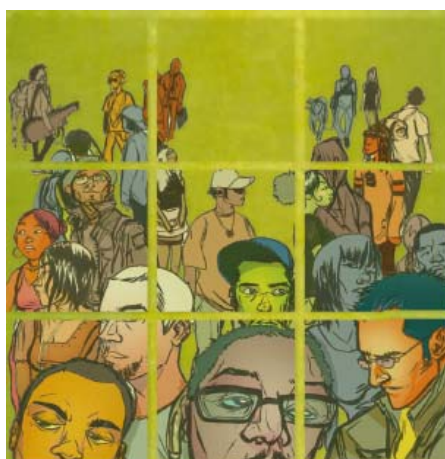




Determinants of caesarean section rates in developed countries: supply, demand and opportunities for control

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Determinants of caesarean section rates in developed countries: supply, demand and opportunities for control

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Abstract

Objective

To study population-level determinants of caesarean section trends in developed countries.

Data sources/study setting

National-level data (1980-2004) from developed countries on trends and potential determinants of caesarean section utilization.

Study design

The effect of maternal mortality, national income, hospital infrastructure and the health system financing and human resources profile on caesarean section rates was analysed with a dynamic econometric model.

Data collection/extraction methods

Annual data on utilization and potential determinants of caesarean section were obtained from health statistical services and international organizations.

Principal findings

The capacity of the health system to deliver surgical obstetric care, its financing structure, and possibly also its human resources profile, have stronger aggregate-level effects on caesarean section rates than does income.

Conclusions

Health system factors are potentially important aggregate-level determinants of caesarean section utilization which have been overlooked in debates focusing on the impact of women's choices and doctors' preferences.

Key words: Caesarean section, international comparisons, health systems, health financing, human resources.

Introduction

Caesarean section rates are high and continue to rise in developed countries.[1][2][3] , However, the impact of guidelines and recommendations in curbing their growth has been limited: in 1985, representatives of a study group convened by the World Health Organization wrote, “there is no justification for any region to have caesarean section rates higher than 10–15%.”[4] Although levels of 10–15% were considered high but acceptable at the time, average caesarean rates in most developed regions (with the exception of eastern Europe) now exceed 20%; the recommendation thus appears to have been largely overtaken by events.[5] Nevertheless, little research exists on determinants of caesarean section utilization, at either the aggregate[6] or the individual level,[7][8] and, until recently,[9] the few randomised trials that have been published have found no effect, for the intervention studied, on rates of caesarean delivery.[10][11]

Understandably, in such a context, there is concern that apparently inexorably rising rates of caesarean delivery have the potential to divert human and financial resources from other, arguably higher priority, interventions.[12] Furthermore, the possibility that indiscriminate use of caesarean section can have a negative impact on maternal and neonatal health has been raised[13] and has recently received support from a number of studies.[3][14][15][16] On the other hand, it has been argued that reducing caesarean delivery rates would have a detrimental effect on mothers’ and infants’ health, and that patients’ choices should be considered.[17]

Against this background, we set out to study trends in caesarean delivery rates in developed countries with the aim of identifying potential population-level determinants. Previous ecological research,[6] limited to cross-sectional analysis in Latin America, has suggested that it is primarily income that determines caesarean section rates at aggregate level. Here we use a cross-country dynamic regression model to exploit the additional information available from data on trends to present evidence that caesarean rates in developed countries respond not only to economic incentives such as income but also, and more strongly, to important modifiable health-system factors.

Methods

Our analysis focuses on developed countries as defined in the United Nations' classification.[18] Developed countries include countries in Europe and Australia, Canada, Japan, New Zealand and the United States of America. Trend data were collected for 38 of these countries since 1980. Variables used in the analysis, and their interpretation, are described in the Table.

For European countries, data were obtained from the European Health for All Database (www.who.dk), maintained by the WHO European Regional Office. For Australia, Canada, Japan, New Zealand, the United Kingdom and the United States, national health statistical services issue regular publications and maintain web pages with information on maternal health indicators.

