Appendix

Contents

Appendix ................................................................................................................................................................................. 1
A. Detailed methods for estimating prescribed pharmaceutical expenditures for primary health care ...................... 1
B. Detailed methods for estimating inpatient vaginal delivery expenditures ................................................................. 14
C. Comparison of estimates of primary health care expenditures versus country reported primary health care expenditures from national health accounts .................................................................................... 21
D. Complete outcome/output fixed effects regression outputs ...................................................................................... 23
E. Binary relationships between PHC expenditures and outcomes/outputs .................................................................... 31
F. Sensitivity analyses: 10-year difference, Mundlak, and ambulatory split model outputs ............................................ 39
References ........................................................................................................................................................................ 45

A. Detailed methods for estimating prescribed pharmaceutical expenditures for primary health care

We used data from IQVIA Analytics Link to estimate the proportion of health expenditures on prescription pharmaceuticals that we considered part of PHC.\textsuperscript{1} IQVIA data obtained for our research contained prescribed pharmaceutical sales records for 49 countries, between 2014 and 2018. These expenditures were reported by the pharmaceutical molecule name as a total for the country and/or by the settings the prescriptions were purchased - hospitals or retailers. To identify the proportion of prescribed pharmaceutical expenditures for PHC within the IQVIA data, the molecule name was matched with the WHO Essential Medicine List.\textsuperscript{2} Any pharmaceuticals not matched with the Essential Medicine List were assumed not to be for PHC. Of the 460 pharmaceutical molecules in the WHO Essential Medicine List, 289 were matched within the IQVIA data. A complete list of countries within the IQVIA data and the settings reported, as well as a list of pharmaceutical molecules matched between the WHO Essential Medicine List and IQVIA found below.

We used Spatio-Temporal Gaussian Process Regression (ST-GPR) to estimate the proportion of prescribed pharmaceutical expenditures that are for PHC within hospitals, retailers, and as an aggregate for all countries between 2000 and 2017.\textsuperscript{3} We modelled expenditures for prescribed essential pharmaceuticals as a proportion of total prescription pharmaceutical expenditures reported in the IQVIA data, for retail and hospital settings separately and as an aggregate. All covariates considered were either from the Global Burden of Disease study or estimates produced by Schneider et al.\textsuperscript{4}[Schneider] Covariates considered for the linear first stage of ST-GPR for all models are shown in Table A.4. Covariates for each model were selected based on Akaike information criterion using the base step function in R version 3.6.0 and are presented in the appendix.

We applied these country-year, setting-specific estimates of the proportion of prescribed pharmaceuticals that are for PHC to the most appropriate cross-classification of health care function and provider expenditure estimates. For prescribed pharmaceutical expenditures (HC 5.1.1) within hospitals (HP 1) and ambulatory care providers (HP 3) we
multiplied the country-year specific estimate of prescribed medicines that are for PHC within hospitals. For prescribed pharmaceutical expenditures within retailers of medical goods (HP 5) we applied the country-year specific estimate of prescribed pharmaceutical that are for PHC within retailers. For all other health care providers with any amount of prescribed pharmaceutical expenditures we applied the average of the two settings – hospitals and retailers - for that given country-year.

Table A.1 Channels available by country in IQVIA Analytics Link

| Country               | Channel   |
|-----------------------|-----------|
| AUSTRALIA             | HOSPITAL  |
| AUSTRALIA             | RETAIL    |
| AUSTRIA               | HOSPITAL  |
| AUSTRIA               | RETAIL    |
| BELARUS               | HOSPITAL  |
| BELARUS               | RETAIL    |
| BELGIUM               | HOSPITAL  |
| BELGIUM               | RETAIL    |
| BOSNIA-HERZEGOVINA   | COMBINED  |
| BULGARIA              | HOSPITAL  |
| BULGARIA              | RETAIL    |
| CANADA                | HOSPITAL  |
| CANADA                | RETAIL    |
| CHINA                 | HOSPITAL  |
| CHINA                 | RETAIL    |
| CROATIA               | HOSPITAL  |
| CROATIA               | RETAIL    |
| CZECH REPUBLIC        | HOSPITAL  |
| CZECH REPUBLIC        | RETAIL    |
| FINLAND               | HOSPITAL  |
| FINLAND               | RETAIL    |
| FRANCE                | HOSPITAL  |
| FRANCE                | RETAIL    |
| GERMANY               | HOSPITAL  |
| GERMANY               | RETAIL    |
| HUNGARY               | HOSPITAL  |
| HUNGARY               | RETAIL    |
| INDIA                 | COMBINED  |
| INDONESIA             | HOSPITAL  |
| INDONESIA             | RETAIL    |
| IRELAND               | HOSPITAL  |
| IRELAND               | RETAIL    |
| ITALY                 | HOSPITAL  |
| Country         | Sector   |
|-----------------|----------|
| ITALY           | RETAIL   |
| JAPAN           | HOSPITAL |
| JAPAN           | RETAIL   |
| KAZAKHSTAN      | HOSPITAL |
| KAZAKHSTAN      | RETAIL   |
| LATVIA          | HOSPITAL |
| LATVIA          | RETAIL   |
| LITHUANIA       | HOSPITAL |
| LITHUANIA       | RETAIL   |
| MALAYSIA        | COMBINED |
| NETHERLANDS     | HOSPITAL |
| NETHERLANDS     | RETAIL   |
| NEW ZEALAND     | HOSPITAL |
| NEW ZEALAND     | RETAIL   |
| NORWAY          | HOSPITAL |
| NORWAY          | RETAIL   |
| PHILIPPINES     | HOSPITAL |
| PHILIPPINES     | RETAIL   |
| POLAND          | HOSPITAL |
| POLAND          | RETAIL   |
| PORTUGAL        | HOSPITAL |
| PORTUGAL        | RETAIL   |
| PUERTO RICO     | HOSPITAL |
| PUERTO RICO     | RETAIL   |
| ROMANIA         | HOSPITAL |
| ROMANIA         | RETAIL   |
| RUSSIA          | HOSPITAL |
| RUSSIA          | RETAIL   |
| SAUDI ARABIA    | HOSPITAL |
| SAUDI ARABIA    | RETAIL   |
| SERBIA          | COMBINED |
| SINGAPORE       | COMBINED |
| SLOVAK REPUBLIC | HOSPITAL |
| SLOVAK REPUBLIC | RETAIL   |
| SLOVENIA        | COMBINED |
| SOUTH AFRICA    | COMBINED |
| SOUTH KOREA     | HOSPITAL |
| SOUTH KOREA     | RETAIL   |
| SPAIN           | HOSPITAL |
| SPAIN           | RETAIL   |
| SWEDEN          | COMBINED |
| Country   | Type     |
|-----------|----------|
| Switzerland | Hospital |
| Switzerland | Retail   |
| Taiwan    | Hospital |
| Taiwan    | Retail   |
| Thailand  | Hospital |
| Thailand  | Retail   |
| Tunisia   | Hospital |
| Tunisia   | Retail   |
| Turkey    | Hospital |
| Turkey    | Retail   |
| UK        | Hospital |
| UK        | Retail   |
| USA       | Hospital |
| USA       | Retail   |
| Vietnam  | Hospital |
| Vietnam  | Retail   |

