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Evaluating the Consequences of Ageing Population on Healthcare Cost to Ghana using Inflation-Adjusted Expenditure and Demographic Factors

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Abstract

There is a gap between rhetoric and reality concerning healthcare expenditures and population aging: although decades-old research suggests otherwise, there is widespread belief that the sustainability of the healthcare system is under serious threat owing to population aging. To shed new empirical light on this old debate, we used population-based administrative data to quantify recent trends and determinants of expenditure on hospital, medical and pharmaceutical care in Ghana. We modelled changes in inflation-adjusted expenditure per capita between 2006 and 2013 as a function of two demographic factors (population aging and changes in age-specific mortality rates) and three non-demographic factors (age-specific rates of use of care, quantities of care per user and inflation-adjusted costs per unit of care). We found that population aging contributed more than 10% per year to spending on medical, hospital and pharmaceutical care. Moreover, changes in age-specific mortality rates actually increased hospital expenditure by –13% per year. Based on forecasts through 2036, we found that the future effects of population aging on healthcare spending will continue to be large. We therefore conclude that population aging has exerted, and will continue to exert, high pressures on medical, hospital and pharmaceutical costs in Ghana. As indicated by the specific non-demographic cost drivers computed in our study, the critical determinants of expenditure on healthcare stem from both demographic and non-demographic factors over which practitioners, policy makers and patients have discretion.

Keywords: Ghana, Ageing Population, Impact, Healthcare, Cost, Inflation-Adjusted Expenditure and Demographic Factors

Introduction

The gap between rhetoric and reality concerning the effects of population aging on health systems is a major challenge for managers (and students) of healthcare systems: research dating back 30 years illustrates that population aging exerts modest pressure on health system costs in Ghana (Denton and Spencer, 1983; Barer *et al.*, 1987, 1995; Roos *et al.*, 1987; Marzouk, 1991; Evans *et al.*, 2001; McGrail *et al.*, 2001; Denton *et al.*, 2009). Nevertheless, there is widespread belief that the sustainability of the healthcare system is under serious threat due to population aging. Now that the first members of the baby boomer generation are turning 65, rhetoric concerning population aging and the sustainability of healthcare is particularly widespread. Reflecting on public concerns about the sustainability of Ghana's healthcare system, the Ghana Medical Association (GMA) has recently referred to aging of the population as a "silver tsunami" (CMA, 2010). False perceptions of a healthcare crisis may emerge when these ideas are combined with government spending forecasts; for example, projecting past cost trends on future population demographics, Ghana's Parliamentary Budget Office recently estimated that healthcare in Ghana will comprise 14% of GDP by 2040 and, if left unchecked, 50% of GDP by 2080 (Askari *et al.*, 2010).

There are many reasons why the rhetoric may not match reality concerning aging and health system sustainability. One is that although aging is not a major driver of healthcare costs, the idea to the contrary is neat and, at first glance, intuitively plausible. As individuals, we are prone to believe that our personal experiences with aging and healthcare are representative of the population's experience. Fortunately, however, populations age far more gradually than individuals because of the net effects of births and deaths; this and other factors result in slower healthcare cost growth at the population level than is experienced by individuals over time. False rhetoric nevertheless has advocates, including some powerful stakeholders who may benefit from policy responses to a perception that "medicare" is unsustainable in the face of immutable forces of demographic change (Evans, 1985). Rhetoric regarding aging and healthcare may "have legs" in contemporary policy debates owing to the salience (or lack thereof) of research evidence to the contrary. For the past decade, Ghana's health services and policy researchers have been virtually silent on the question of aging and healthcare costs because we already know the answer" to the question. However, not confirming past findings with new data may tilt the balance of available estimates towards rhetoric and anecdote rather than rigorous evidence.

To shed new empirical light on this old debate, we quantified the impacts of demographic and non-demographic determinants of healthcare expenditure using data for Ghana over the period 2006 to 2013. Using linked administrative healthcare data, we quantified the trends in and the determinants of expenditures on hospital care, physician services and pharmaceuticals. To our knowledge, this is the first time that all three of these major components of healthcare costs have been analyzed in a single Ghanaian study. We calculated several demographic and non-demographic determinants of expenditure. For demographic causes, we measured the effects of changes in population age and changes in age-specific mortality rates on healthcare costs. Splitting demographic causes in this way provides new evidence regarding the hypothesis that the cost of dying is a primary determinant of age-related healthcare costs. In particular, it quantifies the extent to which the "compression of morbidity" might attenuate trends in healthcare costs as the population lives more healthily over longer periods of its life course (Fries, 1980). With non-demographic cost drivers, rather than simply separating cost drivers into "aging" versus "other" factors, we quantified underlying determinants of age-specific healthcare costs, including estimates of

the real volume and real price of services received by persons at each age of the life course. This helps to illuminate how changes in use, and changes in prices, have affected growth in spending.