Previous research on international comparisons of caesarean delivery rates has relied on cross-sectional data from Latin America and simple bivariate correlation models.[6] As a preliminary analysis, and to establish a baseline for comparison with the results from our trend analysis, we performed a simple linear regression of caesarean section rate versus income per head in Latin America and in developed countries, using a previously published cross-sectional data set, in order to confirm previous findings.[3]

Subsequently, trend data on caesarean section rates and their potential determinants (Table) were analysed using a dynamic econometric model combining a standard time-series analysis with a simple panel-data model for cross-country variation.[19][20] (For full details of analysis methods, see Web Annex).

A basic set of indicators (maternal mortality ratio and income per head) was available for 38 countries (Table), with an average of over 11 years of observation per country. A larger set of indicators (consisting of the basic indicators plus estimates of hospitals, hospital beds and midwives per head as well as the proportion of total expenditure on health derived from government sources) was available for 25 countries, with an average of over 6 years of observation per country.

Results from both data sets (basic and full) using the dynamic econometric model are reported below. Since the 38 countries for which basic data were available might differ systematically from the 25 countries for which full data were available, a model with basic indicators only was

studied for both sets of countries in order to establish that countries with full data were not qualitatively different than those with basic data only.

Results

Cross-sectional analysis

In the same set of developed countries as those studied in the dynamic model, a log-log linear regression of cross-sectional caesarean section rate versus cross-sectional income per head predicts that a doubling in income corresponds to a 33% (95% CI, 18% – 46%) increase in caesarean delivery rate (see Web Annex for details of the log-log regression). For comparison with previous research,[6] the same model estimated in Latin American countries only suggests that a doubling in income would be associated with a 77% (67% – 87%) increase.

Basic dynamic model

At only 4% (3% – 6%), the estimate of the effect of a doubling in income obtained from the basic dynamic model is substantially lower than the estimate obtained from cross-sectional analysis (Web Annex, Table 3). A small positive coefficient was associated with calendar year, indicating an average increase of 0.3% (0.2% – 0.4%) per year after controlling for other variables in the basic model (Web Annex, Table 1). There was also a negative but insignificant association with maternal mortality (Web Annex, Table 1).

These results were qualitatively robust across all alternative model specifications using the basic indicators. Standard tests of model validity show that no estimation assumptions were unsatisfied.[21]

Full dynamic model

When the full set of indicators was analysed, a doubling in income per head was found to correspond to an increase in caesarean section rates of 6% (4% – 8%; Web Annex, Table 3). Notably, however, variables associated with the capacity of the health system to deliver surgical obstetric care were also found to have a significant positive effect on caesarean utilization rates: for example, a doubling in the stock of hospitals per head corresponded to a 15% (4% – 26%) increase in caesarean section rates (Web Annex, Table 3); a doubling in the number of hospital

beds per head, however, was associated with approximately a 26.8% (12.2% – 41.4%) increase in the caesarean section rate (Web Annex, Table 2).

Moreover, the financial organization of the health system appeared to have an even stronger effect on caesarean utilization: a doubling in the share of health expenditure derived from government sources was found to correspond to a 29.8% (9.6% – 50%) decrease in caesarean rates (Web Annex, Table 2). Although the coefficient was not quite significant (Web Annex, Table 3), there was a suggestion that a doubling in the number of midwives per head would result in a 3% (–1% – 6%) increase in caesarean section rates, which is contrary to what might be expected. There was a small, although also not significant, increase in caesarean section rates associated with increased maternal mortality ratio (Web Annex, Table 2).

When the full model was analysed for long-run relationships (Web Annex, Table 4), the effect of health system financing was seen to be much larger, with a doubling of the share of health expenditure from public sources implying a 95% (42% – 149%) reduction in the caesarean section delivery rate in the long run. An effect of similar magnitude but in the opposite direction was observed for the number of hospital beds per head, which was associated with an 86% (45% – 126%) increase in the caesarean section rate in the long run.

Although the coefficient was not significant, the effect of doubling the number of hospitals per head was predicted to have only a 12% (–18% – 42%) increase in the caesarean section rate in the long run. Possibly because hospitals are a relatively fixed measure of health system infrastructure, the long-term effect of the hospital stock was found to be of about the same magnitude as that in the short run. Although still not significant, a doubling in the number of midwives per head was found to be associated with a 14% (–4% – 32%) decrease in the caesarean delivery rate in the long run; in other words, the effect of the number of midwives per head appeared to be different in the long run, and moreover consistent with expectations, as compared with the estimated effect in the short term. A switch in the direction of effect also obtained for income per head in the long run, since a doubling in income was found to imply a 5% (–3% – 14%) decrease in caesarean section rates in the long run (although the coefficient was not significant).

