Health Economics, Policy and Law (2024), **19**, 92–118
doi:10.1017/S1744133123000269

HEALTH ECONOMICS, POLICY and LAW

ARTICLE

Early child health in Africa: do ICT and democracy matter?

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(Received 9 June 2022; revised 29 July 2023; accepted 17 September 2023; first published online 6 November 2023)

Abstract
This article examines the effect of information and communication technologies (ICT) and democracy on early child health using data from 51 African countries. We first specify and estimate a panel data model using ordinary least squares and two-stage least squares over the period 2001–2019. We apply the Hodrick–Prescott filter before analysis. Our results show that the extension of mobile phone use significantly contributes to the improvement of early child health in Africa. This effect is indifferent to the state or the level of democracy. Also, the internet diffusion plays a positive role in early child health when the democracy environment improves and becomes better. We suggest policies in favour of a large access to ICT tools and internet infrastructure as well as the promotion of democracy in Africa to better prevent infant mortality.

Keywords: Africa; democracy; early child health; ICT; 2SLS

1. Introduction

Early childhood health is good for the economy. Beyond the reduction in medical care costs, it enhances cognitive ability and educational human capital of individuals over the course of their life as well as their participation and that of their parents in the labour market (Alex-Petersen *et al.*, 2017). It is with this in mind that the United Nations devoted the second target of the third sustainable development goal to child health. Although the world has been accelerating progress in reducing the child mortality since 1990, many countries mainly in the developing world continue to face poor child health. According to the World Health Organization (WHO), an estimated 5 million children under the age of 5 years died in 2020, mostly from preventable and treatable causes (WHO, 2022). It is during the neonatal period, the first 28 days of life, that this risk of death is the highest (UNICEF, 2019[1]; WHO, 2022). Approximately half of under five deaths, occurred among newborns (WHO, 2022). While the neonatal mortality rate was estimated at 18 deaths per 1000 live births globally in 2018, the probability of dying after the first month and before reaching age 1 was at 11 per 1000 live births. Likewise, the probability of dying after reaching age 1 and before reaching age 5 was at 10 per 1000 (UNICEF, 2019).

Countries located in Africa still have the highest neonatal mortality rates. With 27 deaths per 1000 live births in 2019,[2] a child born in sub-Saharan Africa is ten times more likely to die in the

[1]United Nations Children's Fund (UNICEF).

[2]While countries like Cabo Verde (9‰), Mauritius (10‰), and Sao Tome (8.20‰) are doing better, others like Lesotho (48.80‰), Central Africa Republic (39.60‰), Nigeria (35.90‰), South Soudan (40.2‰), and Somalia (37.40‰) are still very far from the average situation in Africa.

first month than a child born in a high-income country (WHO, 2022). The WHO (2020) documents that these deaths are generally due to conditions and diseases associated with lack of quality care at birth or treatment immediately after birth and in the first days of life. But more generally, that is because of multiple constraints and challenges that health systems are going through in several African countries. For example, the African health system is poor funding. According to WHO estimations, Africa carries 23 per cent of the world's disease burden but its share of global health expenditures was only less than 1 per cent in 2015. The rest of the world therefore spends ten times more on health care than Africa (Ogbuoji *et al.*, 2019). Moreover, though countries of this continent agreed to allocate at least 15 per cent of their budget to health care, only 6 over 54 have met this commitment 20 years later (United Nations Department of Public Information, 2017). Such a context favours millions on deaths among children in Africa and constitutes a pressing concern for policy makers and researchers that consider information and communication technologies (ICT) as a potential opportunity for child health given their externalities in health policy, health services delivery, and health information access (Aker and Mbiti, 2010; Wu and Raghupathi, 2012).

Indeed, the world has undergone a rapid connectivity transition during the past few decades due to the general upward trend in the access to and use of ICT as well as large infrastructure investments in the ICT sector (Haenssgen and Ariana, 2017; ITU, 2018[3]). Nowadays, there are more mobile phone subscriptions than people on the planet, with almost the entire world population (97 per cent) living within reach of a mobile-cellular signal (ITU, 2019). Even in low- and middle-income countries, including in Africa, up to 630 million new subscriptions per year are added; these countries account for three-quarter mobile phone subscriptions worldwide (ITU, 2015a, 2015b).

Despite the persistent high level of child mortality and decades of ICT dramatical extension in Africa, several questions about ICT effects on human capital in general and on child health specifically remain surprisingly unanswered so far. Yet, ICT could affect health through several mechanisms. First, ICT could reduce geographical constraints as they allow people to be reachable individually and virtually everywhere, connecting individuals to other individuals, information, market, and services (ITU, 2018). This provides a great deal of flexibility and brings health care providers and beneficiaries closer (Chandrasekhar and Ghosh, 2001; Dutta *et al.*, 2019). Second, the large diffusion of mobile phones and the growing access to the internet have the particularity to stimulate local applications of information technology in the management of health facilities and programmes and to improve the delivery of health care to the population (Grace *et al.*, 2004; Tariq and Naheed, 2019). ICT contribute also to increasing the provision of health information needed by health workers and patients, improving patient-provider communication, and strengthening the links between front-line health services and qualified doctors (Grace *et al.*, 2004). These mechanisms suggest a positive influence of ICT on early child health.

However, the relation between ICT and child health could depend on the complacent health behaviour women adopt after accessing to health information through ICT. By this way, women could avoid visiting health facilities once they accessed the needed maternal and child health information through ICT. Likewise, pervasive health behaviour practices like self-medication could be encouraged with ICT development and leads to negative effect on child health.[4] In addition, ICT could negatively impact child health through female participation in labour market, given that women's employment decreases the quantity of time mothers spend with their children[5]

[3]International Telecommunication Union.

[4]Self-medication is far from being a completely safe practice and presents potential risks including incorrect self-diagnosis, delays in seeking medical advice when needed, dangerous drug interactions, incorrect dosage or risk of dependence, and abuse (Ruiz, 2010).

[5]Nkoumou Ngoa and Song (2021) showed for example that ICT favour female labour market participation in Africa.

https://doi.org/10.1017/S1744133123000269 Published online by Cambridge University Press

(Basu and Basu, 1991; Bui *et al.*, 2018).[6] Therefore, even though we expect that the more the penetration in ICT better are early child health outcomes, the way ICT impact child health theoretically appears challenging. An empirical verification of the effect of ICT on health outcomes is therefore required.

Early child health however requires costly health infrastructures and good access to health care. That demands the provision of an adequate public health care system, especially for the poor and middle class. Although Malligan *et al.* (2004) failed to prove a significant difference between democracies and non-democracies in terms of public policies, the role of institutions could be an important issue when studying the effect of ICT on child health. The argument is that in democracy societies, most of the population is allowed to vote and express their preferences over health policies and the government is supposed to represent the preferences of this population. In non-democratic regimes in contrast, instead of the wishes of the population at large, government's decisions represent the preferences of a subgroup of the population (Robinson *et al.*, 2003). Therefore, policies in democracy regimes will generally be those that are more favourable to the poor than in non-democratic regimes (Meltzer and Richard, 1981; Robinson *et al.*, 2003; Mulligan *et al.*, 2004). Decision makers in democracies intend to satisfy the demand of the electorate providing suitable public goods and health expenditures than autocracies (Besley and Kudamatsu, 2006; Wang *et al.*, 2019; Blum *et al.*, 2021).

