportions of the population affected by heart disease CHE. Furthermore, based on the regression results, for each percentage point increase in CVD prevalence, substantially more households incurred CHE than the other disease areas, although we note the results appear to be driven substantially by high-prevalence countries. The prevalence of CHE associated with injuries and the crude birth rate was much lower. This suggests that where injuries and births affected a larger share of the population, health systems have developed financial risk protection measures for these causes or afflicted populations are foregoing health care.

The regression results suggest that the stronger relationship between the population afflicted and heart disease CHE is not explained by basic determinants of health systems: GDP per capita, GHES per capita, or the share of total health expenditure that is pooled. The slope of the relationship is effectively unchanged when including these controls. This emphasizes the role of price, availability of care, technology and other unmeasured health system factors as driving up heart disease CHE. Some countries' financial risk protection measures have not kept pace with heart disease prevalence, either by reducing the OOP costs of heart disease treatment or providing insurance covering the costs of heart disease care. Insurance programs and other pooling mechanisms may be focused on other disease areas or otherwise not yet sufficiently cover these costs.

Another key finding was the substantial share of catastrophic spending associated with the "other" cause category. Across all WHS countries, an average of 45% of CHE cases could not be associated with a specific disease area. In the WHS, the options provided to respondents did not capture a range of diseases and conditions, including: HIV/AIDS, malaria, diabetes, cancer, pneumonia, neglected tropical diseases and general well visits. Respondents seeking care for these reasons would have to select the other response option. It is difficult to determine the distribution of these conditions in the other category. Plotting the CHE rates against disease burden suggested that much of this spending could be associated with NCDs, but more research is required in this area.

Data challenges comprised the main limitations of our study. First, the age of the WHS was a limitation – the survey was implemented over 2002-2004. Since this time, disease burden has changed substantially. NCDs, including cardiovascular disease, have risen as a share of disease burden in low- and middle-income countries (GBD 2016). *Ceteris paribus*, this would increase the number of CHE cases associated with heart disease. However, a number of countries have implemented reforms to improve financial risk protection since this time, including expanding insurance schemes and eliminating user fees. While some of these efforts have affected all types of disease areas, a portion of schemes – particularly those funded by development assistance – have focused on maternal and child health and infectious diseases such as HIV/AIDS, tuberculosis and malaria. Second, respondents only reported the reason for using care at their most recent health care visit, and we only considered care in the last month, to match the recall period for utilization with the recall period of health spending. A core assumption was that *all*

household health spending in the last month was related to the health care associated with that visit. It is likely that spending related to other diseases and conditions as well as for other family members was captured. However, we argue that particularly for the cases of catastrophic health spending that we focus on in this analysis, the cause of health care for that spending is most likely to be reported: existing evidence shows that respondents remember large expenditures well and are more likely to report catastrophic health spending events than minor bouts of illness, particularly when a monthly recall period is used (Banerjee et al. 2004; Das et al. 2011). Nonetheless, this approach should be validated with other types of data and analysis, including administrative data on the cause of visits and the impact of recall period on the cause of health care utilization.

Other data limitations related to expenditure. First, the spending captured did not measure non-health spending related to illness onset, including transportation costs and opportunity costs (e.g. lost wages) associated with health care use. Second, the WHS captured a limited amount of household expenditure items and did not capture home production, resulting in underestimates of household expenditure, which tends to inflate rates of CHE relative to more detailed general household budget surveys.

Finally, our study was limited by the lack of more detailed information about the nature of health care delivery and the different health services available in the countries studied. Out-of-pocket spending on any of the disease areas studied is contingent on the availability of health services. If no heart disease treatment was available, afflicted individuals would not be able to spend on health care. Furthermore, we had no information about the severity of conditions and the quality and appropriateness of health care which mitigated symptoms or altered the course of

disease. Highly-detailed data on health care utilization, costs and household characteristics – such as administrative claims data linked with household surveys or tax records – could be used to better understand these features of care and more precisely estimate CHE by disease.

To achieve UHC, health systems will have to respond to challenges along multiple fronts, spanning the coverage, equity, and affordability of services. Countries may have prioritized financial protection in certain disease areas in the past because those disease areas were concentrated among the poor and of high priority on the international agenda. However, as populations develop diseases – such as heart disease, diabetes and cancers – that the health system is not equipped to deliver in an affordable manner, households may increasingly face financial hardship. As countries pursue UHC, policymakers should pay attention to the newly emerging burden of NCDs as a driver of CHE and consider policies and benefits packages that provide financial risk protection tailored to the disease areas most threatening household welfare.

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Appendix

Countries included in the analysis

Bangladesh, Bosnia and Herzegovina, Brazil, Burkina Faso, Chad, China, Cote d'Ivoire, Comoros, Congo, Dominican Republic, Ecuador, Georgia, Ghana, Guatemala, India, Kazakhstan, Kenya, Laos, Mali, Malawi, Malaysia, Mauritania, Mauritius, Mexico, Myanmar, Namibia, Nepal, Pakistan, Paraguay, Philippines, Senegal, South Africa, Sri Lanka, Swaziland, Tunisia, Ukraine, Vietnam, Zambia, Zimbabwe.

Methods for excluding disease cause categories

To calculate our adjusted measures of disease burden and compare to "other" CHE, we excluded the disease areas already included in the disease-specific catastrophic health expenditure estimates. The prevalence estimates could not be simply subtracted from the total NCD or communicable disease prevalence numbers because of the presence of co-morbidities across causes in the Global Burden of Disease study. We assumed independence across causes, which is consistent with the assumptions of independence across comorbidity simulations used in the GBD study, and then computed a total for the respective disease areas, represented in the following:

$$Total\ prevalence = 1 - \prod(1 - disease\ prevalence)$$

Where "Total prevalence" is prevalence (in percent terms) for communicable or noncommunicable diseases, respectively.

The modified version of communicable disease prevalence was represented by:

Encephalitis, Food-borne trematodiases, Leishmaniasis, Leprosy, Lymphatic filariasis, Intestinal

nematode infections, Onchocerciasis, Other neglected tropical diseases, Other communicable, maternal, neonatal, and nutritional diseases, Schistosomiasis, and Trachoma.

For NCDs, modified prevalence was captured by: Cirrhosis and other chronic liver diseases, Diabetes, urogenital, blood, and endocrine diseases, Digestive diseases, Gout, Low back and neck pain, Mental and substance use disorders, Neoplasms, Neurological disorders, Other musculoskeletal disorders, Congenital birth defects, Skin and subcutaneous diseases and Sense organ diseases.

Computing the poverty index (PI)

We used a modified version of the multidimensional poverty index (MPI) to compute our poverty index (PI), which was used to determine whether a household was poor (Alkire & Santos 2011). Because our study focused on health, we omitted the health components of the MPI – nutrition and mortality. Because the World Health Survey did not capture whether household members below the age of 12 were attending school, we were also unable to assess school attendance, and thus relied only on the years of schooling reported for adults as the education component of the index. A household was considered poor if it ws deprived in four or more of the indicators. Table A2.1 reports the definitions of the indicators used to assess deprivation.

Table A2.1: Indicators used in the poverty index (PI).

Indicators	Definition
Education	
Years of schooling	No household member aged ≥ 10 years has completed ≥ 5 years of schooling.
Living standards	
Cooking fuel	The household cooks with dung, wood or charcoal.
Improved sanitation	The household does not have a flush toilet or latrine, or does not have or must share one of the following with other households: a ventilated improved pit or composting toilet.
Safe drinking water	The household does not have piped water, a public tap, a borehole or pump, a protected well or spring or rainwater within a 30 minutes roundtrip walk.
Electricity	The household has no electricity.
Floor	The household has a dirt, sand or dung floor.
Assets	The household does not own more than one of: radio, TV, telephone, bike, motorbike or refrigerator and does not own a car or truck.

Source: Alkire and Santos. 2011.

Table A2.2: Bootstrapped mean, 5th and 95th percentiles for the cases of catastrophic health expenditure by disease area and income group.

	Fever, diarrhea and cough	Other maternal and child health	Heart disease	Injuries	Surgery	Asthma	Other
LICs	49.2%	3.1%	2.3%	5.0%	0.8%	2.9%	36.7%
	(UI: 46.4-52.3%)	(UI: 2.5-3.8%)	(UI: 1.4-3.2%)	(UI: 4.0-6.2%)	(UI: 0.5-1.1%)	(UI: 2.0-3.9%)	(33.7% - 39.6%)
LMICs	28.1%	4.4%	5.2%	5.4%	1.2%	3.2%	52.4%
	(UI: 24.4-32.0%)	(UI: 2.8-6.2%)	(UI: 4.0-6.6%)	(UI: 3.6-7.7%)	(UI: 0.5-2.0%)	(UI: 1.9-4.7%)	(UI: 48.3-56.5%)
UMICs	23.7%	6.3%	10.1%	4.5%	1.2%	2.4%	51.8%
	(UI: 21.7-25.8%)	(UI: 4.6-8.0%)	(UI: 7.9-12.3%)	(UI: 3.4-6.0%)	(UI: 0.8-1.7%)	(UI: 1.2-3.8%)	(UI: 49.0-54.7%)
All	37.6%	3.9%	4.1%	5.2%	1.0%	3.0%	45.1%
	(UI: 35.4-39.9%)	(UI: 3.0-4.9%)	(UI: 3.3-4.9%)	(UI: 4.2-6.4%)	(UI: 0.6-1.4%)	(UI: 2.2-3.9%)	(UI: 42.6-47.6%)

Notes: LICs: Low-income countries; LMICs: Lower-middle-income countries; UMICs: Upper-middle-income countries; according to 2014 World Bank income classifications. UI: uncertainty interval based on 1000 bootstrapped draws.

Table A2.3: Bootstrapped mean, 5th and 95th percentiles for the cases of catastrophic health expenditure by disease area and poverty status.

	Fever, diarrhea and cough	Other maternal and child health	Heart disease	Injuries	Surgery	Asthma	Other
Non-Poor	35.8%	4.6%	4.2%	4.7%	1.0%	3.2%	46.4%
	(UI: 33.1-38.8%)	(UI: 3.5-5.8%)	(UI: 3.3-5.3%)	(UI: 3.6-6.0%)	(UI: 0.6-1.5%)	(UI: 2.2-4.4%)	(UI: 43.5-49.0%)
Poor	42.3%	1.5%	3.8%	4.8%	0.4%	8.3%	38.8%
	(UI: 34.6-50.4%)	(UI: 1.1-2.1%)	(UI: 0.8-5.8%)	(UI: 2.8-7.9%)	(UI: 0.1-0.7%)	(UI: 3.0-14.8%)	(UI: 31.1-47.5%)

Notes: UI: uncertainty interval based on 1000 bootstrapped draws.

Table A2.4: Results of regressing "Other CHE" on standardized prevalence of NCDs and communicable diseases, respectively.

	Other CHE	Other CHE	Other CHE	Other CHE	Other CHE	Other CHE
Standardized NCD prevalence	0.006*	0.006*	0.005†			
Standardized communicable disease prevalence				-0.003	-0.002	-0.002
Log GDP pc		0.004	0.012		0.002	0.012
Log GHES pc			-0.004			-0.005
Pooled/THE			-0.023			-0.024
Constant	0.023***	-0.008	-0.048	0.023***	0.007	-0.043
N	39	39	39	39	39	39

Notes: † p<.1, * p<0.05, ** p<0.01, *** p<0.001.

Chapter III

Toward designing targeted financial risk protection mechanisms for universal health coverage: estimates of catastrophic health expenditure by health focus area in six countries

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Abstract

Background: The growing share of disease burden caused by noncommunicable diseases (NCDs) in developing countries may have implications for the prevalence of catastrophic health expenditure (CHE) or out-of-pocket (OOP) health spending that surpasses 40% of non-food expenditure. This study aims to estimate the magnitude of disease-specific CHE and to characterize the utilization and spending underpinning disease-specific CHE prevalence.

Data & Methods: We utilized the World Health Organization's Study on Global Aging and Adult Health (SAGE), which captured a sample of 44,089 adults in China, Ghana, India, Mexico, Russia, and South Africa and included information about OOP spending and use of health care. We imputed the cause of visit using random forests and disease-specific OOP spending with a two-part logit-log-link model when disease area and OOP spending were missing for some visits in these data. Using these estimates, we computed cumulative OOP spending by disease category and CHE by health focus area.

Results: NCD-related CHE cases comprised at least 50% of all CHE adult cases in Mexico, Russia, and South Africa and more than 20% in all other countries. Compared to communicable CHE cases, NCD CHE cases were 10.9 (95% uncertainty interval: 2.1-19.7) percentage points less likely to be caused by a large spending shock from one visit and 13.1 (5.7-20.5) percentage points more likely to be caused by five or more visits. Relative to communicable diseases, NCD OOP spending per outpatient visit was 1.8 (1.6-2.1) times higher.

Discussion: NCDs seemed to compromise the provision of financial risk protection in all six countries studied. Assessments of CHE by disease category (e.g. NCD vs. communicable CHE

cases) are essential to tailoring national financial risk protection and poverty reduction strategies to deliver on the promise of universal health coverage.

Introduction

Financial hardship due to health care spending, as measured by the prevalence of catastrophic health expenditure (CHE) or out-of-pocket (OOP) health expenditure that surpasses 40% of non-food expenditure, affected an estimated 210 million people worldwide in 2010 (Wagstaff et al. 2017). Reducing CHE prevalence could help countries make considerable progress toward target 3.8 of the Sustainable Development Goal for health (SDG 3): universal health coverage (UHC) (UN 2018). By improving access to health services, reductions in CHE could also contribute to SDG 3's broader aim to "ensure healthy lives and promote well-being for all at all ages".

The rise of non-communicable diseases (NCDs) as a share of disease burden in low- and middle-income countries may pose a challenge for the fulfillment of UHC and the effective provision of financial risk protection (Binagwaho et al. 2014). Historically, health systems in developing countries have been geared toward providing services for maternal and child health conditions and infectious diseases (Wilkinson & Wilkinson 2004). International investments in NCDs are paltry, comprising less than 2% of development assistance for health (DAH) (IHME 2016). The lack of focus and low levels of NCD-targeted DAH and domestic financing in developing countries could leave people afflicted by NCDs vulnerable to financial hardship, including CHE.

Currently, little is known systematically about the contribution of NCDs to CHE and how it contrasts with other health areas, notably infectious diseases and maternal and child health conditions. Existing assessments of financial risk protection predominately focus on estimating the

aggregate (total) prevalence of CHE, both globally and in specific country contexts, without further disaggregation by disease area (Wagstaff et al. 2017). Estimates of CHE prevalence by disease category and, in particular, the prevalence of NCD-induced CHE worldwide, have relied on a small number of studies (Essue et al. 2018), which, according to one systematic review, are too methodologically distinct to be further analyzed in meta-analysis due to convenience sampling, small sample sizes, and/or use of non-representative administrative data (Kankeu et al. 2013). Many studies have estimated the prevalence of CHE associated with a single type of NCD, but few had nationally representative samples that would allow for comparison across countries and disease areas (Smith-Spangler et al. 2012). Of 66 studies on the economic impact of NCDs, just nine were nationally representative (Jan et al. 2018). Only five of these studies compared CHE estimates across more than one country and these focused on a single NCD (e.g. cancer, cardiovascular disease, and diabetes). One recent study estimated 2002-2004 CHE prevalence across countries by specific disease areas, but only cardiovascular disease, among NCDs, was estimated (Haakenstad et al. 2019). Finally, while many studies associated CHE cases with a range of individual, household, and health system factors (Sharma et al. 2018; Njagi et al. 2018; Fernandes et al. 2018; Wang et al. 2018), to our knowledge, no study has investigated differences in how the spending and utilization patterns underpinning CHE might differ across disease areas.

Comparing NCD CHE and communicable CHE is critical to designing effective financial risk protection policies, and prioritizing different features of health insurance schemes and national health benefits packages. First, it is plausible that some health investments, most notably investments funded by DAH, have been enacted with the underlying assumption that

communicable diseases affect the poor disproportionately. However, recent evidence shows that millions living below the poverty line are affected by NCDs (Coates et al. 2019) and that NCDs can have a large economic impact, particularly among the poor (Jan et al. 2018). Thus, estimating the magnitude of CHE by disease is important to informing ongoing disease-specific investments. Second, identifying how CHE arises differently across disease areas can help maximize the impact and effectiveness of financial risk protection policies. When working within constrained health budgets, financial risk reduction policy design must consider tradeoffs between different approaches. Important questions include whether OOP spending reduction strategies should focus on hospitalizations, outpatient visits, or drug spending (Saksena et al. 2010). Another is whether to establish 'catastrophic funds' for preventing acute spending shocks tied to the treatment of certain costly diseases (Lozano & Garrido 2015), or to address user fees and other small costs that can culminate in CHE over many visits (WHO 2019). Finally, policymakers must decide which services, procedures, diagnostics and medicines to include in benefits packages (Glassman et al. 2017). This is why it is crucial to understand how the magnitude of OOP spending and CHE prevalence differs by disease area, so that decision-makers can tailor financial protection policies and insurance schemes to the types of financial hardship observed in their countries.

The objectives of this study were: to estimate and compare the magnitude of disease-specific CHE cases; and use those estimates to characterize the spending and utilization patterns underpinning disease-specific CHE cases. We apply machine learning and regression methods to data from the World Health Organization's (WHO) Study on Global Aging and Adult Health

(SAGE) to quantify CHE prevalence by broad disease areas in six developing countries: China, Ghana, India, Mexico, Russia, and South Africa.

Data & Methods

Data

The SAGE surveys, developed based on the World Health Surveys and 16 other surveys on aging, aimed to assess health systems performance from a household and individual perspective (WHO 2017). The surveys were conducted over 2007-2010 in China, Ghana, India, Mexico, Russia, and South Africa. They captured a nationally-representative sample of adults older than 18 years of age. The number of respondents ranged from 15,009 individuals in China to 2,742 in Mexico and collectively amounted to 44,089 across all countries. These respondents could be stratified by poverty status, which we assessed according to a modified version of the multidimensional poverty index, computing poverty based on the number of deprivations in education and living standards (see Table A3.1 in the appendix) (Alkire & Santos 2011).

Identifying cause of visit by disease area

SAGE respondents were asked to identify the reason for seeking care for their three most recent inpatient stays and three most recent outpatient visits. Respondents selected among 18 distinct health reasons for these visits. Informed by the groupings developed by the Global Burden of Disease (GBD) study (IHME 2018), we categorized these responses into seven groups: NCDs; communicable diseases (which includes maternal and child health, in line with GBD groupings);

injuries; pain; surgery; "other", which included sleep problems, problems with breathing, and work-related conditions; and "unidentified", which indicated the cause was not among the 18 response options provided.

Respondents did not report the reason for seeking care for the fourth most recent visit and other prior encounters, but did report the total number of inpatient and outpatient visits in the past year. The cause of visit was unavailable for 53% of outpatient visits and 6% of inpatient visits. We thus imputed the cause (i.e. disease or condition) for these visits using random forests. Random forests were selected because the approach is well adapted to classification problems with more than two categories and, as measured with out-of-sample prediction, is one of the best-performing machine learning techniques (Caruana & Niculescu-Mizil 2006). Covariates in our models were selected based on out-of-sample prediction.

Computing out-of-pocket expenditure by disease area

SAGE respondents also indicated how much they spent OOP on their most recent inpatient and outpatient visits, respectively. The costs of other visits were not captured. We used reported OOP spending from the most recent visit to model costs for prior visits. We converted OOP spending to 2017 international dollars (purchasing-power-parity adjusted) and applied a two-part logit-log-link generalized linear regression model to predict OOP spending per visit by cause of visit. Covariate selection was based on out-of-sample root-mean squared error.

To calculate annual OOP spending by disease area for each respondent, we multiplied the cause of visit with the OOP cost for each individual *i,* disease *d,* and visit *v.* For visits 1-3, we

used the reported cause. For visit 1, we used the reported OOP cost. For all other visits, we used the predicted cause of visit and visit's OOP spending. OOP spending was then summed across all visits to generate annual OOP spending by disease for each respondent, as in (1):

$$Annual\ OOP_{i,d} = \sum_{visit=1}^{V} OOP_{i,d,v} * Cause\ of\ Visit_{i,d,v} \quad (1)$$

where $OOP_{i,d,1}$ is observed and all other $OOP_{i,d,v}$ values are predicted and *Cause of Visit*$_{i,d,1\text{-}3}$ are observed and all other *Cause of Visit*$_{i,d,v>3}$ are predicted.

Estimating catastrophic health expenditure (CHE)

CHE was based on whether OOP health spending by each individual exceeded 40% of capacity to pay (Xu et al. 2003; Wagstaff et al. 2017). Capacity to pay was calculated as the difference between annual household expenditure and the mean of the 45th to 55th percentile of food consumption expenditure, scaled by household size. The focus on individual OOP spending, as opposed to household OOP spending, is a departure from most approaches to calculating CHE. Nonetheless, because diseases, and thus OOP spending, occur at the individual level, we feel this is not a substantial limitation of this approach.