Table A.2 WHO essential medicines included in analysis

| Medicine                          |
|-----------------------------------|
| AMPHOTERICIN B                    |
| MICONAZOLE                        |
| NATAMYCIN                         |
| TETRACYCLINE                      |
| METRONIDAZOLE                      |
| CLOTRIMAZOLE                      |
| DOXYCYCLINE                       |
| DEXAMETHASONE                     |
| HYDROCORTISONE                    |
| EPINEPHRINE                       |
| ACETYL SALICYLIC ACID             |
| RANITIDINE                        |
| MISOPROSTOL                       |
| OMEPRAZOLE                        |
| ATROPINE                          |
| METOCLOPRAMIDE                    |
| ONDANSETRON                       |
| LACTULOSE                         |
| MANNITOL                          |
| NALOXONE                          |
| NYSTATIN                          |
| VANCOMYCIN                        |
| LOPERAMIDE                        |
| Medicine               |
|------------------------|
| Prednisolone           |
| Betamethasone          |
| Budesonide             |
| Beclometasone          |
| Sulfasalazine          |
| Metformin              |
| Gliclazide             |
| Ergocalciferol         |
| Colecalciferol         |
| Nicotinamide           |
| Calcium                |
| Warfarin               |
| Clopidogrel            |
| Tranexamic Acid        |
| Phytomenadione         |
| Hydroxocobalamin       |
| Folic Acid             |
| Dextran                |
| Blood Plasma           |
| Glucose                |
| Digoxin                |
| Lidocaine              |
| Buprenorphine          |
| Methyldopa             |
| Hydralazine            |
| Hydrochlorothiazide    |
| Furosemide             |
| Spironolactone         |
| Amiloride              |
| Tetracaine             |
| Propranolol            |
| Timolol                |
| Bisoprolol             |
| Amlodipine             |
| Nifedipine             |
| Verapamil              |
| Enalapril              |
| Losartan               |
| Simvastatin            |
| Griseofulvin           |
| Fluconazole            |
| Medication                  |
|----------------------------|
| TERBINAFINE                |
| FLUCYTOSINE                |
| CHLORAMPHENICOL           |
| GENTAMICIN                 |
| MUPIROCIN                  |
| AMIKACIN                   |
| ACICLOVIR                  |
| POVIDONE-IODINE            |
| IODINE                     |
| POTASSIUM PERMANGANATE     |
| ETHANOL                    |
| RETINOL                    |
| CLINDAMYCIN                |
| ERYTHROMYCIN               |
| DAPSONE                    |
| EFLORNITHINE               |
| VERMECTIN                  |
| ACETIC ACID                |
| ERGOMETRINE                |
| LEVONORGESTREL             |
| MEDROXYPROGESTERONE        |
| ETONOGESTREL               |
| OXYTOCIN                   |
| FLUDROCORTISONE            |
| PROPYLTHIOURACIL           |
| GLUCAGON                   |
| AMPICILLIN                 |
| AMOXICILLIN                |
| PENICILLIN V               |
| PENICILLIN G               |
| CLOXACILLIN                |
| CEFALEXIN                  |
| CEFAZOLIN                  |
| CEFOTAXIME                 |
| CEFTRIAXIME                |
| CEFTRIAXONE                |
| CEFIXIME                   |
| SULFADIAZINE               |
| SULFAMETHOXAZOLE + TRIMETHOPRIM |
| CLARITHROMYCIN             |
| AZITHROMYCIN               |
| OFLOXACIN                  |
| Drug Name                        |
|---------------------------------|
| CIPROFLOXACIN                   |
| NITROFURANTOIN                  |
| SPECTINOMYCIN                   |
| ITRACONAZOLE                    |
| VORICONAZOLE                    |
| RIFAMPICIN                      |
| RIFABUTIN                       |
| ISONIAZID                       |
| PYRAZINAMIDE                    |
| ETHAMBUTOL                      |
| ISONIAZID + PYRIDOXINE + RIFAMPICIN |
| ETHAMBUTOL + ISONIAZID + PYRAZINAMIDE + RIFAMPICIN |
| CLOFAZIMINE                     |
| RIBAVIRIN                       |
| VALGANCICLOVIR                  |
| RITONAVIR                       |
| ATAZANAVIR                      |
| DARUNAVIR                       |
| SIMEPREVIR                      |
| ZIDOVUDINE                      |
| LAMIVUDINE                      |
| ABACAVIR                        |
| TENOFOVIR DISOPROXIL            |
| ENTECAVIR                       |
| NEVIRAPINE                      |
| EFAVIRENZ                       |
| ABACAVIR + LAMIVUDINE           |
| LAMIVUDINE + NEVIRAPINE + ZIDOVUDINE |
| EFAVIRENZ + EMTRICITABINE + TENOFOVIR DISOPROXIL |
| LOPINAVIR + RITONAVIR           |
| EFAVIRENZ + LAMIVUDINE + TENOFOVIR DISOPROXIL |
| EMTRICITABINE + TENOFOVIR ALAFENAMIDE |
| RALTEGRAVIR                    |
| DOLUTEGRAVIR                    |
| DACLATASVIR                     |
| SOFOSBUVIR                      |
| DASABUVIR                       |
| LEDIPASVIR + SOFOSBUVIR         |
| OMBITASVIR + PARITAPREVIR + RITONAVIR |
| IMMUNOGLOBULIN ANTI-CORYNEBACTERIUM DIPHTHERIAE TOXIN |
| IMMUNOGLOBULIN ANTIVENOM SNAKES |
| VACCINE, CHOLERA                        |
| VACCINE, PNEUMOCOCCAL                   |
| VACCINE, TETANUS                        |
| VACCINE, TYPHOID                        |
| VACCINE, JAPANESE ENCEPHALITIS          |
| VACCINE, INFLUENZA                      |
| VACCINE, MEASLES                        |
| VACCINE, MUMPS                          |
| VACCINE, RABIES                         |
| VACCINE, ROTAVIRUS                      |
| VACCINE, RUBELLA                        |
| VACCINE, VARICELLA ZOSTER              |
| VACCINE, YELLOW FEVER LIVE              |
| FLUOROURACIL                            |
| VACCINE, TUBERCULOSIS                   |
| PENICILLAMINE                           |
| SUXAMETHONIUM                           |
| VECURONIUM BROMIDE                      |
| ATRACURIUM BESILATE                     |
| ALLOPURINOL                             |
| ISOFLURANE                              |
| FENTANYL                                |
| KETAMINE                                |
| PROPOFOL                                |
| BUPIVACAINE                             |
| MORPHINE                                |
| PARACETAMOL                             |
| PHENYTOIN                               |
| CARBAMAZEPINE                           |
| VALPROIC ACID                           |
| LAMOTRIGINE                             |
| BIPERIDEN                               |
| LEVODOPA                                |
| CHLORPROMAZINE                          |
| FLUPHENAZINE                            |
| HALOPERIDOL                             |
| RISPERIDONE                             |
| DIAZEPAM                                |
| MIDAZOLAM                               |
| CLOMIPRAMINE                            |
| AMITRIPTYLINE                           |
| FLUOXETINE         | NEOSTIGMINE    |
|-------------------|---------------|
| PILOCARPINE       | CHLOROQUINE   |
| PRIMAQUINE        | QUININE       |
| MEFLOQUINE        | ARTEMETHER    |
| ARTESUNATE        | ARTEMETHER + LUMEFANTRINE |
| BENZINIDAZOLE     | SODIUM STIBOGLUCONATE |
| NIFURTIMOX        | PRAZIQUANTEL  |
| MEBENDAZOLE       | ALBENDAZOLE   |
| PYRANTEL          | LEVAMISOLE    |
| PERMETHRIN        | BENZYL BENZOATE |
| XYLOMETAZOLINE    | IPRATROPIUM BROMIDE |
| SALBUTAMOL        | BUDESONIDE + FORMOTEROL |
| ACETYLCYSTEINE    | CODEINE       |
| CYCLIZINE         | LORATADINE    |
| ACETAZOLAMIDE     | LATANOPROST   |
| FLUORESCIN        | TROPICAMIDE   |
| PROTAMINE         | OXYGEN        |
| TUBERCULIN TEST   | IOHEXOL       |
| CHARCOAL          | ETHINYLESTRADIOL + LEVONORGESTREL |
| ETHINYLESTRADIOL + NORGESTIMATE | RIBOFLAVIN |
| ELECTROLYTE SOLUTIONS |           |
| SENNA          |          |
| -------------- | --------|
| PYRIDOXINE    |         |
| ULIPRISTAL ACETATE |      |
| THIAMINE       |         |
| ESTRADIOL + NORETHISTERONE | |
| ZINC           |         |
| NITROGLYCERIN  |         |
| ENOXAPARIN SODIUM |       |
| SENNA + SENNOSIDES A&B | |
| GLIMEPIRIDE + PIOGLITAZONE |    |
| EMPAGLIFLOZIN + LINAGLIPTIN |  |
| ALOGLIPTIN + METFORMIN |    |
| CANAGLIFLOZIN + METFORMIN |  |
| DAPAGLIFLOZIN + METFORMIN |  |
| EMPAGLIFLOZIN + METFORMIN |  |
| GEMIGLIPTIN + METFORMIN |   |
| LINAGLIPTIN + METFORMIN |  |
| METFORMIN + SAXAGLIPTIN |   |
| METFORMIN + SITAGLIPTIN |  |
| METFORMIN + VILDAGLIPTIN |  |
| ALOGLIPTIN + PIOGLITAZONE |   |
| VACCINE, TICK BORNE ENCEPHALITIS | |
| ETHAMBUTOL + ISONIAZID + PYRAZINAMIDE + RIFAMPICIN + STREPTOMYCIN | |
| ETHAMBUTOL + ISONIAZID + RIFAMPICIN | |
| ISONIAZID + PYRAZINAMIDE + RIFAMPICIN | |
| ISONIAZID + PYRIDOXINE |   |
| ISONIAZID + RIFAMPICIN |  |
| ADENOSINE TRIPHOSPHATE + ARGinine + COENZYME A + DEXTRAN + INSULIN HUMAN BASE | |
| ADENOSINE TRIPHOSPHATE + ARGinine + COENZYME A + DEXTRAN + INSULIN UNSPECIFIED BASE | |
| ADENOSINE TRIPHOSPHATE + COENZYME A + INSULIN HUMAN BASE |  |
| ADENOSINE TRIPHOSPHATE + COENZYME A + INSULIN UNSPECIFIED BASE |  |
| INSULIN ASPART |           |
| INSULIN ASPART + INSULIN ASPART PROTAMINE CRYSTALLINE | |
| INSULIN ASPART + INSULIN DEGLUDEC |   |
| INSULIN BOVINE BASE |   |
| INSULIN BOVINE ISOPHANE |  |
| INSULIN BOVINE PROTAMINE ZINC |  |
| INSULIN BOVINE ZINC SUSPENSION (COMPOUND) | |
| INSULIN BOVINE ZINC SUSPENSION (UNSPECIFIED) + INSULIN PORCINE ZINC SUSPENSION (UNSPECIFIED) | |
| INSULIN DEGLUDEC |   |
### Table A.3 WHO essential medicines not available in IQVIA Analytics Link

| Medicine                                                                 |
|--------------------------------------------------------------------------|
| POTASSIUM CHLORIDE                                                        |
| PAROMOMYCIN                                                              |
| ARTESUNATE AND AMODIAQUINE                                               |
| SODIUM NITRITE                                                           |
| BARIUM SULFATE CONTAINING X-RAY CONTRAST MEDIA                           |
| CHLOROXYLENOL                                                            |
| BARIUM SULFATE WITHOUT SUSPENDING AGENTS                                 |
| METHYLPHENOBARBITAL                                                      |
| HEPATITIS A, INACTIVATED, WHOLE VIRUS                                    |
| ETHAMBUTOL AND ISONIAZID                                                 |
| RIFAMPICIN AND ISONIAZID                                                 |
| MELARSOPROL                                                              |
| METHYLTHIONINIUM CHLORIDE                                                |
| CALCIUM GLUCONATE                                                        |
| DRUGS USED IN NICOTINE DEPENDENCE                                        |
| TRICLABENDAZOLE                                                          |
| VAGINAL RING WITH PROGESTOGEN AND ESTROGEN                                |
| POLIOMYELITIS VACCINES          |                      |
|---------------------------------|----------------------|
| DILOXANIDE                      |                      |
| HALOTHANE                       |                      |
| DIPHTHERIA VACCINES             |                      |
| NITROUS OXIDE                   |                      |
| PRUSSIAN BLUE                   |                      |
| TUBERCULOSIS DIAGNOSTICS        |                      |
| CHLORINE CONTAINING PRODUCTS    |                      |
| SILVER SULFADIAZINE             |                      |
| BENZATHINE BENZYLPECILLIN       |                      |
| TETANUS ANTITOXIN               |                      |
| LIDOCAINE, COMBINATIONS         |                      |
| PLASTIC IUD WITH COPPER         |                      |
| ZIDOVDUNIDE AND LAMIVUDINE      |                      |
| ARTESUNATE AND PYRONARIDINE     |                      |
| PENTAMIDINE ISETHIONATE         |                      |
| HEPATITIS VACCINES              |                      |
| MAGNESIUM SULFATE               |                      |
| DOCUSATE SODIUM                 |                      |
| DIETHYLCARBAMAZINE              |                      |
| ORAL REHYDRATION SALT FORMULATIONS |                  |
| SELENIUM SULFIDE                |                      |
| HEPATITIS B, PURIFIED ANTIGEN   |                      |
| SODIUM CHLORIDE                 |                      |
| MILTEFOSINE                     |                      |
| PLASTIC IUD WITH PROGESTOGEN    |                      |
| POTASSIUM IODIDE                |                      |
| SURAMIN SODIUM                  |                      |
| BARIUM SULFATE WITH SUSPENDING AGENTS |          |
| ARTESUNATE AND MEFLOQUINE       |                      |
| NICLOSAMIDE                     |                      |
| DICHLOROBENZYL ALCOHOL          |                      |
| AMODIAQUINE                     |                      |
| PROGUANIL                       |                      |
| RIFAPENTINE                     |                      |
### Table A.4 covariates considered

| Covariate                                                   | Transformation |
|-------------------------------------------------------------|----------------|
| DTP3 coverage proportion                                    | Logit          |
| Gross domestic product per capita                           | Natural log    |
| Lag-distributed income per capita                           | Natural log    |
| Healthcare access and quality index (HAQI)                  | Logit          |
| Primary health care spending per capita                     | Natural log    |
| Primary health care spending as a share of total health expenditure | Logit          |
| Primary health care spending excluding drugs per capita      | Natural log    |
| Primary health care spending excluding drugs as a share of total health expenditure | Logit          |
| Primary health care spending excluding prescription drugs per capita | Natural log    |
| Primary health care spending excluding prescription drugs as a share of total health expenditure | Logit          |
| Health spending in a hospital setting (HP1) per capita      | Natural log    |
| Health spending in a hospital setting (HP1) as a share of total health expenditure | Logit          |
| Health spending from providers of medical goods (HP5) per capita | Natural log    |
| Health spending from providers of medical goods (HP5) as a share of total health expenditure | Logit          |

### Table A.5 Covariates selected for each model

| Dependent variable                                                                 | Covariates selected                                                                 |
|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Total prescription drug spending on essential medicines as a proportion of total prescription drug spending | Gross domestic product per capita, HAQI, primary health care spending excluding prescription drugs as a share of total health expenditure, random effects on GBD region |
| Prescription drug spending on essential medicines in hospitals as a fraction of total prescription drug spending in hospitals | Primary health care spending excluding prescription drugs as a share of total health expenditure, health spending from providers of medical goods (HP5) as a share of total health expenditure |
| Prescription drug spending on essential medicines in retail setting as a fraction of total prescription drug spending in retail setting | Primary health care spending excluding prescription drugs as a share of total health expenditure, HAQI, health spending from providers of medical goods (HP5) as a share of total health expenditure |
B. Detailed methods for estimating inpatient vaginal delivery expenditures

SUMMARY

To incorporate inpatient vaginal delivery expenditures in our estimates of PHC, we derived country-specific volume and cost of inpatient vaginal and Cesarean-section delivery for all countries between 2000 and 2017. Although the cesarean section estimates were not included in our final definition of PHC, they were used as part of the process of estimating the cost and volume of inpatient vaginal delivery. The total number, or volume, of births by delivery method was drawn from 1,043 country-years of data from the Demographic and Health Surveys, Multiple Indicator Cluster Surveys, and online databases provided by the OECD, the Canadian Institute for Health Information, and the United States’ Healthcare Cost and Utilization Project.5–10 160 country-years of cost data were drawn from published literature, and three databases; Healthcare Cost and Utilization Project , Canadian Institute for Health Information , and Health Care Cost Institute.7,8,11

With these data we estimated the proportion of all deliveries that were inpatient vaginal deliveries and cesarean sections using Spatio-Temporal Gaussian Process Regression (ST-GPR)3. We multiplied the modeled proportions by the number of births from the Global Burden of Disease study to estimate the total number of inpatient vaginal and cesarean deliveries by country and year.12 In order to estimate the cost of inpatient vaginal deliveries, we found only 33 cost estimates specifically for inpatient vaginal deliveries. However, the cost of cesarean sections was found for 160 country-years. We first used ST-GPR to model a complete time-series of cesarean section costs. Then based country-years where both vaginal and cesarean section costs were available, we estimated the ratio of the inpatient vaginal to cesarean cost of delivery [for every country-year in the study]. This modeled ratio was then multiplied by the predicted costs of cesarean section to estimate the cost of vaginal delivery for each country and year. Finally, we multiplied the predicted volume and cost estimates to produce estimates of inpatient vaginal delivery expenditures.