ICT led to the creation of a new public sphere that transcends geographical boundaries and highlights issues of concern within a decentralised virtual environment (Azelmat, 2019). In democracies where ICT activities are free, people voice is supposed to be heard and information freely shared, including health information and public policies in health. In this setting, ICT could be a useful tool to promote child health in the country, since democratic governments have an impressive capacity to self-correct and improve public policies. On the contrary, autocracies disappear critics, prohibit independent media, censor and monitor free expression and online activities. Moreover, websites are required to register with the government in order to allow the government to hold websites accountable for what they publish and to criminalise online intervention or criticism that is not approved (Tkacheva *et al.*, 2003). Some governments even take advantage on anti-terrorist legislation to restrict democratic space (Temin, 2017). Therefore, information sharing in non-democratic governments is logically limited, including online activities on health. One can then expect that as countries tend to democracy, ICT improve child health outcomes.

This paper investigates the effect of ICT on early child health in Africa and the way this effect depends on institutional settings. We focus on Africa not only because the continent has known a fast diffusion of ICT in these last two decades, but also because of worrying child health situation in this part of the world before the first life month (UNICEF, 2018; WHO, 2019). This paper contributes to the broader literature of socioeconomic implications of ICT diffusion. It takes advantage of the variety of institutional forms of government in Africa. After the cold war, this continent has experienced significant democratic advances. Many African countries have moved away from autocracy towards democracy. For example, 41 countries over 53 were non-democracies in 1975 while only 3 countries were considered as democracies. By 1990, 39 countries were still non-democratic and by 2018, the number of democracies countries increased to 20 while 11 African countries were still considered non-democracies, representing 22 per cent of countries in the region[7] (International IDEA, 2021). This context offers a special setting to analyse the way institutions could modify the relationship between ICT and child health outcomes.

[6]Indeed, a woman cannot be in two places at once, and the woman who has children and works away from the home must leave the daily care of her children to others unless her work allows them to follow her. Even in this last case, getting a job may often mean that the physical proximity between mother and child is no more the same (Basu and Basu, 1991) with potential effects on child health.

[7]According to International IDEA (2021), West Africa is the Africa's most democratic sub-region, followed by Southern Africa, North Africa, and East Africa. Central Africa is the only African sub-region with no democracies.

https://doi.org/10.1017/S1744133123000269 Published online by Cambridge University Press

Two main findings are highlighted in this study. The first finding is that ICT, measured by the internet, telephones, and mobile phones penetration, have a negative and significant effect on early child mortality. The second one shows that institutional settings are important to understand the way the relation between ICT and early child health outcomes can be modified, since as democracy improves in a country, ICT positively affect early child health.

The rest of the paper is organised as follows: Section 2 presents literature review. In Section 3 the methodology is explained. Section 4 describes data, while Section 5 analyses and discusses results. Section 6 concludes.

2. Literature review

The frequently assessed determinant in child health literature is socioeconomic status (SES), especially income and education. Concerning income for example, it has appeared as a factor that explains better child health, probably because families with high income may be able to provide their children with more goods, services, and resources that can help to prevent them from diseases (Brooks-Gunn and Duncan, 1997). Education also has raised as an important SES element that explains child health. Indeed, greater maternal education translates into greater health care utilisation including prenatal visits (Günes, 2015). Also, better-educated women are associated with greater female autonomy, which in turn influences health-related decisions and the allocation of resources within the household (Caldwell *et al*., 1983; Günes, 2015).

However, with the emergence of the New Economy,[8] the perception of ICT as an opportunity for health has led to a well-documented literature on their effects (Dutta *et al*., 2019; Tariq and Naheed, 2019). It is argued that ICT contribute to the qualitative and quantitative improvement of child health by bringing health care providers and beneficiaries closer (Chandrasekhar and Ghosh, 2001; Dutta *et al*., 2019) and increasing the provision of health information needed by health workers and patients (Grace *et al*., 2004). However, the relation between ICT and child health could depend on the complacent health behaviour women adopt once they access to health information through ICT channel, as women could avoid visiting health facilities once they accessed the needed maternal and child health information through ICT (Obasola and Mabawonku, 2017).

Empirically, some studies have examined the effect of ICT on health services and outcomes. In Montevideo, Uruguay, Balsa and Gandelman (2010) summarised a randomised experiment to study the effects of an internet-based intervention on type 2 diabetes patients, designing a special website and electronic social network that allowed participants to navigate freely, download materials, and interact with other diabetics and specialists. The authors found no significant effect on participants' knowledge, behaviour, or health outcomes. Singh and Banerjee (2019) showed that a large proportion of patients, mainly located in urban areas, used internet to get medical information in India. These patients empowered themselves through online health information when they deal with doctors. At Tafo Government Hospital, Addo and Agyepong (2020) sought to uncover the effects of ICT on health service delivery. They found that ICT improves collaboration and clinical decision support in facilitating clinical workflow integration among nurses and other medical professionals.

Seeking whether the use of internet in the USA is associated with a subsequent change in psychological wellbeing and health, Bessière *et al*. (2010) found that using the internet for health purposes was associated with increased depression, probably due to increased rumination, unnecessary alarm, or over-attention to health problems. Additionally, those with unmeasured problems or those more prone to health anxiety may self-select online health resources. In contrast, using the internet to communicate with friends and family was associated with declines in depression. In developing countries, Tariq and Naheed (2019) showed that there is a positive and

[8]The New Economy is associated with the invention of computer technologies and the use of computers, software, the internet, and smartphones.

https://doi.org/10.1017/S1744133123000269 Published online by Cambridge University Press

significant impact of ICT on population health. Specifically in Africa, Adeola and Evans (2018) found that ICT have a positive and significant relationship with life expenditures. Likewise, Dutta *et al.* (2019) documented that as ICT infrastructure increases infant mortality rate decreases in Asian countries. Using data on African countries, Kouton *et al.* (2021) showed that economic freedom matters in the relationship between ICT development and health outcomes by playing a critical role in ICT diffusion. They found that when economic freedom is associated with ICT diffusion, the net effect on under-five mortality is small and negative, suggesting that the strategies to drive ICT development in Africa to date have not been implemented within a framework that advocates the development of economic freedom.

Obasola and Mabawonku (2017), investigating the use of ICT by women in Nigeria to access maternal and child health information as well as the role of its use on their health practices, showed that maternal and child health information acquired through ICT tools can positively or negatively influence health practices. All depending on the complacent health behaviour women could adopted once they access to health information through ICT channels. Using data of 28 European countries, Tavares (2018) showed that no relation exists between eHealth technologies in the primary services, ICT development, and self-reported health outcomes, except for self-reported chronic health problems, suggesting that the more advanced countries are in ICT, the larger is the share of people reporting a chronic health problem.

In China, Wang *et al.* (2020) used data from the Chinese General Social Survey to investigate the effects of internet use on the elderly's physical health, mental health, and self-rated health. They showed that internet use significantly affects the physical and mental health of the elderly but does not significantly affect self-rated health. A similar result is found by Zhu *et al.* (2021) who revealed that internet use has a positive association with the health of older adults.

When democracy is associated with ICT and health, literature is more interested in health effect of democracy and democracy effect of ICT. For example, Safaei (2006) found that democracy may have an impact on health independent of the effects of socioeconomic factors, while Franco *et al.* (2004) showed that democracy has a positive association with life expectancy and infant mortality even after adjustment for country's wealth, level of inequality, and the size of public sector. Wang *et al.* (2018) also confirmed that democratic elections have consistent effects on health outcomes even when other important factors, including good governance, are considered. The positive effects they found, however, are particularly salient once the quality of elections has achieved a certain threshold.