See Annex for further details on the estimation model, interpretation and results.

Discussion

The estimate of a 77% increase in the caesarean section rate for a doubling of income in the Latin American region that we obtained from the preliminary cross-sectional analysis is remarkably close to the value of the linear correlation reported for that region previously.[6] For developed countries, however, the cross-sectional relationship, estimated here at 32%, is substantially weaker. In any case, both previous ecological research[6] and our own preliminary cross-sectional analysis could be claimed to support the hypothesis that, at aggregate level, caesarean section rates respond strongly to income, or to factors that are themselves strongly associated with income. Results from cross-sectional analyses would therefore seem to raise the possibility of dramatically increasing caesarean section rates with rising incomes in the future.

Our principal new finding, however, is that the relationship of caesarean section rates with income is in fact substantially weaker when longitudinal rather than cross-sectional data are analysed. Since, in either the basic or the full dynamic model, the effect of income on caesarean section rates is an order of magnitude weaker than that found in cross section, estimates derived from cross-sectional studies would appear to be biased. Such bias could be attributable to either the failure to control for the dynamic aspects of the relationship, as well as possibly also the absence of relevant control variables in the cross-sectional analyses. Our second important finding is that, when health system variables are included, a much richer picture of the population-level determinants of caesarean section rates emerges than that available from previous research.

The main strength of the study is its application of dynamic econometric models to health-care utilization trends in developed countries so as to explore competing hypotheses about aggregate-level determinants of caesarean section rates. Its main limitations are those inherent in the ecological nature of the data;[22] there are clearly individual-level factors affecting the utilization of caesarean section[9] which this study could only measure in the aggregate. A specific limitation of the econometric model is its assumption that different countries respond similarly to determinants of caesarean section utilization.[23] Finally, since several of the estimates for coefficients of interest were not significant, we cannot be certain that their reported value was not positive or negative due merely to chance.

The conventional model for growth in caesarean section rates implies that caesarean delivery is a conventional economic good, in the sense that the higher one's income the more one is inclined

to “purchase” it. We call such a model “demand-driven”. A demand-driven model is consistent with the hypothesis that it is primarily women’s choices that determine caesarean section rates. Although a demand-driven model receives support from the results presented here, the size of the estimated effect is nevertheless much smaller than that previously reported.[6]

The observed effect of the number of hospitals and of hospital beds per head suggests that, in addition to demand, supply factors are also important. A supply-driven model would imply that, regardless of medical need, the greater the capacity of the health system to deliver surgical obstetric care, the more will be delivered. Such a model suggests that “suppliers” of caesarean delivery (e.g. obstetricians) have substantial influence on delivery mode, and contribute importantly to rising caesarean section rates. A “supply-driven” model also receives support from the data analysed here.

Nevertheless, health system factors such as the human-resources and financing profile are seen to have the largest impact on caesarean utilization rates. Health system financing, in both the short and the long run in fact, is the single factor among those studied here with the strongest impact on aggregate levels of caesarean delivery. This finding suggests the importance of a previously under-recognized model for determinants of caesarean section, one related neither to supply or to demand factors but rather to the health system itself. Health system factors are largely institutional, in other words, related to the legal environment in which health-care decisions are made.

Overall, our results therefore suggest that, in the context of debates about whether patients’ choices or doctors’ preferences are more responsible for rising caesarean delivery rates,[24][25], health system factors may be an important overlooked population-level determinant. One obvious implication is that caesarean delivery rates might be amenable to control through policy instruments acting at the health system level. While it is acknowledged that such instruments would be likely to affect a broad range of other outcomes as well, these findings nevertheless suggest novel avenues for policy intervention and investigation into determinants of utilization of this important obstetrical procedure.