INTRODUCTION

In order to estimate spending on inpatient vaginal deliveries, we utilized a cost * volume approach. We estimated the volume and unit cost of inpatient vaginal deliveries for 195 countries from 2000-2017, and then multiplied the predicted volume and cost for each country-year. This framework is illustrated below in equation 1.

\[
\text{Spending on Inpatient Vaginal Delivery} = N \times \text{Inpatient Vaginal Deliveries} \times \text{Cost of Inpatient Vaginal Delivery}
\]

In the sections that follow, we outline (1) our methods for estimating the volume of inpatient vaginal deliveries, (2) the methods used to estimate the unit cost of inpatient vaginal deliveries, and (3) how we combined these predictions to produce our final estimates of spending on inpatient vaginal delivery.

ESTIMATING VOLUME OF INPATIENT DELIVERY

Methods
To estimate the number of inpatient vaginal deliveries for 195 countries from 2000 to 2017, we ran three models to produce complete time series of the following proportions: the proportion of all deliveries that are (1) vaginal deliveries in an inpatient setting, (2) cesarean sections in an inpatient setting, and (3) either delivery type in an inpatient setting. The second and third fractions were not directly used, but were modeled in order to give strength to the predictions of the first through a process of raking. In order to estimate the total number of inpatient vaginal deliveries, the predicted fractions from the raked vaginal model were multiplied by the total number of births from the Global Burden of Disease study. This calculation is presented below in equation 2.

Equation 2

\[
\text{Inpatient Deliveries} = \frac{\text{Inpatient Deliveries}}{\text{Deliveries}} \times \text{Total Births}
\]

Sources of data

We extracted data from the following sources:

- Demographic and Health Surveys (DHS)
- Multiple Indicator Cluster Surveys (MICS)
- Online databases provided by the Organisation for Economic Co-operation and Development (OECD)
- Canadian Institute for Health Information (CIHI)
- Healthcare Cost and Utilization Project (HCUP)

Below in table B.1, we present the number of country-years of data by component that we used for each source. In the following sections, we briefly outline the differing ways in which we incorporated data from each source.

| Source  | Cesarean section | Inpatient Vaginal delivery | Total Inpatient delivery |
|---------|------------------|-----------------------------|-------------------------|
| DHS     | 457              | 457                         | 457                     |
| MICS    | 126              | 0                           | 0                       |
| OECD    | 448              | 0                           | 539                     |
| CIHI    | 5                | 5                           | 5                       |
| HCUP    | 7                | 7                           | 7                       |

DHS

Using the GHDx, we identified 86 DHS surveys with relevant data. For each birth year reported within each survey, we calculated the weighted proportion of all deliveries that were (1) cesarean sections in a hospital setting with a length of
stay greater than 24 hours (2) vaginal deliveries in a hospital setting with a length of stay greater than 24 hours, and (3) any delivery type that took place in a hospital setting with a length of stay greater than 24 hours. When two surveys contained data for the same year, we dropped the data point with fewer observations. Finally, we removed all country-years of data with 140 or fewer observations. Visual inspections made clear that country years with sample sizes below this threshold were inconsistent with the rest of the data and appeared not to be representative of the broader population. This resulted in a removal of 12% of the data. However, because these data points only occurred on the ends of a survey’s time range, this did not prevent us from using any of the identified surveys.

**MICS**

We utilized 55 MICS surveys with relevant data within the GHDx (http://ghdx.healthdata.org/). Although we identified MICS data on delivery location and whether the birth was a cesarean section, we were not able to identify data on the length of stay in the birthing facility. As such, we did not feel confident that this data had the capacity to accurately represent inpatient vaginal deliveries or total inpatient deliveries, especially since some encoded delivery locations were somewhat vague (e.g. “Hospital/clinic/health center”). However, since the surgical nature of cesarean sections implies that patients remain in a health facility for at least 24 hours, we used MICS surveys to calculate, for each birth year, the weighted proportion of all deliveries that were cesarean sections in a hospital setting. Finally, to establish consistency between the treatment of MICS and DHS, we removed all country years with 140 or fewer observations. This removed 34% of the data points. However, because these data points only occurred on one end of a survey’s time range, this only prevented us from utilizing 3 of the identified surveys.

**OECD**

OECD databases provided 448 and 539 country-years of data on the rates of in-hospital cesarean sections and the total number of inpatient deliveries, respectively. Because these data were drawn from distinct OECD sources, we did not subtract these data to calculate the number of inpatient vaginal deliveries. Cesarean section rates were drawn directly from the OECD online database. We used OECD data on hospital discharges to calculate the rate of inpatient deliveries. Specifically, we summed the number of discharges that were assigned one of the following diagnostic related groups; “Complications of pregnancy predominantly during labour and delivery”, “Single spontaneous delivery”, and “Other delivery.” In order to convert these sums to proportions, we divided them by the number of births from the Global Burden of Disease study. Finally, we manually outliered Norway’s total inpatient delivery data from 2011-2017, as these data represent a definitional break from the more robust, pre-2011 time series.

**CIHI and HCUP**

CIHI and HCUP are hospital databases from Canada and the US. Data from CIHI was downloaded directly. HCUP data was downloaded from the online querying system after the following selections were made: Get Quick Statistical Tables -> Inpatient -> National -> Do you want data on a specific diagnosis or procedure? : Yes -> MS-DRG -> Detailed Tables. Within each database, we summed the number of cesarean sections and vaginal deliveries by year and divided by these numbers by the number of births from the Global Burden of Disease study. We then summed these proportions to calculate the proportion of all deliveries that took place in an inpatient setting.

**Covariate Selection**

Once we compiled data from the above sources, we split the data into the parts, corresponding to the three fractions outlined above: the proportion of all deliveries that are (1) vaginal deliveries in an inpatient setting (2) cesarean sections...
in an inpatient setting, and (3) any delivery type in an inpatient setting. These fractions were modeled in logit space such that the predictions for each would remain bound between 0 and 1. Each of these fractions was modeled individually, and we performed covariate selection to identify the best set of covariates for each model.

In order to select each model’s covariates, the following process was undertaken for each of the three fractional dependent variables outlined above: We first conducted a lasso regression to determine which covariates were least correlated, conditional on other covariates, with the dependent variable. Covariates with an estimated coefficient of zero were removed from the set of possible covariates. We then used linear mixed effects regression to assess all possible models based on combinations of the remaining covariates. Next, we selected the intersection of the 1000 models with the lowest Akaike information criterion (AIC) and the 1000 models with the lowest Bayesian information criterion (BIC). Finally, we completed a 10-fold cross-validation with out-of-sample predictions each of these remaining models. We selected the best model based on out-of-sample root mean squared error. Model selection considered the following covariates for inclusion in each model: Antenatal Care (4 visits) Coverage (proportion), In-Facility Delivery (proportion), Lag distributed income per capita, Skilled Birth Attendance (proportion), Total Fertility Rate, Healthcare access and quality index, Maternal Education (years per capita), and Socio-demographic Index. All covariates were drawn from the Global Burden of Disease study. Covariates bound between 0 and 1 were logit transformed, while the others were log transformed. The final selected covariates for each delivery fraction are shown below in Table B.2. Random effects were determined a priori.

Table B.2

| Selected Covariates                                                                 |
|-------------------------------------------------------------------------------------|
| **Cesarean section**                                                                |
| Lag distributed income per capita, Maternal Education (years per capita),           |
| Antenatal Care (4 visits) Coverage (proportion), Skilled Birth Attendance (proportion), |
| Socio-demographic Index, and In-Facility Delivery (proportion), with random effects at the country, region, and super region levels. |
| **Inpatient Vaginal delivery**                                                      |
| Lag distributed income per capita, Maternal Education (years per capita),           |
| and Socio-demographic Index, with random effects at the region, and super region levels. |
| **Total Inpatient delivery**                                                        |
| Skilled Birth Attendance (proportion), Healthcare access and quality index, and In-Facility Delivery (proportion), with random effects at the country, region, and super region levels. |

**Modeling**

We modeled each of these logit-transformed delivery proportions (vaginal inpatient, cesarean inpatient, and total inpatient) using spatiotemporal Gaussian process regression (ST-GPR). ST-GPR generates a complete time-series of data for a set of locations, follows the data where it is available and borrows strength across time, geographic regions, and covariates’ predictive power when data is not available. STGPR has three primary steps. First, a linear mixed effects model is run with a given set of predictors. These first-stage models are displayed above in Table B.2. Predictions from the first step provide the general trend within the data. In the second step, spatiotemporal patterns are estimated by applying a series of spatiotemporal weights to average the residuals of the first step linear model. These spatiotemporal patterns are then added to the linear predictions to generate spatiotemporally smoothed predictions. Finally, the smoothed predictions are passed as the mean function to a Gaussian process regression along with the data to produce
final ST-GPR predictions. For every country-year for each model, 1,000 draws were generated from the Gaussian process regression model and used in subsequent calculations.

**Raking**

In order to strengthen the predictions of the volume of inpatient vaginal delivery, we raked the modeled vaginal and cesarean fractions such that they summed to the modeled inpatient delivery fraction. Raking was done at the draw level, such that the sum of draw 1 from the vaginal and cesarean proportions was forced equal draw 1 of the total inpatient delivery envelope. Draws were raked proportionally such that the original relationship between the vaginal and cesarean fractions was preserved.

**Final Calculation**

Once the country and year specific inpatient delivery fractions had been raked, we multiplied them by the total number of births from the Global Burden of Disease study to obtain the total number of inpatient vaginal deliveries, as illustrated in Equation 2. This multiplication was done at the draw level. Because these estimates were raked, the modeled total number of inpatient deliveries is equal to the predicted sum of the number of inpatient vaginal and cesarean deliveries.

**ESTIMATING THE COST OF INPATIENT VAGINAL DELIVERY**

**Summary of methods**

In order to estimate the cost of inpatient vaginal deliveries for 195 countries from 2000 to 2017, we conducted a literature review and extracted cost data from the existing research. Because data on the cost of inpatient vaginal deliveries was sparse, we leveraged more data on the cost of cesarean sections. Specifically, we modeled the extracted cesarean section costs to produce a complete time series, and then, using extracted data on the cost of vaginal deliveries in inpatient settings, scaled the modeled cesarean costs to estimate the cost of inpatient vaginal delivery.

**Sources of data**

Overall, we utilized 160 and 33 country-years of cesarean section and inpatient vaginal delivery unit costs, respectively. This data was drawn from 10 research articles and 3 databases. When aggregate volume and cost data were provided, we divided the two to estimate unit costs. When disaggregated unit costs were provided along with data weights (e.g. the cost of cesarean sections with and without complications, and the number or proportion of each), we took the weighted average of the disaggregate costs.

**Currency Conversion**

All final estimates are presented in 2017 United States dollars (USD). As such, it was necessary to convert all extracted cost data to 2017 USD. Data sources reported spending in either nominal local currency units (LCU) or nominal USD. To convert nominal LCU to USD, we applied deflators to nominal LCU to inflate to 2017 LCU. We then applied exchange rates to produce 2017 USD. When LCU were not reported, we extracted reported expenditure in nominal USD, applied corresponding nominal exchange rates to produce nominal LCU, inflated nominal LCU to 2017 LCU with deflators, and finally exchanged 2017 LCU to 2017 USD.

**Scaling data from Gibbons et al.**
Gibbons et al. (2010)\textsuperscript{20} was our main source of cesarean section costs, especially for low- and middle-income countries. However, this research only provided the additional cost of cesarean section over and above the cost of vaginal delivery, and as such, “none of the routine costs associated with antenatal care visits were included, nor were other services that would be considered part of normal vaginal delivery” (p.6). In order to use this data in our models, it was necessary to scale the raw data. We assumed that the data from Gibbons et al. was equal to the cost of cesarean section (CS) minus the cost of vaginal delivery (VD).

In order to scale this data to the full cost of cesarean sections, we multiplied this raw data by the scalar
\[ \rho = \frac{CS\ cost\ -\ VD\ cost}{CS\ cost}, \]
or the ratio between the full cost of cesarean sections and the additional cost of cesarean sections. We first calculated this ratio using data from sources which reported the full unit cost of both cesarean section and inpatient vaginal delivery. This calculation yielded 33 data points. We then ran a mixed effects linear regression on these 33 data points using lag-distributed income (LDI) from the Global Burden of Disease study as a covariate with random effects at the country level. Next, we used the resulting model along with data on LDI to predict this ratio, $\hat{\rho}$, for all country-years of data for which we had extracted data from Gibbons et al. Finally, we multiplied the raw data from Gibbons et al. by these predicted ratios to scale the additional cost of cesarean sections up to the full cost. This calculation is illustrated below in Equation 3, where $\hat{\rho}$ is the predicted ratio described above.

\begin{equation}
\text{CS cost}_{\text{Gibbons}} = \text{Gibbons raw data} \ast \hat{\rho}
\end{equation}

After scaling, we used visual inspection to outlier the costs from Iceland and Estonia, which were unreasonably high. The remaining 121 scaled data points from Gibbons et al. were appended to the rest of the extracted data, yielding a total of 160 data points on the cost of cesarean sections, spanning 151 country years.