Additionally, ICT could affect democracy by discouraging officials and politicians from making false statements and giving out wrong information during political campaigns. Also, mobile phones and the internet can increase the participation of people in the democratic process, mobilise them to debate and influence relevant subjects to the political life of their country (Suarez, 2006). In developed and developing countries, Ben Ali (2020) assessed the impact of ICT adoption on democracy and found that the internet and mobile technologies increase the level of democracy. On the contrary, exploring the global effect of the internet on democracy, Best and Wade (2009) showed that some regions do not enjoy a positive internet/democracy correlation suggesting that the internet can be used as a tool for democratisation as well as an instrument for authoritarianism.

Two main features arise from this literature. First, it has surprisingly devoted little attention to the child health effect of ICT in the African continent, where child health outcomes are still poorer and economically costly. Second, the literature failed to uncover the way the effect of ICT on health outcomes changes with institutional or democracy dynamics. We address a significant gap in the literature by examining these two points.

3. The empirical strategy

The empirical strategy consists in the presentation of the model, the justification of the estimation technique, and at the end sheds light the sources of the data.

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3.1. The empirical model

The estimated model is an extension of the work of Novignon and Lawanson (2017), Novignon *et al.* (2018), and Tariq and Naheed (2019) who investigated the impact of ICT on child health. The basic empirical model adopted is specified bellow by equation (1):

$$ECH_{it} = \alpha + \beta ICT_{it} + \lambda X_{it} + \nu_i + \mu_t + \varepsilon_{it} \tag{1}$$

where ECH_{it} refers to the early health indicator for country i at the time t. As a dependent variable, early child health is captured by the neonatal mortality. It is measured as the number of neonates dying before reaching 28 days of age, per 1000 live births in a given year.

ICT_{it} represents the information and communication technology of country i in period t. Three interest variables are considered: (i) people using the internet (per cent of the population) in the past 3 months; (ii) cellular mobile subscriptions (per 100 people) are subscriptions to a public mobile telephone service which provide access to the public switched telephone network using cellular technology, and (iii) fixed-telephone subscriptions refer to the sum of active number of analogue fixed-telephone lines, voice-over-IP subscriptions, fixed wireless local loop subscriptions, integrated services digital network voice-channel equivalents, and fixed public payphones.

X_{it} is a set of control variables made of the GDP per capita, health expenditure, human capital, regime duration, electricity, democracy, women political empowerment (WPE), ethnolinguistic fragmentation (ELF), rule of law. Likewise, ν_i is the country-temporal effects, μ_t is the country-specific effect, and ε_{it} is the error term. Thus, ν_i, μ_t, and ε_{it} are the fixed temporal effects, the country fixed effects, and the disturbance, respectively. It then controls for unobserved country-specific and time-invariant factors affecting child health.

The model to be estimated is specified by equation (2):

$$\begin{aligned} Early\_Child\_Health_{it} = {} & \alpha + \beta_1 Internet_{it} + \beta_2 Mob\_phone_{it} + \beta_3 Fixed\_phone_{it} \\ & + \lambda_1 GDP/Capita_{it} + \lambda_2 Health\_exp_{it} + \lambda_3 Hum\_cap_{it} \\ & + \lambda_4 Regime\_duration_{it} + \lambda_5 Electricity_{it} + \lambda_6 Democracy_{it} \\ & + \lambda_7 Women\_pol\_emp_{it} + \lambda_8 Eth\_lin\_frag_{it} \\ & + \lambda_9 Rule\_law_{it} + \nu_i + \mu_t + \varepsilon_{it} \end{aligned} \tag{2}$$

3.2. The estimation technique

Borrowing from contemporary empirical literature, this research motivates the choice of ordinary least squares (OLS) empirical strategies for two reasons: (i) it minimises the impact of measurement errors and (ii) it assumes that the countries in the sample are perfectly homogeneous. OLS-based econometric techniques are generally used as an initial framework in analysis to give the overall trend of results. Developed by Legendre (1805) and Gauss (1809), it allows regressions on panel data and highlights the effects of ICT diffusion on early child health. For our robustness analysis, the estimation technique adopted is two-stage least squares (2SLS), which is used when in a linear regression at least one of the explanatory variables is endogenous (Nwakuya and Ijomah, 2017).

Indeed, when an endogenous variable however exists, the classic model techniques are no longer considered since it may lead to inconsistent estimates and incorrect inferences, which may provide misleading conclusions, wrong sign of coefficient and inappropriate interpretations (Ullah *et al.*, 2018). In these cases, that variable and the error term will be correlated. To estimate such a model, it is more advisable to consider instrumental variables. However, strong

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instruments are difficult to find at the aggregate level (Sharma and Cárdenas, 2018). It is also advisable to use the generalised method of moments. However, considering the changes in the data on the child health mortality rate, very little fluctuations emerge. Thus, the lagged variables have little influence on the present variables. We declined this technique. In that situation, the most classical way to obtain a convergent estimate of the parameter of interest is to consider the 2SLS estimator. It is obtained by regressing the dependent variable, not on the endogenous regressor, but its OLS prediction from the first-stage regression. We then performed a double estimation. Hence the name 2SLS.

4. Data

The data for this study come from 51 African countries and cover the period 2001–2019. The sample of countries and of the periodicity of the variables were constrained by data availability at the time of the study. The included countries are listed in Appendix Table A1. The dependent variables, notably child health indicators are obtained from the World Bank World Development Indicators (2020), as well as the ICT variables (mobile phone, fixed phone, and the internet penetration). Other control variables are from Varieties-Democracy (2020) for Women's Political Empowerment, Polity IV (2020) for democracy and ethnolinguistic fragmentation, World Governance Indicators (2020) for Rule of Law and the Database of Political Institutions (2020) for regime duration. Definitions and sources of each variable are provided in Appendix Table A2.

Descriptive statistics of the variables are provided in Table 1. They show small variations. It is generally accepted that small fluctuations in data lead to unbiased results (Wooldridge, 2013). The average level of neonatal mortality rate in the sample is 28.8 per cent, with values ranging from 5.6 to 54.7 per cent. The average proportion of individuals using the internet (as a share of total population) is 10.3 per cent, with a minimum of 0.006 per cent and a maximum of 64.8 per cent. Mobile phone subscriptions (per 100 people) range from 0.001 to 184.3, with an average of 46.9. There is also a huge variability in fixed-phone subscriptions. They vary

Table 1. Descriptive statistics

	Observations	Mean	Standard deviation	Minimum	Maximum
Neonatal mortality rate	969	28.8485	10.4943	5.6	54.7
Internet	967	10.2643	13.7024	0.0059	64.8038
Mobile phone	968	46.8715	43.3933	0.0011	184.2980
Fixed phone	966	3.6642	6.0755	0.0059	34.2728
Electricity	969	42.9764	29.6141	1.2701	100
Education	969	45.6572	24.1316	6.1973	109.4441
Health expenditure	969	5.4446	2.3172	1.2635	20.4134
Regime duration	969	12.3419	12.8142	0	59
Democracy	969	2.0800	5.0241	−7	10
Women political empowerment	969	0.6853	0.1571	0.2072	0.9502
Ethnolinguistic fragmentation	969	0.1634	0.6000	0	3
Rule of law	969	−0.6644	0.6192	−2.0085	1.0771
GDP per capita	969	2.0995	62.3780	6.6987	121.7795

Source: Authors.