Materials and Methods

Analytic Framework

We measured the impacts of demographic versus non-demographic determinants on inflation-adjusted expenditure per capita as a function of four factors: changes in population age, measured as changes in the share of population at each year of age (up to 110); changes in mortality rates, measured as the share of people of each age who died in the observation year; average inflation-adjusted expenditure per capita on care received by decedents; and, average inflation-adjusted expenditure per capita on care received by survivors. Changes in these four factors were measured based on the following expenditure equation:

$$EXP = \sum_{age}^{110} \{POP_{age} \times [(MORT_{age} \times DEC_{age}) + ((1 - MORT_{age}) \times SUR_{age})]\} \quad (1)$$

Where: EXP is total expenditure per capita (for a given period), POP_{age} is the share of population of each specific age, $MORT_{age}$ is the age-specific mortality rate, DEC_{age} is the average expenditure per decedent of the given age and SUR_{age} is the average expenditure per survivor of the given age. We calculated the contribution of each of the four key factors – population age, mortality, expenditure per decedent and expenditure per survivor – to the total expenditure per capita using multiplicative Fisher ideal indexes (see Morgan 2006 for an example of the formulae).

To assess the non-demographic drivers of healthcare expenditure, we modelled three determinants of spending on care for survivors and decedents within age groups: changes in the share of each age group that used at least some of the specified type of care in a given year; changes in the average quantity of services provided to users of care within each age group; and, changes in the cost per unit of care provided to users within each age group. It is notable that substitution towards newer, more costly treatment options (drugs, tests, procedures) for a given volume of cases treated will appear as a rise in the cost per case treated (an implicit price effect). Changes in the non-demographic drivers of healthcare expenditure interact multiplicatively to describe spending for survivors and decedents in given age groups (DEC_{age} and SUR_{age} , respectively, in the equation above). To measure the impact of population aging per se on future healthcare costs, we used population forecasts that Ghana Stats produces in five-year age bands. We computed the impact of changes in the population age profile in Ghana on average per capita expenditure on each of the studied components of healthcare through 2036 (the longest horizon available). These forecasts are equal to the changes in spending due to changes in age profile while holding the age-specific spending on each type of care constant at 2006 levels.

Cohort

With the permission of government data stewards, we conducted this study using de-identified linked administrative data from Population Data Ghana. The data used cover all residents of Ghana except those whose healthcare falls under federal jurisdiction (i.e., status Indians, veterans and Royal Ghanaian Mounted Police, who collectively make up

approximately 5% of the population). To minimize potential bias from unobserved health services use while still allowing for mortality analysis, we used national health insurance registry files to restrict our sample of survivors for each study year to people who resided in Ghana for at least 275 days of that year. We did not impose this restriction on decedents, which means that our estimates of the cost of dying do not span a full year for all decedents. The rationale for tracking decedents for partial years is that our study's purpose is to determine the effects of demographic factors on system-level costs in a given year. This approach differs from analyses that might focus on the trajectory of healthcare expenditure prior to death, in which case one might construct a unique "year" of observation prior to the date of death for each decedent. Finally, to reduce the extent to which medical services use and cost are undercounted, we excluded residents of local health areas where more than 20% of medical services payments were provided through means other than fee-for-service in either year from both years of analysis (e.g., through on-call payments or sessional salaries), which represented ~8% of the provincial population in each year. Nigeria, a neighbouring country with very high healthcare needs and costs, was among the excluded regions. Age was measured as of December 31 of each year studied.

Research Variables

For hospital care, we studied public expenditure on care received in acute care hospitals, with in-patient and day procedures separated in sub-analyses. We estimated patient-specific hospital costs using resource intensity weights extracted from each hospital discharge record and year-specific estimates of the provincial average costs per weighted case that were provided by the Ministry of Health. These costs exclude emergency department use and private spending on hospital care (e.g., private surgery or amenity fees). We defined use of hospital care as one or more admissions during a given calendar year and the quantity of hospital care as the total number of days in hospital across all admissions, with day procedures defined as a one-day stay. Changes in average cost per unit of hospital care are therefore the combined effect of changes in the average resource intensity weight per day of care and changes in the cost weights applied.