In more than 70% of CHE cases, all OOP spending was associated with one spending category (including other) and we assigned CHE cases to that category. For people with a mix of different spending areas, each CHE case was assigned to the disease-specific spending category (NCDs, communicable diseases, or injuries) if OOP spending on that disease comprised more than 75% of disease-specific OOP spending. About 13% of CHE cases were tagged in this way. All

other CHE cases were considered "unallocable". These CHE cases included spending on a mix of the three disease areas (NCDs, communicable diseases, or injuries), as well as spending for which we could not identify the cause. Uncertainty intervals (UIs) were generated with 1000 non-parametric bootstrap draws, resampled by strata to incorporate the survey design (Kovar et al. 1988).

Assessing patterns in utilization and spending

We examined patterns of disease-specific OOP spending and utilization for the most recent inpatient and outpatient visit, for which the most detailed, non-modeled information was available from the SAGE survey. We used ordinary least squares (OLS) regression models to examine the variation in total and drug OOP spending per visit, drug share of OOP spending per visit, and private facility attendance. OLS regressions were implemented separately for inpatient and outpatient visits with the following covariates: an indicator for disease category (NCDs, communicable diseases, injuries, and other), a country indicator, age, an indicator for urban residence, educational attainment, sex, and wealth quintile. Standard errors were clustered by primary sampling unit.

Finally, we analyzed characteristics of CHE cases by disease area, which were built off our predictions of OOP spending and cause of visit. We examined how CHE cases differed by disease area with three measures: 1) the inpatient share of health spending; 2) the number of outpatient and inpatient visits; and 3) the number of visits that occurred in order to push health spending over the 40% capacity-to-pay threshold, which we called the number of "visits-to-CHE". The

visits-to-CHE number was based on ranking visit OOP spending from the highest to the lowest spending amount and calculating culminative spending for each additional visit, starting with the most expensive visit. To test whether these characteristics were distinct by disease area, we regressed: outpatient share of health spending, number of outpatient visits, number of inpatient visits and number of "visits-to-CHE" on the following covariates: an indicator for CHE disease type, a country indicator, age, an indicator for urban residence, educational attainment, sex, and wealth quintile, restricting to CHE cases only. Standard errors were clustered by the primary sampling unit.

More details on all aspects of the modeling process are available in the appendix. Analyses were conducted with R (version R 3.4.0) and STATA (version 14.0).

Results

The characteristics of the respondents in the SAGE surveys varied from country to country (Table 3.1). Mean age ranged from 41 to 48 years, and the share of individuals living in rural areas ranged from 24% (Mexico) to 74% (India). The average number of outpatient visits per year was lowest in Ghana (2.8) and highest in South Africa (4.0). In India, almost 40% of survey respondents were considered poor, whereas less than 1% were considered poor in Russia.

Table 3.1: Descriptive statistics from the Study on Global Aging and Adult Health (SAGE) surveys.

Country	Number of individuals surveyed	Mean age (years)	Share female (%)	Share rural (%)	Average number of outpatient visits (per year)	Average number of inpatient visits (per year)	Share of households considered poor (%)
China	15,009	48	53.4	51.0	3.8	0.9	2.1
India	12,196	41	61.4	74.3	3.5	0.8	39.8
Mexico	2,741	43	61.7	23.5	5.2	0.8	1.0
Russia	4,355	47	64.4	25.0	2.9	0.9	0.2
South Africa	4,223	42	57.4	33.4	4.0	1.5	7.6
Ghana	5,565	45	49.4	59.1	2.8	1.0	29.7
Pooled	44,089	45	50.0	56.4	3.6	1.0	16.0

Notes: SAGE survey weights applied in computation of all metrics. Poverty status based on a modified version of the multidimensional poverty index from Alkire & Santos (2011).

The distribution of CHE cases by disease area is presented as a share of all individuals surveyed (Figure 3.1a) and scaled to 100% of all CHE cases (Figure 3.1b). NCD-induced CHE was at least 20% of all CHE adult cases in all countries and at least 50% of disease-specific CHE in Mexico, Russia, and South Africa. China had the largest share of individuals affected by NCDs (2.6%, 95% UI: 2.3-2.9%). NCDs were the biggest proportion of CHE cases in Russia (62.5%, 44.9-83.0%). Communicable disease CHE was largest in India as a share of individuals (3.1%, 2.7-3.5%) and, as a share of all CHE cases, was largest in Ghana (45.0%, 32.2-57.1%) and India (44.7%, 40.7-48.5%). The two countries with the highest CHE prevalence – India and China – also had the largest share of CHE cases that could not be attributed to a cause category (unallocable).

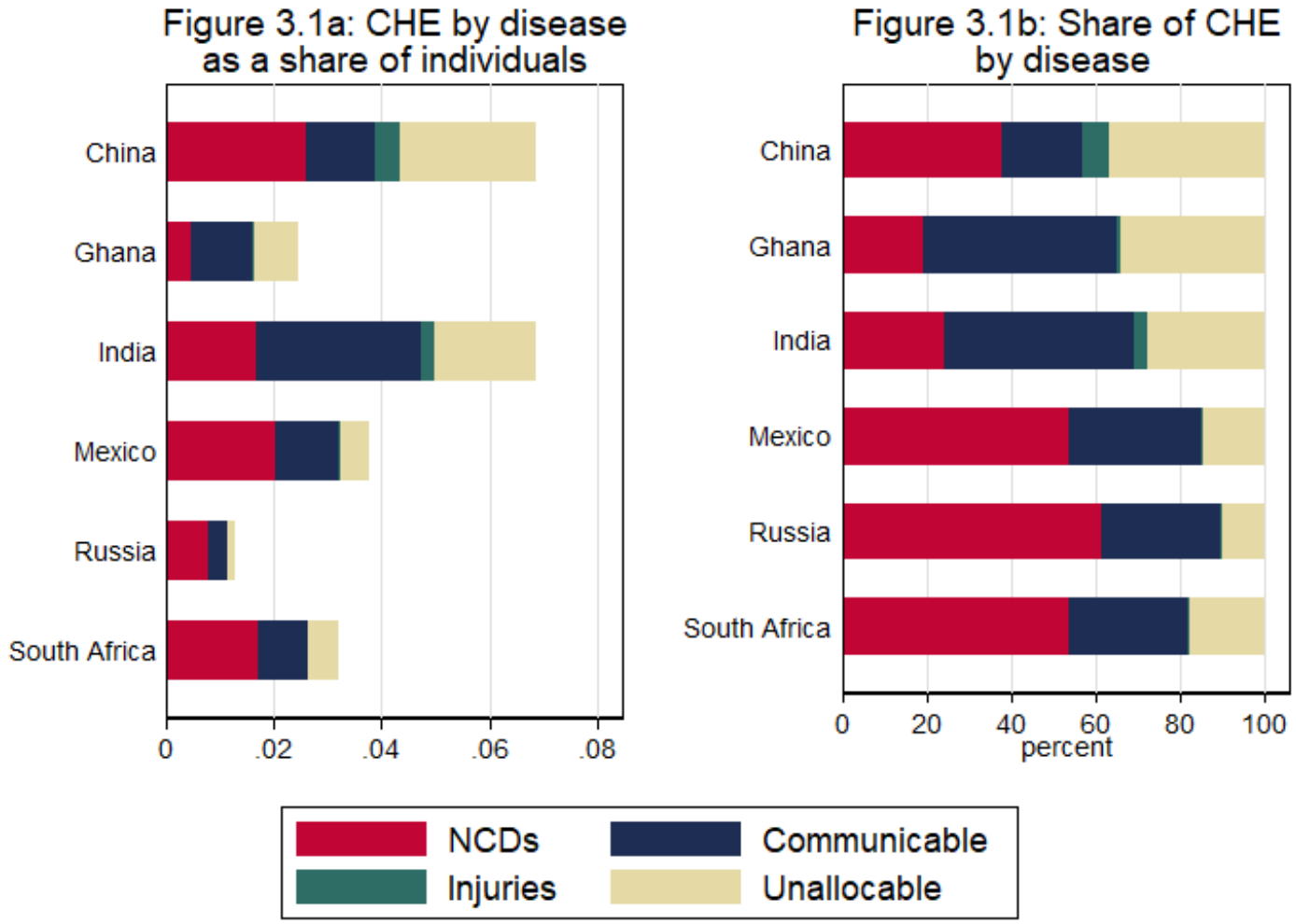

Figure 3.1: Distribution of catastrophic health expenditure (CHE) by disease area in China, Ghana, India, Mexico, Russia, and South Africa.

Table 3.2 represents the characteristics of individuals incurring CHE by disease area. Relative to adults impacted by communicable CHE, NCD CHE cases tended to be older, used more outpatient care and were less likely to live in a rural area. Communicable CHE cases had the highest poverty rate. These differences were robust to controlling for sociodemographic and health system characteristics: compared to CHE cases, NCD CHE cases had more outpatient visits ($p = 0.005$), but not more inpatient visits ($p = 0.215$) nor more inpatient spending as a share of health spending ($p = 0.282$) (Tables A3.20 and A3.21 in the appendix).

Table 3.2: Characteristics of adults incurring catastrophic health expenditure (CHE) by disease area in China, Ghana, India, Mexico, Russia, and South Africa.

Characteristics	NCD CHE cases (N = 1539)	Communicable CHE cases (N = 684)	Injury CHE cases (N = 99)
Mean age (years)	58 (56 to 59)	46 (44 to 47)	45 (41 to 49)
Mean number of inpatient visits in past 12 months	0.86 (0.56 to 1.11)	0.44 (0.36 to 0.51)	0.82 (0.70 to 0.93)
Mean number of outpatient visits in past 12 months	8.8 (8.1 to 9.6)	5.7 (5.2 to 6.2)	2.3 (1.6 to 3.4)
Share of individuals considered poor according to poverty index	19% (16 to 22)	38% (34 to 43)	19% (9 to 29)
Mean inpatient spending share of total out-of-pocket spending	37% (32 to 41)	26% (22 to 31)	73% (61 to 84)
Share of individuals living in a rural area	65% (61 to 70)	83% (76 to 89)	81% (65 to 94)

Notes: poverty index based on the multidimensional poverty index as defined by Alkire & Santos (2011) (Table A3.8 in the appendix). Differences for noncommunicable (NCD) and communicable disease care were robust to controlling for country, age, sex, education, wealth quintile and residence, and the total number of inpatient and outpatient visits in the last 12 months using ordinary least squares regression.

The average number of visits occurring to push health spending over the 40% capacity-to-pay threshold (the CHE threshold) was distinct across cause categories (Table 3.3). Controlling

for socioeconomic and health system characteristics, NCD CHE cases were associated with 1.01 (0.41-1.60, p = 0.001) more visits-to-CHE than communicable CHE cases. Compared to communicable CHE cases, NCD CHE cases were 10.9 percentage points (2.1-19.7, p = 0.016) less likely to be pushed over the CHE threshold with just one visit and 13.1 (5.7-20.5, p = 0.001) percentage points more likely to be caused by five or more visits.

Table 3.3: Number of visits to catastrophic health expenditure (CHE).

	Number of visits to CHE	**One visit to CHE** (OLS)	**One visit to CHE** (Logit)	**Five or more visits to CHE** (OLS)	**Five or more visits to CHE** (Logit)
Communicable CHE case (Reference)	-	-	-	-	-
NCD CHE case	1.007***	-0.109*	-0.481*	0.131***	0.763***
	(0.414 to 1.599)	(-0.197 to -0.021)	(-0.865 to -0.0968)	(0.057 to 0.205)	(.0336 to 1.189)
Injury CHE case	-1.087**	0.244***	1.497***	-0.0963	-1.017
	(-1.838 to -0.335)	(0.112 to 0.376)	(0.681 to 2.312)	(-0.199 to 0.007)	(-2.118 to 0.083)
Other CHE case	0.246	-0.0265	-0.124	0.0263	0.165
	(-0.363 to 0.856)	(-0.116 to 0.063)	(-0.511 to 0.262)	(-0.046 to 0.099)	(-.0280 to 0.611)
Constant	0.336	0.887***	1.715**	0.0137	-2.565***
	(-1.033 to 1.705)	(0.665 to 1.110)	(0.686 to 2.745)	(-0.135 to 0.162)	(-3.543 to -1.588)
N	3226	3226	3225	3226	3225
* p<0.05, ** p<0.01, *** p<.001					

Notes: "One visit to CHE" is an indicator for whether one visit pushed health spending over the CHE threshold. "Five or more visits to CHE" is an indicator for whether five or more visits pushed health spending over the CHE threshold. Other controls included indicators for whether a visit was due to an injury or another cause, country indicators, wealth quintile, educational attainment, age, sex, and an indicator for urban residence. All regressions run with survey weights and robust standard errors clustered by primary sampling unit. Full regression results in Table A3.22 (appendix).

Lastly, we analyzed observed characteristics of each respondent's most recent inpatient and outpatient visit, because the most detailed information was available for this visit. Figure 3.2 presents the regression coefficients and confidence intervals for the indicator representing whether a visit was caused by an NCD, quantifying the difference in the dependent variable (labeled on the x-axis) between NCD visits and communicable visits. Figure 3.2a shows that outpatient and inpatient OOP spending per visit were 1.8 (1.6-2.1) and 1.8 (1.3-2.6) times higher, respectively, for NCDs than for communicable diseases. NCD drug OOP spending was 1.5 (1.3-1.7) and 1.8 (1.3-2.7) times higher for outpatient and inpatient visits, respectively. Compared to communicable disease outpatient visits, the share of OOP outpatient expenditure spent on drugs was lower for NCDs (9.6%, 6.8-12.3%). The probability of using care in a private facility was not statistically different for NCD and communicable disease outpatient visits ($p = 0.744$) and inpatient stays ($p = 0.994$) (see Tables A3.11-A3.18 in the appendix for further detail).

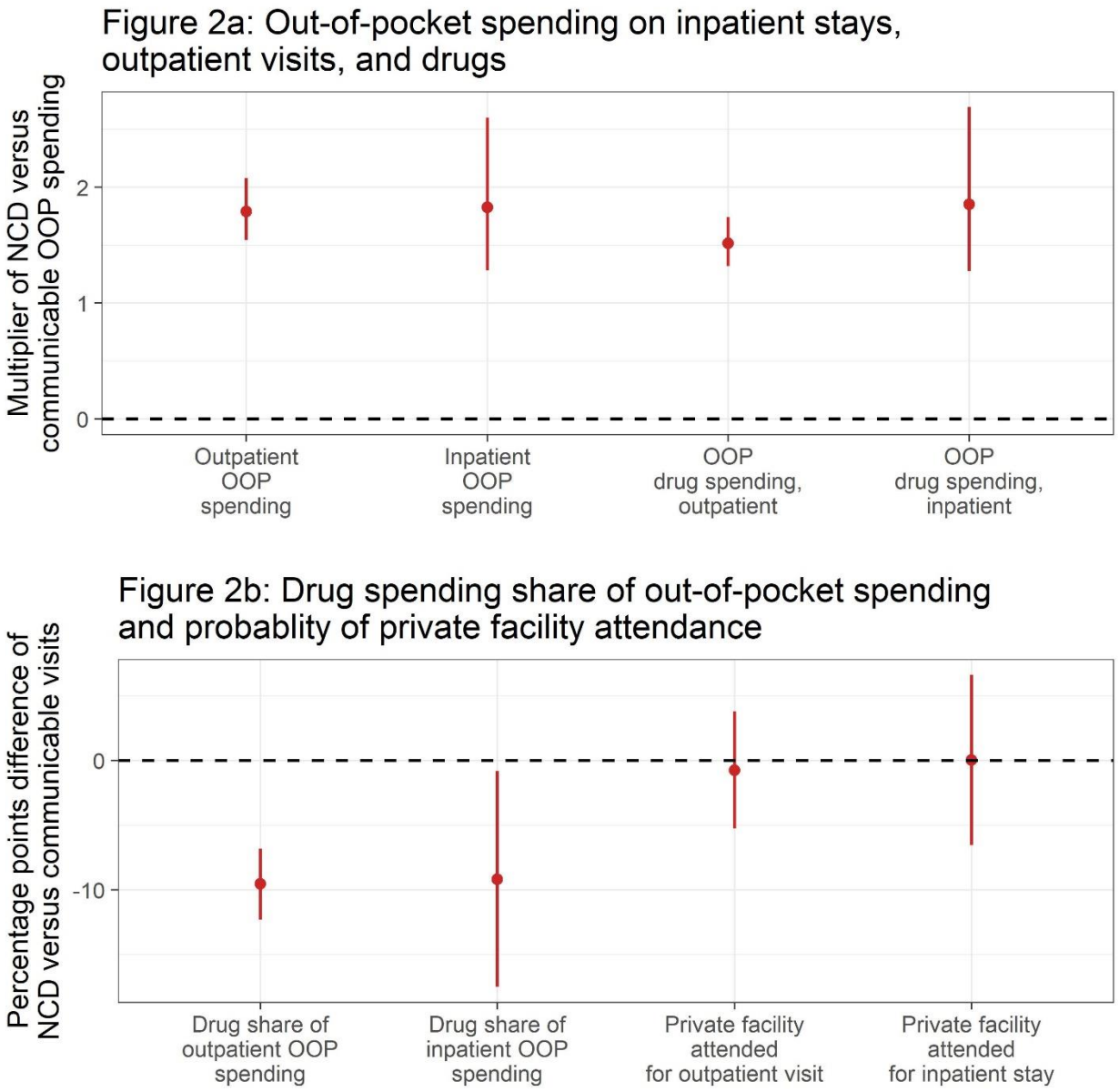

Figure 3.2: Testing NCD versus communicable differences in spending and utilization in China, Ghana, India, Mexico, Russia, and South Africa.

Notes: Points capture coefficient estimates and bars capture coefficient uncertainty intervals from an ordinary least squares regression of the dependent variable (labeled on the x-axis) on an indicator for whether the respondent's most recent visit was due to noncommunicable disease (NCD). Visits caused by communicable diseases are the reference category. Other controls in the regression included indicators for whether a visit was due to an injury or another cause (respectively), country indicators, wealth quintile, educational attainment, age, sex, and an indicator for urban residence. All regressions run with survey weights and robust standard errors clustered by primary sampling unit. OOP: out-of-pocket. Full regression results in the appendix Tables A3.11-A3.18.

Discussion

This study quantified the distribution of CHE prevalence by disease area in six developing countries, with a specific emphasis on comparing NCD and communicable disease CHE. Among adults, NCDs were a major threat to financial risk protection. In Mexico, Russia, and South Africa, NCD CHE comprised more than 50% of all CHE cases and affected nearly 2% of all individuals. However, the impact of NCD CHE was not evenly distributed: NCD CHE cases were more likely to occur among older, wealthier individuals in urban areas. Expenditure on inpatient stays, outpatient care, and drugs were nearly twice as high for NCDs than for communicable diseases. NCD-induced CHE cases were more likely to be the result of five or more health care encounters; communicable CHE cases were more likely to arise because of a large, one-visit spending shock.

Although we would not expect them to be aligned perfectly for many reasons, disease burden and disease-specific CHE were more aligned in some countries than others and the amount of alignment can be contextualized by features of the health systems studied. In Mexico and Russia, the distribution of CHE by disease was similar to the distribution of disease burden: NCDs constituted the largest share of disability-adjusted life years (DALYs) in these two countries (IHME 2016). The alignment between disease burden and CHE in Mexico in particular may be related to the *Seguro Popular* insurance program aimed at making financial risk protection more equitable (Frenk et al. 2009).

In South Africa, in contrast, NCDs make up less than 30% of DALYs – communicable diseases and conditions are a much larger driver of mortality and morbidity (UNAIDS 2015).

This divergence between burden of disease and CHE may be related to the segmentation of the South African health system: wealthier South Africans, who are more impacted by NCDs, typically turn to private health services where OOP payments can be substantially higher (Ele-Ojoe et al. 2010).

The share of NCD CHE in China is also salient. NCDs comprised 80% of DALYs in China in 2008 (IHME 2016), substantially more than the NCD share of CHE (37.7%, 95% UI: 34.2-41.5%), although a substantial share could not be allocated to a disease area. Even with recent health reforms to improve financial risk protection, NCDs have not been highly prioritized by the government, translating into limited access to NCD prevention and treatment services for many low-income populations (Tang et al. 2013). Treatment for communicable causes is, in contrast, more widely available, providing populations with more opportunities to incur CHE for those conditions.

In Ghana and India, communicable diseases caused the most CHE cases, more than 45%. Communicable DALYs comprised more than 45% all DALYs in 2008 in both countries (IHME 2016). In India, catastrophic and impoverishing expenditures are known to be high, particularly for low-income populations (Berman et al. 2010). In Ghana, the National Health Insurance Scheme theoretically covers the bulk of the costs of both cause categories, but the program has not been as pro-poor as originally intended (Kotoh & Van der Geest 2016).