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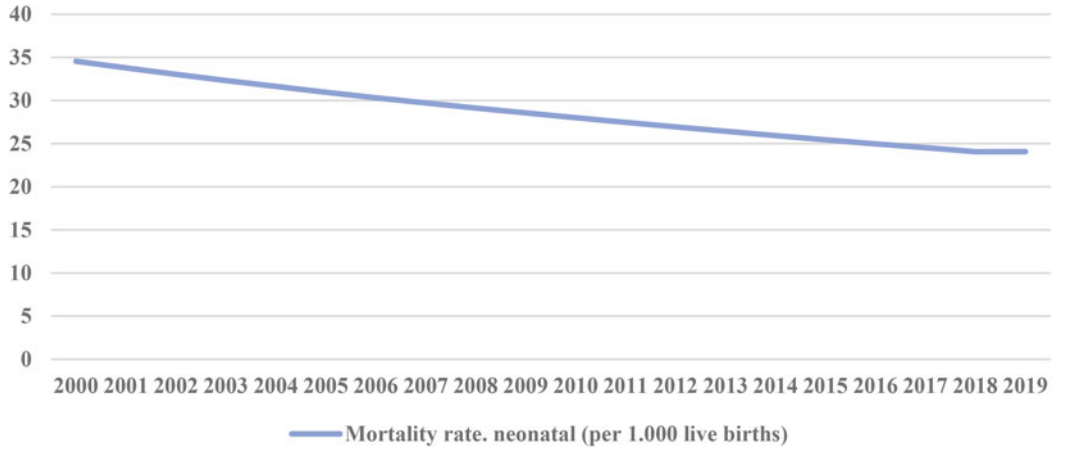

Figure 1. Average evolution of mortality rate in Africa.
Source: Authors, from World Development Indicators (2020).

from 0.006 to 34.3 per cent with an average of 3.7 per cent. Democracy variable varies from −7 to 10. Its average value is 2.1. In the sample, 45.6 per cent of the population are enrolled in secondary school and 43 per cent have access to electricity.

Figures 1 and 2 provide information on the evolution of neonatal mortality and the different components of ICT, respectively. Over the period, Figure 1 shows that neonatal mortality has followed a downward trend, probably as a result of policies aimed at achieving the millennium development goals, which have been implemented since 1990 and which have evolved into the sustainable development goals.

Regarding ICTs, it can be seen in Figure 2 that the use of the internet and cell phones has evolved rapidly over the period, unlike fixed-line telephones, whose use has remained relatively low and constant over time.

As expected, Figure 3a (Figure 3b respectively) exhibits a negative correlation between ICT spread and neonatal (under five) mortality over the period.

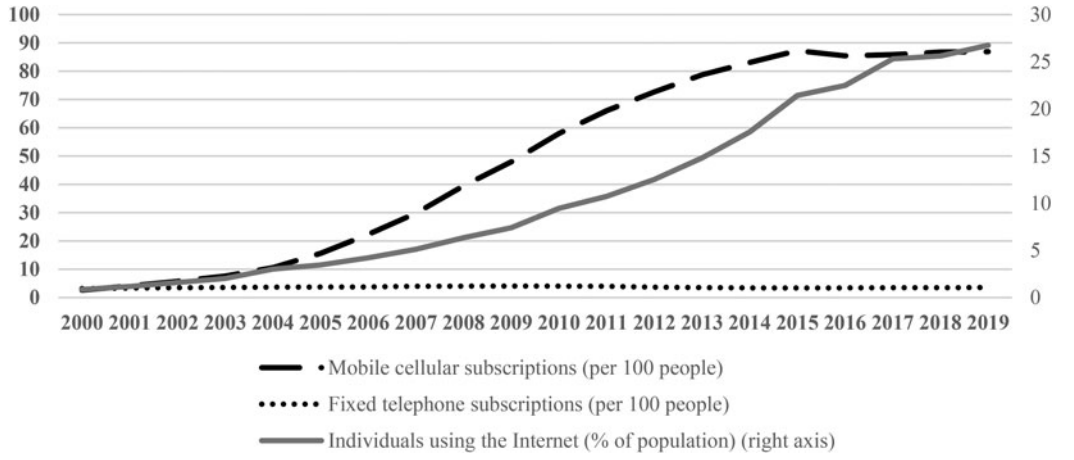

Figure 2. Average evolution of ICT diffusion in Africa.
Source: Authors, from World Development Indicators (2020).

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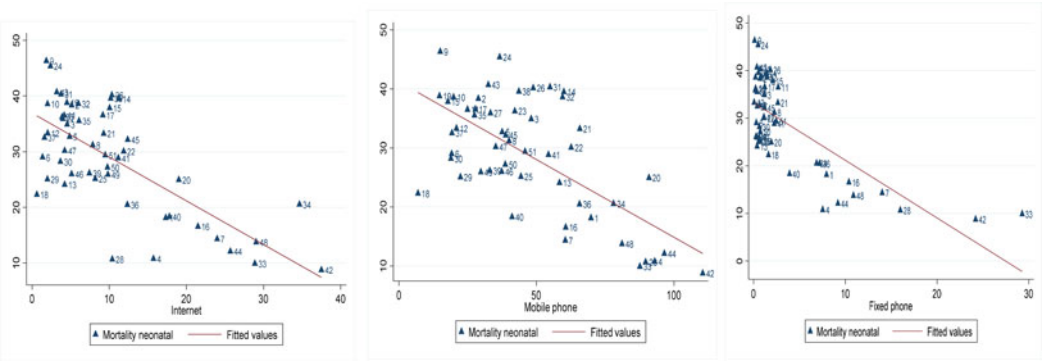

Figure 3a. Correlations between ICT diffusion and neonatal mortality rate in Africa.
Source: Authors, from World Development Indicators (2020).

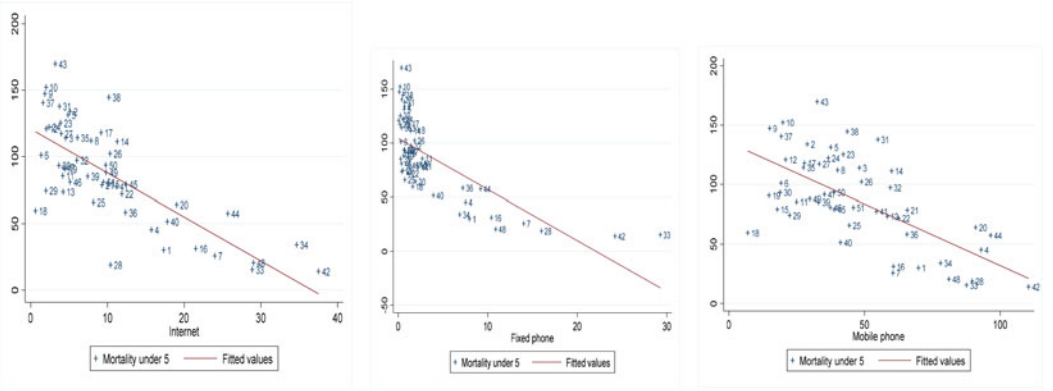

Figure 3b. Correlation between ICT diffusion and child (under 5) mortality rate.
Source: Authors.