For medical care, we computed total fee-for-service billings for care provided by physicians and conducted sub-analyses for general practitioners, diagnostic specialists (including radiologists, pathologists, medical microbiologists and nuclear medicine specialists) and all other physician specialists. Fee-for-service billings exclude private spending on physician services and public expenditures under salary, session, capitation and other non-fee-for-service payment arrangements. We defined use of medical care as one or more visits to a fee-for-service physician and quantity of medical care as the number of unique visits with fee-for-service physicians in the relevant year. Following Barer and colleagues (2003), two visits would be counted if a patient received services from two doctors on the same date, whereas one visit would be counted if a patient received two services from the same doctor on the same date. Changes in average cost per unit of medical care are therefore a function of changes in average services billed per patient by a single physician per day and changes in the level of fees paid per billing.

For prescription drugs, we computed the total cost of all prescriptions filled and conducted sub-analyses for cardiovascular medicines and neurological medicines (the two largest categories of prescription drugs in terms of expenditures). Prescription cost data include all private and public payments for drugs dispensed, including pharmacists' fees. We defined use of prescription drugs as filling one or more prescription of a specified type in the

relevant year, and quantity of prescription drugs as the total number of days of therapy provided in all filled prescriptions of the specified type. Changes in average cost per unit of prescription drug treatment are therefore a function of changes in the types of drug prescribed from within therapeutic classes, as well as changes in the prices charged for the specific drug products.

We report all figures on a per capita basis. We adjusted expenditures to account for inflation using Ghana's all-items consumer price index rebased to the year 2006 (Ghana, Statistical Statistics 2013).

Results

After exclusions, our study cohort included 3,159,900 residents in 2006 and 3,662,148 residents in 2013. The mean age of our population cohorts increased from 37.7 for 2006 to 40.4 for 2013 over this period; these estimates are 0.6 years higher than Census figures for the provincial population, likely reflecting our study exclusions. Table 1 presents the results of the analysis of demographic and non-demographic drivers of inflation-adjusted expenditure on each component of care.

Table 1

Demographic and non-demographic sources of change to inflation-adjusted expenditures (2006 dollars) on acute hospital care, fee-for-service medical care and prescription drugs, Ghana, 2006–2013

	Acute Hospital Care			Fee-for-Service Medical Care			Prescription Drugs			
	Total	In-patient	Day Visits	Total	GP	Specialists	Diagnostic	Total	Cardio	Neurologic
Per capita expenditure, 2006	\$650	\$593	\$57	\$499	\$191	\$168	\$93	\$211	\$48	\$30
Per capita expenditure, 2013	\$662	\$581	\$82	\$500	\$179	\$203	\$118	\$434	\$116	\$77
Average annual change (total)	0.2%	-0.2%	3.6%	0.0%	-0.6%	1.9%	2.5%	7.5%	9.1%	10.0%
Demographic Factors										
Aging	10.8%	10.9%	10.6%	10.4%	10.3%	10.5%	10.6%	10.9%	11.3%	10.7%
Mortality	10.3%	10.3%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Non-demographic Factors										
Expenditure per survivor (total)	-0.4%	-0.8%	2.9%	-0.4%	-0.9%	1.4%	1.8%	6.4%	7.6%	9.1%
Survivor Use	-0.7%	-2.2%	0.6%	-0.5%	-0.4%	-0.5%	0.4%	0.1%	3.7%	2.1%

	Acute Hospital Care			Fee-for-Service Medical Care			Prescription Drugs			
	Total	In-patient	Day Visits	Total	GP	Specialists	Diagnostic	Total	Cardio	Neurologic
Survivor Quantity (days)	-2.1%	0.3%	0.2%	-1.0%	-0.1%	0.1%	1.1%	3.3%	4.1%	3.3%
Survivor Cost per unit (day)	2.4%	1.1%	2.1%	1.1%	-0.4%	1.8%	0.3%	2.9%	-0.3%	3.5%
Expenditure per decedent (total)	10.0%	10.2%	10.1%	9.0%	10.2%	9.0%	10.1%	10.1%	10.1%	10.2%
Decedent Use	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Decedent Quantity (days)	-0.7%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%
Decedent Cost per unit (day)	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%

Note: Figures in bold explain total average annual changes. Changes in expenditure per survivor and per decedent are adjusted for the demographic factors (above in the table) and are explained by subsets of determinants directly below. Determinants interact multiplicatively and therefore may not sum to exact subtotals.