Analyzing patterns of utilization and spending highlighted distinctions in the impact on household welfare and the potential for adopting different policies for tackling CHE by health focus area. Communicable CHE cases were more prevalent among the poor and were more likely

to be caused by a single, very expensive visit. Large spending shocks driven by unexpected health events are difficult to plan for, potentially making it more difficult for households to smooth consumption. Substantial dispersion in OOP spending in particular may decrease household (reference-dependent) welfare (Flores & O'Donnell 2016). Financial risk protection policies could directly target large spending events for communicable causes, for example by creating catastrophic health funds such as those in place in Mexico (Lozano & Garrido 2015) or subsidizing health insurance that kicks in when OOP costs surpass a relatively high threshold, like in the high deductible health plans increasingly prevalent in the US.

In contrast, NCD CHE was more likely to be caused by the culmination of spending over many visits and was associated with more outpatient visits, a reflection of NCDs as chronic conditions. If the frequency of care means that OOP spending is more predictable, households may be better able to form expectations and plan for health care costs, which could be beneficial for household welfare and consumption expenditure. NCD care was also associated with higher unit costs, including for drugs, however, and, in other studies, chronic care has been associated with higher dispersion (Flores & O'Donnell 2016). Thus, reducing higher per visit costs for NCDs, potentially through market shaping interventions for drugs similar to the approaches used for HIV/AIDS (Waning et al. 2009), malaria (Global Fund 2009), and immunizations (Nguyen et al. 2011), or the subsidization of highly-effective NCD outpatient services by governments and aid agencies, could be targeted strategies to financially protect the growing population afflicted by NCDs.

Our study had a number of limitations related to data and methodology. First, only 18 broad response options were provided in the SAGE questionnaire, limiting our ability to fully allocate CHE cases across all disease areas. Our analysis focused only on disease burden and CHE caused by adult health care, which could lead to underestimation of the share of CHE associated with communicable causes (e.g. childhood vaccine-preventable diseases). The consumption module of the SAGE also did not include home consumption, potentially underestimating capacity to pay and inflating CHE. Second, we assumed respondents correctly recalled the cause of visit and the number of visits in the last year. Evidence from a number of settings indicate that respondents underestimate their health care utilization (Ansah & Powell-Jackson 2013). Respondents are unlikely to remember accurately all visits in the last year, which would deflate our estimates of utilization and thus CHE, but they are also more likely to remember catastrophic health and health spending events, which would inflate our estimates of OOP and thus CHE (Das et al. 2011). Third, measuring spending at the individual level was required to connect spending to a disease area and utilization, which may result in lower CHE than if assessed by household unit. Fourth, we were unable to allocate 20% of CHE cases in the three poorest countries in our sample: China, India and Ghana. Lack of investment in proper diagnosis, poor communication with patients or lack of education about disease areas could explain why patients were unable to identify the visit cause. Finally, we imputed both the cause of visit and OOP. The cause of visit models performed very well out of sample (appendix Table A3.2) but relied on extending relationships among the three most recent visits to other prior visits. Modeling OOP spending

captured the mean visit spending while smoothing over stochastic noise; and OOP spending may be overestimated for some visits and underestimated for others.

Given the significant and rising share of disease burden represented by NCDs, decision-makers must think critically about the right strategies to reduce CHE and improve financial risk protection in the pursuit of UHC. Communicable CHE will also continue to occur, and tradeoffs among different diseases areas and health interventions may be needed to optimize financial risk protection policies. Further investigation of the burden of CHE by disease is therefore critical to enacting the appropriate reforms and publicly financed health benefits packages on the path to UHC.

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Appendix

Determining poverty status

We used a modified version of the multidimensional poverty index (MPI) to compute our poverty index (PI), which was used to determine whether a household was poor (Alkire & Santos 2011). Because our study focused on health, we omitted the health components of the MPI – nutrition and mortality. Because the SAGE surveys did not capture whether household members below the age of 10 were attending school, we were also unable to assess school attendance, and thus relied only on the years of schooling reported for adults as the education component of the index. A household was considered poor if it was deprived in four or more of the indicators. Table A3.1 reports the definitions of the indicators used to assess deprivation.

Table A3.1: Indicators used in the poverty index (PI).

Indicators	Definition
Education	
Years of schooling	No household member aged ≥ 10 years has completed ≥ 5 years of schooling.
Living standards	
Cooking fuel	The household cooks with dung, wood or charcoal.
Improved sanitation	The household does not have a flush toilet or latrine, or does not have or must share one of the following with other households: a ventilated improved pit or composting toilet.
Safe drinking water	The household does not have piped water, a public tap, a borehole or pump, a protected well or spring or rainwater within a 30 minute roundtrip walk.
Electricity	The household has no electricity.
Floor	The household has a dirt, sand or dung floor.
Assets	The household does not own more than one of: radio, TV, telephone, bike, motorbike or refrigerator and does not own a car or truck.

Source: Alkire & Santos 2011.

Estimating cause-of-visit by disease area

Estimating cause of visit by disease first required grouping each of the 18 response options provided in the World Health Organization (WHO) Study on Global Aging and Adult Health (SAGE) into broad Global Burden of Disease (GBD) categories. The exact response options provided and the GBD cause category each was tagged to are listed in Table A3.2. The categories listed in Table A3.2 are used to model utilization and out-of-pocket (OOP) expenditure. In the final estimates, all those categories with "(Unallocable)" (i.e. no disease area could be assigned) are presented as belonging to that category.

Table A3.2: Cause categories and response options.

Cause category	Response options
Noncommunicable diseases	• diabetes or related complications • heart problems • high blood pressure/hypertension • stroke/sudden paralysis • depression or anxiety • cancer • problems with mouth, teeth or swallowing • chronic pain in joints/arthritis
Communicable, maternal, neonatal and nutritional diseases	• communicable disease (HIV, infections, malaria, tuberculosis) • maternal and perinatal conditions (pregnancy) • nutritional deficiencies • acute conditions (diarrhea, fever, flu, headaches, cough, other)
Injuries	• injury (not occupation-related)
Pain (Unallocable)	• generalized pain (stomach, muscle or other nonspecific pain)
Surgery (Unallocable)	• surgery
Other (Unallocable)	• occupation/work related condition/injury • sleep problems • problems with breathing
Unidentified (Unallocable)	• other, specify • don't know

Random Forests approach: prediction problem

The SAGE surveys captured the cause of visit for the most recent visit, the second most recent and the third most recent. However, individuals were also asked about the number of outpatient visits and the number of inpatient visits in the last 12 months. The purpose of the cause-of-visit models was to predict the cause of visits beyond the third most recent visit (i.e. fourth most recent visit and beyond).

A visual example is presented in Figure A3.1. In this example, a respondent reports having 5 outpatient visits in the past year. The individual indicates that visit 1 was for an NCD, visit 2 was for pain and visit 3 was for an NCD. We have no information about the cause of visit for visits 4 and 5.

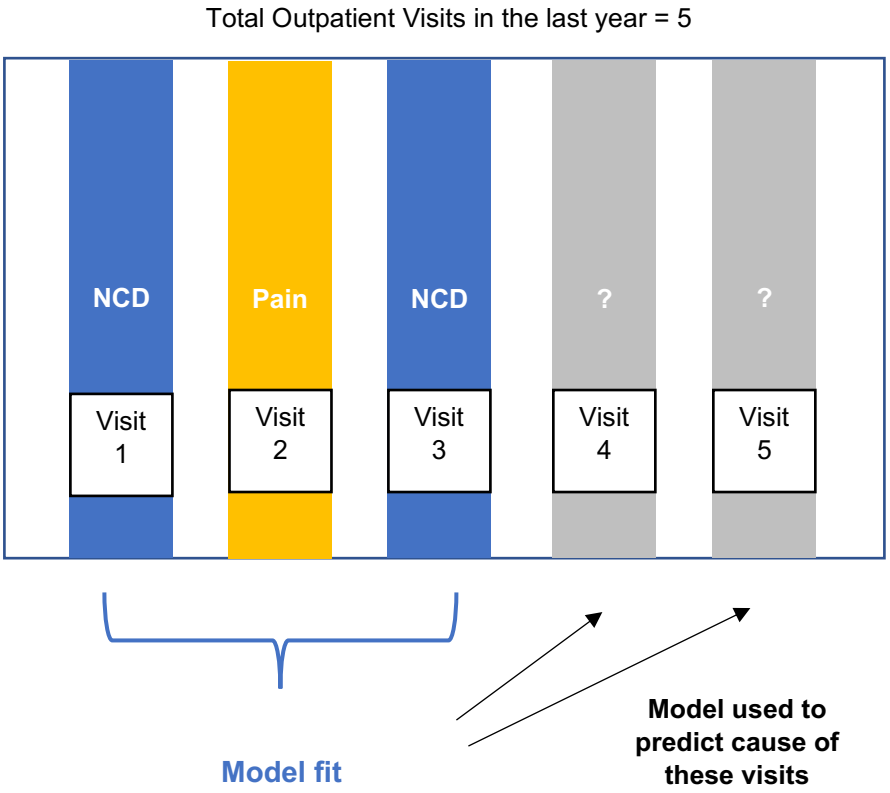


Figure A3.1: Visual representation of data and modeling exercise for assigning the cause of visit for visits beyond the third most recent visit.

The cause-of-visit models took advantage of the within-person relationships among the cause of visits 1, 2, and 3. This relationship was harnessed to predict cause of visit for visits 4 and 5, in the example presented, and for the fourth most recent visit and other visits further back in time for all other SAGE respondents.

Modeling utilization: random forests model[*]

Our main approach to the prediction problem was to deploy random forest models. Random forests combine decision trees and bootstrap to classify each observation into one of the disease categories presented in Table A3.1. Random forests were our preferred method for two reasons: a) they are well adapted to classification problems with more than two categories; and b) measured with out-of-sample prediction, they are one of the best-performing machine learning techniques (Caruana & Niculescu-Mizil 2006).

Decision trees classify observations into different categories by splitting observations at a series of nodes, often presented in the form of a decision tree, similar to Figure A3.2. At each node, observations are separated into two categories based on the sorting that minimizes the share of observations misclassified by the split. The classification error rate is used to determine the best split at each node. The classification error rate is the share of observations in a given grouping that do not belong to the most common class.

[*] Description of random forests was based predominately on: James G, Witten D, Hastie T and Tibshirani T. 2015. *An Introduction to Statistical Learning: with Applications in R.* Springer: New York, NY.

Starting with all observations, the model produces successive divisions, separating observations into a series of splits. At each split, a prediction for each observation is produced, assigning each the most commonly occurring class in the branch. The number of splits or branches depends on the number of observations in the final node and in our case was set to a minimum of five.

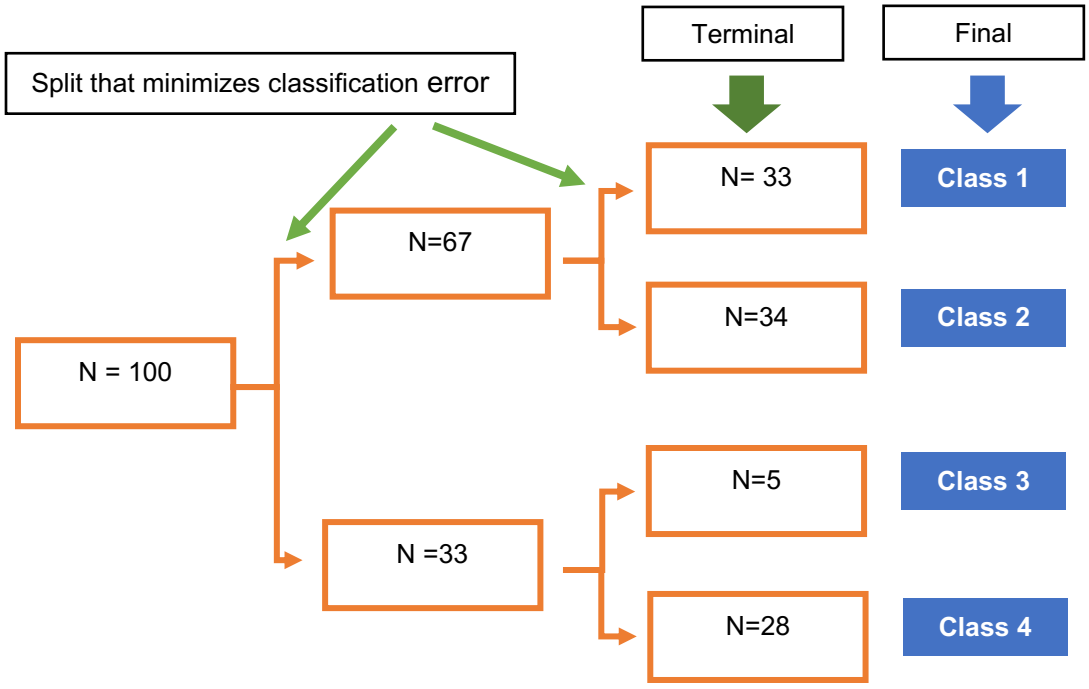
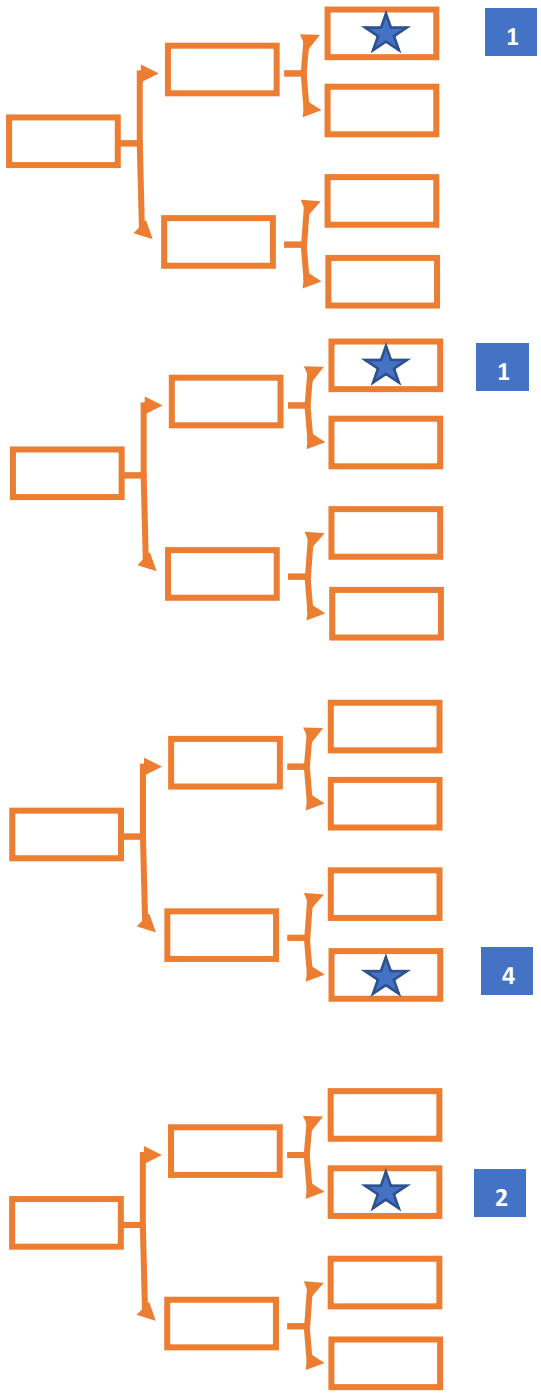


Figure A3.2: Visual representation of a decision tree implemented in random forests models.

Random forests were developed in part in response to the recognition that a single decision tree tends to overfit, producing poor out-of-sample predictions. Random forests minimize this error in two ways. First, at each node, only a random sample of covariates is used. Using a sub-sample of covariates ensures that highly predictive variables do not overpower classification, which can lead to overfitting and classification error.



Observation ★ classified as 1 because it is the most common classification across decision trees.

Second, random forest methods combine many decisions trees – in our case 500 – to make the final classification of each observation. In each terminal node, observations are classified based on the most common category in their final grouping. Across the more than 500 trees we estimated, the most common classification was used as the final prediction.

Figure A3.3: Visual representation of random forests.

Assessing performance

We assessed performance of the random forests model with out-of-sample prediction. To test performance in a way that simulates our prediction problem, we trained the model on visits 1-2 and tested how well the model predicted visit 3. We tested the predictive power of the models by generating predictions of the out-of-sample cause of visit and calculating how often that classification aligned with the true cause category.

An extensive range of covariates – more than 50 – were tested in the different models. Streamlining the number of covariates improved our classification error and thus not all covariates were ultimately deployed. We decided on our final set of covariates based on which ones had the highest variable importance and produced the lowest classification error for visit 3 predictions. Variable importance represents the mean decrease in the share of variables misclassified – i.e. classified to a category other than the observed category – in each node. We eliminated the variables with the lowest variable importance until classification error was minimized.

In both the inpatient and outpatient random forests models, selected covariates included: wealth quintile, age, sex, country, educational attainment, annual household expenditure, and the health area that caused each respondent's most recent prior visit (lag cause of visit). Because they improved out-of-sample prediction, additional covariates were included in the outpatient model including: visit number (i.e. third most recent visit, fourth most recent visit, etc.), body mass index (BMI), and whether the respondent lived in a rural or urban area.

The random forests models performed well as measured by out-of-sample prediction, correctly classifying between 76.0% of outpatient visits and 81.9% of inpatient visits (Table A3.3).

Out-of-sample prediction was highest for communicable causes and NCDs. The chronicity of care-seeking is likely an important driver of the high predictive validity for NCDs. The more erratic nature of contracting infectious diseases, one aspect of the communicable cause category, likely leads to reduced precision in this area. The random nature of injuries also likely drives the poor precision for that cause.

Table A3.3: Precision of cause-of-visit random forests models.

	Outpatient	**Inpatient**
Communicable	70.3%	69.6%
Injury	63.5%	66.7%
NCD	85.0%	82.4%
Other	72.5%	88.8%
Unidentified	67.6%	85.1%
Pain	65.9%	75.0%
Surgery	69.1%	100.0%
Overall	76.0%	81.9%

Notes: Precision is calculated as the number of true-positive classifications divided by the total number of positive classifications (true positives plus false positives). The model was run on visits 1 and 2 only and predictions produced for the third most recent visit. Precision based on the predictions for visit 3 and is averaged across all trees.

Figures A3.4 and A3.5 capture the "variable importance" of the covariates included in the two random forests models, which is represented by the Gini index of node impurity. The higher the mean decrease, the higher the predictive power of the variable. The figures underscore how, for both types of health care service, the cause of the most recent visit (*"Lag cause of visit"*) is the most predictive – more than twice any other variable. Note that the values are larger for the outpatient model than the inpatient model, which is related to the larger outpatient sample size and nodes created in the random forests model for outpatient visits.

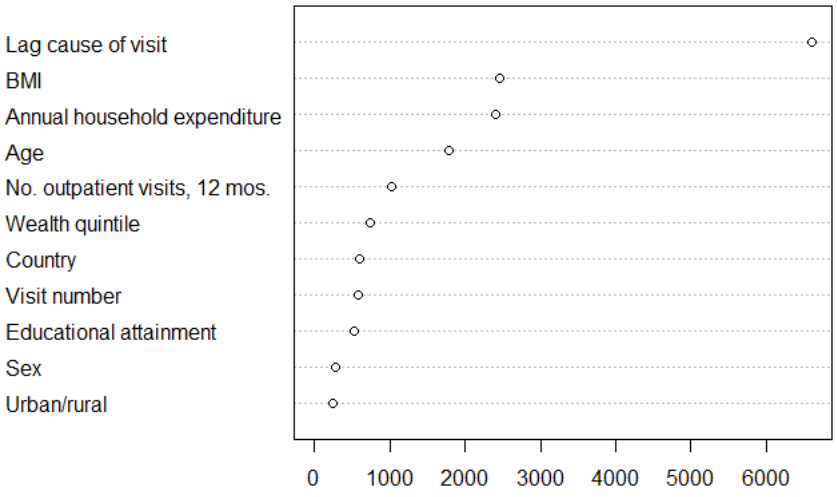


Figure A3.4: Variable importance of covariates in the random forest outpatient model.