\textbf{Caesarean Cost Modeling}

The methodology for modeling cesarean section costs was similar to that used in our volume models. The dependent variable in the cesarean section cost model was the natural log of the unit cost of cesarean sections. Covariates for this model were identified using the same methods as previously described for the volume models. Model selection considered the following covariates for inclusion in each model: Antenatal Care (4 visits) Coverage (proportion), In-Facility Delivery (proportion), Lag distributed income per capita, Skilled Birth Attendance (proportion), Total Fertility Rate, Healthcare access and quality index, Inpatient Unit Costs, Maternal Education (years per capita), and Socio-demographic index. Inpatient unit costs were drawn from Moses et al. (2018)\textsuperscript{23}, and all other covariates were drawn from the Global Burden of Disease study.\textsuperscript{4} Covariates bound between 0 and 1 were logit transformed, while the others were log transformed. The final selected model used the following covariates: Antenatal Care (4 visits) Coverage (proportion), Socio-demographic Index, Maternal Education (years per capita), Inpatient Unit Costs, with random effects at the country, region, and super region level. To detect and remove the influence of outlier data points, we used the selected model to measure Cooke’s distance for each data point. We excluded 7 data points whose Cook’s distance was greater than 4/n, where n is the total number of data points in the model. After removing these outlier points, we ran ST-GPR on the data, using the selected model as the first stage of ST-GPR. The workings of ST-GPR are described above in the section on volume modeling. For every country-year, 1,000 draws were generated and used in subsequent calculations.

\textbf{Calculating the Cost of Inpatient Vaginal Delivery}
We did not identify sufficient data on the cost of inpatient vaginal deliveries to directly model these data. As such, similar to the way in which we scaled the data from Gibbons et al. (2010)\textsuperscript{20}, we used the available raw cost data to scale down the modeled cost of cesarean sections to the cost of inpatient vaginal delivery. Specifically, we calculated the ratio

\[
\hat{\theta} = \frac{VD\text{ cost}}{CS\text{ cost}}
\]

using data from sources which provided both cesarean and inpatient vaginal costs. This calculation yielded 33 data points. We then ran a mixed effects linear regression to predict this ratio with lag-distributed income (LDI) from the Global Burden of Disease study as a covariate and random effects at the country level. Next, we used this model and data on LDI to predict the ratio \(\hat{\theta}\) for all 195 countries from 2000 to 2017. Finally, for each country-year, we applied this ratio to scale down the draws from the cesarean section cost model to the cost of inpatient vaginal delivery. This calculation is illustrated below in Equation 4.

\[
VD\text{ cost} = CS\text{ cost} \times \hat{\theta}
\]

TOTAL SPENDING ON INPATIENT VAGINAL DELIVERY

Calculating Total Spending

Before final calculations were done, the volume and cost models were vetted to ensure reasonable model fit using a custom Shiny app built in R. Once the best model versions were identified, the following steps were taken: The raked predictions of the number of inpatient vaginal deliveries were multiplied by the predicted costs of inpatient vaginal deliveries to yield total spending on inpatient vaginal deliveries, for each country-year. These calculations were done at the draw level to propagate uncertainty.

Adjusting the Estimates to Correspond with NHA Estimates

In order to ensure that our estimates correspond with existing estimates of inpatient spending, we compared the estimates of total inpatient delivery spending (cesarean + inpatient vaginal) to the predicted total inpatient spending from Schneider et al.\textsuperscript{24} (In order to generate estimates of total inpatient spending, we multiplied the modeled cesarean volume and cost estimates produced above and summed these with the modeled inpatient vaginal delivery estimates). In order to compare to the NHA envelope, we divided the predicted spending on inpatient delivery by the predicted total inpatient spending. We identified, by visual inspection, that this proportion fell below 0.6 for almost all country years; however, in some countries, the proportion exceeded 1. As such, we applied the following correction to the estimates of delivery spending: For all country-years where the mean spending on inpatient delivery was higher than 60\% of the total spending on inpatient care, we scaled down the draws of inpatient delivery spending such that (1) their new mean is 60\% of all inpatient spending and (2) no delivery spending draws exceed the predicted total spending on inpatient care. This adjustment was only necessary for 5 countries: Bangladesh, Myanmar, Nepal, South Sudan, and Yemen. Finally, we proportionally raked the draws of spending on inpatient vaginal delivery and cesarean section such that they sum to this newly adjusted total. This yielded the final estimates of inpatient vaginal delivery spending which were used as a component of the spending on primary health care.
C. Comparison of estimates of primary health care expenditures versus country reported primary health care expenditures from national health accounts

Based upon the national health accounts (NHAs) reviewed by Schneider et al, we extracted all instances of reported primary health are (PHC) expenditures from NHA reports. As definitions of PHC expenditure by countries who create NHAs varies, we attempted to categorize these expenditures based upon if the definition focused on the types of facilities or the services provided. All extracted PHC expenditures were converted to per capita 2017 US dollars as to be comparable with the PHC estimates provided within the main article of this research. Figure C.1 presents the comparison of the extracted expenditures (x-axis) and the estimated PHC expenditures (y-axis, which consider all PHC services irrelevant of the provider). Figure C.2 presents the comparison of the extracted expenditures (x-axis) and the estimated PHC expenditures within ambulatory settings (y-axis). We can see from these two figures that the PHC expenditures reported by countries align more closely with the definition of PHC expenditures in an ambulatory setting. It is unclear if this alignment is due to countries consciously defining their PHC expenditure estimate to the ambulatory setting or more driven by lack of clarity of health PHC services provided outside of ambulatory settings.

Figure C.1
Figure C.2

Comparing Estimates of PHC Expenditures Per Capita (2017 USD)

Extracted PHC Definition Category
- Facility level expenditures across platforms 1–3, includes population, community level expenditures, and health center expenditures
- Facility level expenditures across platforms 1–4, includes population, community level expenditures, as well as health center and first–level hospital
- Facility level expenditures across platforms 2–3, includes community level and health center expenditures
- Facility level expenditures across platforms 2–4, includes community level, health center expenditures, and first–level hospitals
- Service level expenditures for outpatients
- Service level expenditures for PHC services (defined by country)
- Facility level expenditures across platforms 1–3, and out–patients from platform 4

Primary Health Care Expenditures Per Capita: Data Extracted From NHAs
### D. Complete outcome/output fixed effects regression outputs

#### Low and Middle Income Countries: Fixed Effects: Health Outcomes

| Dependent variable: | All-age mortality | Communicable DALYs | Non-communicable DALYs | Diabetes Prevalence | Maternal mortality | Neonatal mortality | Under-5 mortality |
|---------------------|-------------------|--------------------|------------------------|---------------------|-------------------|-------------------|-------------------|
| PHC/THE             | 1.076             | 0.995              | 0.071                  | -0.846              | -10.309**         | -3.285            | -0.120            |
|                     | (0.819)           | (1.329)            | (0.391)                | (0.388)             | (1.681)           | (1.124)           | (1.167)           |
| THE per capita (log)| -0.020            | -0.065***          | 0.023**                | -0.008              | -0.028            | -0.077***         | -0.075**          |
|                     | (0.012)           | (0.019)            | (0.006)                | (0.006)             | (0.026)           | (0.017)           | (0.020)           |
| LDI per capita (log)| -0.150***         | -0.297***          | -0.121***              | -0.010              | -0.442***         | -0.213***         | -0.305***         |
|                     | (0.019)           | (0.039)            | (0.009)                | (0.007)             | (0.041)           | (0.028)           | (0.027)           |
| Fertility rate (log)| -0.031            | -0.063             | -0.027                 | -0.030              | -0.400***         | -0.337***         | -0.152*           |
|                     | (0.026)           | (0.044)            | (0.014)                | (0.013)             | (0.064)           | (0.041)           | (0.050)           |
| Hospital beds per 1000 (log) | -0.127***         | 0.082              | -0.131***              | -0.695***           | -0.120            | -0.057            |
|                     | (0.027)           | (0.052)            | (0.017)                | (0.085)             | (0.054)           | (0.046)           |
| Education yrs. per capita (log) | -0.200***         | -0.553***          | 0.164***               | -0.226              | -0.548***         | -0.751***         |
|                     | (0.037)           | (0.064)            | (0.020)                | (0.093)             | (0.074)           | (0.081)           |
| HIV Prevalence (log) | 0.053***          | 0.069***           | 0.004                  | 0.027***            | -0.003            | -0.106***         | -0.057***         |
|                     | (0.006)           | (0.013)            | (0.003)                | (0.004)             | (0.020)           | (0.010)           | (0.011)           |
| Urbanicity (logit)  | -0.084*           | -0.158***          | -0.031                 | -0.024*             | -0.139            | -0.075            | -0.174***         |
|                     | (0.023)           | (0.037)            | (0.011)                | (0.007)             | (0.052)           | (0.027)           | (0.040)           |
| OOP as a share of THE (logit) | -0.006            | -0.009             | -0.036                 | 0.003               | 0.004             |
|                     | (0.012)           | (0.003)            | (0.016)                | (0.009)             | (0.010)           |
| GHES as a share of THE (logit) | -0.0001           | -0.025             | 0.006                  | 0.004               | -0.044***         | -0.027*           |
|                     | (0.006)           | (0.010)            | (0.003)                | (0.002)             | (0.012)           | (0.008)           | (0.009)           |
| Population over 65 (logit) | 0.112***          | 0.145***           | 0.027                  | -0.050***           | 0.213***          | -0.118***         | 0.055             |
|                     | (0.023)           | (0.035)            | (0.010)                | (0.012)             | (0.048)           | (0.033)           | (0.045)           |
| Observations        | 2,430             | 2,430              | 2,430                  | 2,430               | 2,430             | 2,414             | 2,430             |
| R²                  | 0.152             | 0.224              | 0.141                  | 0.110               | 0.218             | 0.289             | 0.205             |
| Adjusted R²         | 0.092             | 0.169              | 0.080                  | 0.046               | 0.162             | 0.238             | 0.148             |

*Note:* *p<0.05; **p<0.01; ***p<0.001
## Low and Middle Income Countries: Fixed Effects: Health Outputs