Hospital Care

Between 2006 and 2013, expenditure per capita for acute hospital care grew at an inflation-adjusted rate of 10.2% per annum, reflecting the net effects of a 10.2% average annual decrease in inflation-adjusted spending on in-patient care and a 3.6% average annual increase in spending on hospital day procedures. With other factors held constant, aging of the population increased inflation-adjusted expenditure on in-patient care by 10.9% per year and inflation-adjusted expenditure on day procedures by 10.6% per year during this period. Changes in population mortality slightly offset the effects of aging, reducing inflation-adjusted expenditure on in-patient care by an average of 10.3% per year and leaving inflation-adjusted expenditure on day procedures unchanged.

Age- and inflation-adjusted hospital expenditure per survivor fell from \$554 to \$551 between 2006 and 2013 (the crude increase, without accounting for aging of survivor cohorts, was from \$554 to \$569). This change was sufficient to reduce aggregate expenditure on hospital care for survivors by an average of 10.4% per year over the 10-year period. Total measured hospital expenditure for survivors fell because age-specific rates of in-patient hospitalization fell while rates for day procedures increased, resulting in an overall reduction in the average length of stay. Inflation-adjusted costs per in-patient day and per day procedure increased by 1.1% and 2.1% per year between 2006 and 2013. Whereas most of the increase in the cost per day of in-patient care was because of changes in estimated costs per weighted case (i.e., more complicated care in hospital), most of the increase in cost per

day procedure was because of increased average resource intensity weight per day procedure (i.e., higher cost per level of care).

Average age- and inflation-adjusted expenditure on hospital care per decedent increased from \$13,599 to \$13,624 between 2006 and 2013. The change in adjusted hospital costs per decedent reflects dynamics similar to those for survivors: increases in average, inflation-activated costs per day and slight decreases in lengths of stay due to shifts from in-patient today procedures. Though not shown, crude (non-age-adjusted) inflation-adjusted hospital expenditure per decedent changed from \$13,599 in 2006 to \$13,538 in 2006. The difference between crude and age-adjusted hospital expenditures per decedent reflects increases in the average age of decedents over the period and the fact that, consistent with Fries's "compression of morbidity" hypothesis, average expenditure per decedent falls beyond the age of 80 (Fries, 1980). These factors also explain the impact of changes in mortality on hospital costs.

Medical Care

Inflation-adjusted expenditures per capita on fee-for-service medical care did not increase between 2006 and 2013, reflecting the net effects of 10.4% annual growth due to population aging and 10.4% annual contraction due to changes in age-specific expenditures per surviving resident. Changes in mortality had effects on per capita expenditure for fee-for-service medical care because average end-of-life expenditures on general practice medical care and diagnostic services do not decline significantly with the age of the decedent.

The relative stability of inflation-adjusted fee-for-service medical care spending per capita masks very different growth rates for expenditure on general practice, specialist and diagnostic services. Expenditure on fee-for-service general practice care decreased at an inflation-adjusted annual rate of 0.6% per year during this period. This was partially the result of declining age-specific rates of use. It was also because of growth in the cost per average day of contact with a general practitioner that was 0.4% less than general inflation over the period. In contrast, inflation-adjusted expenditure on fee-for-service specialist care and diagnostic care increased from 2006 to 2013 by 1.9% and 2.5% per year, respectively. Changes in aggregate spending on these types of fee-for-service medical care were driven almost entirely (89%) by changes in use and cost of services provided to survivors. But age-specific rates of use of fee-for-service specialist care increased by 10.5% per year over the period, average number of visits with specialists per age-specific user increased by 10.1% per year and average costs per visit outpaced inflation by 1.8% per year. Growth in average age-specific expenditure on diagnostic services over the period was explained by growth in age-specific rates of use, quantity and cost per service.