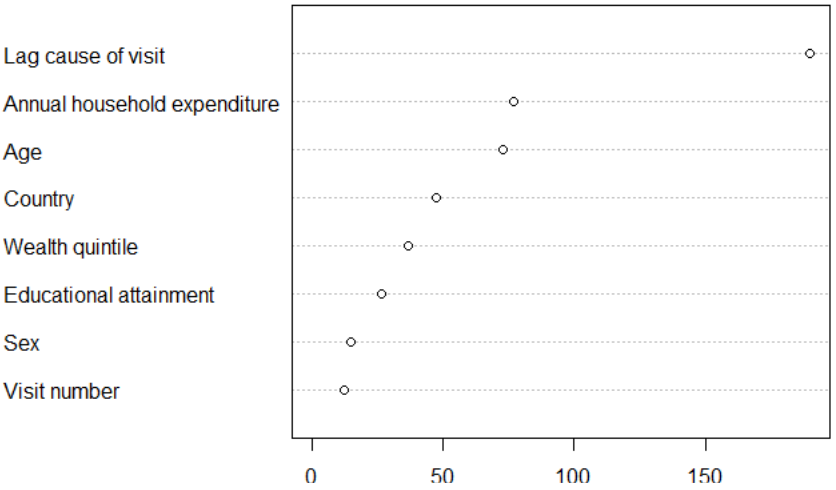


Figure A3.5: Variable importance of covariates in the random forest inpatient model.

We generated the final predictions recursively. We first predicted visit 4 using the lag cause of visit 3. For visit 5, we used the lag cause of visit 4, and so on, until all visits reported by the respondents were tagged by cause.

Estimating per visit out-of-pocket expenditure by disease area

Many respondents who used health services reported paying nothing. This high number of "zero spending" resulted in a zero-inflated lognormal distribution, which was difficult to model with available one-part models. We used a two-part regression model, an approach commonly used for fitting distributions of health expenditure (Wang et al. 2015; Deb et al. 2006). This two-part approach allowed us to model *whether* a health service user paid or not separately from *how much* health care users paid, given they expended some amount.

The two-part model developed by Belotti et al. (2012) was designed particularly for producing predictions with two-stage models, and we used the associated TPM package in STATA for estimating OOP expenditure for each cause, visit and individual.

The dependent variable is OOP spending on the most recent visit. This was converted to purchasing-power-parity adjusted 2016 international dollars. For each reported inpatient or outpatient visit, we summed all sub-categories of reported expenditure to compute total cost per visit. Each respondent also reported the total spending on each visit. When there were discrepancies between these two values, we took the mean of the created and reported totals to generate our dependent variable.

We regress this OOP spending value on dummies for country, wealth quintile, and sex, because health system features as well as wealth and sex affect spending on health care. *Cause of visit 1* is a categorical variable capturing the reason for seeking care at the most recent visit, included in the model with a dummy representing each type of care and allowing us to estimate disease-area-specific OOP spending. *Total visits* represents the sum of all reported outpatient and inpatient visits in the last 12 months and is used as a proxy for severity of disease – assuming that respondents who used a lot of care tend to be sicker and thus have distinct per visit costs. Finally, we include a dummy for whether a respondent resided in an urban area, as the costs associated with care were likely to vary according to the availability and specialization of health providers and the distances traveled to access services. All variables were interacted to test the predictive power of additional dimensions of covariates. Covariates were selected based on the lowest RMSE calculated with 10-fold cross validation. Newton-Raphson iterations were limited to 200. Models that did not converge within 200 iterations were excluded.

Table A3.4: Top five outpatient models and their average root-mean squared error.

Regression Number	Interactions	Average RMSE
10	Wealth X Disease area, Country X Urban	163.1
28	Wealth X Disease area, Country X Visits	163.2
13	Wealth X Disease area	163.3
7	Wealth X Disease area, Country X Female	163.3
25	Wealth X Disease area, Urban X Visits	163.3

Table A3.5: Top five inpatient models and their average root-mean squared error.

Regression Number	Interactions	Average RMSE
28	Wealth X Disease area, Country X Visits	3202.5
41	Country X Wealth, Age X Disease area	3205.4
25	Wealth X Disease area, Urban X Visits	3205.6
10	Wealth X Disease area, Country X Urban	3207.3
19	Wealth X Disease area, Age X Urban	3207

Table A3.6 displays the coefficients from the final two-part models selected. These models are run with the household survey weights for each country and are estimated with standard errors clustered by primary sampling unit.

Table A3.6: Coefficients from two-stage OOP spending models.

(1) Outpatient OOP spending		(2) Inpatient OOP spending	
LOGIT		**LOGIT**	
China (Reference)		China (Reference)	
India	-0.300	India	0.276
Mexico	-4.391***	Mexico	-3.504***
Russia	-4.014***	Russia	-3.865***
South Africa	-3.942***	South Africa	-3.586***
Ghana	-3.105***	Ghana	0.939
Urban	-2.180***	NCDs	-2.153*
India X Urban	1.441*	Injury	-4.176*
Mexico X Urban	3.076***	Pain	0.410
Russia X Urban	1.719**	Surgery	-2.250
South Africa X Urban	1.056	Other	-0.756
Ghana X Urban	1.568*	Unidentified	-2.188
NCDs	0.374	WQ2	-2.056
Injury	0.620	WQ3	1.405
Pain	-0.565	WQ4	-0.747
Surgery	3.574***	WQ5	-2.864**
Other	0.509	NCDs X WQ2	2.243
Unidentified	-0.904	NCDs X WQ3	-0.335
WQ2	-0.909	NCDs X WQ4	1.296
WQ3	0.272	NCDs X WQ5	3.158*
WQ4	0.410	Injury X WQ2	7.209**
WQ5	0.285	Injury X WQ3	-1.763
NCDs X WQ2	-0.239	Injury X WQ4	3.190
NCDs X WQ3	-0.279	Injury X WQ5	5.400**
NCDs X WQ4	-1.573	Pain X WQ2	-0.351
NCDs X WQ5	-0.219	Pain X WQ3	-3.291
Injury X WQ2	-1.630	Pain X WQ4	0.352
Injury X WQ3	-2.536	Pain X WQ5	-0.790
Injury X WQ4	-2.204*	Surgery X WQ2	2.674
Injury X WQ5	-1.323	Surgery X WQ3	7.858**
Pain X WQ2	3.202*	Surgery X WQ4	1.705
Pain X WQ3	1.024	Surgery X WQ5	3.008*
Pain X WQ4	2.215	Other X WQ2	1.318
Pain X WQ5	0.599	Other X WQ3	-4.687
Surgery X WQ2	-3.158*	Other X WQ4	0.599
Surgery X WQ3	-2.552	Other X WQ5	1.061
Surgery X WQ4	0.266	Unidentified X WQ2	1.784
Surgery X WQ5	-3.110**	Unidentified X WQ3	-3.905
Other X WQ2	-1.002	Unidentified X WQ4	0.742

Table A3.6: Coefficients from two-stage OOP spending models (Continued).

Other X WQ3	-1.610	Unidentified X WQ5	3.657*
Other X WQ4	0.379	Female	0.856
Other X WQ5	-0.443	Total inpatient & outpatient visits (Visits)	-0.344*
Unidentified X WQ2	2.231**	Urban	-0.398
Unidentified X WQ3	0.133	Age	-0.0151
Unidentified X WQ4	-0.0786	China X Visits	0.340*
Unidentified X WQ5	-1.455	India X Visits	0.586**
Female	-0.577*	Mexico X Visits	0.427*
Total inpatient & outpatient visits (Visits)	0.0278	Russia X Visits	0.423**
Age	-0.0297***	South Africa X Visits	0.141
Constant	7.523***	Constant	6.965***
GLM		**GLM**	
India	-0.300	India	-0.726***
Mexico	-4.391***	Mexico	-0.176
Russia	-4.014***	Russia	-2.379***
South Africa	-3.942***	South Africa	-0.102
Ghana	-3.105***	Ghana	-2.493***
Urban	-2.180***	NCDs	1.176***
India X Urban	1.441*	Injury	2.173***
Mexico X Urban	3.076***	Pain	0.645*
Russia X Urban	1.719**	Surgery	1.197***
South Africa X Urban	1.056	Other	0.347
Ghana X Urban	1.568*	Unidentified	0.905***
NCDs	0.374	WQ2	0.663*
Injury	0.620	WQ3	0.890**
Pain	-0.565	WQ4	0.893**
Surgery	3.574***	WQ5	0.973***
Other	0.509	NCDs X WQ2	0.001
Unidentified	-0.904	NCDs X WQ3	-0.804*
WQ2	-0.909	NCDs X WQ4	-0.474
WQ3	0.272	NCDs X WQ5	-0.019
WQ4	0.410	Injury X WQ2	-0.671
WQ5	0.285	Injury X WQ3	-1.347
NCDs X WQ2	-0.239	Injury X WQ4	-2.021**
NCDs X WQ3	-0.279	Injury X WQ5	-0.740
NCDs X WQ4	-1.573	Pain X WQ2	-0.630
NCDs X WQ5	-0.219	Pain X WQ3	-0.903
Injury X WQ2	-1.630	Pain X WQ4	-1.666**
Injury X WQ3	-2.536	Pain X WQ5	-0.081

Table A3.6: Coefficients from two-stage OOP spending models (Continued).

Injury X WQ4	-2.204*	Surgery X WQ2	-0.578
Injury X WQ5	-1.323	Surgery X WQ3	-0.147
Pain X WQ2	3.202*	Surgery X WQ4	-0.906*
Pain X WQ3	1.024	Surgery X WQ5	-0.399
Pain X WQ4	2.215	Other X WQ2	-1.022
Pain X WQ5	0.599	Other X WQ3	0.519
Surgery X WQ2	-3.158*	Other X WQ4	-1.812**
Surgery X WQ3	-2.552	Other X WQ5	0.224
Surgery X WQ4	0.266	Unidentified X WQ2	-0.453
Surgery X WQ5	-3.110**	Unidentified X WQ3	-0.504
Other X WQ2	-1.002	Unidentified X WQ4	-0.223
Other X WQ3	-1.610	Unidentified X WQ5	-0.685*
Other X WQ4	0.379	Female	-0.158
Other X WQ5	-0.443	Total inpatient & outpatient visits (Visits)	0.073
Unidentified X WQ2	2.231**	Urban	0.167
Unidentified X WQ3	0.133	Age	-0.001
Unidentified X WQ4	-0.079	China X Visits	-0.059
Unidentified X WQ5	-1.455	India X Visits	-0.089
Female	-0.577*	Mexico X Visits	-0.062
Total inpatient & outpatient visits (Visits)	0.028	Russia X Visits	-0.037
Age	-0.030***	South Africa X Visits	-0.023
Constant	7.523***	Constant	6.195***
N	19654	N	3481

Notes: * p<0.05, ** p<0.01.

OOP expenditure aggregation

To produce final annual OOP expenditure by cause for each respondent in the SAGE surveys, we multiply the observed and predicted values for both utilization (from the random forest model) and OOP (from the two-stage model) for each individual i, disease d, and visit v. For visits v=1-3, we use the observed cause of care and for visit v=1, we used the reported OOP

value. For all other visits, we used the predicted cause and predicted OOP estimates from the models described in A3.1 and A3.2.

The spending and cause of visit were then summed across all visits to generate an annual OOP spending estimate, by disease *d*, for each respondent *i*, as shown in equation (1). Uncertainty intervals (UIs) were generated using n=1000 draws with a non-parametric bootstrap, resampled at the stratum level to capture the variation introduced by the SAGE complex survey design.

$$Annual\ OOP_{i,d} = \sum_{visit=1}^{V} OOP_{i,d,v} * Cause\ of\ Visit_{i,d,v} \qquad (1)$$

where $OOP_{i,d,1}$ is observed and all other $OOP_{i,d,v}$ values are predicted and *Cause of Visit*$_{i,d,1\text{-}3}$ are observed and all other *Cause of Visit*$_{i,d,v>3}$ are predicted.

Catastrophic health expenditure estimation

Catastrophic health expenditure (CHE) is defined as OOP health spending that surpasses 40% of capacity to pay, as shown in (2). Capacity to pay is defined as household spending minus the mean of the 45th to the 55th percentile of food expenditure in the population, adjusted for household size:

$$CHE = 1\ if\ \frac{health\ spend}{capacity\ to\ pay} > 0.40 \qquad (2)$$

$$capacity\ to\ pay = household\ spend\ - mean(45\ to\ 55th\ perc.\ adjusted\ food\ spend) * hh\ size^{1/2}$$

We use the adjustment for household size deployed in Xu et al. (2007), which uses decreasing returns to scale exponent of 1/2 as in equation (3) (Wagstaff et al. 2017). Food expenditure is first normalized with this adjustment:

$$adjusted\ food\ spend = \frac{food\ spend}{hh\ size^{1/2}} \quad (3)$$

Tagging catastrophic health expenditure by disease area

We tagged each CHE case to a disease area, or alternatively to the "unallocable" category, based on the disease composition of OOP spending. More than 70% of people used care for the same broad disease area for all visits and thus all OOP spending was associated with that one disease area. This includes people who designated the cause of visit as "pain" or "other" for all visits and thus where CHE cases were tagged as "unallocable".

The existence of these categories is due to the response options provided by the SAGE. If "pain" or "surgery" had not been a response option, it is possible that respondents would have selected a category more informative to a disease grouping. Furthermore, some response options were not designed to elicit a clear disease category. The response option "problems with breathing", for instance, could be associated with a communicable disease (e.g. tuberculosis) or an NCD (e.g. chronic obstructive pulmonary disease). For this reason, some options could simply not be associated with any broad disease category and were allocated to "unallocable".

For CHE cases that had a mix of OOP spending, we designated CHE by disease based on OOP spending associated with NCDs, injuries and communicable diseases. CHE grouping was

based on whether 75% of this disease-specific spending was associated with one of these three categories. Across all CHE cases, 12.6% were tagged in this way. (Relaxing the threshold to 50% would reallocate 14.5% and increasing the threshold to 99% would reallocate 11.3%.) CHE cases with less than 75% of all OOP spending going to one disease category were grouped into the unallocable category. CHE cases with only OOP spending on pain, surgery, other or unidentified were designated as unallocable.

Table A3.7: Catastrophic health expenditure by disease area as a share of all surveyed individuals.

	NCDs	Communicable diseases	Injuries	Unallocable
China	2.6%	1.3%	0.4%	2.5%
	(2.3 -2.9%)	(1.1-1.5%)	(0.3-0.6%)	(2.1-2.9%)
Ghana	0.5%	1.1%	<0.1%	0.8%
	(0.4%-0.6%)	(0.6%-1.5%)	(<0.1%-0.1%)	(0.5%-1.2%)
India	1.7%	3.1%	0.2%	1.9%
	(1.4% - 2.0%)	(2.7%-3.5%)	(0.1%-0.3%)	(1.6%-2.2%)
Mexico	2.0%	1.2%	<0.1%	0.6%
	(0.7% - 3.1%)	(0.2%-2.1%)	(<0.1%-0.1%)	(0.2%-1.0%)
Russia	0.8%	0.4%	<0.1%	0.1%
	(0.5%-1.0%)	(<0.1%-0.8%)	(<0.1%-<0.1%)	(<0.1%-0.2%)
South Africa	1.7%	0.9%	<0.1%	0.6%
	(1.1%-2.3%)	(0.2%-1.6%)	(0.0%-<0.1%)	(0.3%-0.9%)

Note: Uncertainty intervals in parentheses.

Table A3.8: Catastrophic health expenditure (CHE) by disease area as a share of all CHE cases.

	NCDs	Communicable diseases	Injuries	Unallocable
China	37.7%	18.8%	6.5%	36.8%
	(34.2-41.5%)	(16.1-21.5%)	(4.2-8.5%)	(32.9-40.7%)
Ghana	19.5%	45.0%	1.1%	33.9%
	(14.9%-25.7%)	(32.2%-57.1%)	(0.3%-2.2%)	(22.1%-44.3%)
India	24.3%	44.7%	3.4%	27.6%
	(20.8%-28.3%)	(40.7%-48.5%)	(1.8%-4.8%)	(24.1%-30.9%)
Mexico	54.1%	30.2%	0.3%	15.4%
	(30.9%-76.7%)	(7.6%-56.1%)	(<0.1%-2.3%)	(7.1%-27.8%)
Russia	62.5%	26.2%	0.5%	10.7%
	(44.9%-83.0%)	(.6%-44.4%)	(<0.1%-0.2%)	(3.7%-18.6%)
South Africa	53.5%	27.3%	0.3%	17.9%
	(41.3%-69.8%)	(7.6%-41.5%)	(<0.1%-0.6%)	(9.3%-27.4%)

Note: Uncertainty intervals in parentheses.

Calculating catastrophic health expenditure by poverty status

We calculated the share of individuals and the share of CHE attributed to each disease area, broken down by whether a household was poor or not, shown in Tables A3.9 and A3.10.

Table A3.9: Catastrophic health expenditure (CHE) by disease area as a share of all surveyed individuals, by poor and non-poor households according to the poverty index.

	NCDs	Communicable diseases	Injuries	Unallocable
China - Non-poor	2.6%	1.2%	0.4%	2.4%
	(2.2%-2.9%)	(1.0%-1.5%)	(0.3%-0.6%)	(2.1%-2.7%)
China - Poor	4.7%	4.4%	0.8%	6.6%
	(3.4% -5.9%)	(3.3%-5.5%)	(0.2%-1.2%)	(5.1%-8.1%)
Ghana - Non-poor	0.5%	1.0%	<0.1%	0.5%
	(0.4%-0.6%)	(0.4%-1.6%)	(<0.1%-<0.1%)	(0.3%-0.8%)
Ghana – Poor	0.4%	1.3%	<0.1%	1.6%
	(0.3%-0.6%)	(0.4%-2.0%)	(<0.1%-0.1%)	(0.6%-2.2%)
India - Non-poor	1.2%	2.1%	0.1%	1.3%
	(1.0%-1.5%)	(1.7%-2.4%)	(0.1%-0.2%)	(1.0%-1.5%)
India - Poor	2.4%	4.6%	0.4%	2.9%
	(1.8%-2.9%)	(3.9%-5.3%)	(0.1%-0.5%)	(2.3%-3.4%)
Mexico - Non-poor	2.0%	1.2%	<0.1%	0.5%
	(0.9%-3.1%)	(0.2%-2.0%)	(<0.1%-0.1%)	(0.2%-1.0%)
Mexico - Poor	3.9%	1.0%	<0.1%	0.9%
	(0.6%-8.6%)	(<0.1%-2.6%)	(<0.1%-<0.1%)	(<0.1%-3.5%)
South Africa - Non-poor	1.4%	1.0%	<0.1%	0.4%
	(1.0%-2.0%)	(0.2%-1.7%)	(<0.1%-<0.1%)	(0.2%-0.8%)
South Africa - Poor	3.0%	0.3%	<0.1%	2.3%
	(1.6%-4.3%)	(<0.1%-0.6%)	(<0.1%-<0.1%)	(0.3%-3.9%)

Note: Uncertainty intervals in parentheses. Russia excluded because no households were considered poor in Russia according to the poverty index used.

Table A3.10: Catastrophic health expenditure (CHE) by disease area as a share of all CHE cases, by poor and non-poor households according to the poverty index.

	NCDs	Communicable diseases	Injuries	Unallocable
China - Non-poor	38.4%	18.6%	6.6%	36.3%
	(34.6%-42.3%)	(15.6%-21.7%)	(4.3%-8.6%)	(32.5%-40.1%)
China - Poor	28.3%	26.5%	4.7%	39.9%
	(22.0%-35.0%)	(21.0%-32.2%)	(1.4%-7.4%)	(32.9%-47.0%)
Ghana - Non-poor	23.8%	49.2%	1.2%	25.5%
	(16.5%-34.1%)	(28.1%-63.8%)	(0.4%-2.3%)	(13.6%-38.9%)
Ghana – Poor	13.5%	38.2%	1.1%	46.1%
	(8.1%-21.9%)	(15.2%-59.4%)	(<0.1%-3.7%)	(23.4%-66.0%)
India - Non-poor	26.2%	44.0%	3.1%	26.7%
	(21.1%-31.4%)	(38.6%-49.0%)	(1.7%-4.9%)	(22.0%-31.5%)
India - Poor	23.1%	45.3%	3.5%	28.0%
	(18.3%-27.8%)	(39.8%-50.8%)	(1.3%-5.3%)	(23.1%-33.1%)
Mexico - Non-poor	53.9%	30.9%	0.4%	14.7%
	(31.6%-75.5%)	(7.8%-53.7%)	(<0.1%-2.6%)	(6.3%-27.5%)
Mexico - Poor	68.5%	18.4%	<0.1%	13.0%
	(29.5%-100%)	(<0.1%-47.6%)	(<0.1%-<0.1%)	(<0.1%-46.8%)
South Africa - Non-poor	49.7%	33.5%	(0.4%	15.4%
	(36.7%-67.6%)	(10.0%-48.6%)	(<0.1%-0.8%)	(7.4%-24.6%)
South Africa - Poor	55.7%	5.7%	<0.1%	37.3%
	(33.5%-84.5%)	(<0.1%-12.4%)	(<0.1%-<0.1%)	(8.8%-59.0%)

Note: Uncertainty intervals in parentheses. Russia excluded because no households were considered poor in Russia according to the poverty index used

Characterizing utilization and spending patterns

Tables A3.11-A3.18 show the regressions results for the coefficients shown in Figure 3.2. Regressions used SAGE's individual survey weights and clustered by primary sampling unit.