5. Results

This section presents results of the ICT effects on early child health and the role of democracy on this effect. In the first step, we present baseline estimate results and discussions about the analysis of robustness estimates. The second and last step is dedicated to the discussions on the modifying effect of democracy on the ICT–early child health nexus.

5.1 Baseline estimates

For the baseline analysis, this study considers OLS estimates of the neonatality mortality rate effects of ICT. These estimates are shown in Table 2. Columns 1–3 report pooled OLS estimates when each dimension of ICT is included alone in the model. The estimated coefficients associated with the internet (−1.111), mobile phones (−0.349), and fixed phones (−2.722) are all negative and significant. These results document that an increase in the internet, mobile phones, and fixed phone penetration is negatively associated with neonatal mortality rates. When these ICT measures increase, the proportion of children that dead in the 28 days after birth decreases. Even though the magnitude of coefficients decreases, these estimates remain negative and significant when all the ICT measures are together included in the model (column 4). In column 5, various controls are added in the equation. All the coefficients associated with these control variables are

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Table 2. OLS results of ICT effect on neonatal mortality rate

	Estimation technique: OLS						
	Dependent variable: neonatal mortality rate						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Internet	−1.111*** (0.049)			−0.220*** (0.070)	0.044 (0.074)	−0.154** (0.071)	−0.138* (0.080)
Mobile_phone		−0.349*** (0.016)		−0.190*** (0.021)	−0.185*** (0.021)	−0.211*** (0.021)	−0.186*** (0.021)
Fixed_phone			−2.722*** (0.105)	−1.967*** (0.105)	−1.248*** (0.131)	−1.779*** (0.113)	−1.957*** (0.109)
Electricity					−0.528*** (0.046)		
GDP per capita					0.405*** (0.051)		
Education					−0.609*** (0.045)		
Health_expenditure					−0.455*** (0.072)		
Regime_duration						−0.184** (0.073)	
Democracy						−2.204** (0.022)	
Women_political_empowerment						−2.144*** (0.123)	
Ethnolinguistic_fragmentation							0.214*** (0.021)
Rule_of_law							−1.895*** (0.111)
Constant	68.248*** (0.839)	73.128*** (0.991)	66.618*** (0.742)	74.813*** (0.841)	77.182*** (0.867)	76.129*** (0.891)	78.495*** (1.558)
Observations	969	969	969	969	969	969	969
Countries	51	51	51	51	51	51	51
R^2	0.35	0.34	0.41	0.55	0.58	0.56	0.58

Source: Authors.

significant as well as the estimated coefficients associated with mobile phones and fixed phones. The estimated coefficient of the internet turns to positive but is no longer significant.

In columns 6 and 7, selected governance and fragmentation control variables are added to the equation, showing negative and significant estimated coefficients of ICT variables as in column 4. After including all the variables in the equation as it is shown in column 8, the estimated coefficients of ICT variables remain negative and significant even though their magnitudes are smaller than without control variables in the model. Beyond the potential and the capacity of ICT diffusion to remove geographic constraints and to connect individuals, the possible interpretation of the results about the effect of ICT penetration is that they keep health care providers and beneficiaries closer (Dutta *et al.*, 2019). Through ICT for example, telemedicine offers to patients and practitioners the convenience by obviating the necessity for a physical visit to get medical advice or treatment. In addition, some devices like eHealth facilitated by ICT diffusion allow the use of communication technologies and information about specific health issues, based on electronic tools. Likewise, mHealth devices allow the implementation of services, based on mobile telephony, aimed at contributing to one or more functions of the health system. More generally, ICT ease the provision of health information needed by health workers and patients, by improving patient–provider communication and strengthening the links between frontline health services and qualified doctors (Grace *et al.*, 2004).

Always from column 8, where all the selected control variables are added in the equation, it appears that, beyond ICT variables, several variables are associated with early child health. That is the case for electricity, education, and health expenditures. The estimated coefficients associated with these variables are all negative and significant. Therefore, when access to electricity and education improve in a country, child mortality decreases. Several studies acknowledge the availability of electricity as an important determinant of receiving health information and a supply side prerequisite for health facilities to provide efficient, safe, and good-quality health service (Banerjee *et al.*, 2004; Singh, 2016; Chen *et al.*, 2019). As far as education is concerned, it is important for both preventing and treating poor health outcomes and illness. Education could affect child health behaviour like skill building, socialisation, information provision, and delays in childbearing (Rowe *et al.*, 2005; Mensch *et al.*, 2019). More precisely, educated women are aware of health-related information and avoid risky behaviour (Tariq and Naheed, 2019).

Health expenditures also are negatively associated with child mortality probably due to the role of health systems in maintaining and improving health human capital; health expenditures would contribute to employ skilled health workers, pay medical equipment, and promote health or prevent diseases (Kiross *et al.*, 2020). Arthur and Oaikhenan (2017) add that health expenditures can serve as a tool for government to affect health outcomes through the provision and administration of health care services. Additionally, WPE appears as an important early child health determinant. As this empowerment increase, early child health decreases. An explanation of this result could be that political women leaders could devote priority to change in political choices that shape health programmes and social values that affect maternal and child health (Wadsworth and Butterworth, 2005; Besnier, 2023). Beside governance variables that appear as determinant factors of early child mortality, estimated coefficient of democracy is negative and significant (−2.204), meaning that the more the country leaves autocratic institutions for democracy, the more child mortality decreases. This result is important in Africa where democratic institutions remain weak despite some improvements, and child mortality figures still poorer. It does confirm previous results that highlighted the importance of democracy and democracy elections on various dimensions of health (Franco *et al.*, 2004; Wang *et al.*, 2018).

5.2 The robustness verification

The main result of the previous section indicated that ICT are significantly and negatively associated with early child mortality. In this section, we check the robustness of this baseline finding using other measures of child health and a different estimation method.

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5.2.1. Estimates using other child health measures

In this section, rather than using neonatality mortality rate as in the previous section, we now capture child health by infant mortality and under five mortality rates. Table 3 reports OLS results of ICT effects on infant mortality rate. In all equations, from equations (1)–(7), the estimated coefficients of ICT variables are negative and significant even when control variables are added in the model. These results are similar to those we found previously.

Table 4 reports OLS results of ICT on under five mortality rate. For most of the estimated equations, the ICT estimated coefficients are negative and significant. Even when coefficients are not significant, they are negative. These results are consistent once again with the negative nexus between ICT and early child mortality obtained in baseline results.

5.2.2. Robustness results using 2SLS estimates

Keeping OLS results in the presence of endogeneity could be econometrically problematic. Estimated coefficients could bear a bias if the effects of ICT on child health are confounded with unobservable determinants. Identifying causal inference under this condition is not feasible without addressing the endogeneity problem (Sharma and Cárdenas, 2018). To estimate such a model, one way of advisable is to proceed by the 2SLS estimation technique (Nwakuya and Ijomah, 2017). It is obtained by regressing the dependent variable, not on the endogenous regressor, but on its OLS prediction from the first-stage regression, then performing a double estimation.

Table 5 reports results obtained from the 2SLS estimation technique. From columns 1 to 3 the sign and significance of the coefficients of ICT variable remain similar to those obtained using OLS estimation, confirming the negative effect of ICT on neonatal mortality.