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Table

Potential determinants of CS rates

Determinant	Reason for inclusion
Medical	
✓ Maternal mortality ratio*	Indicator of medical need
Non-medical	
<i>Income</i>	
✓ Gross domestic product per capita (GDP per capita)*	Indicator of consumer demand
<i>Health-system infrastructure</i>	
✓ Number of hospitals per capita [#]	Relatively fixed indicator of the capacity of the health system to deliver surgical obstetric procedures
✓ Number of hospital beds per capita [#]	More flexible indicator of the capacity of the health system to deliver surgical obstetric procedures
<i>Health-system financing and human resources organization</i>	
✓ Proportion of total health expenditure derived from government sources [#]	Indicator of the financial organization of the health system
✓ Number of midwives per capita [#]	Indicator of the human resources profile of the reproductive health system

*Data available for all 38 countries ("basic" data).

[#] Data available for only 25 countries ("full" data).

Annex: estimation methods, interpretation and detailed results

Characteristics of the estimation model

A time-series regression model using lagged dependent variables is typically used to analyse complex systems whose time-dependent outcome (here, caesarean section rate) is held to depend on numerous intermediate outcomes, some of which may not be directly observed. In such an approach, the effect of the intermediate outcomes is controlled for by using lagged values of the dependent variable as instruments (i.e. variables with many of the same statistical properties as the variables that cannot be observed). The effect of other, directly observed, covariates in the regression equation can then be inferred from their coefficients in the standard way.

Since we wish however to study relationships between caesarean section rates and their determinants across a group of countries with similar characteristics, a standard time-series model is inadequate.[1] We therefore use a so-called “dynamic panel” model, which combines the time series (i.e. “dynamic”) approach with a simple model for inter-country (i.e. “panel”) variation.[2][3]

A requirement of the particular dynamic panel model used here is that inter-country variation is measurable in terms of a single parameter; the model requires, in other words, the assumption that slope coefficients are homogeneous across countries and that inter-country differences are expressible by means of country-specific intercepts.[4]

Theoretical basis of the model

On the hypothesis that caesarean delivery is a conventional economic good, it is expected that caesarean rates will respond positively (i.e. in direct relationship) to income per capita as a result of increased patient demand. On the alternative hypothesis that doctors’ preferences are an important determinant of caesarean section rates (i.e. the hypothesis that, other things being equal, obstetricians prefer patients to have caesarean deliveries), a direct relationship with caesarean rates is posited for measures of the capacity of the health system to deliver surgical obstetric care (for example, the stock of hospitals, or of hospital beds, per capita). On the still different hypothesis that health system factors, such as the human resources profile of obstetric care and the organization of health system financing, are important determinants of caesarean section rates, it is expected that caesarean utilization would respond negatively (i.e. in inverse relationship) to the number of midwives per capita or to the proportion of total expenditure on

health derived from government sources. Finally, since it has been shown to be a covariate of caesarean section rates in cross-sectional analysis,[5] we include the maternal mortality ratio as a control variable representing medical need.

With the exception of calendar year, all variables are entered as the logarithm.

The two model specifications that we report (i.e. “basic” and “full”, described below) are robust in the sense that, except as noted immediately following, in any alternative model specification tested, the coefficients of all variables included in the reported model specifications were strongly significant; conversely, the coefficients of none of the variables not included in the reported model specifications were significant in any of the alternative model specifications. The sole exceptions were that the coefficients for maternal mortality ratio and for the number of midwives per capita in the current period, t , were not significant in most of the model specifications tested; nevertheless, these variables were retained in the corresponding reported model specifications on account of their interest as potential determinants of caesarean section rates. The inclusion or exclusion of these variables in any case had no important effect on the coefficient values of any of the other variables reported.

The basic model, ignoring error terms, can be written:

$$CS_t = c_1 \cdot CS_{t-1} + c_2 \cdot CS_{t-2} + c_3 \cdot GDP_t + c_4 \cdot GDP_{t-1} + c_5 \cdot MMR_t + c_6 \cdot Year_t$$

The full model, ignoring error terms, can be written:

$$CS_t = c_1 \cdot CS_{t-1} + c_2 \cdot CS_{t-2} + c_3 \cdot GDP_t + c_4 \cdot GDP_{t-1} + c_5 \cdot MMR_t + c_6 \cdot Year_t + c_7 \cdot Hosp_t + c_8 \cdot Hosp_{t-1} + c_9 \cdot HospBed_t + c_{10} \cdot Midw_t + c_{11} \cdot Midw_{t-1} + c_{12} \cdot PubHExp_t$$