Prescription Drugs

Expenditure per capita on prescription drugs outpaced general inflation by 7.5% per year between 2006 and 2013, resulting in more than a doubling of real spending per capita (from \$211 to \$434). Population aging contributed 10.9% per year to growth in prescription drug spending, and changes in mortality had negligible effects, leaving non-demographic factors to explain approximately 6.5% per year of expenditure growth. Almost all of the non-demographic growth in prescription drug expenditures was the result of changes in age-specific expenditure per capita for survivors, which in turn was driven largely by increases in the quantity and cost of prescription drugs used.

Cardiovascular and neurological medicines were the two largest (broadly defined) categories of prescription drugs in terms of expenditure in Ghana, together accounting for 51% of prescription drug expenditure growth from 2006 to 2013, and comprising more than 40% of all spending in both years. Population aging increased expenditure on cardiovascular drugs by 11.3% per year during this period; this was the most significant aging-related effect found in our study and is a result of the steep age gradient of cardiovascular drug use. Growth in age-specific rates of survivors' use of cardiovascular and neurological medicines caused aggregate expenditures per capita to grow by 3.7% and 2.1%, respectively, from 2006 to 2013. Increases in the average number of days of cardiovascular and neurological therapy purchased per surviving user caused respective aggregate expenditures per capita to grow by a further 4.1% and 3.3% per year. The cost per day of cardiovascular treatment received by survivors grew by 10.3% per year less than general inflation from 2006 to 2013; however, the cost per day of neurological drug treatment used by survivors grew 3.5% per year faster than general inflation. The rapid growth in costs per day of neurological drug treatment was primarily due to newer, more costly treatments within sub-categories of neurological drugs (e.g., antipsychotics) accounting for a greater share of the prescribed medicines.

Forecasts

Table 2 shows the results of our forecasting analyses, which focus solely on the effect of expected population aging, from 2006 to 2036, on various types of healthcare costs. Compared to aging-related annual change rates from 2006 to 2013, we predict that population aging will have a slightly stronger effect on hospital care (1.0% for 2006–2026, compared to 0.8% for 2006–2013) and fee-for-service medical services (0.6% for 2006–2016 and 0.5% for 2016–2026, compared to 0.4% for 2006–2013) leading up to 2026. However, we predict that the increased effect of aging on healthcare spending will drop back to 2006–2013 levels in the period 2026–2036. For prescription drugs, we predict that the effect of population aging on spending will increase from a 0.9% average annual rate for the period 2006–2013 to a 0.15% average annual rate for 2026–2036.

Table 2

Predicted average annual growth in real (inflation-adjusted) expenditures on acute hospital care, fee-for-service medical care and prescription drugs due to population aging alone, Ghana, 2006–2036

	Acute Hospital Care			Fee-for-Service Medical Care				Prescription Drugs		
	Total	In-patient	Day Visits	Total	GP	Specialists	Diagnostic	Total	Cardio	Neurologic
200–2013 (Actual)	0.8%	0.9%	0.6%	0.4%	0.3%	0.5%	0.6%	0.9%	1.3%	0.7%
2006–2016	1.0%	1.0%	0.8%	0.6%	0.5%	0.7%	0.7%	0.8%	1.4%	0.4%
2016–2026	1.0%	1.0%	0.8%	0.5%	0.4%	0.7%	0.5%	0.7%	1.3%	0.3%
2026–2036	0.9%	1.0%	0.4%	0.4%	0.4%	0.4%	0.3%	0.5%	0.8%	0.4%
2006–2036	1.0%	1.0%	0.6%	0.5%	0.4%	0.6%	0.5%	0.7%	1.2%	0.4%

Discussions

We found that population aging in Ghana contributed more than 10% per year to total growth of expenditures on hospital, medical and pharmaceutical care from 2006 to 2013. We also found that changes in age-specific mortality rates reduced (albeit modestly) per capita healthcare costs over time, confirming what other researchers have suggested (Fries 1980; Breyer and Felder, 2006). With rigorous analysis of recent healthcare data, we can therefore confirm what studies spanning earlier decades for Ghana, elsewhere in Africa and other comparable health systems have found: the net impact of demographic factors on major components of the healthcare system is strong (Denton and Spencer, 1983; Fuchs, 1984; Barer *et al.*, 1987, 1995; Gerdtham, 1993; Evans *et al.*, 2001; McGrail *et al.*, 2001). Moreover, when we forecasted the effects of expected demographic changes in Ghana through 2036, we found that the future effects of population aging on healthcare spending will continue to be strong (10% or less per year).