5.3 The role of democracy

In the previous sections, we found a negative effect of ICT on early child mortality. In this section, we add in equation (2) an interaction variable of ICT and democracy. The equation we estimate is as follows:

$$ECH_{it} = \alpha + \beta ICT_{it} + \lambda X_{it} + \pi (ICT \times Democracy)_{it} + \nu_i + \mu_t + \varepsilon_{it} \tag{3}$$

GIVING $Z = ICT \times Democracy$ where Z is the interactive variable considering the combination between ICT variables and Democracy. Equation (3) can be presented as follows if we replace $ICT \times Democracy$ by Z:

$$ECH_{it} = \alpha + \beta ICT_{it} + \lambda X_{it} + \pi Z_{it} + \nu_i + \mu_t + \varepsilon_{it} \tag{4}$$

Z reflects the following interactions: (Internet × Democracy; Mobile phone × Democracy; Fixed phone × Democracy) of country i in period t.

In order to verify if Democracy mediates the effect of ICT on Child health, equation (5) is estimated as below:

$$\begin{aligned} ECH_{it} = {} & \alpha + \beta_1 Internet_{it} + \beta_2 Mobile\_phone_{it} + \beta_3 Fixed\_phone_{it} + \lambda_1 GDP/Capita_{it} \\ & + \lambda_2 Health\_exp_{it} + \lambda_3 Human\_capital_{it} + \lambda_4 Regime\_duration_{it} + \lambda_5 Electricity_{it} \\ & + \lambda_6 Democracy_{it} + \lambda_7 Women\_pol\_emp_{it} + \lambda_8 Eth\_lin\_frag_{it} + \lambda_9 Rule\_of\_law_{it} \\ & + \pi_1 (Internet \times Democracy)_{it} + \pi_2 (Mobile\_phone \times Democracy)_{it} \\ & + \pi_3 (Fixed\_phone \times Democracy)_{it} + \nu_i + \mu_t + \varepsilon_{it} \end{aligned} \tag{5}$$

Table 6 reports results estimated from equation (5). Columns 1–3 report estimates of different models including the interaction variable between ICT indicators and democracy. Estimated

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Table 3. OLS results of ICT effect infant mortality rate

	Estimation technique: OLS						
	Dependent variable: infant mortality rate						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Internet	−0.430** (0.020)			−0.079*** (0.028)	−0.060** (0.027)	−0.044* (0.026)	−0.058** (0.029)
Mobile_phone		−0.131** (0.007)		−0.061*** (0.008)	−0.006 (0.008)	−0.015* (0.008)	−0.068*** (0.009)
Fixed_phone			−0.338*** (0.065)	−0.920*** (0.042)	−0.483*** (0.050)	−0.403*** (0.049)	−0.061*** (0.008)
Electricity					−0.323*** (0.017)		
GDP per capita					0.021 (0.016)		
Education					−0.132*** (0.017)		
Health_expenditure					−0.233*** (0.027)		
Regime_duration						−0.047* (0.027)	
Democracy						−0.062*** (0.008)	
Women_political_empowerment						−0.723*** (0.046)	
Ethnolinguistic_fragmentation							0.134*** (0.046)
Rule_of_Law							−1.021*** (0.050)
Constant	33.283** (0.349)	34.989** (0.418)	33.092*** (0.287)	35.815*** (0.338)	36.350*** (0.357)	36.665*** (0.353)	38.121*** (0.603)
Observations	969	969	969	969	969	969	969
Countries	51	51	51	51	51	51	51
R^2	0.47	0.56	0.57	0.58	0.62	0.67	0.76

Source: Authors.

Table 4. OLS results of ICT effect under 5 mortality rate

	Estimation technique: OLS						
	Dependent variable: under five mortality rate						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Internet	−1.961*** (0.083)			−0.466*** (0.122)	−0.291** (0.125)	−0.362*** (0.124)	−0.340*** (0.111)
Mobile_phone		−0.614*** (0.026)		−0.324*** (0.037)	−0.056 (0.038)	−0.326*** (0.036)	−0.122*** (0.035)
Fixed_phone			−4.558*** (0.184)	−3.149*** (0.183)	−0.859*** (0.232)	−2.855*** (0.197)	−0.893*** (0.213)
Electricity					−0.122*** (0.035)		
GDP per capita					−0.893*** (0.213)		
Education					−0.684*** (0.125)		
Health_expenditure					−1.043*** (0.078)		
Regime_duration						−0.684*** (0.125)	
Democracy						−1.043*** (0.078)	
Women_political_empowerment						−0.743*** (0.079)	
Ethnolinguistic_fragmentation							1.043*** (0.078)
Rule_of_Law							−0.743*** (0.079)
Constant	10.106*** (1.429)	11.649*** (1.691)	10.376*** (1.308)	11.244*** (1.463)	18.955*** (4.387)	12.945*** (2.733)	14.301*** (2.164)
Observations	969	969	969	969	969	969	969
Countries	51	51	51	51	51	51	51
R^2	0.36	0.36	0.39	0.54	0.51	0.413	0.505

Source: Authors

Table 5. 2SLS results of ICT effect on early child health

	Estimation technique: 2SLS		
	Dependent variable: neonatal mortality rate		
	(1)	(2)	(3)
Internet	−1.257*** (0.0595)	−1.882*** (0.284)	−1.717*** (0.349)
Mobile_phone	−2.077* (1.163)	−1.422*** (0.609)	−1.695*** (0.687)
Fixed_phone	−0.068* (0.647)	−1.134*** (0.118)	−1.105*** (0.154)
GDP per capita	−0.799*** (2.395)		
Energy	−2.047*** (0.484)		
Health_expenditure	−0.105** (0.118)		
Regime_duration		−0.030*** (0.604)	
Democracy		−0.993*** (1.475)	
Women_political_empowerment		−0.211*** (0.066)	
Ethnolinguistic_fragmentation			1.226*** (0.199)
Rule_of_Law			−1.996** (1.180)
Constant	6.392*** (1.403)	4.127*** (1.423)	4.681* (3.579)
Observations	969	969	969
Countries	51	51	51
R^2	0.432	0.427	0.477
Prob. $>\chi^2$	0.0000	0.0000	0.0000

Source: Authors.

coefficients of ICT variables and democracy remain negative and significant. As far as ICT is concerned, its diffusion generates the demand for neonatal, maternal and reproductive health products, allowing a qualitative and quantitative improvement in early child health.[9] Also, decision makers in democracies intend to satisfy the demand of the electorate providing suitable public goods and health expenditures than autocracies (Besley and Kudamatsu, 2006; Wang *et al.*, 2019; Blum *et al.*, 2021). These policies result in the improvement of early child health. Moreover, coefficients of the interaction between the internet and democracy are negative and significant for most of the models. However, for a good understanding of the signification of the effect of the ICT when democracy change, a mediation analysis is required.

5.4 Mediation analysis of the effect of ICT on early child health

In order to test whether democracy mediates the effect of ICT on early child health, we use causal mediation analysis. This analytical approach inspired and taken over by Brambor *et al.* (2006), Avom *et al.* (2021), or Ndoya *et al.* (2022), is illustrated in Figure 4. It assumes that ICT diffusion is prior to the transmission channel of democracy.