| Dependent variable: | HAQ Index | Health worker Density | Smoking Prevalence | UHC index | ANC4 coverage | ART Coverage | DTP3 coverage | Measles vaccine Coverage | SBA coverage |
|---------------------|-----------|-----------------------|-------------------|-----------|---------------|--------------|---------------|------------------------|-------------|
| PHC/THE             | 1.294*    | -1.072                | -0.954            | -0.249    | 12.556***     | -10.301      | 9.311          | 20.975***              | -2.713      |
|                     | (0.415)   | (0.622)               | (0.627)           | (0.573)   | (2.223)       | (10.507)     | (4.982)        | (4.927)                | (3.364)     |
| THE per capita (log)| -0.010    | 0.129***              | 0.009             | 0.002     | 0.232***      | 0.552*       | 0.212*         | 0.560***               | 0.154*       |
|                     | (0.007)   | (0.009)               | (0.011)           | (0.010)   | (0.036)       | (0.176)      | (0.069)        | (0.080)                | (0.051)     |
| LDI per capita (log)| 0.216***  | 0.289***              | 0.018             | 0.165***  | 0.474***      | 1.122**      | -0.426*        | 0.941***               |             |
|                     | (0.10)    | (0.018)               | (0.017)           | (0.014)   | (0.053)       | (0.291)      | (0.125)        | (0.082)                |             |
| Fertility rate (log)| -0.082*** | -0.331***             | 0.136***          | 0.074**   | -0.355***     | 1.816***     | -0.362         | -0.902***              | -0.787***   |
|                     | (0.016)   | (0.025)               | (0.027)           | (0.020)   | (0.082)       | (0.408)      | (0.242)        | (0.256)                | (0.098)     |
| Hospital beds per 1000 (log) | 0.077*** | 0.209***              | 0.088             | -0.026    | -0.123        | 0.687        | -0.718*        | -1.375***              | 1.037***    |
|                     | (0.018)   | (0.029)               | (0.034)           | (0.021)   | (0.106)       | (0.509)      | (0.213)        | (0.259)                | (0.150)     |
| Education yrs. per capita (log) | 0.469*** | -0.070                | -0.010            | 0.202***  | 1.085***      | 5.917***     | 2.183***       | 2.273***               | 1.356***    |
|                     | (0.028)   | (0.044)               | (0.045)           | (0.033)   | (0.123)       | (0.674)      | (0.273)        | (0.349)                | (0.143)     |
| HIV Prevalence (log) | -0.008    | 0.025***              | 0.024*            | -0.061*** | 0.147***      | 0.125        | -0.004         | 0.079                  |             |
|                     | (0.005)   | (0.006)               | (0.007)           | (0.005)   | (0.026)       | (0.115)      | (0.048)        | (0.027)                |             |
| Urbanicity (logit)  | 0.103***  | 0.097***              | 0.065***          | 0.420***  | -0.562        | 0.683***     | 0.380          | -0.050                 |             |
|                     | (0.015)   | (0.017)               | (0.018)           | (0.069)   | (0.380)       | (0.110)      | (0.144)        | (0.095)                |             |
| OOP as a share of THE (logit) | -0.018*  | -0.014                | 0.011             | -0.008    | 0.355         | -0.112       | 0.068          | -0.092*                |             |
|                     | (0.005)   | (0.006)               | (0.007)           | (0.006)   | (0.126)       | (0.039)      | (0.044)        | (0.030)                |             |
| GHES as a share of THE (logit) | -0.005   | -0.002                | -0.009            | 0.042     | 0.258         | 0.174***     | 0.144***        |             |
|                     | (0.004)   | (0.006)               | (0.006)           | (0.016)   | (0.108)       | (0.038)      | (0.025)        |             |
| Population over 65 (logit) | -0.060*** | 0.004                | -0.081*           | -0.162*** | 0.547***      | -2.897***    | 0.135          | -0.114                 | 0.056       |
|                     | (0.011)   | (0.021)               | (0.027)           | (0.017)   | (0.064)       | (0.384)      | (0.179)        | (0.164)                | (0.081)     |
| Observations        | 2,430     | 2,430                  | 2,430             | 2,430     | 2,430         | 2,430        | 2,430          | 2,430                  | 2,430       |
| R²                  | 0.503     | 0.429                  | 0.049             | 0.281     | 0.252         | 0.138        | 0.072          | 0.082                  | 0.263       |
| Adjusted R²         | 0.467     | 0.388                  | -0.019            | 0.230     | 0.199         | 0.076        | 0.007          | 0.017                  | 0.210       |

**Note:** *p<0.05; **p<0.01; ***p<0.001
| Variable | All-age mortality | Communicable DALYs | Non-communicable DALYs | Diabetes Prevalence | Maternal mortality | Neonatal mortality | Under-5 mortality |
|----------|------------------|--------------------|------------------------|--------------------|-------------------|-------------------|------------------|
| PHC/THE  | 4.707            | 5.110              | 3.663***               | -0.120            | -4.977            | -6.343*           | 0.135            |
|          | (1.602)          | (2.054)            | (0.459)                | (0.563)           | (2.204)           | (1.915)           | (3.045)          |
| THE per capita (log) | -0.010           | -0.057             | 0.025                  | -0.017            | 0.0003            | -0.162***         | -0.219***        |
|          | (0.020)          | (0.028)            | (0.010)                | (0.007)           | (0.032)           | (0.022)           | (0.039)          |
| LDI per capita (log) | -0.198***        | -0.464***          | -0.132***              | -0.279**          | -0.044            | -0.219***         |                 |
|          | (0.034)          | (0.056)            | (0.016)                | (0.071)           | (0.037)           | (0.054)           |                 |
| Fertility rate (log) | 0.174            | 0.379*             | 0.101*                 | 0.051             | 0.259             | 0.222             |                 |
|          | (0.090)          | (0.112)            | (0.033)                | (0.148)           | (0.133)           | (0.186)           |                 |
| Hospital beds per 1000 (log) | -0.022           | -0.253*            | -0.127***              | 0.016             | -0.283            | -0.479***         |                 |
|          | (0.051)          | (0.074)            | (0.030)                | (0.020)           | (0.098)           | (0.089)           |                 |
| Education yrs. per capita (log) | 0.355*           | 0.291              | 0.054                  | 0.444*            | -0.483***         | 0.373             |                 |
|          | (0.111)          | (0.126)            | (0.036)                | (0.130)           | (0.081)           | (0.234)           |                 |
| HIV Prevalence (log) | 0.115***         | 0.153***           | 0.043***               | 0.050***          | 0.012             | 0.011             | 0.034            |
|          | (0.017)          | (0.022)            | (0.007)                | (0.008)           | (0.027)           | (0.013)           | (0.030)          |
| Urbanicity (logit) | -0.854***        | -0.856***          | -0.703***              | -0.544***         | -0.876***         |                 |                 |
|          | (0.086)          | (0.123)            | (0.145)                | (0.102)           | (0.164)           |                 |                 |
| OOP as a share of THE (logit) | -0.040**         | -0.062*            | -0.00000               | -0.051            | -0.034            | -0.101***         |                 |
|          | (0.011)          | (0.018)            | (0.005)                | (0.017)           | (0.013)           | (0.022)           |                 |
| GHEs as a share of THE (logit) | 0.031*           | 0.011              | 0.011                  | 0.004             | 0.016             | 0.005             | 0.042            |
|          | (0.010)          | (0.017)            | (0.004)                | (0.004)           | (0.017)           | (0.012)           | (0.014)          |
| Population over 65 (logit) | 0.158            | -0.059             | -0.047                 | -0.001            | 0.209*            | 0.128             |                 |
|          | (0.074)          | (0.025)            | (0.025)                | (0.112)           | (0.066)           | (0.182)           |                 |
| Observations | 558              | 558                | 558                    | 558               | 542               | 558               |                 |
| R²       | 0.422            | 0.528              | 0.271                  | 0.232             | 0.376             | 0.266             |                 |
| Adjusted R² | 0.355            | 0.474              | 0.189                  | 0.149             | 0.303             | 0.161             |                 |

Note: *p<0.05; **p<0.01; ***p<0.001
### Low Income Countries: Fixed Effects: Health Outputs

| Dependent variable: | HAQ Index | Health worker Density | Smoking Prevalence | UHC index | ANC4 coverage | ART Coverage | DTP3 coverage | Measles Vaccine Coverage | SBA coverage |
|---------------------|-----------|-----------------------|-------------------|-----------|---------------|--------------|--------------|--------------------------|-------------|
| PHC/THE             | -0.356    | 1.490                 | -0.613            | -4.600**  | 25.842***     | 37.829       | -20.041       | 12.309                   | -2.972      |
|                     | (1.026)   | (1.086)               | (1.439)           | (1.304)   | (4.371)       | (15.600)     | (11.131)     | (6.875)                  | (4.286)     |
| THE per capita (log)| 0.028     | 0.190***              | -0.025            | 0.036     | 0.473***      | 1.080**      | 0.120         | 0.737***                 | 0.160       |
|                     | (0.015)   | (0.014)               | (0.023)           | (0.020)   | (0.059)       | (0.175)      | (0.145)      | (0.106)                  | (0.077)     |
| LDIP per capita (log)| 0.287***  | 0.187***              | 0.011             | 0.334***  | 0.752***      | 1.158'       |              |                          | 1.423***    |
|                     | (0.028)   | (0.030)               | (0.048)           | (0.036)   | (0.114)       | (0.364)      |              |                          | (0.148)     |
| Fertility rate (log)| 0.312***  | 0.029                 | 0.146             | 1.260***  | 2.134'        | 1.126        | 0.244         | 1.604***                 | 0.296       |
|                     | (0.056)   | (0.074)               | (0.054)           | (0.280)   | (0.645)       | (0.459)      | (0.322)      | (0.296)                  |             |
| Hospital beds per 1000 (log)| -0.510*** | -0.044 | -0.127 | 0.341 | 1.874 | 0.320 | 2.193*** |                       |             |
|                     | (0.056)   | (0.074)               | (0.083)           | (0.294)   | (0.783)       | (0.471)      | (0.399)      |                          |             |
| Education yrs. per capita (log)| 0.207 | -0.128 | 0.276' | 0.319'' | 1.743*** |                      | -1.013' | (0.296) |
|                     | (0.080)   | (0.075)               | (0.091)           | (0.086)   | (0.417)       |             |              |                          |             |
| HIV Prevalence (log)| -0.046**  | -0.032 | -0.140*** | -0.083 |                      | -0.082 | (0.053) |
|                     | (0.013)   | (0.012)               | (0.020)           | (0.070)   |             |              |              |                          |             |
| Urbanicity (logit) | 0.209     | 0.184**              | -0.231            | -1.394*** | 1.790       | 1.942''      | 2.685***     |                          |             |
|                     | (0.074)   | (0.053)               | (0.100)           | (0.263)   | (0.807)       | (0.558)      | (0.350)      |                          |             |
| OOP as a share of THE (logit)| 0.016 | -0.037 | 0.044'' | 0.436'' | -0.102 | 0.422*** | 0.003 | (0.041) |
|                     | (0.010)   | (0.016)               | (0.012)           | (0.114)   | (0.067)       | (0.075)      | (0.041)      |                          |             |
| GHEs as a share of THE (logit)| -0.019 | -0.010 | 0.028 | 0.112' | -0.239 |                      | (0.066) | (0.096) |
|                     | (0.009)   | (0.007)               | (0.013)           | (0.033)   | (0.033)       |             |              |                          |             |
| Population over 65 (logit)| 0.072 | -0.047 | -0.095 | 1.359*** | 0.961 | 0.116 | 1.380' | 0.547 | (0.186) |
|                     | (0.034)   | (0.034)               | (0.051)           | (0.174)   | (0.560)       | (0.384)      | (0.402)      |                          |             |

**Observations**: 558

**R²**: 0.429

**Adjusted R²**: 0.363

**Note**: *p<0.05; **p<0.01; ***p<0.001
### Lower Middle Income Countries: Fixed Effects: Health Outcomes

| Dependent variable: | All-age mortality | Communicable DALYs | Non-communicable DALYs | Diabetes Prevalence | Maternal mortality | Neonatal mortality | Under-5 mortality |
|---------------------|-------------------|--------------------|------------------------|--------------------|-------------------|-------------------|------------------|
| PHC/THE             | -2.925            | -6.658**           | -1.392                 | -1.227**           | -4.550            | -4.320***         | -3.892*          |
|                     | (1.048)           | (1.847)            | (0.495)                | (0.349)            | (1.470)           | (0.975)           | (1.282)          |
| THE per capita (log)| -0.023            | -0.043             | 0.003                  | 0.001              | 0.102             | -0.039            | -0.027           |
|                     | (0.021)           | (0.032)            | (0.009)                | (0.006)            | (0.036)           | (0.017)           | (0.020)          |
| LDI per capita (log)| -0.041            | -0.170             | -0.083***              | -0.430***          | -0.129***         | -0.215***         |                  |
|                     | (0.038)           | (0.062)            | (0.014)                | (0.048)            | (0.028)           | (0.028)           |                  |
| Fertility rate (log)| -0.061            | -0.013             | -0.096***              | -0.324**           | -0.256***         | -0.110            |                  |
|                     | (0.048)           | (0.096)            | (0.020)                | (0.086)            | (0.058)           | (0.060)           |                  |
| Hospital beds per 1000 (log)| -0.103 | -0.015 | -0.062 | -0.181 | 0.142 |
|                     | (0.040)           | (0.022)            | (0.032)                | (0.079)            |                  |                  |                  |
| Education yrs. per capita (log)| -0.170 | -0.040 | 0.151*** | 0.256 | -0.635*** | -0.875*** |
|                     | (0.071)           | (0.031)            | (0.030)                | (0.120)            | (0.091)           | (0.083)           |                  |
| HIV Prevalence (log)| 0.058***          | 0.081***           | -0.002                 | 0.001              | -0.018            | -0.059***         | -0.005           |
|                     | (0.009)           | (0.019)            | (0.004)                | (0.005)            | (0.016)           | (0.012)           | (0.012)          |
| Urbanicity (logit)  | -0.062            | -0.164             | -0.001                 | -0.038             | 0.017             | -0.087            | -0.202*          |
|                     | (0.045)           | (0.092)            | (0.024)                | (0.019)            | (0.060)           | (0.055)           | (0.057)          |
| OOP as a share of THE (logit)| 0.057 | 0.007 | 0.0004 | -0.008 | 0.022 |
|                     | (0.021)           | (0.005)            | (0.005)                | (0.010)            | (0.012)           |                  |                  |
| GHES as a share of THE (logit)| 0.007 | 0.022 | 0.007 | 0.003 | 0.037 | -0.003 |
|                     | (0.008)           | (0.017)            | (0.003)                | (0.003)            | (0.013)           | (0.009)           |                  |
| Population over 65 (logit) | 0.058 | 0.126 | 0.037 | -0.085*** | -0.244* | -0.195*** | -0.054 |
|                     | (0.039)           | (0.070)            | (0.022)                | (0.020)            | (0.078)           | (0.040)           | (0.053)          |
| Observations        | 846               | 846                | 846                    | 846                | 846               | 846               | 846              |
| R²                  | 0.103             | 0.146              | 0.153                  | 0.162              | 0.273             | 0.264             | 0.389            |
| Adjusted R²         | 0.018             | 0.066              | 0.073                  | 0.083              | 0.204             | 0.195             | 0.332            |