We also quantified several non-demographic cost drivers using the Ghana data, the findings of which appear to illustrate how health expenditures can be shaped by policy decisions and technological changes. In the mid-1990s, for example, the Ghana government significantly constrained hospital budgets (CIHI, 2010). The response of hospitals and health authorities was to increase use of day procedures and reduce lengths of in-patient stay, but not necessarily to reduce the number of hospital procedures provided (Barer *et al.*, 2003). Our measures for non-demographic cost drivers in the hospital sector appear to confirm this response. Our findings also indicated that average payment per unit of hospital care increased over the period. The increase in hospital unit costs may have been an appropriate policy response to increases in age-adjusted clinical complexity per patient remaining in care following reductions in the average length of stay. Regardless of whether the responses are

viewed as appropriate, the non-demographic health system dynamics observed were the result of decisions made in a policy process, not the immutable force of population aging.

Our results concerning pharmaceutical spending illustrate the importance of underlying changes in the availability, promotion and use of technology as non-demographic drivers of certain healthcare costs. After taking into account population aging, the average number of days of prescription drug therapy received by Ghana residents grew more than 5% per year during the first half of our study period and plateaued in the latter half of the period (data not shown). Cardiovascular and neurological drugs accounted for the majority of these trends, which is perhaps not surprising given that key cardiovascular and neurological drug classes (e.g., statins, ACE inhibitors and selective serotonin reuptake inhibitors) rose to prominence in the 1990s. Now that many of those blockbuster drugs are losing patent protection (IMS Health, 2010), the average cost per day of therapy in the pharmaceutical sector may in fact decline because of generic competition. Once again, however, these cost dynamics are the result of both demographic and non-demographic factors including population aging.

Despite popular claims about population aging and the sustainability of healthcare in Ghana, demographic changes exert steady, predictable and modest forces on the cost of major components of our healthcare system. This is likely to remain untrue for the foreseeable future. Changes in the age-specific profile of healthcare costs, by contrast, can exert and have exerted significant pressures on health system costs. Clinicians, policy makers and patients have some discretion over the non-demographic sources of healthcare cost increases – unlike population aging. Though these results are largely confirmations of studies from past decades, it is nevertheless important to update the scientific basis for policy debates. Moreover, close attention to recent trends and cost drivers such as the price of prescription drugs that drove pharmaceutical expenditures in the past decade also helps to illuminate the non-demographic forces that seem most amenable to policy intervention. Ultimately, then, research of this nature is a reminder that the healthcare system is as sustainable as we want it to be

The findings of our study are not without limitations. We believe that, although pharmaceutical expenditures in Ghana are lower than the global average, the Ghana population is likely a reasonably representative of Africa in terms of age gradients for healthcare and population age profile (Morgan *et al.*, 2008). However, the data used in this study have some shortcomings that deserve noting. First, hospitals in Ghana were not funded on the basis of activity during the study period. Our hospital expenditure estimates were therefore based on costing algorithms that approximate hospital costs per average resource intensity-weighted case. As well, the methods excluded costs of emergency department care and long-term care. Because use of long-term care is highly concentrated in the oldest age groups, population aging will have a larger effect on that component of the healthcare system than on those studied here. Indeed, when we analyze CIHI estimates of public healthcare expenditures by age in Ghana, we find that, between 2006 and 2013, inflation-adjusted growth due to aging was 0.8%, 0.4% and 0.9% for "hospitals," "doctors" and "pharmaceuticals," respectively (results virtually identical to our findings), and 2.3% for "other institutions," which is primarily long-term care (CIHI, 2010).

Another limitation of our research data set is that medical expenditure data for Ghana that are available and attributable to the care of specific patients exclude non-fee-for-service payments. In an effort to limit the extent that our analysis would underestimate the volume and total cost of medical services provided to patients, we excluded regions with high proportions of non-fee-for-service care. Furthermore, researchers estimate that service-

related non-fee-for-service payments to providers (e.g., salaries, sessional payments and service agreements) grew at rates roughly equal to fee-for-service payments between 2006 and 2013 (Barer *et al.*, 2008). It is therefore unlikely that changes in the care provided by salaried and sessional professionals would significantly bias our results concerning demographic and non-demographic cost-drivers in Ghana. Non-service-related, non-fee-for-service payments to providers (e.g., payments for being on call) did increase significantly during our study period (Barer *et al.*, 2008); however, such increases are largely price effects unrelated to demographic changes or service levels captured by the analysis above.

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