Table A3.11: Log Outpatient Spending (2016 PPP).

	(1) All	(2) China	(3) Ghana	(4) India	(5) Mexico	(6) Russia	(7) South Africa
Communicable (Ref.)							
NCDs	0.583***	0.585***	0.001	0.565***	-0.888*	0.487	0.721
Injury	0.744***	1.120***	0.548*	0.602*	-4.004***	-0.513	0.441
Pain	0.475***	0.635***	-0.141	0.464***	-0.468	-1.781*	2.003***
Surgery	1.138***	1.064***	0.551	1.377***	2.023**	-0.639	0.528
Other	0.998***	1.448***	-0.0665	0.677***	-0.397	0.764	1.429
Unidentified	0.728***	0.935***	0.0275	0.443***	-1.092*	0.909*	1.447*
China (Ref.)							
India	-0.232*						
Mexico	0.178						
Russia	0.020						
South Africa	-0.045						
Ghana	-0.408***						
Urban	0.255**	0.543**	0.526**	-0.010	-0.134	0.827	-0.250
No Schooling (Ref.)							
Primary School	-0.0001	0.104	-0.143	-0.080	0.566	0.104	0.629*
Secondary School	-0.0390	-0.064	0.122	0.0414	0.815	-0.134	2.011***
College	0.061	0.034	0.087	-0.020	0.821	0.023	2.177***
Post-College	-0.552*		-0.857*				
WQ 1 (Ref.)							
WQ 2	0.300***	0.204	0.0871	0.303**	-0.639	1.699**	0.246
WQ 3	0.292***	0.217	0.119	0.312**	1.471**	1.289**	0.447
WQ 4	0.251*	0.0953	0.124	0.412***	0.502	0.985*	-0.432
WQ 5	0.441***	0.226	0.410*	0.641***	0.109	1.077*	-0.957
Female	0.076	0.053	-0.005	0.076	-0.026	0.549	-0.525
Age	0.003	0.004	-0.006	0.0003	0.012	0.003	0.045**
Constant	2.027***	1.934***	2.428***	1.975***	2.730**	0.862	-0.357
N	18241	6144	2421	7942	406	891	437

Notes: * p<0.05, ** p<0.01, *** p<0.001.

Table A3.12: Log Inpatient Spending (2016 PPP).

	(1) All	(2) China	(3) Ghana	(4) India	(5) Mexico	(6) Russia	(7) South Africa
Communicable (Ref.)							
NCDs	0.603***	0.506	0.221	0.735**	-0.0003	0.763	-0.149
Injury	1.005***	1.149**	1.100	0.722*		0.440	0.418
Pain	0.009	0.039	1.037	0.481	0.678	-1.133**	-1.517
Surgery	0.682**	0.563	0.507	0.766*	0.241	1.598***	-2.899***
Other	-0.781	-1.171	1.473	0.370	-1.754	-0.991	-2.059
Unidentified	0.554***	0.625*	0.294	0.414*	-0.985	0.334	-3.143*
China (Ref.)							
India	-1.052***						
Mexico	-0.275						
Russia	-2.501***						
South Africa	-0.959						
Ghana	-2.708***						
Urban	0.345**	0.349	1.259*	0.311	-1.230*	0.131	-0.740
No Schooling (Ref.)							
Primary School	-0.120	-0.113	-0.447	-0.156	1.968	0.424	0.825
Secondary School	-0.071	0.003	1.060	-0.187	-0.140	-0.013	1.426
College	-0.208	-0.079	-0.249	-0.500	2.353	0.214	3.512*
Post-College	1.043		2.257*				
WQ 1 (Ref.)							
WQ 2	0.187	0.033	0.539	0.266	0.568	0.782	2.119
WQ 3	0.227	-0.093	-0.377	0.624**	0.110	-0.102	2.798***
WQ 4	0.306	-0.038	0.0637	0.966***	0.795	0.054	2.840***
WQ 5	0.611***	0.195	-0.145	1.214***	-1.473	0.623	4.050***
Female	-0.255*	-0.286*	0.557	-0.347	-0.854	0.037	0.434
Age	-0.006	-0.001	-0.010	-0.017***	0.019	0.002	0.063
Constant	6.303***	6.330***	3.029***	5.462***	5.648*	3.324***	-1.499
N	3159	1505	303	976	42	269	64

Notes: * p<0.05, ** p<0.01, *** p<0.001.

Table A3.13: Log Outpatient Drug Spending (2016 PPP).

	(1) All	(2) China	(3) Ghana	(4) India	(5) Mexico	(6) Russia	(7) South Africa
Communicable (Ref.)							
NCDs	0.416***	0.449**	0.037	0.386***	-0.194	0.300	0.222
Injury	0.763***	1.123***	0.838**	0.626**	-1.163*	0.220	0.095
Pain	0.381***	0.398*	-0.072	0.398***	0.307	0.012	
Surgery	0.862***	0.700*	0.220	1.137***	0.015	-1.281***	0.299
Other	0.729***	0.925*	-0.061	0.529***	-0.887**	0.873*	-0.281
Unidentified	0.538***	0.730***	0.229	0.363***	0.103	0.863**	-0.754
China (Ref.)							
India	-0.407***						
Mexico	0.522*						
Russia	0.118						
South Africa	0.544**						
Ghana	-0.438***						
Urban	0.258**	0.688**	0.544**	-0.0420	0.348	0.344*	-0.906***
No Schooling (Ref.)							
Primary School	-0.055	0.012	-0.208	-0.096	-0.106	-0.263	0.087
Secondary School	-0.135	-0.267*	0.202	0.033	0.373	-0.399	0.501
College	0.029	-0.071	0.086	-0.0354	0.222	-0.245	0.160
Post-College	0.086		-0.009				
WQ 1 (Ref.)							
WQ 2	0.233***	0.194	0.047	0.213*	-0.256	1.661**	0.188
WQ 3	0.168*	0.149	0.158	0.183*	0.646*	1.134***	-0.578*
WQ 4	0.202*	0.151	0.399	0.254**	-0.373	1.271***	0.339
WQ 5	0.354***	0.333	0.510*	0.387***	-0.00904	0.988**	1.070***
Female	0.0900	0.0317	-0.0656	0.0881	-0.674*	0.424*	0.246
Age	0.00223	0.00190	-0.000135	0.000424	0.0103	0.0134***	-0.00319
Constant	2.116***	2.070***	1.885***	1.891***	2.992***	0.985*	3.458***
N	15101	5116	1608	7374	234	694	75

Notes: * p<0.05, ** p<0.01, *** p<0.001.

Table A3.14: Log Inpatient Drug Spending (2016 PPP).

	(1) All	(2) China	(3) Ghana	(4) India	(5) Mexico	(6) Russia	(7) South Africa
Communicable (Ref.)							
NCDs	0.617**	0.563*	0.454	0.727**	2.896	0.962*	2.303
Injury	0.753*	0.907	-0.458	0.626		0.932	
Pain	0.183	-0.0494	0.818*	0.324	1.909	-0.348	
Surgery	0.644**	0.470	-0.676	0.910**	3.051	1.400**	2.749
Other	-0.403	-0.714	1.572***	0.00366	4.888	0.618	7.483
Unidentified	0.328	0.339	-1.212*	0.335	1.928	0.830*	-1.386
China (Ref.)							
India	-1.126***						
Mexico	-0.835***						
Russia	-2.040***						
South Africa	-1.742***						
Ghana	-2.478***						
Urban	0.418**	0.461*	0.245	0.374	0.908	-0.0737	1.204
No Schooling (Ref.)							
Primary School	-0.173	-0.385	1.170***	-0.0167	0.982	0.582	-1.833
Secondary School	-0.274	-0.282	-0.187	-0.308	1.264	0.333	
College	-0.0921	-0.183	1.040	-0.0484	4.062	0.679	
Post-College	-0.815*		0.740				
WQ 1 (Ref.)							
WQ 2	0.338	0.335	0.545	0.302	1.814	-0.109	
WQ 3	0.298	-0.0647	0.655	0.609*	0.000111	-0.0953	-0.916
WQ 4	0.430*	0.137	0.128	0.780**	0.115	0.181	
WQ 5	0.589***	0.220	-0.328	0.920***	-1.846	0.658	
Female	-0.250	-0.439*	0.105	-0.120	0.701	0.417*	
Age	-0.00674	-0.000788	0.00435	-0.0148***	0.00465	0.0106	
Constant	5.868***	5.967***	2.456***	4.729***	0.803	1.951**	3.825
N	2188	986	136	870	22	166	8

Notes: * p<0.05, ** p<0.01, *** p<0.001.

Table A3.15: Outpatient Drug Spending / Total Visit Spend.

	(1) All	(2) China	(3) Ghana	(4) India	(5) Mexico	(6) Russia	(7) South Africa
Communicable (Ref.)							
NCDs	-0.096***	-0.093***	-0.085	-0.088***	-0.136*	-0.490***	0.145*
Injury	-0.067	-0.178**	-0.084	-0.0165	0.041	-0.250**	0.029
Pain	-0.067***	-0.121**	0.082	-0.0237	0.153	-0.709***	-0.090
Surgery	-0.056*	-0.059	-0.044	-0.066	-0.354**	-0.752**	-0.126
Other	-0.118**	-0.211**	-0.120	-0.073*	0.037	-0.178	-0.107
Unidentified	-0.115***	-0.161***	-0.249***	-0.059**	-0.078	-0.460***	0.030
China (Ref.)							
India	-0.196***						
Mexico	-0.230***						
Russia	-0.230**						
South Africa	-0.729***						
Ghana	-0.259***						
Urban	-0.066***	-0.108***	-0.004	-0.0439*	-0.029	0.003	-0.094
No Schooling (Ref.)							
Primary School	-0.002	-0.008	0.036	-0.011	0.139	0.220	-0.020
Secondary School	-0.013	-0.048**	-0.053	0.004	-0.116	0.298*	0.125
College	-0.030	-0.031	-0.020	-0.018	0.196*	-0.093	0.068
Post-College	-0.537***		-0.559***				
WQ 1 (Ref.)							
WQ 2	-0.039*	-0.016	-0.003	-0.039	-0.086	-0.238	-0.0435
WQ 3	-0.040*	-0.013	0.0004	-0.043*	-0.181**	-0.314	0.0735
WQ 4	-0.0486**	0.033	-0.112	-0.0939***	-0.0167	-0.367*	0.0588
WQ 5	-0.070***	0.010	-0.072	-0.102***	-0.190*	-0.428*	0.104
Female	-0.003	-0.032*	-0.050	0.010	-0.057	0.132	0.102
Age	0.0001	0.0007	-0.0007	-0.0003	0.001	0.002	-0.002
Constant	1.002***	0.973***	0.750***	0.805***	0.673***	1.223***	0.0135
N	17017	5387	2205	7905	245	859	416

Notes: * p<0.05, ** p<0.01, *** p<0.001.

Table A3.16: Inpatient Drug Spending / Total Visit Spend.

	(1) All	(2) China	(3) Ghana	(4) India	(5) Mexico	(6) Russia	(7) South Africa
Communicable (Ref.)							
NCDs	-0.092*	-0.165	-0.154	-0.050	-0.402	-0.266	0.010
Injury	-0.046	-0.133	0.252	0.004		0.274	0.020
Pain	-0.165*	-0.158	0.074	-0.00200	0.0823	-0.511*	-0.007
Surgery	-0.125**	-0.114	0.047	-0.122	-0.385	-0.599***	0.010
Other	0.003	0.021	0.355*	-0.110	0.090	-0.392*	0.101
Unidentified	-0.126**	-0.208	-0.108	-0.067	-0.181	-0.239	0.006
China (Ref.)							
India	-0.067						
Mexico	-0.104						
Russia	-0.141						
South Africa	-0.629***						
Ghana	-0.313***						
Urban	0.028	-0.026	0.166*	0.090*	0.541**	-0.055	-0.003
No Schooling (Ref.)							
Primary School	-0.092*	-0.153**	-0.036	-0.020	-0.176	-0.333*	0.006
Secondary School	-0.024	-0.031	-0.128	-0.063	-0.508	0.039	0.012
College	-0.021	0.038	-0.021	-0.010	-0.434	-0.173	-0.001
Post-College	0.002		0.116				
WQ 1 (Ref.)							
WQ 2	0.003	0.0455	0.040	-0.008	-0.043	-0.0751	-0.004
WQ 3	-0.022	-0.007	0.055	-0.032	-0.294	-0.181	0.094***
WQ 4	-0.029	0.0121	-0.035	-0.050	-0.152	-0.227	0.010
WQ 5	-0.052	-0.026	-0.135	-0.0945	-0.347	-0.224*	0.010
Female	-0.014	-0.004	-0.155*	0.017	0.094	-0.107	0.008
Age	0.001	0.001	-0.002	0.0001	-0.004	0.005	-0.001
Constant	0.674***	0.709***	0.411*	0.584***	0.767	0.944**	0.037
N	2610	1046	261	952	25	265	61

Notes: * p<0.05, ** p<0.01, *** p<0.001.

Table A3.17: Outpatient: probability of utilization a private facility.

	(1) All	(2) China	(3) Ghana	(4) India	(5) Mexico	(6) Russia	(7) South Africa
Communicable (Ref.)							
NCDs	-0.008	-0.095*	-0.063	0.056*	-0.132	0.141	0.026
Injury	-0.046	-0.287**	0.017	0.045	-0.428*	-0.0267	0.094
Pain	0.011	0.003	-0.057	0.005	0.057	-0.012	0.369*
Surgery	-0.044	-0.185**	-0.004	0.202*	-0.047	0.251	-0.321*
Other	-0.047	-0.151*	0.479***	0.071	0.135	-0.026	0.204
Unidentified	-0.094***	-0.15***	-0.026	-0.029	-0.101	0.0008	0.207
China (Ref.)							
India	0.334***						
Mexico	0.066						
Russia	-0.176***						
South Africa	0.0169						
Ghana	-0.116**						
Urban	-0.056	-0.138**	0.036	0.055	0.111	0.075	-0.0002
No Schooling (Ref.)							
Primary School	-0.006	-0.057	-0.043	-0.005	-0.197*	-0.018	0.110
Secondary School	-0.003	-0.068	-0.028	0.041	-0.128	-0.032	0.141
College	0.0007	-0.113*	-0.026	0.079*	-0.193	0.034	0.324**
Post-College	-0.0972		-0.096*			-0.224*	
Graduate	-0.125**					0.025	
WQ 1 (Ref.)							
WQ 2	0.080**	-0.018	-0.061	0.102**	-0.0482	0.093	0.058
WQ 3	0.068*	-0.090	0.035	0.108**	0.139	0.0052	-0.029
WQ 4	0.042	-0.19**	0.075	0.146***	0.230	0.044	0.038
WQ 5	0.012	-0.26***	0.094	0.167***	0.110	0.120	0.203
Female	0.008	-0.006	-0.003	0.057*	-0.130	-0.089	-0.133
Age	-0.002**	-0.004**	-0.0005	-0.001*	0.0004	-0.002	0.003
Constant	0.363***	0.797***	0.183**	0.509***	0.410	0.00454	-0.0354
N	23150	6640	2962	8436	991	2446	1675

Notes: * p<0.05, ** p<0.01, *** p<0.001.

Table A3.18: Inpatient: probability of utilization a private facility.

	(1) All	(2) China	(3) Ghana	(4) India	(5) Mexico	(6) Russia	(7) South Africa
Communicable (Ref.)							
NCDs	0.0003	-0.022	0.198	0.019	-0.002	0.041	-0.524***
Injury	0.032	0.070	-0.177	-0.114	-0.307	0.011	-0.263*
Pain	0.025	-0.013	-0.043	0.071	-0.0491	-0.007	-0.297**
Surgery	0.015	-0.014	-0.196	0.031	-0.342*	0.057	-0.009
Other	-0.058	-0.060	-0.197	-0.137	-0.070	0.021	0.723*
Unidentified	-0.041	-0.047	0.033	-0.056	0.032	0.021	-0.250**
China (Ref.)							
India	0.570***						
Mexico	0.156						
Russia	-0.045*						
South Africa	0.243**						
Ghana	0.231***						
Urban	0.022	-0.005	-0.0147	0.067	0.207	0.0005	0.156*
No Schooling (Ref.)							
Primary School	-0.049	-0.022	-0.261*	-0.103	0.065	-0.003	-0.101
Secondary School	-0.009	0.005	-0.0318	-0.013	-0.446	-0.005	-0.198
College	-0.038	-0.005	-0.0203	-0.109	-0.217	0.004	0.302**
Post-College	-0.356***		-0.417**				
WQ 1 (Ref.)							
WQ 2	0.015	0.014	0.0978	-0.027	0.008	0.05	0.086
WQ 3	0.049	-0.005	0.0420	0.110	0.031	0.004	0.432**
WQ 4	0.022	-0.042	0.190	0.10	0.090	0.002	0.430**
WQ 5	0.097*	-0.004	0.312*	0.270***	-0.122	0.009	0.473***
Female	0.006	-0.005	-0.0986	0.006	-0.013	0.017	0.187*
Age	-0.001	-0.0008	-0.00302	-0.002	0.002	-0.001	0.004
Constant	0.086	0.122	0.405*	0.627***	0.194	0.029	-0.400
N	3989	1571	366	1035	99	706	212

Notes: * p<0.05, ** p<0.01, *** p<0.001.

Table A3.19: Estimated number of visits to catastrophic health expenditure (CHE) by disease area in China, Ghana, India, Mexico, Russia, and South Africa.

Number of visits to CHE (UIs)	NCD CHE Cases	Communicable CHE cases	Injury CHE cases
1	25% (23% - 27%)	29% (27% - 31%)	51% (44% - 59%)
2	6% (5% - 7%)	8% (7% - 9%)	4% (2% - 7%)
3	5% (4% - 5%)	6% (5% - 7%)	4% (<1% - 7%)
4	4% (3% - 5%)	5% (3% -6%)	2% (<1% - 5%)
5	61% (58% - 64%)	53% (50% - 55%)	39% (32% - 46%)

Notes: The number of visits to CHE captures the cumulative number of visits that occurred before CHE took place. Visits were ranked by the most expensive to the least expensive. Out-of-pocket spending was then calculated cumulatively, based on the rank-order of visits, and then compared with capacity-to-pay to assess how many visits occurred before spending was pushed across the 40% capacity to pay CHE threshold. The objective was to assess whether there were differences by disease area in the share of CHE cases that arose because of one, large spending visit (shock) versus the cumulation of spending over many visits. Differences for noncommunicable disease (NCD) and communicable disease care were robust to controlling for country, age, sex, education, wealth quintile and residence using ordinary least squares regression. All results presented with survey weights to depict results to be nationally representative.

Tables A3.20-A3.21 show the regression results for CHE cases that only examined: 1) the outpatient spending share out of total health spending, 2) the number of outpatient visits, and 3) the number of visits that occurred in order to push health spending over the 40% capacity-to-pay threshold, which we called the number of "visits-to-CHE".

Table A3.20: Inpatient expenditure as a share of total health expenditure.

	Inpatient spending as a share of total health spending (OLS)	Inpatient spending as a share of total health spending (Logit)
Communicable CHE case (Ref.)		
NCD CHE case	0.044	0.456*
Injury CHE case	0.364***	1.830***
Other CHE case	0.155***	0.911***
China (Ref.)		
Ghana	-0.346***	-1.529**
India	-0.225***	-0.941***
Mexico	-0.288**	-1.274
Russia	-0.288**	-1.158*
South Africa	-0.335***	-1.936**
Urban residence	0.128*	0.582*
WQ1 (Ref.)		
WQ 2	0.016	0.092
WQ 3	-0.016	-0.005
WQ 4	0.031	0.150
WQ 5	0.114	0.528
No Schooling (Ref.)		
Primary School	-0.049	-0.245
Secondary School	0.057	0.255
College	0.025	0.210
Post-College	-0.026	
Female	-0.092*	-0.416*
Age	-0.00234	-0.008
Constant	0.481***	-0.275
N	3226	3225

Notes: * p<0.05, *** p<0.001.

Table A3.21: Number of outpatient and inpatient visits.

	Log inpatient visits	Log outpatient visits
Communicable CHE case (Ref.)		
NCD CHE case	0.090	0.267**
Injury CHE case	-0.220*	-0.425*
Other CHE case	-0.128*	0.113
China (Ref.)		
Ghana	-0.096	-0.137
India	0.052	0.177
Mexico	0.659**	0.789*
Russia	0.194	0.010
South Africa	0.685	0.278
Urban residence	-0.018	-0.160
WQ1 (Ref.)		
WQ 2	-0.058	0.093
WQ 3	0.145	0.282*
WQ 4	0.005	0.436***
WQ 5	0.096	0.445**
No Schooling (Ref.)		
Primary School	-0.050	0.065
Secondary School	0.128	0.043
College	0.155	0.246
Post-College		0.731***
Female	0.093	0.071
Age	0.0006	0.007*
Constant	0.099	0.859***
N	1196	2746

Notes: * p<0.05, *** p<0.001.