Note: *p<0.05; **p<0.01; ***p<0.001
### Lower Middle Income Countries: Fixed Effects: Health Outputs

| Dependent variable: | HAQ Index | Health worker Density | Smoking Prevalence | UHC index | ANC4 coverage | ART Coverage | DTP3 coverage | Measles Vaccine Coverage | SBA coverage |
|---------------------|-----------|-----------------------|-------------------|----------|--------------|--------------|---------------|--------------------------|-------------|
| **PHC/THE**         | 0.486     | -1.454                | -1.737            | 1.708    | 13.403       | 4.895        | -17.829       | 15.894                   | 10.090†     |
|                     | (0.746)   | (1.073)               | (1.163)           | (1.217)  | (3.071)      | (7.457)      | (8.811)       | (3.180)                  |
| **THE per capita (log)** | -0.061*** | 0.079***              | -0.025            | -0.058*  | 0.126        | -0.057       | -0.043        | 0.437                  | 0.325***    |
|                     | (0.012)   | (0.019)               | (0.020)           | (0.019)  | (0.077)      | (0.350)      | (0.151)       | (0.148)                  |
| **LDI per capita (log)** | 0.254*** | 0.317***              | 0.033             | 0.201*** | 1.553        | 0.130        | -0.314        |                         |
|                     | (0.019)   | (0.033)               | (0.026)           | (0.028)  | (0.111)      | (0.545)      | (0.193)       | (0.224)                  |
| **Fertility rate (log)** | 0.017     | -0.582***            | 0.476***          | 0.210*** | 2.976***     | -2.139**     | -3.825***     | -0.935***               |
|                     | (0.028)   | (0.047)               | (0.059)           | (0.044)  | (0.636)      | (0.548)      | (0.564)       | (0.187)                  |
| **Hospital beds per 1000 (log)** | 0.152     | 0.038                 | -0.504            | 2.358    | 15.894       |              |               |                          |
|                     | (0.065)   | (0.038)               | (1.009)           |          |              |              |               |                          |
| **Education yrs. per capita (log)** | 0.451*** | -0.497***            | 0.063             | 0.019    | 1.569        | -0.038       | 0.668         |                         |
|                     | (0.048)   | (0.086)               | (0.089)           | (0.061)  | (0.236)      | (0.568)      | (0.575)       | (0.287)                  |
| **HIV Prevalence (log)** | 0.024*** | 0.041**              | -0.046***         | -0.679** | 0.045        | 0.108        | -0.004        |                         |
|                     | (0.005)   | (0.010)               | (0.009)           | (0.196)  | (0.086)      | (0.087)      | (0.053)       |                          |
| **Urbanicity (logit)** | 0.086     | -0.156                | 0.109             | 0.159    | 0.395        | 1.161**      | 0.493         |                         |
|                     | (0.036)   | (0.053)               | (0.062)           | (0.050)  | (0.153)      | (0.324)      | (0.175)       |                          |
| **OOP as a share of THE (logit)** | -0.050*** | -0.025                | 0.004             | -0.057*** |              | 0.103        |               |                          |
|                     | (0.007)   | (0.015)               | (0.013)           | (0.010)  |              | (0.039)      |               |                          |
| **GHES as a share of THE (logit)** | -0.003    | -0.030                | -0.034***         | -0.021   | 0.489        | 0.185        | 0.197         | 0.021                  |
|                     | (0.005)   | (0.010)               | (0.008)           | (0.027)  | (0.184)      | (0.080)      | (0.067)       | (0.028)                  |
| **Population over 65 (logit)** | 0.016     | 0.066                 | 0.028             | -0.119†  | 0.787***     | -2.383       | -0.151        | -0.431                 |
|                     | (0.024)   | (0.047)               | (0.048)           | (0.038)  | (0.144)      | (0.846)      | (0.308)       | (0.294)                 |

| Observations | 846 | 846 | 846 | 846 | 846 | 846 | 846 | 846 |
| R²           | 0.545 | 0.425 | 0.174 | 0.261 | 0.212 | 0.103 | 0.130 | 0.184 | 0.159 |
| Adjusted R²  | 0.502 | 0.370 | 0.097 | 0.190 | 0.140 | 0.020 | 0.051 | 0.108 | 0.079 |

*Note:* *p<0.05; **p<0.01; ***p<0.001
## Upper Middle Income Countries: Fixed Effects: Health Outcomes

### Dependent variable:

|                         | All-age mortality | Communicable DALYs | Non-communicable DALYs | Diabetes Prevalence | Maternal mortality | Neonatal mortality | Under-5 mortality |
|-------------------------|-------------------|--------------------|------------------------|--------------------|--------------------|-------------------|-------------------|
| PHC/THE                 | 0.847             | -1.078             | 0.476                  | -1.453             | -24.442***        | -3.664            | -2.106            |
|                         | (1.297)           | (2.074)            | (0.597)                | (0.777)            | (2.449)           | (2.014)           | (1.863)           |
| THE per capita (log)    | -0.006            | -0.054             | 0.041***               | -0.004             | -0.130            | -0.006            | 0.004             |
|                         | (0.019)           | (0.030)            | (0.009)                | (0.009)            | (0.050)           | (0.033)           | (0.031)           |
| LDI per capita (log)    | -0.178***         | -0.281**           | -0.148***              | -0.377***          | -0.259***         | -0.330***         |                  |
|                         | (0.029)           | (0.074)            | (0.018)                | (0.088)            | (0.059)           | (0.048)           |                  |
| Fertility rate (log)    | -0.086            | -0.352***          | -0.083**               | -0.784***          | -0.451***         | -0.432***         |                  |
|                         | (0.033)           | (0.067)            | (0.022)                | (0.109)            | (0.075)           | (0.069)           |                  |
| Hospital beds per 1000 (log) | -0.199***       | 0.088              | -0.171***              | -1.179***          | -0.339***         | -0.197            |                  |
|                         | (0.037)           | (0.070)            | (0.022)                | (0.142)            | (0.061)           | (0.063)           |                  |
| Education yrs. per capita (log) | -0.621***      | -0.821***          | -0.300***              | 0.300***           | -0.766**          | -0.800***         | -1.005***         |
|                         | (0.089)           | (0.120)            | (0.051)                | (0.046)            | (0.213)           | (0.189)           | (0.178)           |
| HIV Prevalence (log)    | 0.033*            | 0.075*             | 0.033***               | 0.044              | -0.154***         | -0.102***         |                  |
|                         | (0.010)           | (0.023)            | (0.007)                | (0.039)            | (0.019)           | (0.018)           |                  |
| Urbanicity (logit)      | -0.027            | -0.020             | 0.001                  | -0.109             |                  | -0.086*           |                  |
|                         | (0.017)           | (0.010)            | (0.006)                | (0.061)            | (0.028)           |                  |                  |
| OOP as a share of THE (logit) | -0.014           | 0.025              | -0.027*                | -0.044             | 0.015             |                  |                  |
|                         | (0.013)           | (0.021)            | (0.008)                | (0.038)            | (0.019)           |                  |                  |
| GHEC as a share of THE (logit) | 0.019           | -0.015             | -0.004                 | 0.049              | -0.049*           | -0.028            |                  |
|                         | (0.012)           | (0.018)            | (0.006)                | (0.029)            | (0.015)           | (0.015)           |                  |
| Population over 65 (logit) | 0.185***         | 0.145              | 0.072**                | -0.001             | 0.600***          | -0.042            | 0.126             |
|                         | (0.034)           | (0.066)            | (0.019)                | (0.021)            | (0.096)           | (0.065)           | (0.063)           |
| Observations            | 1,026             | 1,026              | 1,026                  | 1,026              | 1,026             | 1,026             | 1,026             |
| R²                      | 0.197             | 0.230              | 0.245                  | 0.141              | 0.331             | 0.341             | 0.297             |
| Adjusted R²             | 0.126             | 0.162              | 0.180                  | 0.068              | 0.272             | 0.282             | 0.235             |

Note: *p<0.05; **p<0.01; ***p<0.001
### Upper Middle Income Countries: Fixed Effects: Health Outputs

| Dependent variable | HAQ Index | Health worker Density | Smoking Prevalence | UHC index | ANC4 coverage | ART Coverage | DTP3 coverage | Measles Vaccine Coverage | SBA coverage |
|--------------------|-----------|-----------------------|--------------------|-----------|---------------|--------------|---------------|--------------------------|--------------|
| PHC/THE            | 5.003***  | -2.646**              | -3.162             | 2.162***  | 12.521***     | -18.220      | 45.795***     | 22.325**                 | -2.593       |
|                     | (0.489)   | (0.769)               | (1.087)            | (0.539)   | (3.496)       | (17.503)     | (6.916)       | (7.051)                  | (5.318)      |
| THE per capita (log)| -0.008    | 0.131***              | 0.079**            | -0.009    | 0.327***      | 0.223        | 0.235         | 0.415***                 | 0.100        |
|                     | (0.008)   | (0.013)               | (0.022)            | (0.008)   | (0.049)       | (0.293)      | (0.095)       | (0.101)                  | (0.074)      |
| LDI per capita (log)| 0.172***  | 0.256***              | 0.010              | 0.095***  | 1.802**       |              |               |                          | 1.205***     |
|                     | (0.017)   | (0.025)               | (0.027)            | (0.016)   | (0.508)       |              |               |                          | (0.157)      |
| Fertility rate (log)| -0.124**  | -0.083                | 0.047              | 0.044     |               | -0.201       | -0.780***     |                          |              |
|                     | (0.015)   | (0.031)               | (0.031)            | (0.019)   |              | (0.326)      | (0.153)       |                          |              |
| Hospital beds per 1000 (log)| 0.175*** | 0.188***              | -0.063             | -0.293    | -0.017        | -0.269       | -1.848***     | 1.361***                 |              |
|                     | (0.018)   | (0.029)               | (0.026)            | (0.118)   | (0.677)       | (0.241)      | (0.350)       | (0.177)                  |              |
| Education yrs. per capita (log)| 0.831*** | 0.270**               | 0.084              | 6.035***  | -0.130        | 1.681        | 3.318***      |                          |              |
|                     | (0.057)   | (0.071)               | (0.039)            | (0.241)   |               | (0.491)      | (0.611)       | (0.299)                  |              |
| HIV Prevalence (log)| -0.013    | 0.003                 | -0.013             | -0.028*** | 0.190***      | 1.203***     | 0.049         |                          | 0.236***     |
|                     | (0.005)   | (0.007)               | (0.011)            | (0.006)   | (0.036)       | (0.151)      | (0.073)       |                          | (0.038)      |
| Urbanicity (logit)   | 0.054***  | 0.113***              | 0.154**            | -0.012    | 0.539***      | -1.578***    | 0.319         | 0.057        | -0.309**     |
|                     | (0.006)   | (0.016)               | (0.017)            | (0.010)   | (0.090)       | (0.209)      | (0.113)       | (0.113)                  | (0.077)      |
| OOP as a share of THE (logit)| 0.022    | 0.062***              | -0.002             | 0.027     | 0.686*        | -0.085       | -0.253***     |                          |              |
|                     | (0.012)   | (0.012)               | (0.005)            | (0.005)   | (0.041)       | (0.210)      | (0.081)       |                          | (0.049)      |
| GHES as a share of THE (logit)| 0.006    | 0.007                 | 0.040**            | 0.167***  | 0.633*        | -0.099       | 0.007         |                          |              |
|                     | (0.005)   | (0.012)               | (0.011)            | (0.037)   | (0.185)       | (0.069)      | (0.066)       |                          |              |
| Population over 65 (logit)| -0.125***| -0.135***             | -0.207***          | -0.194*** | 0.340         | -2.844***    | 0.015         | -0.422       |                          |
|                     | (0.018)   | (0.033)               | (0.046)            | (0.023)   | (0.119)       | (0.593)      | (0.262)       | (0.308)      |                          |
| Observations        | 1,026     | 1,026                 | 1,026              | 1,026     | 1,026         | 1,026        | 1,026         | 1,026        | 1,026        |
| R^2                 | 0.555     | 0.520                 | 0.125              | 0.286     | 0.273         | 0.228        | 0.063         | 0.071        | 0.407        |
| Adjusted R^2        | 0.516     | 0.477                 | 0.048              | 0.224     | 0.211         | 0.160        | -0.018        | -0.009       | 0.355        |