[9]One example is the one found in rural Ghana, the mobile technology for health community (mobile technology for community health – MOTECH), which aimed to improve quantity and quality of antenatal and neonatal care. Another example is the mobile alliance for maternal action (MAMA) found in Bangladesh and South Africa that uses technology to improve results of initiatives in favour of health and of the nutrition that it sets up with pregnant women and young mothers and their children.

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Table 6. 2SLS results of the interaction effect of ICT and democracy on early child health

	Estimation technique: 2SLS		
	Dependent variable: infant mortality rate		
	(1)	(2)	(3)
Internet	−1.261*** (0.0548)	−1.894*** (0.300)	−0.625*** (0.154)
Mobile_phone	−1.111*** (0.0490)	−1.457*** (0.648)	−1.655*** (1.068)
Fixed_phone	−1.722*** (0.105)	−1.161*** (0.242)	−1.027*** (0.145)
GDP per capita	−0.261*** (0.0548)		
Electricity	−0.394 (0.845)		
Health_expenditure	−0.217*** (0.047)		
Regime_duration		−0.179*** (0.735)	
Democracy		−0.032*** (2.992)	
Women_political_empowerment		−0.0158 (0.068)	
Ethnolinguistic_fragmentation			1.860* (0.235)
Rule_of_Law			−1.376* (0.845)
Internet × democracy	−0.211*** (0.0669)	−0.542** (0.233)	−0.624*** (0.039)
Mobile phone × democracy	−0.0158 (0.0683)	−0.319 (0.199)	−0.628*** (0.040)
Fixed phone × democracy	−0.436*** (0.078)	−0.0982*** (0.019)	−0.535*** (0.039)
Constant	5.211*** (1.403)	4.465* (2.600)	4.415*** (1.757)
Observations	969	969	969
Countries	51	51	51
R^2	0.551	0.533	0.630
Prob. $>\chi^2$	0.0000	0.0000	0.0000

Source: Authors.

We proceed to the estimates in two stages. First, by estimating equation (3) which highlights the effect of ICT diffusion on the mediating variable (Democracy):

$$Model\ 1: \quad Med_{it} = a_1 + b_1 ICT_{it} + c' X_{it} + \mu_{it}$$

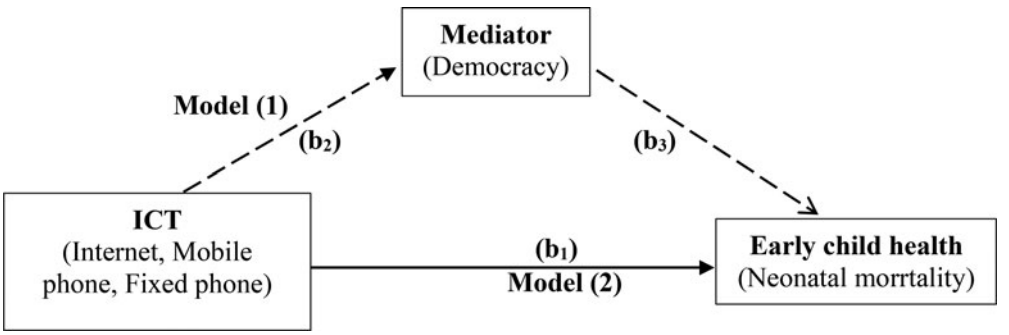

Figure 4. Modelling the mediation effect.
Source: Authors, modified from McKinnon *et al*. (1995, 2005).

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with Med_{it} is the mediating variable (democracy) of country i at time t. X represents the matrix of control variables. However, b_1 is the parameter describing this effect. If b_1 is statistically significant, that's to say ICT diffusion explains part of variation in the transmission channel, then we compute the indirect effects of ICT diffusion on early child health.

Second, we regress ICT on early child health by controlling for the mediating variable democracy:

$$Model\ 2\text{: } Early\_Child\_Health_{it} = a_2 + b_2 ICT_{it} + b_3 Med_{it} + + c_2^2 X_{it} + \nu_{it}$$

Thus, b_2 is the parameter describing the direct effect of ICT diffusion on early child health, and b_3 is the strength of the correlation between ICT and the mediating variable. It also provides information on the size of the mediation, which essentially depends on the extent to which the diffusion of ICT affects the mediator (b_1) and the extent to which the mediator affects early child health (b_3). These effects are estimated by the structural equation modelling approach which enables to test these effects in a single analysis instead of testing separate regressions. According to Brambor *et al.* (2006), the mediation is empirically valid only if the indirect effect ($b_1 b_3$) is statistically significant.

However, the different effects (indirect, direct, and total) are derived from models 3 and 4 by the following formulations:

- indirect effect: $b_1 b_3$.
- direct effect: b_2.
- total effect: $(b_1 b_3) + b_2$.

The estimation results for regressing these models are reported in Table 7. Columns 1a, 1b, and 1c report the results of estimating model 1 using control for democracy as the mediator of the internet, mobile phone, and fixed-phone dimension of ICT respectively. The regression results for model 2 using the mediator democracy as control variable are reported in columns 2a, 2b, and 2c accordingly.

Overall, the results show that the internet, mobile phone, and fixed phone have a positive and significant effect on the democracy channel. All things being equal, an increase in ICT adoption significantly stimulates democracy. In fact, a 1 per cent increase in the number of internet users will significantly increase democracy by 0.7227 per cent, against 0.6469 per cent for mobile phone and 0.1008 per cent for fixed phone. The positive effect of ICT diffusion (internet, mobile phone, fixed phone) on democracy is in line with Best and Wade (2009) who concluded that higher ICT penetration rates are associated with strong democracy.

The components of ICT have separate and statistically significant effects on the early child health. The estimated coefficients of ICT on early child health decrease once the mediating variable is included in columns 2a, 2b, and 2c. A 1 per cent increase in internet penetration leads to a decrease in early child health by 0.3765 per cent. Similarly, a 1 per cent increase in mobile phone penetration decreases early child health by 0.2388 per cent, then a 1 per cent increase in fixed-phone penetration decreases early child health by 0.5771 per cent.

Table 7 also provides a formal analysis of the mediation effects based on several statistical approaches popularised by MacKinnon *et al.* (1995). It considers several mediation tests to investigate if the indirect effect of ICT on neonatal health via the influence of democracy is statistically different from zero. Looking at the statistics of the *Sobel* test, this is estimated at 0.009 considering the internet, 0.008 with the mobile phone, and 0.001 for the fixed phone. All p-values are <1 per cent level of significance whatever the form of ICT, suggesting that the null hypothesis of no mediation is rejected. The results are similar when using alternative mediation tests (Delta and Monte Carlo). Given that the diffusion of ICT explains part of the variation of the transmission channel, we calculate the direct and indirect effects of ICT on early child health. Although the size

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Table 7. Mediation effects of democracy

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Variables	Democracy	Mortality	Democracy	Mortality	Democracy	Mortality
Democracy		0.0128*** (0.003)		0.0116*** (0.004)		0.0006 (0.002)
Internet	0.7227*** (0.149)	−0.3765*** (0.013)				
Mobile phone			0.6469*** (0.109)	−0.2388*** (0.011)		
Fixed phone					0.1008* (0.227)	−0.5771** (0.015)
Constant	0.8712*** (0.289)	4.9439*** (0.022)	0.0599 (0.372)	5.0578*** (0.035)	1.9901*** (0.237)	4.9044*** (0.020)
Baseline control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	969	969	969	969	969	969
Bootstrap replications	500	500	500	500	500	500
Mediating effect of democracy						
Mediating test	Coeff.	Std. error	p-value	Coeff.	Std. error	p-value	Coeff.	Std. error	p-value
Delta	0.009***	0.003	0.000	0.008***	0.003	0.000	0.001***	0.001	0.000
Sobel	0.009***	0.003	0.000	0.008***	0.003	0.000	0.001***	0.001	0.000
Monte Carlo	0.009***	0.003	0.000	0.008***	0.003	0.000	0.001***	0.002	0.000
Composition of the effect									
Indirect effect (Sobel)	0.009			0.008			0.001		
Direct effect	0.376			0.239			0.577		
Total effect	0.385			0.247			0.578		
% of total effect mediated	2.33			3.23			0.17		