A list of variables and their abbreviations follow:

Caesarean section rate in the current year (t)	CS_t
Caesarean section rate in the previous year ($t-1$)	CS_{t-1}
Caesarean section rate two years previous to the current year ($t-2$)	CS_{t-2}
Income per head in the current year (t)	GDP_t

Income per head in the previous year (t−1)	GDP_{t-1}
Maternal mortality ratio in the current year (t)	MMR_t
Number of hospitals per head in the current year (t)	$Hosp_t$
Number of hospitals per head in the previous year (t−1)	$Hosp_{t-1}$
Number of hospital beds per head in the current year (t)	$HospBed_t$
Number of midwives per head in the current year (t)	$Midw_t$
Number of midwives per head in the previous year (t−1)	$Midw_{t-1}$
Proportion of total expenditure on health from government sources in the current year (t)	$PubHExp_t$
Calendar year (t)	Year.

Raw coefficient estimates for the variables are reported below in Table 1 (basic model) and Table 2 (full model).

The dynamic model is estimated using the Stata (version 9) procedure `xtabond`.

Model and parameter interpretation

Log-log regression

Regression with logarithmically transformed dependent (i.e. left-hand side) and independent (i.e. right-hand side) variables yield coefficients that can be interpreted as elasticities, which means that the coefficient value gives the proportional change in the dependent variable (i.e. caesarean section rate) associated with a doubling in the independent variable (i.e. potential determinant).

Changes rather than levels

In the Results section of the main text, it is claimed that “changes” in income or other variables are a potential determinant of caesarean section rates. This is a common interpretation applied to dynamic econometric models of the type used here, and it relies on the following argument.

Taking income as an example, the relevant part of the regression equation can be written as follows:

$$CS_t = \dots + c_3 \cdot GDP_t + c_4 \cdot GDP_{t-1} + \dots$$

If the estimated value of the coefficient c_3 is approximately equal in absolute value to the estimated value of the coefficient c_4 , and if, in addition, c_4 is negative in sign (i.e. $c_3 > 0$ and $c_3 = -c_4$), we can then write the regression equation as, with approximate equality:

$$CS_t \approx \dots + c_3 \cdot GDP_t - c_3 \cdot GDP_{t-1} + \dots$$

The following rearrangement and relabelling is then possible:

$$CS_t \approx \dots + c_3 \cdot (GDP_t - GDP_{t-1}) + \dots \Rightarrow$$

$$CS_t \approx \dots + c_3 \cdot \Delta GDP + \dots,$$

where Δx is used as an abbreviation for $x_t - x_{t-1}$ (i.e. “changes in x ”). When the above conditions hold, this argument gives rise to the interpretation that it is changes in, rather than levels of a variable (e.g. income) that determine caesarean section rates.[6]

This interpretation can in fact be legitimately applied whenever the confidence intervals of the coefficients, for example c_3 and c_4 , are substantially overlapping (i.e. the coefficients are equal within statistical error). Since, in practice, the coefficients will rarely be exactly equal, their absolute values can be averaged to produce a statistically more robust estimate of the impact of changes in the independent variable on the dependent variable.

Averaging the coefficients is equivalent to defining a new coefficient based on a combination of the original ones:

$$c_\Delta \equiv (c_3 - c_4)/2.$$

The transformed coefficient c_Δ is then used to infer the effect of changes in the independent variable.

This is the procedure used to interpret the effect of income, the number of hospitals per capita and the number of midwives per capita on caesarean section rates. The transformed coefficients, and their approximate confidence intervals, corresponding to these variables are reported below in Table 3.

Long run

In Results, so-called “long run” relationships are reported for certain variables. This is another standard interpretation for econometric models of this type.

This interpretation is motivated by the argument that, in the long run, the values of variables at different time periods (i.e. at t , $t - 1$ and so forth) will become equal. In other words, the dynamic system estimated by the model is assumed to reach equilibrium in the long run in the sense that there are no further changes in the values of any of the variables.