Note: *p<0.05; **p<0.01; ***p<0.001
E. Binary relationships between PHC expenditures and outcomes/outputs
### F. Sensitivity analyses: 10-year difference, Mundlak, and ambulatory split model outputs

#### LMIC: 10-year Long Difference: Health Outcomes

| Dependent variable: | All-age mortality | Communicable DALYs | Non-communicable DALYs | Diabetes Prevalence | Maternal mortality | Neonatal mortality | Under-5 mortality |
|---------------------|-------------------|--------------------|------------------------|---------------------|-------------------|-------------------|------------------|
| PHC/THE             | 1.317             | 1.091              | 0.063                  | -0.830              | -10.629***        | -3.607            | -0.511           |
|                     | (1.122)           | (1.712)            | (0.487)                | (0.456)             | (2.082)           | (1.318)           | (1.431)          |
| THE per capita (log)| -0.020            | -0.063             | 0.026*                 | -0.05               | -0.027            | -0.089**          | -0.085*          |
|                     | (0.017)           | (0.025)            | (0.008)                | (0.007)             | (0.034)           | (0.023)           | (0.028)          |
| LDI per capita (log)| -0.158***         | -0.297***          | -0.124***              | -0.015              | -0.443***         | -0.203***         | -0.302***        |
|                     | (0.027)           | (0.049)            | (0.012)                | (0.009)             | (0.051)           | (0.035)           | (0.035)          |
| Fertility rate (log)| -0.035            | -0.068             | -0.036                 | -0.027              | -0.389***         | -0.343***         | -0.179           |
|                     | (0.034)           | (0.055)            | (0.017)                | (0.016)             | (0.078)           | (0.052)           | (0.062)          |
| Hospital beds per 1000 (log) | -0.132*** | 0.071 | -0.133*** | -0.695*** | -0.132 | -0.073 |
|                     | (0.036)           | (0.062)            | (0.021)                | (0.105)             | (0.069)           | (0.056)           |                  |
| Education yrs. per capita (log) | -0.167* | -0.528*** | 0.180*** | -0.206 | -0.556*** | -0.747*** |
|                     | (0.047)           | (0.079)            | (0.022)                | (0.115)             | (0.092)           | (0.098)           |                  |
| HIV Prevalence (log) | 0.058***          | 0.079***           | 0.004                  | 0.028***            | -0.002            | -0.099***         | -0.045*          |
|                     | (0.007)           | (0.015)            | (0.004)                | (0.004)             | (0.025)           | (0.012)           | (0.014)          |
| Urbanicity (logit)  | -0.091            | -0.156*            | -0.033                 | -0.027              | -0.162            | -0.080            | -0.177**         |
|                     | (0.029)           | (0.046)            | (0.014)                | (0.008)             | (0.065)           | (0.034)           | (0.048)          |
| OOP as a share of THE (logit) | -0.006 | -0.010 | -0.038 | -0.009 | -0.004 |
|                     | (0.017)           | (0.005)            | (0.023)                | (0.012)             |                  |                  |                  |
| GHES as a share of THE (logit) | 0.002 | -0.028 | 0.006 | 0.007 | 0.001 | -0.058*** | -0.034 |
|                     | (0.008)           | (0.014)            | (0.005)                | (0.004)             | (0.017)           | (0.011)           | (0.012)          |
| Population over 65 (logit) | 0.116*** | 0.162** | 0.030 | -0.055** | 0.250*** | -0.101 | 0.064 |
|                     | (0.028)           | (0.043)            | (0.012)                | (0.014)             | (0.060)           | (0.042)           | (0.054)          |
| Constant            | -0.107***         | -0.196***          | -0.062***              | 0.035***            | -0.154***         | -0.113***         | -0.159***        |
|                     | (0.016)           | (0.027)            | (0.005)                | (0.006)             | (0.036)           | (0.025)           | (0.027)          |
| Observations        | 1,080             | 1,080              | 1,080                  | 1,080               | 1,073             | 1,080             |                  |
| R²                  | 0.165             | 0.230              | 0.156                  | 0.126               | 0.238             | 0.300             | 0.226            |
| Adjusted R²         | 0.157             | 0.222              | 0.149                  | 0.118               | 0.230             | 0.292             | 0.218            |

**Note:** *p<0.05; **p<0.01; ***p<0.001
| Dependent variable: | HAQ Index | Health worker Density | Smoking Prevalence | UHC index | ANG4 coverage | ART Coverage | DTP3 coverage | Measles Vaccine Coverage | SBA coverage |
|---------------------|-----------|-----------------------|-------------------|-----------|---------------|--------------|---------------|--------------------------|-------------|
| PHC/THE             | 1.268     | -1.042                | -1.051            | -0.334    | 12.756***     | 1.073        | 7.085         | 23.316***                | -3.448      |
|                     | (0.561)   | (0.707)               | (0.853)           | (0.790)   | (2.871)       | (15.577)     | (6.415)       | (6.000)                  | (4.431)     |
| THE per capita (log)| -0.007    | 0.139***              | 0.018             | 0.005     | 0.278***      | 1.227***     | 0.231         | 0.659***                 | 0.181       |
|                     | (0.011)   | (0.013)               | (0.016)           | (0.013)   | (0.051)       | (0.250)      | (0.094)       | (0.102)                  | (0.071)     |
| LDI per capita (log)| 0.208***  | 0.279***              | 0.008             | 0.165***  | 0.430***      | 0.594        | -0.517*       | 0.929***                 |             |
|                     | (0.012)   | (0.022)               | (0.022)           | (0.017)   | (0.068)       | (0.379)      | (0.156)       | (0.110)                  |             |
| Fertility rate (log)| -0.081*** | 0.318***              | 0.146***          | 0.075     | -0.323        | 2.098**      | -0.141        | -0.866                   | -0.828***   |
|                     | (0.020)   | (0.032)               | (0.036)           | (0.026)   | (0.111)       | (0.551)      | (0.297)       | (0.322)                  | (0.137)     |
| Hospital beds per 1000 (log) | 0.070* | 0.200***              | 0.076             | -0.033    | -0.161        | 0.486        | -0.764        | -1.417***                | 1.097***    |
|                     | (0.021)   | (0.037)               | (0.043)           | (0.025)   | (0.146)       | (0.632)      | (0.278)       | (0.331)                  | (0.204)     |
| Education yrs. per capita (log) | 0.466*** | -0.058                | 0.028             | 0.209***  | 1.117***      | 6.991***     | 2.370***      | 2.137***                 | 1.409***    |
|                     | (0.033)   | (0.055)               | (0.057)           | (0.040)   | (0.160)       | (0.867)      | (0.347)       | (0.409)                  | (0.188)     |
| HIV Prevalence (log) | -0.003    | 0.027**               | 0.031**           | -0.061*** | 0.155***      | 0.275        | 0.014         | 0.088                    |             |
|                     | (0.005)   | (0.007)               | (0.008)           | (0.007)   | (0.033)       | (0.149)      | (0.063)       | (0.035)                  |             |
| Urbanicity (logit)  | 0.100***  |                     | 0.102***          | 0.066     | 0.459***      | -0.169       | 0.722***      | 0.460                    | 0.070       |
|                     | (0.017)   | (0.021)               | (0.024)           | (0.084)   | (0.408)       | (0.408)      | (0.152)       | (0.196)                  | (0.133)     |
| OOP as a share of THE (logit) | -0.022* | -0.017                | 0.010             | -0.005    | 0.110         | -0.133       | 0.033         | 0.121                    |            |
|                     | (0.007)   | (0.009)               | (0.010)           | (0.009)   | (0.179)       | (0.054)      | (0.061)       | (0.048)                  |            |
| GHES as a share of THE (logit) | -0.009  | 0.0001                | -0.011            | 0.044     | -0.149        | 0.132        | 0.140**       |                         |             |
|                     | (0.006)   | (0.009)               | (0.009)           | (0.009)   | (0.179)       | (0.054)      | (0.061)       | (0.048)                  |             |
| Population over 65 (logit) | -0.058***| -0.002                | -0.077            | -0.161*** | 0.529***      | -3.653***    | 0.225         | -0.262                   | 0.002       |
|                     | (0.013)   | (0.026)               | (0.034)           | (0.021)   | (0.080)       | (0.469)      | (0.235)       | (0.205)                  | (0.108)     |
| Constant            | -0.013    | 0.156***              | -0.066***         | 0.091***  | -0.147        | 2.319***     | -0.459**      | -0.393                   | 0.037       |
|                     | (0.008)   | (0.014)               | (0.014)           | (0.004)   | (0.050)       | (0.250)      | (0.128)       | (0.134)                  | (0.055)     |

| Observations | 1,080 | 1,080 | 1,080 | 1,080 | 1,080 | 1,080 | 1,080 | 1,080 | 1,080 |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| R\(^2\)      | 0.495 | 0.424 | 0.302 | 0.251 | 0.206 | 0.078 | 0.090 | 0.276 |       |
| Adjusted R\(^2\) | 0.490 | 0.419 | 0.295 | 0.244 | 0.198 | 0.070 | 0.082 | 0.268 |       |

*Note:* *p<0.05; **p<0.01; ***p<0.001
### LMIC: Mundlak: Health Outcomes

| Dependent variable:       | All-age mortality | Communicable DALYs | Non-communicable DALYs | Diabetes Prevalence | Maternal mortality | Neonatal mortality | Under-5 mortality |
|---------------------------|-------------------|-------------------|------------------------|--------------------|-------------------|-------------------|------------------|
| PHC/THE (Country Mean)    | -0.248            | 0.934             | -0.372                 | -0.349             | 0.241             | 0.136             | -0.034           |
| (0.222)                   | (0.411)           | (0.167)           | (0.304)                | (0.559)            | (0.307)           | (0.284)           |                  |
| PHC/THE (Dev)             | 1.463             | 1.590             | 0.022                  | -1.151             | -11.310           | -3.526            | -0.380           |
| (0.798)                   | (1.273)           | (0.426)           | (0.409)                | (1.615)            | (1.115)           | (1.168)           |                  |
| THE per capita (log)      | -0.036*           | -0.112***         | 0.002                  | -0.003             | -0.095**          | -0.107***         | -0.113***        |
| (0.011)                   | (0.019)           | (0.006)           | (0.006)                | (0.024)            | (0.016)           | (0.019)           |                  |
| LDI per capita (log)      | -0.161***         | -0.396***         | -0.140***              | 0.011              | -0.429***         | -0.244***         | -0.354***        |
| (0.017)                   | (0.034)           | (0.009)           | (0.007)                | (0.035)            | (0.026)           | (0.027)           |                  |
| Fertility rate (log)      | 0.040             | 0.047             | 0.093***               | -0.031             | -0.315***         | -0.257***         | -0.003           |
| (0.025)                   | (0.044)           | (0.011)           | (0.012)                | (0.063)            | (0.040)           | (0.048)           |                  |
| Hospital beds per 1000 (log) | 0.127***       | 0.210***         | 0.017                  | -0.386             | 0.069             | 0.193***          |                  |
| (0.018)                   | (0.034)           | (0.013)           | (0.047)                | (0.026)            | (0.030)           |                  |                  |
| Education yrs. per capita (log) | -0.416***     | -1.006***        | 0.270***               | -0.610***          | -0.792***         | -1.075***         |                  |
| (0.022)                   | (0.042)           | (0.012)           | (0.012)                | (0.045)            | (0.037)           | (0.039)           |                  |
| HIV Prevalence (log)      | 0.041***         | 0.095***         | -0.007                 | 0.035***           | 0.017             | -0.083***         | -0.031**         |
| (0.005)                   | (0.011)           | (0.003)           | (0.004)                | (0.015)            | (0.008)           | (0.009)           |                  |
| Urbanicity (logit)        | -0.046***         | -0.051           | -0.058***              | -0.030**           | -0.105**          | -0.013            | -0.015           |
| (0.011)                   | (0.018)           | (0.009)           | (0.009)                | (0.026)            | (0.023)           | (0.023)           |                  |
| OOP as a share of THE (logit) | -0.011             | -0.012**          | -0.044                 | 0.004              | 0.014             |                  |                  |
| (0.012)                   | (0.003)           | (0.015)           | (0.009)                | (0.010)            |                  |                  |                  |
| GHES as a share of THE (logit) | -0.004            | -0.035*           | 0.011*                 | 0.007              | 0.001             | -0.051***         | -0.032**         |
| (0.006)                   | (0.010)           | (0.004)           | (0.003)                | (0.012)            | (0.008)           | (0.009)           |                  |
| Population over 65 (logit) | 0.001             | -0.122**          | -0.011                 | -0.032             | -0.013            | -0.275***         | -0.192***        |
| (0.019)                   | (0.033)           | (0.009)           | (0.011)                | (0.046)            | (0.028)           | (0.037)           |                  |
| Constant                  | -2.102***         | 2.587***          | -0.416**               | -2.944***          | 10.216***         | 1.267***          | -0.271           |
| (0.176)                   | (0.315)           | (0.111)           | (0.147)                | (0.401)            | (0.284)           | (0.316)           |                  |