Table A3.22: Number of visits to catastrophic health expenditure (CHE).

	Number of visits to CHE	One visit to CHE (OLS)	One visit to CHE (Logit)	Five or more visits to CHE (OLS)	Five or more visits to CHE (Logit)
Communicable CHE case (Ref.)					
NCD CHE case	1.007***	-0.109*	-0.481*	0.131***	0.763***
Injury CHE case	-1.087**	0.244***	1.497***	-0.0963	-1.017
Other CHE case	0.246	-0.0265	-0.124	0.0263	0.165
China (Ref.)					
Ghana	0.134	-0.321***	-1.408***	-0.0533	-0.654
India	1.489***	-0.233***	-1.014***	0.147***	0.863***
Mexico	3.490	-0.106	-0.457	0.107	0.555
Russia	0.0143	-0.165	-0.716	0.121	0.672
South Africa	1.170*	-0.338***	-1.502***	0.189*	1.022**
Age	0.0162	-0.00188	-0.00852	-0.0000173	-0.000944
Urban residence	-0.614	0.127*	0.572*	-0.0612	-0.364
Female	0.473	-0.110***	-0.495***	0.0492	0.304
No Schooling (Ref.)					
Primary School	0.384	-0.0427	-0.186	0.0381	0.228
Secondary School	0.849	-0.111	-0.462	0.102	0.584
College	1.271	-0.117	-0.516	0.110	0.624
Post-College	-0.695	-0.195		-0.234***	
WQ1 (Ref.)					
WQ 2	0.281	-0.00169	-0.00764	-0.00711	-0.0299
WQ 3	1.158**	-0.140*	-0.625*	0.157***	0.914***
WQ 4	0.944*	-0.0288	-0.137	0.0979	0.631
WQ 5	1.304	-0.0400	-0.202	0.0844	0.575
Constant	0.336	0.887***	1.715**	0.0137	-2.565***
N	3226	3226	3225	3226	3225

Notes: * p<0.05, ** p<0.01, *** p<0.001.

Chapter IV

The impact of the Affordable Care Act on rural-urban disparities in colonoscopies in Maine: an interrupted time series analysis

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Abstract

Introduction: Improving the prevention and early detection of colorectal cancer is a priority for reducing rural-urban disparities in colorectal cancer mortality. One objective of the Patient Protection and Affordable Care Act (ACA) was to reduce geographic health disparities. We assess whether the elimination of out-of-pocket (OOP) costs for screening colonoscopies by the ACA could have reduced rural-urban disparities in screening.

Data & Methods: We used the Maine Health Data Organization All-Payer Claims Database for Maine and included all commercially-insured and Medicare beneficiaries aged 50-75 over 2009-2012 (N=342,797). Beneficiaries were classified as rural/urban based on zip code level Rural-Urban Commuting Areas. ICD-9 and CPT codes were used to identify screening colonoscopies, and OOP payments were the sum of all OOP costs on the day of the colonoscopy. A differenced interrupted time series model was used to estimate the impact of the ACA on trends in rural-urban disparities in colonoscopy rates and OOP costs.

Results: Before the ACA, colonoscopy screening rates as a share of insured enrollees were 16% lower in rural areas than urban areas (5.1% vs. 6.1% of enrollees annually, p<.001) and median OOP costs for colonoscopies were nearly twice as high in rural ($195) than urban areas ($98; p<.001). The ACA reduced median OOP by $94 (p =.001) initially, and $4 monthly (p=.038) in rural areas, and $63 (p <.001) in urban areas. The rural-urban gap in OOP payments dropped by $4 monthly (p=.007). The ACA also significantly reduced rural-urban disparities in colonoscopy rates (disparity decrease of .005 (6%) monthly, p<.001). The rural-urban gap in colonoscopy rates declined 40% relative to the pre-ACA period by the end of 2012.

Discussion: The ACA significantly reduced rural-urban disparities in colonoscopies in Maine, suggesting that OOP costs are an important barrier to accessing colonoscopies for rural residents. Further research is needed to determine whether increased uptake, particularly in rural areas, translated into cancer prevention or better patient outcomes for colorectal cancer.

Introduction

Colorectal cancer (CRC) is the second-leading cause of cancer-related deaths in the United States (US), accounting for 70,000 deaths annually (IHME 2016). CRC incidence is similar in urban and rural areas, but the probability of mortality from the disease is 15% higher for rural residents (Coughlin et al. 2016; Hines et al. 2012). Rural-urban disparities in CRC mortality are likely driven, at least in part, by large disparities in screening rates (Cole et al. 2012; Rabeneck et al. 2010). Screening colonoscopies have been shown to prevent CRC and detect the disease at an earlier stage, when treatment can reduce risk of death (Zauber et al. 2012). However, rural residents are 17% less likely to be up-to-date on CRC screenings than urban residents, a difference that has persisted since 1998 (Cole et al. 2012; Rabeneck et al. 2010).

The lower screening rates are associated with barriers to access that are more substantial in rural areas than urban areas. First, rural residents are more likely to report costs are a barrier to CRC screening (Hughes et al. 2015), have lower income on average (Bishaw & Posey 2016), and are more likely to be underinsured, defined as paying more than 10% of income OOP for patient care (Ziller et al. 2016). Second, rural residents express different attitudes about screening – they are more likely to believe that CRC cannot be prevented as compared to urban residents (Hughes et al. 2015). Finally, compared to urban areas, the density of gastroenterologists and surgeons is lower in rural areas, resulting in restricted access and longer travel times to colonoscopies in rural areas (Aboagye et al. 2014; Hughes et al. 2015).

One objective of the Patient Protection and Affordable Care Act (ACA) was to reduce geographic health disparities (ACA 2010). We assess how the ACA could have reduced rural-

urban disparities in colorectal cancer screening by eliminating out-of-pocket (OOP) patient costs of preventive colonoscopies for privately insured and Medicare enrollees. Eliminating OOP costs could plausibly increase preventive colonoscopy rates because the procedure is expensive, making costs an important potential deterrent. Furthermore, because preventive colonoscopies do not address ongoing health problems or medical emergencies (they are elective), there is reason to believe that the insured population is price-sensitive and would respond to the elimination of costs.

The implications for rural-urban disparities, however, are unclear. Removal of these costs could disproportionately stimulate demand in rural populations if OOP costs were more of a deterrent for rural than urban populations. On the other hand, rural populations could have benefited less from the ACA because the law did not alter other major barriers to colonoscopies that more substantially affect rural areas, including the supply of colonoscopy providers, and attitudes and beliefs about preventing CRC.

Existing evidence on the impact of the ACA's no-cost-sharing provision on CRC screening rates is mixed, with some evidence of increases in CRC screening for enrollees in high deductible health plans and people of low socioeconomic status (Wharam et al. 2016; Richman et al. 2016; Fedewa et al. 2015; Hamman & Kapinos 2015), and modest increases in CRC screenings for the Medicare population but not the privately insured (Mehta et al. 2015; Cooper et al. 2015, 2017). Only one study has examined the impact of the ACA's elimination of cost-sharing in rural areas: Wan et al. (2015) showed that the ACA increased CRC screenings among Medicare enrollees in rural health clinics in California (Wan et al. 2015). However, this analysis had no urban

comparator group, and thus could not shed light on the impact of the ACA on rural-urban disparities.

This study assesses the association between the ACA's elimination of OOP patient costs and changes in rural-urban disparities in colonoscopy rates in the state of Maine, the most rural state in the United States (US Census Bureau). We use the Maine All-Payer Claims Database to identify all preventive colonoscopies for people aged 50-75 enrolled in commercial insurance and Medicare between 2009 and 2012 and apply an interrupted time series model to test whether the ACA was associated with changes in colonoscopy disparities.

Data & Methods

This study uses the Maine Health Data Organization All Payer Claims Database (APCD), which captures all Medicare and commercial payer claims from 2009 to 2012 in the state of Maine. We included members aged 50-75, the recommended age group for CRC screening (American Cancer Society 2011). We examined colonoscopies because they are the most common CRC screening method (De Moor et al. 2018) and tend to be expensive (Hoover et al. 2017). The ACA cost-sharing elimination policy pertained to preventive colonoscopies only, which we identified using common procedural terminology (CPT) and International Classification of Disease (ICD)-9 codes (Table A4.2). These codes were based on the billing guidelines of the largest insurers in Maine (Table A4.1). We classified enrollees' resident zip codes as rural or urban based on Rural-Urban Commuting Areas (RUCAs) (USDA-ERS 2016a), which designate rurality based on

population density and the share of the population that commutes to urban areas (Morrill et al. 1999; Hart et al. 2005).

We examined two measures of the impact of the ACA: OOP costs and colonoscopy rates. First, our measure of OOP patient costs is the sum all OOP costs (deductible, co-payment, and co-insurance) for all claims on the day the colonoscopy occurred. We summed all patient-day costs because total costs associated with a colonoscopy are unlikely to be captured by the colonoscopy claim line only: patients receive anesthesia and provider consultation for the colonoscopy, services which are billed on different claim lines. We calculated the median by month. Second, colonoscopy rates were calculated as the share of enrolled members aged 50-75 who received a colonoscopy each month. The numerator is the number of screening colonoscopies that occurred each month and the denominator is the number of unique insured individuals enrolled each month. This fraction was multiplied by 100 to represent percentages. Each monthly measure was constructed for rural residents and urban residents separately, and as the difference of rural minus urban measures.

Analysis

We first show urban and rural monthly trends in outcomes visually. Consistent with other studies on the ACA's elimination of cost-sharing for preventive services (Cooper et al. 2016; Nelson et al. 2015; Mehta et al. 2015), we consider January 2011 to be the start of the post-period because many insurers, including Medicare, update insurance plan features such as OOP costs at the start of the calendar year. We plot the median patient-day OOP and percent of enrollees

receiving a colonoscopy by month and fit a trend line based on the linear predictions for the pre-period (January 2009 to December 2010) and post-period (January 2011 to December 2012). We extend the pre-policy linear trend into the post-period to visualize the projected OOP and colonoscopy rates if the pre-trend had continued. A vertical dashed line in January 2011 represents the first month of the post-period.

We conducted two regression analyses for each measure. First, we implemented an interrupted time series (ITS) regression model for colonoscopy rates and OOP for urban and rural areas separately. Second, we implemented a "differenced ITS", similar to Mehta et al. (2015), where we applied an ITS model to the difference between rural minus urban OOP and colonoscopy rates. Each regression model included: i) a trend variable capturing a sequential count of the number of months before (negative) and after (positive) December 2010 (zero), ii) a "post" indicator variable equal to one for January 2011 to December 2012, iii) an interaction between the trend and post variables, and iv) a dummy for the "season" or quarter of the year. The coefficient on the post variable gives the change in the level after the ACA went into effect, whereas the coefficient on the interaction term provides the impact of the ACA on the trend in OOP, colonoscopy rates, and the rural-urban differences in both measures. Newey-West standard errors with a lag of four were used to adjust for clustering over time (Newey & West 1987).

We tested the sensitivity of our results to a range of regression specifications, to ensure model choice did not drive our results. We included controls (average age of beneficiaries and the share of beneficiaries that are female), a lag of the dependent variable, and omit the "implementation period" between September 2010 and June 2011, using the concept of an impact

model articulated by Bernal et al. (2018), and similar to the approach implemented in Haffajee et al. (2017). We also conduct regressions by week, controlling with an indicator for month, covariates and omitting the implementation period. Finally, because the ACA began providing subsidies for insurance to small businesses and people retiring between the ages of 55-65 during this time, we also assess changes in enrollment as a possible alternative driver of changes in colonoscopy rates.

All analyses were conducted in Stata (14.0). Approval for this study was obtained from the Institutional Review Boards of the Harvard T.H. Chan School of Public Health and Boston College School of Social Work.

Results

The MHDO APCD includes 73,344 commercially insured and Medicare enrollees in rural areas and 284,675 in urban areas. 84,038 colonoscopy claims were included in our analysis (15,004 among rural residents and 69,034 among urban residents). Table 4.1 provides descriptive statistics of the rural and urban populations, aged 50-75, in Maine before the ACA took effect. A larger share of the study population was enrolled in Medicare in rural areas (49%) as compared to urban areas (42%). Median OOP costs for a colonoscopy for rural residents was nearly double that of urban residents ($195 vs. $98, $p<.001$). Rural-urban disparities in OOP costs were present for both Medicare ($118 vs. $41) and commercially-insured patients ($314 vs. $245). At both the patient-day and claim-line level, recipients of colonoscopies in rural areas paid a larger share of the total reimbursement costs (calculated as total payment to the provider by the insurer for the

entire patient-day or the colonoscopy claim line, respectively) as compared to urban patients. The rural-urban gap in colonoscopies in the pre-period was 5.1% vs. 6.1% per year (0.39% vs. 0.47% per month, p<.001).

Table 4.1: Descriptive statistics of rural and urban insurance enrollees, aged 50-75, January 2009 to December 2010.

	Rural	**Urban**	**P-value [H_0 difference = 0]**
Female share of members	51%	52%	<.001
Average age	62	61	<.001
Share of members enrolled in Medicare	49%	42%	<.001
Monthly share of members receiving a colonoscopy	.39%	.47%	<.001
Annual share of members receiving a colonoscopy	5.1%	6.1%	-
Median patient-day OOP	$195	$98	<.001
Medicare enrollee median patient-day OOP	$118	$41	<.001
Privately insured median patient-day OOP	$314	$245	<.001
Median patient-day OOP as a share of patient-day provider reimbursement	22.6%	9.7%	.001
Median claim-line OOP as a share of claim-line provider reimbursement	11.1%	0%	<.001
Median patient-day provider reimbursement	$960	$932	.001
Median claim-line provider reimbursement	$407	$433	.951

Notes: The annual share of members receiving a colonoscopy was calculated for August 1, 2009 to August 31, 2010. P-values based on unequal variance (Welch) t-test of difference in monthly values. OOP: out-of-pocket payments. Median patient-day OOP calculated as the sum of co-insurance, co-pays and deductibles of all claims on the day of the colonoscopy.

Trends in OOP costs for colonoscopies prior to the ACA were roughly parallel for rural and urban areas (Figure 4.1a). After the ACA, OOP costs in rural areas dropped by $94 or 48%

(p=.001) and continued to decrease by $4 per month (or 2% monthly, p=.038, Table 4.2, Column 1). In urban areas, median OOP costs also dropped after the introduction of the ACA by $63 or 64% (p <.001) (Table 4.2, Column 2). By the last six months of 2012, OOP costs declined to just $5 (min/max: 0 to $20) in rural areas and $0 in urban areas (min/max: 0 to 0).

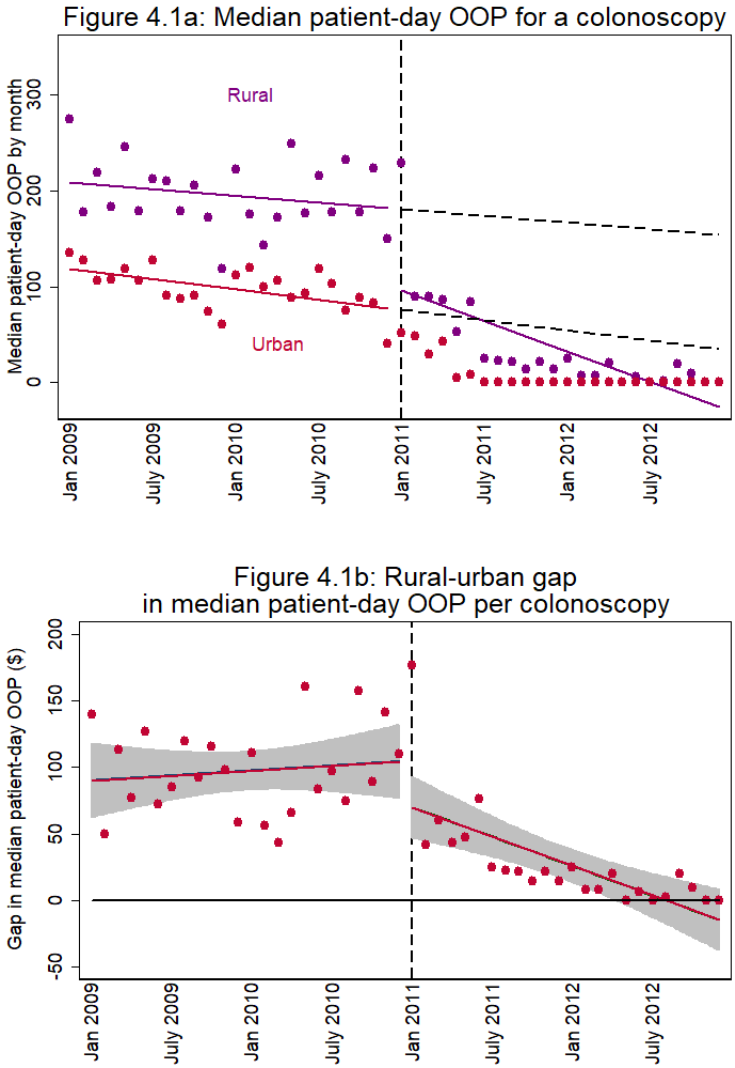

Figure 4.1: Median monthly patient-day out-of-pocket (OOP) patient costs for a colonoscopy 2009-2012, by residence.

Notes: Solid lines represent a linear regression of the patient-day OOP costs (A) and the differenced patient-day OOP costs (B) on the month trend. The gray area represents the 95% confidence interval of the linear regression. The horizontal dashed lines in (A) represent the extension of pre-period trends into the post-period.

With respect to rural-urban disparities in OOP payments for colonoscopies, rural patients paid nearly $100 (p<.001) more than urban patients prior to the ACA. The rural-urban gap in median patient-day OOP declined after the ACA by $4 (p =.007) or 4% monthly after January 2011 (Table 4.2, Column 3). By the end of the study period, rural-urban differences in OOP costs were just $5 (min/max: 0 to 20).

Table 4.2: Interrupted time series regression results.

	(1) Rural median patient-day OOP ($)	**(2) Urban median patient-day OOP ($)**	**(3) Difference (Urban – Rural) in median patient-day OOP**	**(4) Rural colonoscopy rate (%)**	**(5) Urban colonoscopy rate (%)**	**(6) Difference (Urban – Rural) in colonoscopy rate (%)**
Month	-0.62	-1.23**	0.61	-0.002	0.003***	-0.004***
	(-2.40 to 1.16)	(-2.15 to -0.32)	(-1.03 to 2.25)	(-0.004 to .001)	(0.002 to 0.004)	(-0.006 to -0.003)
Post	-93.83**	-63.29***	-30.54	0.023	-0.013	0.0361**
	(-149.1 to -38.57)	(-88.93 to -37.66)	(-70.35 to 9.27)	(-0.013 to 0.059)	(-0.034 to 0.008)	(0.013 to 0.059)
Post X Month	-4.11*	0.184	-4.30**	0.007***	0.002*	0.005***
	(-7.99 to -.23)	(-1.12 to 1.49)	(-7.33 to -1.26)	(0.004 to 0.010)	(0.0002 to 0.004)	(0.003 to 0.007)
Season Dummies	X	X	X	X	X	X
N	48	48	48	48	48	48

Notes: † p<0.1, * p<0.05, ** p<0.01. Confidence intervals in parentheses. Post is an indicator for all months from January 2011 to December 2012. OOP: out-of-pocket payments calculated as the sum of all co-insurance, co-pays and deductibles incurred on the day of the colonoscopy. Colonoscopy rates calculated as percent of private insurance and Medicare enrollees aged 50-75 receiving a screening colonoscopy: sum of colonoscopies divided by the sum of enrollees times 100. Differences are all calculated in terms of urban minus rural.

Before the ACA, the rural-urban gap in colonoscopy rates was increasing (Figure 4.2) (-.004, p <.001, Table 4.2 Column 6). After the ACA, the colonoscopy rate increased significantly in rural areas at .007 percentage points (p <.001) or 2% per month (Table 2, Column 4). The urban colonoscopy rate increased .002 or .4% (p=.027) after the ACA (Table 4.2, Column 5).