However, if the use of the term “long run” seems objectionable for any reason, one can alternatively think of the long run relationships as equilibrium relationships. They are, in other words, the relationships that would obtain if and when the system estimated by the model reaches a steady state. The long run coefficients thus show the intrinsic response (equilibrium elasticity) of the estimated dynamic system to exogenous shocks in any of the variables.

If we are interested in the long-run relationship between caesarean section and income, for example, we suppress the corresponding subscripts for period (since the variables have reached steady state and are therefore equal in all periods). The relevant part of the regression equation can then be written:

$$CS_t = c_1 \cdot CS_{t-1} + c_2 \cdot CS_{t-2} + c_3 \cdot GDP_t + c_4 \cdot GDP_{t-1} + \dots \Rightarrow$$

$$CS = c_1 \cdot CS + c_2 \cdot CS + c_3 \cdot GDP + c_4 \cdot GDP + \dots$$

The common terms for caesarean section and income are then collected together and their coefficients added:

$$(1 - c_1 - c_2) \cdot CS = (c_3 + c_4) \cdot GDP + \dots$$

The long-run relationship of caesarean section and income can then be calculated by solving the above equation for CS:[6]

$$CS = (c_3 + c_4)/(1 - c_1 - c_2) \cdot GDP + \dots$$

This defines a new, long run (“LR”) coefficient for the independent variable in terms of the estimated coefficients; it expresses the proportional response of the caesarean section rate to exogenous shocks in income at steady state:

$$c_{LR} \equiv (c_3 + c_4)/(1 - c_1 - c_2) .$$

We have calculated long run elasticities of caesarean section rates for income per head, hospitals per head, hospital beds per head and the number of midwives per head. The transformed coefficients, and their approximate confidence intervals, for the long run elasticities for these variables are reported below in Table 4.

Uncertainty estimates

Approximate 95% confidence intervals are reported in the web tables for both raw and transformed coefficient estimates. The estimates for the raw coefficients are derived directly from the standard errors of the regression coefficients in the conventional manner. The confidence intervals reported for the transformed coefficients, however, are derived using a statistical technique called the “delta method” that relies on a linear-order series expansion of the equation for the transformed coefficient. The variance of the linear-order expansion of the coefficient equation can then be calculated by using standard statistical identities. This approach takes into account the main (i.e. first-order) effect of the variance and covariance of the raw coefficients (Table 5).

Tables

Table 1: Raw coefficients estimates for the basic model^a.

Variable	Coefficient	<i>P</i> value	95% Confidence Interval	
CS ^b (<i>t</i> −1)	0.646	0.000	0.557	0.735
CS (<i>t</i> −2)	0.178	0.000	0.091	0.265
GDP ^c	0.040	0.000	0.020	0.060
GDP (<i>t</i> −1)	−0.045	0.000	−0.062	−0.029
MMR ^d	−0.013	0.373	−0.043	0.016
Year	0.003	0.000	0.002	0.004

^a Sargan test of over-identifying restrictions: $\chi^2(479) = 404.7$; Probability $> \chi^2 = 0.994$. Arellano-Bond test that average autocorrelation in residuals of order 1 is 0: H_0 : no autocorrelation; $z = -14.00$, Probability $> z = 0.000$. Arellano-Bond test that average autocorrelation in residuals of order 2 is 0: H_0 : no autocorrelation; $z = 0.580$, Probability $> z = 0.562$.

^b CS = caesarean section rate.

^c GDP = gross domestic product per capita (income per head).

^d MMR = maternal mortality ratio.

Table 2: Raw coefficients estimates for the full model^a.

Variable	Coefficient	<i>P</i> value	95% Confidence Interval	
CS ^b (<i>t</i> −1)	0.430	0.000	0.318	0.542
CS (<i>t</i> −2)	0.257	0.000	0.150	0.363
GDP ^c	0.052	0.000	0.022	0.081
GDP (<i>t</i> −1)	−0.069	0.000	−0.094	−0.049
MMR ^d	0.011	0.569	−0.027	0.049
Hospitals per capita	0.167	0.007	0.045	0.289
Hospitals per capita (<i>t</i> −1)	−0.130	0.024	−0.242	−0.017
Hospital beds per capita	0.268	0.000	0.122	0.414
Midwives per capita	0.006	0.805	−0.045	0.058
Midwives per capita (<i>t</i> −1)	−0.051	0.011	−0.091	−0.012
Share of health expenditure from government sources	−0.298	0.004	−0.500	−0.096
Year	0.007	0.000	0.005	0.010