**Note:** *p<0.05; **p<0.01; ***p<0.001

**Observations:** 2,430

**R²:** 0.587

**Adjusted R²:** 0.585

Supplemental material

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## LMIC: Mundlak: Health Outputs

| Dependent variable | HAQ Index | Health worker Density | Smoking Prevalence | UHC index | ANC4 coverage | ART Coverage | DTP3 coverage | Measles Vaccine Coverage | SBA coverage |
|--------------------|-----------|-----------------------|--------------------|----------|---------------|--------------|---------------|--------------------------|-------------|
| PHC/THE (Country Mean) | 0.255     | 0.433                 | -2.70**            | 0.447    | 1.336         | 5.612        | 1.623         | 1.574                    | 1.649        |
| PHC/THE (Dev)       | 1.969**   | -1.760*               | -0.598             | -0.523   | 12.509**      | 18.335       | 9.136         | 20.557***               | 0.356        |
| THE per capita (log)| 0.004     | 0.158***              | 0.018              | 0.015    | 0.218***      | 1.256***     | 0.170         | 0.470***                 | 0.191***     |
| DLI per capita (log)| 0.194***  | 0.319***              | 0.007              | 0.185*** | 0.435***      | 0.797*       | -0.363**      | 0.768***                 |              |
| Fertility rate (log)| -0.107*** | -0.342***             | 0.146***           | 0.013    | -0.309***     | -0.447       | -0.576        | -1.148**                 | -0.779***    |
| Hospital beds per 1000 (log)| 0.019     | 0.028                 | 0.194***           | -0.147***| 0.010         | -4.453***    | -0.059        | -0.132                   | 0.445***     |
| Education yrs. per capita (log)| 0.418***  | 0.395***              | -0.127***          | 0.403*** | 0.838***      | 8.698***     | 0.819***      | 0.715***                 | 1.444***     |
| HIV Prevalence (log)| -0.018**  | 0.057***              | 0.007              | -0.038***| 0.111**       | 0.644***     | -0.082        | 0.072*                   |              |
| Urbanicity (logit)  | 0.059***  | 0.033                 | 0.032***           | 0.070    | 0.021         | 0.110        | 0.067         | 0.051                    |              |
| OOP as a share of THE (logit)| -0.021*** | -0.018                | 0.012              | -0.024***| -0.539***     | -0.158***    | -0.043        | -0.095*                  |              |
| GHES as a share of THE (logit)| -0.011    | -0.001                | -0.012             | 0.038    | -0.505***     | 0.106        | 0.134***      |                          |              |
| Population over 65 (logit)| -0.037*   | 0.125***              | -0.096***          | -0.061***| 0.467***      | -0.414       | -0.046        | -0.334                   | 0.107        |
| Constant            | 1.165***  | 0.378                 | -2.317***          | -3.647***| -3.205***     | -28.917***   | -1.164        | 0.982                    | -6.908***    |

| Observations | 2,430       | 2,430                  | 2,430              | 2,430       | 2,430         | 2,430        | 2,430         | 2,430                    | 2,430        |
| R²           | 0.836       | 0.864                  | 0.164              | 0.678       | 0.613         | 0.612        | 0.151         | 0.161                    | 0.688        |
| Adjusted R²  | 0.835       | 0.863                  | 0.160              | 0.677       | 0.611         | 0.610        | 0.147         | 0.157                    | 0.686        |

Note: *p<0.05; **p<0.01; ***p<0.001
|                        | All-age mortality | Communicable DALYs | Non-communicable DALYs | Diabetes Prevalence | Maternal mortality | Neonatal mortality | Under-5 mortality |
|------------------------|-------------------|--------------------|------------------------|---------------------|------------------|-------------------|-------------------|
| Ambulatory PHC/THE     | 2.377             | -2.211             | 2.148                  | -0.150              | -13.111**        | 8.834**           | 7.479***          |
|                        | (1.652)           | (2.429)            | (0.989)                | (0.877)             | (3.512)          | (2.421)           | (1.733)           |
| Non-Ambulatory PHC/THE | 0.515             | 2.381              | -0.815                 | -1.144**            | -9.097***        | -8.548***         | -3.406            |
|                        | (1.063)           | (1.638)            | (0.431)                | (0.382)             | (1.856)          | (1.329)           | (1.590)           |
| THE per capita (log)   | -0.024            | -0.054             | 0.016                  | -0.010              | -0.018           | -0.119***         | -0.101***         |
|                        | (0.013)           | (0.020)            | (0.006)                | (0.005)             | (0.026)          | (0.017)           | (0.022)           |
| LDI per capita (log)   | -0.141***         | -0.319***          | -0.107***              | -0.005              | -0.462***        | -0.129***         | -0.253***         |
|                        | (0.020)           | (0.038)            | (0.010)                | (0.008)             | (0.044)          | (0.030)           | (0.031)           |
| Fertility rate (log)   | -0.030            | -0.065             | -0.026                 | -0.030              | -0.402***        | -0.327***         | -0.146            |
|                        | (0.026)           | (0.044)            | (0.013)                | (0.013)             | (0.064)          | (0.041)           | (0.050)           |
| Hospital beds per 1000 (log) | -0.124***      | 0.074              | -0.124***              | -0.703***           | -0.087           | -0.036            |
|                        | (0.027)           | (0.052)            | (0.015)                | (0.086)             | (0.050)          | (0.046)           |
| Education yrs. per capita (log) | -0.198***   | -0.558***          | 0.166***               | -0.231              | -0.528***        | -0.738***         |
|                        | (0.036)           | (0.064)            | (0.020)                | (0.094)             | (0.071)          | (0.075)           |
| HIV Prevalence (log)   | 0.054***          | 0.065***           | 0.007                  | 0.028***            | -0.006           | -0.093***         | -0.049***         |
|                        | (0.006)           | (0.013)            | (0.003)                | (0.004)             | (0.021)          | (0.010)           | (0.011)           |
| Urbanicity (logit)     | -0.085**          | -0.154***          | -0.033                 | -0.025              | -0.137           | -0.087***         | -0.181***         |
|                        | (0.023)           | (0.037)            | (0.012)                | (0.008)             | (0.052)          | (0.028)           | (0.041)           |
| OOP as a share of THE (logit) | -0.006        | -0.009             | -0.037                 | 0.004               | 0.005            |
|                        | (0.012)           | (0.032)            | (0.016)                | (0.009)             | (0.011)          |
| GHES as a share of THE (logit) | 0.002         | -0.030             | 0.009                  | 0.009               | 0.00002          | -0.026**          | -0.015            |
|                        | (0.006)           | (0.012)            | (0.003)                | (0.003)             | (0.012)          | (0.008)           | (0.009)           |
| Population over 65 (logit) | 0.109***       | 0.151***           | 0.023                  | -0.051***           | 0.219***         | -0.141***         | 0.041             |
|                        | (0.023)           | (0.035)            | (0.009)                | (0.012)             | (0.048)          | (0.033)           | (0.045)           |
| Observations           | 2,430             | 2,430              | 2,430                  | 2,430               | 2,430            | 2,430             | 2,430             |
| $R^2$                  | 0.152             | 0.226              | 0.147                  | 0.110               | 0.219            | 0.313             | 0.212             |
| Adjusted $R^2$         | 0.092             | 0.170              | 0.087                  | 0.047               | 0.162            | 0.263             | 0.155             

*Note:* $p<0.05; **p<0.01; ***p<0.001
### LMIC: Fixed Effects (PHC Ambulatory Split): Health Outputs

**Dependent variable:**
- HAQ Index
- Health worker Density
- Smoking Prevalence
- UHC index
- ANC4 coverage
- ART Coverage
- DTP3 coverage
- Measles Vaccine Coverage
- SBA coverage

| Variable                                      | Ambulatory PHC/THE | Non-Ambulatory PHC/THE | THE per capita (log) | LDI per capita (log) | Fertility rate (log) | Hospital beds per 1000 (log) | Education yrs. per capita (log) | HIV Prevalence (log) | Urbanicity (logit) | OOP as a share of THE (logit) | GHES as a share of THE (logit) | Population over 65 (logit) | Observations | \( R^2 \) | Adjusted \( R^2 \) |
|-----------------------------------------------|--------------------|------------------------|----------------------|----------------------|----------------------|-----------------------------|-------------------------------|----------------------|------------------|-----------------------------|-----------------------------|-----------------------------|----------------|------|-------------|
| HAQ Index                                     | -1.096             | 2.327                  | -0.002               | 0.199                | -0.084              | 0.070                       | 0.465                        | -0.011               | 0.105            | -0.019                      | -0.008                      | -0.056                     | 2,430         | 0.507 | 0.471        |
| Health worker Density                         | -7.076***          | 1.493                  | 0.150***             | 0.248***             | -0.336***           | 0.193***                    | 0.092                        | -0.019               | 0.096            | -0.015                      | -0.011                      | -0.083                     | 2,430         | 0.507 | 0.471        |
| Smoking Prevalence                            | 0.225              | -1.398                 | 0.004                | 0.026                | 0.137***            | -0.032                      | -0.080                       | 0.025                | 0.067            | -0.011                      | 0.011                       | 0.015                      | 2,430         | 0.507 | 0.471        |
| UHC index                                     | -2.330             | 12.803***              | 0.009                | 0.151***             | -0.356***           | -0.125                      | 0.098                        | -0.063               | 0.067            | -0.008                      | -0.008                      | -0.083                     | 2,430         | 0.507 | 0.471        |
| ANC4 coverage                                 | 11.984             | -11.699                | 0.234***             | 0.470***             | 1.819***            | 0.695                       | 1.084***                     | 0.146               | 0.421***         | -0.565                      | 0.126                       | 0.263                      | 2,430         | 0.507 | 0.471        |
| ART Coverage                                  | -7.070             | -1.319                 | 0.540                | 1.144**              | -0.337              | 0.695                       | 5.923***                     | 0.128               | -0.565           | -0.056                      | 0.127                       | 0.192                      | 2,430         | 0.507 | 0.471        |
| DTP3 coverage                                 | 60.916***          | 4.981                  | 0.169                | 1.144**              | -0.337              | -0.736**                    | 2.169***                     | 0.128               | 0.702***         | 0.365                       | 0.127                       | 0.192                      | 2,430         | 0.507 | 0.471        |
| Measles Vaccine Coverage                      | 32.917***          | 6.160                  | 0.522***             | 0.865***             | -0.890**            | -1.339**                    | 2.272***                     | 0.192               | 0.702***         | -0.039                      | 0.127                       | 0.192                      | 2,430         | 0.507 | 0.471        |
| SBA coverage                                  | -13.746            | 2.058                  | 0.192**              | 0.865***             | -0.795***           | -1.339**                    | 1.337***                     | 0.127               | 0.192***         | -0.039                      | 0.127                       | 0.192                      | 2,430         | 0.507 | 0.471        |

**Note:**
* \( p<0.05 \); ** \( p<0.01 \); *** \( p<0.001 \)
References

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