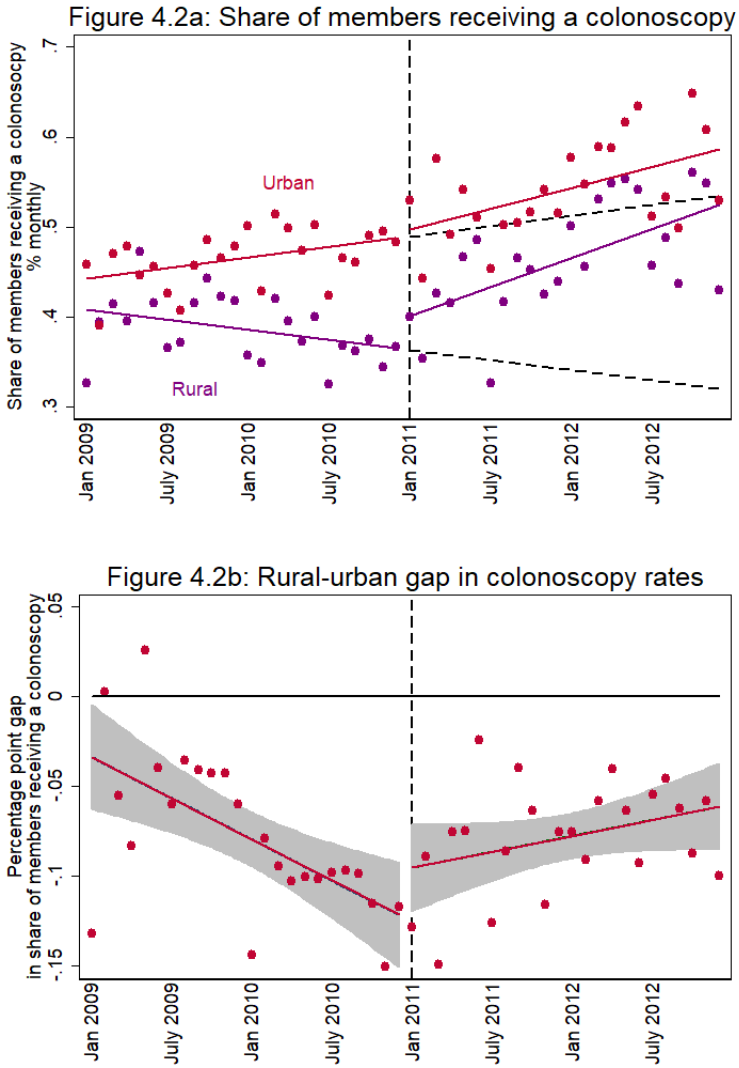

Figure 4.2: Monthly colonoscopy rates, 2009-2012, by residence.

Notes: Solid lines represent a linear regression of the colonoscopy rate (A) and the differenced colonoscopy rate (B) on the month trend. The gray area represents the 95% confidence interval of the linear regression. The horizontal dashed lines in (A) represent the extension of the pre-period trend into the post-period.

With respect to rural-urban disparities, the gap in colonoscopy rates declined by .005 percentage points ($p < .001$) or 6% monthly after the introduction of the ACA (Table 4.2, Column 6). Compared to the rural-urban gap for the last six months of 2010 (-.11%, min/max: -.15 to -.10), the rural-urban gap had declined by nearly 40% by the last six months of 2012 (-.07%, min/max: -.10 to -.05).

Robustness checks

Robustness tests confirm that rural residents on the whole responded more substantially to the ACA in terms of uptake of screening colonoscopies. Our results are robust to a wide range of regressions specifications (Tables A4.3-A4.8 in the appendix). In all regression specifications, rural colonoscopy rates increased significantly, and the rural-urban gap in OOP and colonoscopy rates decreased significantly. Major differences pertain to the urban only regressions for OOP costs and colonoscopy rates, which estimate statistically significant coefficients only for a small subset of the post and post X month covariates, suggesting a weaker association between the ACA and changes in colonoscopy rates among urban residents. Controlling for age and share female also resulted in non-significant results for rural OOP and the rural-urban gap in OOP, but this is the only specification for which this is observed.

Although we cannot rule out an association with changes in insurance enrollment, our results suggest they are unlikely to be a prominent driver. We depict trends over time in enrollment counts (Figure A4.3 in the appendix), showing that no major changes in insurance enrollment occurred during the study period. Regression results suggest a small increase in

enrollment at the beginning of 2011 but the differences are larger (as a percent of existing enrollees) in urban areas than rural areas. Furthermore, the increases in rural areas are not large enough to explain the sustained 6% monthly increases in colonoscopy rates: enrollment increased just 1.6% initially and .07% monthly.

Finally, we examine whether the share of the population living below the federal poverty line, rather the rural-urban status of the zip code, was associated with the reductions in the rural-urban gap in median OOP and colonoscopy rates. Visualization of trends are found in Figure A4.2 and regression results are found Table A4.9 in the appendix. Overall, visualizations and regression results are suggestive but not conclusive that zip codes with higher shares of the population living below the poverty line responded more to the elimination of cost-sharing. This underscored that while income could be an important feature in colonoscopy and CRC disparities, we detect more changes in rural-urban inequities after the ACA.

Discussion

This study demonstrates that the ACA led to a reduction in rural-urban disparities in OOP costs for colonoscopies and colonoscopy rates in Maine. Prior to the ACA, median OOP patient costs were nearly $100 higher for rural versus urban enrollees. The ACA effectively closed this gap in OOP patient costs, with a difference of just $5 (min/max: 0 to 20) remaining by the end of December 2012, a 95% decline. Reducing these costs was associated with a 2% increase in colonoscopies each month in rural areas, reversing the declines in the colonoscopy rate among the

rural insured population observed before the ACA took effect. The rural-urban gap in colonoscopy rates had closed by nearly 40% by the end of 2012.

The more substantial increase in colonoscopy rates among rural residents than urban residents emphasizes how the distributional effects of policy changes like the elimination OOP costs are embedded in key health systems features and the broader social and economic context. First, rural areas in the US (and in many other countries) tend to be less wealthy: in Maine, the rural population earns 16% less in income per capita and had a 38% higher poverty rate than the urban population (USDA-ERS 2016b). Therefore, at the same price, the OOP costs of a colonoscopy were a larger share of income for rural residents than urban residents and thus potentially a more significant barrier to colonoscopies. However, we also showed that the OOP costs of a colonoscopy were more substantial in rural areas than urban areas before the ACA came into effect. Thus, even for households with the same level of income, rural residents spent a larger share of income on a colonoscopy. This is connected to how insurance is obtained in the US: for most Americans under the age of 65, insurance coverage is tied to employment. The type of employment tends to be distinct in rural area, including higher rates of self-employment and employment in small businesses in rural areas (McDaniel 2001). Small businesses are less likely to provide insurance at all, and when they do, employees tend to pay a higher share of premiums, have higher deductibles and spend more OOP on health care (Kaiser Family Foundation 2016; Lenardson et al. 2009). This is reflected in the larger share of reimbursements paid by rural residents than urban residents in our study (Table 4.1).

The fact that the ACA did not tackle other known barriers to CRC screenings may explain the rural-urban gap that remained by the end of 2012. None of the provisions of the ACA that came into place between September 2010 and December 2012 directly targeted the supply of colonoscopy providers or primary care providers, a critical issue in rural areas (Rosenblatt et al. 2010). Public awareness and acceptability were also not targeted. Both provider supply, notably provider preferences about where to practice, and beliefs about medicine are embedded in broader social and cultural differences between rural and urban areas that may be more difficult to tackle through changes to the health system.

The substantial impact on rural residents is striking given the mixed impact of the ACA overall on rural communities, including provisions of the law that came into effect after the elimination of patient cost-sharing. Evidence suggests that the ACA improved access to insurance in some rural areas, but urban residents benefited more from improved access to health care and reduced OOP health care costs than rural residents, potentially because, as we show in Maine, the financial coverage of insurance plans in rural areas was worse than in urban areas, but also because of supply-side and attitudinal factors. First, existing studies conflict as to whether Medicaid expansion increased insurance rates in rural areas or urban areas more; impact varied depending on the state (Barker et al. 2017). Post-Medicaid expansion, reductions in costs were higher in urban areas and upticks in a regular source of medical care and doctor visits were detectable only among urban residents. Second, the extension of parental insurance coverage to people under the age of 26 increased insurance rates similarly across both urban and rural settings through the first year of the mandate, and much of the prevailing gap in coverage between urban

and rural young adults was erased (Look et al. 2017). However, rural-urban disparities in unmet need for mental health or substance abuse treatment for young adults persisted in 2014 (Chavez et al. 2018). Finally, enrollment in the federally-facilitated nongroup Marketplace was much slower among rural residents than urban residents (Drake et al. 2016). Premium rates in the state and federal exchanges have been higher and premiums increased faster in rural areas than urban areas over 2015-16 (Barker et al. 2016).

The main limitations of this study are that focusing on a single state limits the generalizability to other settings. Because of the time frame (two years before/after the ACA), we were unable to assess the share of beneficiaries that are up-to-date on CRC screening according to screening guidelines, which is more pertinent for understanding whether these changes could have implications for CRC health outcomes. We are unable to compare trends in colonoscopy rates and OOP spending between the insured and uninsured populations and thus rule out the role of increased insurance coverage. Finally, we cannot rule out the role of the ACA in increasing the inclusion of preventive colonoscopies in insurance benefits packages, and better protection of the financial risks of health care more generally, in changing the propensity of the insured population to take-up screening colonoscopies.

Rural-urban disparities in CRC screenings persisted for at least ten years nationwide before the ACA took effect (Cole et al. 2012). This makes the closing of the rural-urban gap by the ACA an achievement of the law and a result that can be used to assess how to tackle other rural-urban disparities in screening nationwide. Even so, further research is needed to determine whether

increased uptake, particularly in rural areas, translated to cancer prevention or better patient outcomes.

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Zauber AG, Winawer SJ, O'Brien MJ, Lansdorp-Vogelaar I, van Ballegooijen M, Hankey BF, et al. Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. *New England Journal of Medicine* 2012; 366(8): 687-696.

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Appendix

CPT & ICD codes used to identify colonoscopies

We first identified the insurers that covered the largest population in the state of Maine. Based on a report by the Maine Bureau of Insurance in 2016 (Maine Bureau of Insurance 2016), the largest insurers by market share are reported in Table A4.1.

Table A4.1: Top insurers in Maine by market share.

Insurer	Market share
Anthem	48.7%
Harvard Pilgrim	20.4%
Maine Community Health Options	16.8%
Aetna	9.0%
Cigna	4.2%
United	0.9%

Source: Maine Bureau of Insurance, 2016.

Next, we referred to the guidelines for preventive services published by each insurer. These were available for all insurers with the exception of Maine Community Health Options. Guidelines indicated which combination of Common Procedural Terminology (CPT) codes and International Classification of Disease (ICD) codes should be used to indicate the colonoscopy was a preventive procedure, and therefore, to which the ACA's no cost-sharing policy applied. If one insurer used a CPT code but did not indicate a corresponding ICD code, but another insurer required the use of both the CPT code and an ICD code, we used the more conservative approach of using both types of codes to identify colonoscopies. This could result in some preventive colonoscopies being omitted but safeguards against the inclusion of diagnostic or therapeutic

colonoscopies. The combination of CPT and ICD codes used to identify preventive colonoscopies are listed in full in Table A4.2.

Table A4.2: Common Procedural Terminology and International Classification of Disease Codes used to identify preventive colonoscopies.

CPT Codes	ICD codes
44392	V700, V7641, V7650 and V7651
44393	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
44394	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
44388	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
44389	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
45378	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
45379	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
45380	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
45381	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
45382	V700, V7641, V7650, V7651
45383	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
45384	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
45385	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
45386	V700, V7641, V7650, V7651
45388	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
45389	All diagnoses
45392	V700, V7641, V7650, V7651, V7652, V160, V1851 and V1859
G0105	V7641, V7650, V7651, V7652, V160, V1851 and V1859
G0120	V7641, V7650, V7651, V7652, V160, V1851 and V1859
G0121	V7641, V7650, V7651, V7652, V160, V1851 and V1859
G0122	V7641, V7650, V7651, V7652, V160, V1851 and V1859

Robustness checks for main regression results

Table A4.3: Robustness checks of rural median OOP.

	(1)	(2)	(3)	(4)	(5)	(6)
	Age and share female	Lag	Omitting "intervention period": September 2010 to June 2011	Week with month dummy	Week with age and share female	Week omitting "intervention period": September 2010 to June 2011
Trend	-12.41*	-0.332	-1.917†	-0.158	-2.618**	-0.323†
	(5.317)	(0.655)	(0.972)	(0.179)	(0.831)	(0.176)
Post	-44.07	-81.79*	-139.4***	-84.05***	-29.65	-142.8***
	(38.45)	(31.10)	(17.17)	(20.07)	(42.95)	(14.67)
Post X Trend	-3.985†	-4.547*	0.895	-0.964***	-0.783	0.106
	(2.174)	(1.783)	(1.156)	(0.269)	(0.481)	(0.247)
Average age	525.8				443.5**	
	(262.3)				(161.3)	
Share female (%)	213.2				239.6†	
	(106.8)				(141.8)	
Lag		0.0661				
		(0.137)				
Season Dummies	X	X	X			
Month Dummies				X	X	X
Rural	X	X	X	X	X	X
N	48	47	38	208	208	167

Notes: † p<0.1, * p<0.05, ** p<0.01. Standard errors in parentheses.

Table A4.4: Robustness checks of urban median OOP.

	(1)	(2)	(3)	(4)	(5)	(6)
	Age and share female	Lag	Omitting "intervention period": September 2010 to June 2011	Week with month dummy	Week with age and share female	Week omitting "intervention period": September 2010 to June 2011
Trend	-1.183	-0.776†	-0.911†	-0.297**	-0.182	-0.249*
	(1.408)	(0.411)	(0.469)	(0.0984)	(0.226)	(0.114)
Post	-74.83*	-43.83*	-92.98***	-64.18***	-44.00	-90.53***
	(31.89)	(16.33)	(10.30)	(8.840)	(25.42)	(10.02)
Post X Trend	0.144	0.191	1.202*	0.101	0.217	0.341*
	(1.239)	(0.506)	(0.574)	(0.133)	(0.218)	(0.146)
Average age	-12.31				-36.93	
	(138.0)				(93.57)	
Share female (%)	-102.5				193.5	
	(213.1)				(191.9)	
Lag		0.324*				
		(0.139)				
Season Dummies	X	X	X			
Month Dummies				X	X	X
Rural						
N	48	47	38	208	208	167

Notes: † p<0.1, * p<0.05, ** p<0.01. Standard errors in parentheses.

Table A4.5: Robustness checks of rural colonoscopy rates.

	(1)	(2)	(3)	(4)	(5)	(6)
	Age and share female	Lag	Omitting "intervention period": September 2010 to June 2011	Week with month dummy	Week with age and share female	Week omitting "intervention period": September 2010 to June 2011
Trend	-0.00551	-0.00272*	-0.00116	-0.0000898†	-0.000155	-0.0000784
	(0.00510)	(0.00117)	(0.00139)	(0.0000516)	(0.000283)	(0.0000554)
Post	0.0384	0.0296	0.0250	0.00645†	0.00611	0.00937
	(0.0366)	(0.0188)	(0.0339)	(0.00377)	(0.00904)	(0.00636)
Post X Trend	0.00720**	0.00984***	0.00636**	0.000391***	0.000369**	0.000332**
	(0.00219)	(0.00168)	(0.00230)	(0.0000661)	(0.000122)	(0.0000996)
Average age	0.182				0.0176	
	(0.211)				(0.0514)	
Share female (%)	0.0656				-0.00231	
	(0.183)				(0.0417)	
Lag		-0.202				
		(0.118)				
Season Dummies	X	X	X			
Month Dummies				X	X	X
Rural	X	X	X		X	X
	48	47	38	208	208	167

Notes: † p<0.1, * p<0.05, ** p<0.01. Standard errors in parentheses.

Table A4.6: Robustness checks of urban colonoscopy rates.

	(1)	(2)	(3)	(4)	(5)	(6)
	Age and share female	Lag	Omitting "intervention period": September 2010 to June 2011	Week with month dummy	Week with age and share female	Week omitting "intervention period": September 2010 to June 2011
Trend	0.000953	0.00400***	0.00284***	0.000144***	0.0000597	0.000137**
	(0.00128)	(0.000884)	(0.000706)	(0.0000417)	(0.000121)	(0.0000493)
Post	-0.0168	-0.0202	-0.00533	-0.00283	0.00499	0.000860
	(0.0315)	(0.0125)	(0.0177)	(0.00379)	(0.0120)	(0.00662)
Post X Trend	0.000533	0.00292**	0.00132	0.000111	0.0000592	0.0000772
	(0.00143)	(0.00103)	(0.00124)	(0.0000613)	(0.000102)	(0.000104)
Average age	0.186				0.0435	
	(0.130)				(0.0487)	
Share female (%)	-0.0713				0.0646	
	(0.270)				(0.108)	
Lag		-0.449**				
		(0.140)				
Season Dummies	X	X	X			
Month Dummies				X	X	X
Rural						
	48	47	38	208	208	167

Notes: † p<0.1, * p<0.05, ** p<0.01. Standard errors in parentheses.

Table A4.7: Robustness checks of rural minus urban difference in median OOP.

	(1)	(2)	(3)	(4)	(5)	(6)
	Age and share female	Lag	Omitting "intervention period": September 2010 to June 2011	Week with month dummy	Week with age and share female	Week omitting "intervention period": September 2010 to June 2011
Trend	-1.912	1.183	-1.005	-0.0445	0.128	-0.189
	(4.752)	(0.765)	(0.745)	(0.154)	(0.639)	(0.144)
Post	-25.90	-34.61	-46.41***	-41.78*	-34.23	-101.6***
	(27.97)	(22.00)	(11.60)	(18.41)	(28.86)	(11.29)
Post X Trend	-3.031	-5.313**	-0.307	-1.122***	-1.135**	-0.0757
	(2.470)	(1.679)	(0.834)	(0.244)	(0.389)	(0.193)
Average age	198.8				-176.3	
	(411.7)				(288.1)	
Share female (%)	72.46				53.82	
	(118.2)				(127.3)	
Lag		-0.0862				
		(0.141)				
Season Dummies	X	X	X			
Month Dummies				X	X	X
	48	47	38	208	206	167

Notes: † p<0.1, * p<0.05, ** p<0.01. Standard errors in parentheses.

Table A4.8: Robustness checks of rural minus urban difference in colonoscopy rates.

	(1)	(2)	(3)	(4)	(5)	(6)
	Age and share female	Lag	Omitting "intervention period": September 2010 to June 2011	Week with month dummy	Week with age and share female	Week omitting "intervention period": September 2010 to June 2011
Trend	-0.00121	-0.00626***	-0.00400***	-0.000238***	0.0000413	-0.000223***
	(0.00248)	(0.000732)	(0.00108)	(0.0000474)	(0.000191)	(0.0000561)
Post	0.0409*	0.0473***	0.0303	0.00962*	0.00906†	0.00867
	(0.0152)	(0.0127)	(0.0224)	(0.00386)	(0.00472)	(0.00668)
Post X Trend	0.00424**	0.00776***	0.00504**	0.000288***	0.000166	0.000269**
	(0.00135)	(0.000955)	(0.00150)	(0.0000654)	(0.000118)	(0.0000988)
Average age	-0.388				-0.121	
	(0.269)				(0.0780)	
Share female (%)	0.00285				-0.0190	
	(0.0590)				(0.0326)	
Lag		-0.240**				
		(0.0695)				
Season Dummies	X	X	X			
Month Dummies				X	X	X
N	48	47	38	208	206	167

Notes: † p<0.1, * p<0.05, ** p<0.01. Standard errors in parentheses.

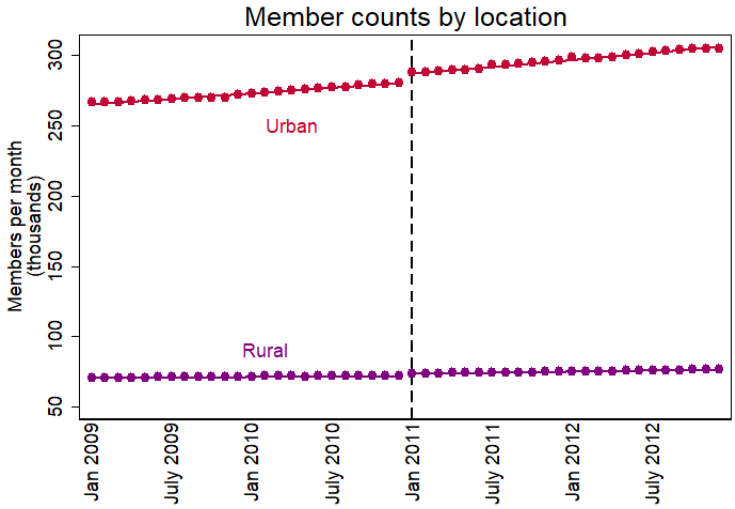

Figure A4.1: Member counts, 2009-2012, by residence.

Table A4.9: Regression results for member counts.