^a Sargan test of over-identifying restrictions: $\chi^2(479) = 198.43$; Probability $> \chi^2 = 1.000$. Arellano-Bond test that average autocorrelation in residuals of order 1 is 0: H_0 : no autocorrelation $z = -4.72$, Probability $> z = 0.0000$. Arellano-Bond test that average autocorrelation in residuals of order 2 is 0: H_0 : no autocorrelation $z = 0.390$, Probability $> z = 0.698$.

^b CS = caesarean section rate.

^c GDP = gross domestic product per capita (income per head).

^d MMR = maternal mortality ratio.

Table 3: Transformed regression coefficients for changes in independent variables.

Δ Variable (model)	Equation for transformed coefficient	Numerical value	Approximate 95% Confidence Interval	
Δ GDP ^a (basic)	$(c_3 - c_4)/2$	0.04	0.03	0.06
Δ GDP ^a (full)	$(c_3 - c_4)/2$	0.06	0.04	0.08
Δ Hospitals per capita (full)	$(c_7 - c_8)/2$	0.15	0.04	0.26
Δ Midwives per capita (full)	$(c_{10} - c_{11})/2$	0.03	-0.01	0.06

^a GDP = gross domestic product per capita (income per head).

Table 4: Transformed regression coefficients for the long-run elasticities of the independent variables.

Variable (model)	Equation for transformed coefficient	Numerical value	Approximate 95% Confidence Interval	
GDP ^a (basic)	$(c_3 + c_4)/(1 - c_1 - c_2)$	-0.02	-0.11	0.07
GDP ^a (full)	$(c_3 + c_4)/(1 - c_1 - c_2)$	-0.05	-0.14	0.03
Hospitals per capita (full)	$(c_7 + c_8)/(1 - c_1 - c_2)$	0.12	-0.18	0.42
Hospital beds per capita (full)	$c_9/(1 - c_1 - c_2)$	0.86	0.45	1.26
Midwives per capita (full)	$(c_{10} + c_{11})/(1 - c_1 - c_2)$	-0.14	-0.32	0.04
Share of health expenditure from government sources (full)	$c_{12}/(1 - c_1 - c_2)$	-0.95	-1.49	-0.42

^a GDP = gross domestic product per capita (income per head).

Table 5: Approximate variance–covariance estimates for the raw coefficients in the full model.

Variable	CS_{t-1}	CS_{t-2}	GDP_t	GDP_{t-1}	MMR_t	$Hosp_t$	$Hosp_{t-1}$	$HospBed_t$	$Midw_t$	$Midw_{t-1}$	$PubHExp_t$	Year
CS_{t-1}	0.003											
CS_{t-2}	-0.002	0.003										
GDP_t	-0.0001	0.00002	0.0002									
GDP_{t-1}	0.00002	0.0001	0.0001	0.0002								
MMR_t	0.00009	0.0004	-0.00003	0.00002	0.0004							
$Hosp_t$	0.001	0.001	0.0001	0.0001	0.00002	0.004						
$Hosp_{t-1}$	-0.001	-0.0002	0.0001	-0.00006	0.00005	-0.002	0.003					
$HospBed_t$	-0.001	-0.001	0.0002	-0.00001	0.00006	-0.002	0.0003	0.006				
$Midw_t$	0.0002	0.0002	-0.00003	-0.00003	-0.0002	0.0001	-0.0003	-0.001	0.001			
$Midw_{t-1}$	0.0001	0.0001	0.00001	-0.00003	-0.0006	0.0002	-0.0003	-0.0003	-0.00005	0.0004		
$PubHExp_t$	0.002	0.002	0.00008	0.00008	-0.0001	0.001	0.00003	-0.003	0.00001	0.00009	0.011	
Year	-0.00003	-0.00002	~0	~0	~0	-0.00002	0.00002	0.0001	-0.00002	0.00001	0.00003	~0

Annex references

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