	(1)	(2)	(3)
	Rural member count (thousands)	Urban member count (thousands)	Gap (rural minus urban) in member counts (thousands)
Trend	0.0724***	0.650***	-0.577***
	(0.00415)	(0.0308)	(0.0330)
Post	1.150***	6.191***	-5.041***
	(0.0976)	(0.451)	(0.501)
Post X Trend	0.0539***	0.169***	-0.116**
	(0.00535)	(0.0325)	(0.0344)
Season Dummies	X	X	X
N	48	48	48

Notes: P-values in parentheses. † < p0.1, * p<0.05, ** p<0.01, *** p<0.001. All regressions are conducted by month.

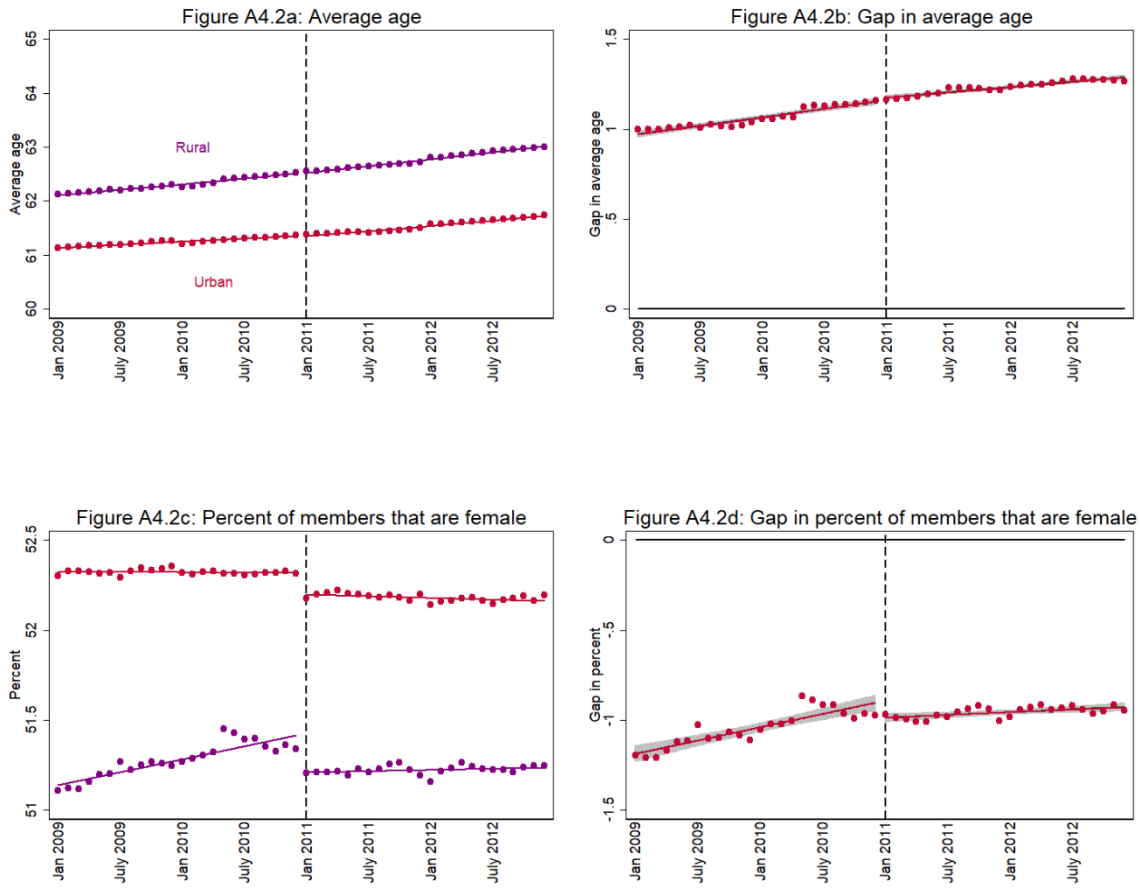

Figure A4.2: Age and gender, 2009-2012, by residence.

Table A4.10: Regression results for age and gender analysis.

	Rural Age (years)	Urban Age (years)	Gap (rural minus urban) in Age (years)	Rural Share Female (percent)	Urban Share Female (percent)	Gap (rural minus urban) in Share Female (percent)
Trend	0.0190***	0.001***	0.008***	0.017***	-0.001	0.010*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.202)	(0.022)
Post	-0.036	-0.010	0.016	-0.209***	-0.108***	-0.010*
	(0.314)	(0.694)	(0.392)	(0.000)	(0.000)	(0.024)
Post X Trend	0.003	0.007***	-0.003*	-0.010***	-0.002	-0.009***
	(0.073)	(0.000)	(0.039)	(0.000)	(0.079)	(0.000)
Share Female (percent)	-0.121	0.117	0.0413			
	(0.256)	(0.501)	(0.645)			
Age (years)				-0.277	0.063	0.283
				(0.244)	(0.509)	(0.659)
Season Dummies	X	X	X	X	X	X
N	48	48	48	48	48	48

Notes: P-values in parentheses. † < p0.1, * p<0.05, ** p<0.01, *** p<0.001. All regressions are conducted by month.

Analysis of zip codes grouped by share of the population living below the federal poverty line

We divide zip codes into those above and below the zip code median of 25% of the population living below the federal poverty line based on the 2008-2012 American Community Survey. Figure A4.2 depicts the median OOP and share colonoscopy by these two zip code categories, which highlights that a small gap between rural and urban areas existed in both median OOP and share of enrollees receiving a colonoscopy. Regression results confirm that the initial drop in median OOP is statistically significant for <25% poor zip codes (p = .011), >25%

poor zip codes (p=.024) and the gap (p=.009). However, changes in colonoscopy rates are not significant both as an initial post-ACA drop or as a change in the trend over time for both areas separately. The regression results for the gap in colonoscopy rates pick up a small increase in the gap post-ACA (p=.003) and detect a small but only borderline statistically significant effect for the trend in the gap in colonoscopy rates (p=.072).

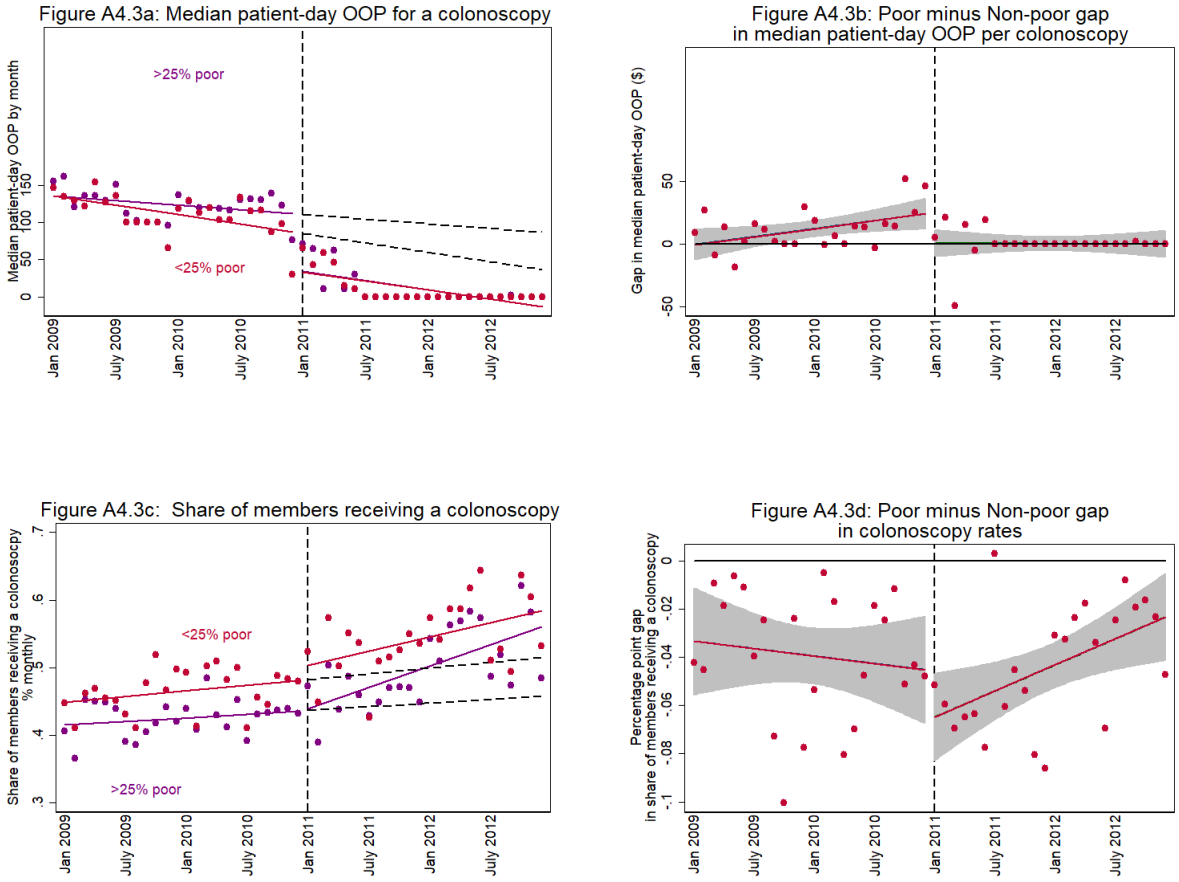

Figure A4.3: Sub-group analysis by zip code poverty share: median OOP and share of enrollees receiving a colonoscopy.

Table A4.11: Regression results for poverty share analysis.

	(1)	(2)	(3)	(4)	(5)	(6)
	>25% poor median person-day OOP ($)	<25% poor median person-day OOP ($)	Difference (<25% – minus >25% poor) in median person-day OOP	>25% poor colonoscopy rate (%)	<25% poor colonoscopy rate (%)	Difference (<25% minus >25% poor) in colonoscopy rate
Month	-0.584	-1.488*	0.904	0.002*	0.002*	0.00004
	(0.346)	(0.014)	(0.056)	(0.012)	(0.026)	(0.957)
Post	-86.50***	-66.78***	-19.73**	-0.027†	0.008	-0.035**
	(0.000)	(0.000)	(0.007)	(0.054)	(0.499)	(0.002)
Post X Month	-1.017	0.0704	-1.09†	0.004***	0.002*	0.002**
	(0.280)	(0.933)	(0.062)	(0.000)	(0.043)	(0.007)
Season	X	X	X	X	X	X
Poor	X			X		
N	48	48	48	48	48	48

Notes: † < p0.1, * p<0.05, ** p<0.01, *** p<0.001. P-value in parentheses.

Chapter V

Conclusion

This dissertation sought to assess how out-of-pocket (OOP) payments for noncommunicable disease (NCD) care could be both a threat and opportunity for the pursuit of universal health coverage (UHC). Estimates of catastrophic health expenditure (CHE) by disease showed that NCD OOP spending potentially threatens financial risk protection – and that this threat is distinct from other disease areas (Chapters II and III). NCD OOP spending was also examined as an opportunity: removing cost-sharing for one preventive NCD procedure in the United States exposed the potential for NCD OOP elimination to boost service coverage rates (Chapter IV). While a smaller share of NCD CHE was observed among poor and rural populations (Chapters II and III), OOP costs were also associated with lower utilization of NCD preventive services by people in poorer and more rural areas (Chapter IV), highlighting the role of OOP costs as a deterrent that may prevent disadvantaged groups from accessing care.

Summary of findings

The analyses in Chapter II contributed to the financial risk protection literature by examining CHE by disease at the macro level. Comparable cross-country estimates permitted the examination of disease-specific CHE against country-level indicators. The CHE associated with heart disease was the only disease area with a statistically significant relationship with disease prevalence. No effect was detected for income or health financing, highlighting the role of unmeasured health system factors, in addition to disease prevalence, in explaining heart disease CHE. Heart disease CHE also exhibited substantially more cross-country variation than the CHE associated with maternal care and injuries. This suggests that as NCDs comprise a larger share of

disease burden, they could pose a more substantial threat to financial risk protection than the CHE associated with the other disease areas examined, depending on how health systems respond.

Chapter III focused on the variation in CHE by disease for a more recent time period and in six countries. Focusing on a smaller set of countries allowed for consideration of the health system context and generation of hypotheses about the variation observed. The distributions of CHE and disability-adjusted life years (DALYs) by broad disease areas were more aligned in some countries than others. China's NCD CHE rate was much lower than the NCD share of DALYs, potentially a reflection of the low prioritization by the Chinese government of NCD services (Tang et al. 2013). South Africa's NCD CHE was a much higher portion of CHE than NCDs' share of total DALYs, which may be connected to the segregated nature of the South African health system; richer patients are more likely to have NCDs and are more likely to seek care in the private sector, which tends to have higher OOP costs (Ele-Ojoe Ataguba & Akazilla 2010).

In addition, differences across disease areas in the drivers of CHE were assessed in Chapter III. NCD OOP costs per visit, including OOP drug costs, were nearly twice as high as communicable disease OOP costs. However, NCD OOP costs were not disproportionately driven by drugs (even though drug costs were higher), and NCD visits were not more likely to occur in the private sector, ruling out two potential drivers of higher NCD OOP costs. NCD CHE was more likely to be caused by the culmination of spending over many visits, as opposed to communicable CHE, which was more likely to be caused by a single health spending shock. NCD CHE cases used more outpatient care than communicable CHE cases. These findings suggest that NCD OOP spending could be more regular, and thus easier to plan for, although even good

planning will not protect households from high OOP spending per visit. Regardless, the analysis underscored that distinct policies could be more effective for different disease areas. For instance, catastrophic funds and catastrophic health insurance may be useful tools for households affected by the high spending shocks associated with communicable CHE, whereas reductions in NCD OOP outpatient costs or market shaping interventions for drugs might be effective approaches for tackling NCD CHE.

Chapter IV contributed to the literature on the program effects of user fee elimination by focusing on NCDs and a single health procedure. This study is also unique because it examines the distributional effects of the policy change (Lagarde and Palmer 2008; Wiysonge et al. 2017). Chapter IV showed that inequities in OOP spending were associated with inequities in the utilization of a highly-effective NCD service: the rural insured population paid twice as much OOP for screening colonoscopies and took up the procedure at a 16% lower rate than urban insurance enrollees. Eliminating OOP costs closed the gap in OOP payments, and reduced the rural-urban gap in colonoscopy rates by 40%. These results emphasized the deterrent role of OOP costs in inequities in service coverage, but the remaining rural-urban gap in colonoscopy rates suggested that other, more difficult-to-change, health system and behavioral features could also be key barriers to access. Finally, these results underscore that, instead of the sweeping elimination of user fees that occurred in a number of developing countries over the past 20 years, policymakers focused on tackling inequities could consider the elimination of OOP costs for specific costly but highly-effective preventive procedures.

With varying depth, Chapters II, III and IV assessed the inequities associated with NCD OOP costs. Chapter II showed that, in most countries, the portion of heart disease CHE that occurred among the poor was lower than for injuries and maternal care CHE. In Chapter III, NCD CHE cases were less likely to be poor and live in a rural area than communicable CHE cases. It is not possible to know whether the lower rates of NCD CHE among the poor and rural populations were reflections of lack of need or lack of access, however. Chapter IV avoided the question of need by focusing on a service recommended for everyone in the study population. This chapter showed that rural populations responded more to the elimination of NCD OOP costs than urban populations, highlighting the deterrent effect of OOP costs, and hinting that OOP costs could play some role in the lower rates of NCD CHE in Chapters II and III in addition to the key driver of disease prevalence.

Policy implications and avenues for future research

This dissertation provided evidence that, in designing UHC policies, it may be useful for decision-makers to think in a targeted and comparative way about diseases and conditions. How the distribution of service coverage and CHE compares across diseases and conditions and sociodemographic groups can lend insights about where the health system is falling short in reaching UHC goals, but also which policies might achieve UHC most cost-effectively. Policymakers may want to develop a typology of which diseases and conditions are associated with spending shocks versus the slow buildup of health spending, for instance, and tailor policies to these types of CHE.

The three analyses also suggested that policymakers should pay special attention to the availability and costs of NCD care as this disease area become a larger share of disease burden. Cross-country patterns in Chapter II showed wide variation in heart disease CHE and Chapter III emphasized how the health system context might be driving variation in NCD CHE. Policymakers should examine how their health system is performing in this area, particularly whether there are major gaps or disparities in service coverage or CHE rates for NCDs, in the event that health system organization and financing have not kept pace with the rise of NCDs.

An important contribution of both Chapters II and III is in highlighting the methodological challenges associated with estimating CHE by disease. CHE is defined at the household level, as it is the primary economic unit through with OOP spending is financed and decisions about consumption expenditure are made. Diseases are specific to an individual however. Chapter II was consistent with the definition of CHE at the household level, but made strong assumptions about the connection between household health spending and the reason health care was sought by a randomly-selected household member. Chapter III focused on health spending at the individual level, potentially underestimating household health spending and CHE.

In both analyses, a substantial share of CHE cases could not be tagged to a specific disease area, limiting knowledge of the magnitude and distribution of CHE cases, and the possibility of making specific policy conclusions. This is connected to less than comprehensive response options in the SAGE and WHS, but is also related to recall and respondents' lack of knowledge, issues which are more concentrated among the poor (Das et al. 2011), and potentially poor provider communication and diagnostic capacity.

Ideally, the OOP spending of each individual in the household could be tied to a specific disease, spending could be summed by disease, and CHE could be tied to the disease that pushes spending over the threshold used, or the disease that contributes the most to OOP spending. Only one nationally-representative household survey – the National Sample Survey in India – currently has data that captures all these features of household health spending for all household members. Besides the National Sample Survey, WHS and SAGE, very few existing surveys inquire about why health care is sought, limiting our ability to extend these analyses to more recent years. Using claims data like those used in Chapter IV would permit more accurate accounting of the diseases and conditions associated with OOP spending. However, the availability and usability of claims and other administrative data in low- and middle-income countries is only beginning to develop (Wyber et al. 2015). Investment in household surveys that better capture utilization and spending by disease and reliable administrative datasets would be a major boon to estimating CHE by disease area in the future.

While the focus in this dissertation was on NCDs broadly, NCDs encompass a wide array of symptoms and treatment. Chapter II focused on one single NCD, heart disease, but was unable to delve further into the severity of the disease, which can vary substantially and have major implications for the need for health care and OOP spending. Chapter III aggregated a wide array of NCDs and communicable conditions, respectively, into broad cause categories. Broad groupings were required because of limited sample sizes but, ideally, the analyses could have focused on better defined disease categories, such as heart disease, diabetes, malaria, and HIV/AIDS, as well

as the severity of the conditions. Analyzing costs and utilization patterns at this more refined level, such as in Chapter IV, would be more useful for developing specific policy recommendations.

This dissertation did not address important issues around whether people who get care need it and whether they got appropriate care (Wagstaff et al. 2015). In both Chapters II and III, service coverage was not investigated and underlying need, represented by prevalence and DALYs, was considered using coarse proxies. Examining the connection between need, service coverage and CHE is critical to understanding whether the magnitude of NCD CHE and CHE caused by other disease areas is concerning, as well as whether foregone care is a substantial concern in a given country context. Assessing whether unnecessary care is causing CHE is also critical, particularly because this cause of financial hardship might lead to different policy choices.

While Chapter IV sheds light on the deterrent effect of OOP spending, this an area where much more research in low- and middle-income countries is required. Cost-effective preventive services and disease control strategies exist for an array of NCDs (Jamison et al. 2018). If OOP for this care deters patients from getting treated early on in disease progression, patients may miss the chance to avert the more severe cases that pose a much larger threat to well-being and household consumption.

Finally, the analyses only used proxies – such as NCD OOP spending and NCD CHE – to assess the impact of NCD care on household welfare. None of the analyses considered how households financed OOP costs – whether spending is covered through borrowing, selling assets, transfers from relatives or friends, or by reducing non-health consumption expenditure (Kruk et al. 2009, Flores et al. 2008). Ignoring the source of OOP spending risks overestimating the threat to

current consumption (Flores et al. 2008). In Chapter III, differences in the number of visits required to push spending over the CHE threshold suggested that NCD OOP spending could be more predictable, but analyses did not assess the dispersion of NCD OOP spending, whether dispersion differed from communicable OOP, and the implications of volatility differences for longer-term household welfare. Extending existing theories about volatility (Flores & O'Donnell 2016) to differences by disease area could inform the design of policy tools. Developing and testing theories about the relationship between disease areas and household coping mechanisms, including informal insurance and labor substitution, are also important avenues for future research and UHC policy development.

Conclusion

This dissertation tackled key questions about NCD OOP spending, but also prompted new questions about the future of UHC as NCDs continue to rise as a share of disease burden. Achieving UHC within limited health budgets will require selecting approaches that maximize financial risk protection and (effective) service coverage while minimizing the health system costs. While more research is needed to determine which specific policies to adopt in which contexts, this dissertation provided evidence that, by considering the effects of NCD OOP spending, countries may be able to develop targeted strategies that accelerate progress toward UHC goals.

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