Notes: *, **, and *** indicates statistically significant at 10, 5, and 1%, respectively. () robust standard error.
Source: Authors.

of the coefficients is different, this result is broadly consistent with those obtained from OLS in basis results. Thus, the transmission channel of democracy mediates the effects of ICT on early child health. Over the time horizon considered, ICTs have indirectly reduced infant mortality through the gradual establishment of instrumental democracy, which promotes the emergence of other institutions conducive to the consolidation of children's rights.

The contribution of the democracy channel to the total effect of ICT on early child health is provided by $\{b_1 b_3 \mid (b_1 b_3 + b_2)\}$ for each form of ICT. The evidence presented in Table 7 suggests that the mediation effect of democracy is low, approximately 2.23 per cent of the total negative effect of the internet on early child health being partially mediated by democracy improvement against 2.33 per cent of the total effect of mobile phone and 0.17 per cent of the total effect of fixed phone.

In addition of this mediation analysis, it is important to visualise the interactions effects of democracy and ICT on early child health. To make it possible, we plot marginal effects. Figures 5–7 respectively, plot marginal effects of internet, mobile phones, and fixed phones diffusion on neonatal mortality when democracy values change. For all forms of ICT, their marginal effects on neonatal mortality are higher for lower values of democracy and decline as democracy get better. However, these effects are higher for internet and fixed phones, followed by those of mobile phones.

5.5 Application of the Hodrick–Prescott filter to ICT and infant mortality series

The common problem in econometric investigations is to separate long-term trends from short-term movements. A plausible technique for accomplishing this task is to use a filter to dissociate short-term business cycles from long-term trends (Van Norden, 2004). The Hodrick–Prescott (HP) filter proposed by Hodrick and Prescott (1981, 1997) is the standard technique in macroeconomics for separating the long-run trend in a data series from short-run fluctuations or cycles.

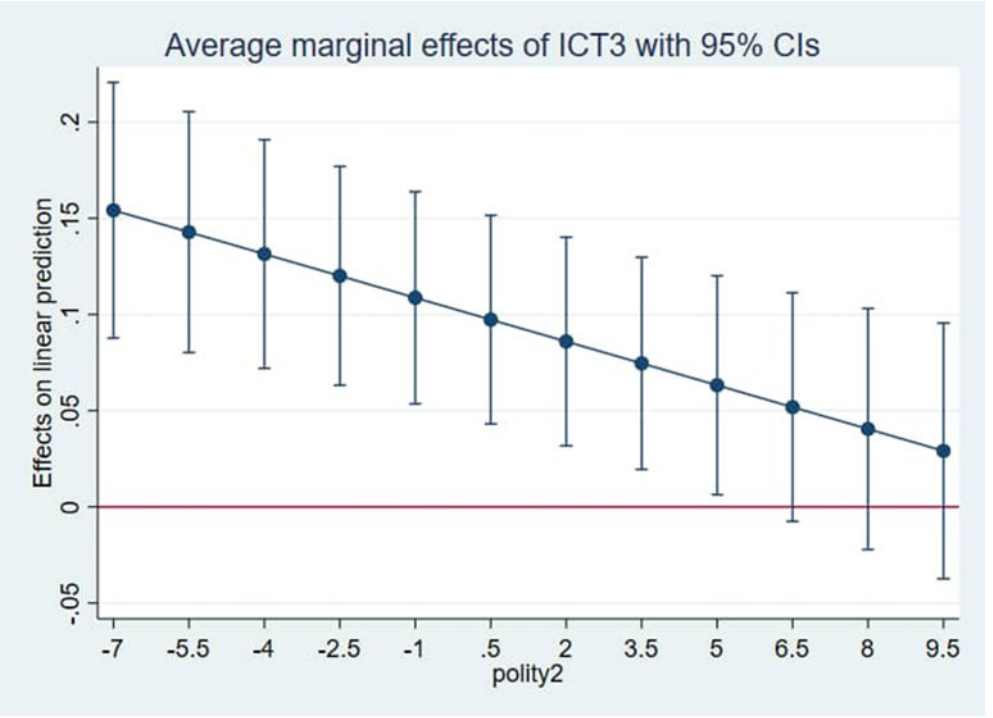

Figure 5. Marginal effects of democracy on relation between internet and early child health.
Source: Authors.

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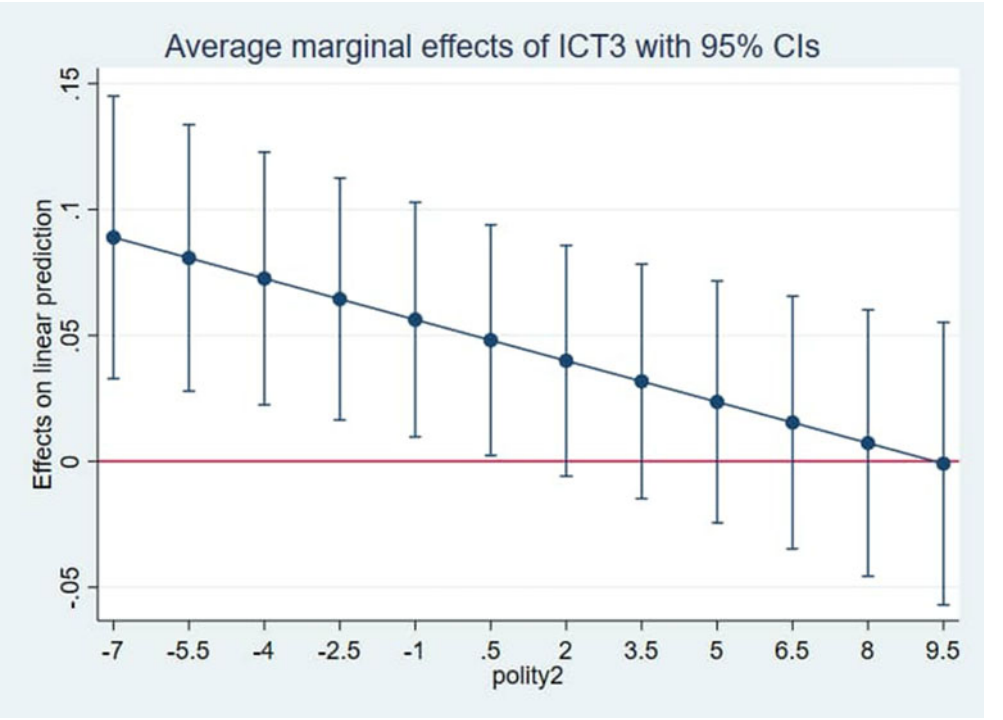

Figure 6. Marginal effects of democracy on relation between mobile phones and early child health.
Source: Authors.

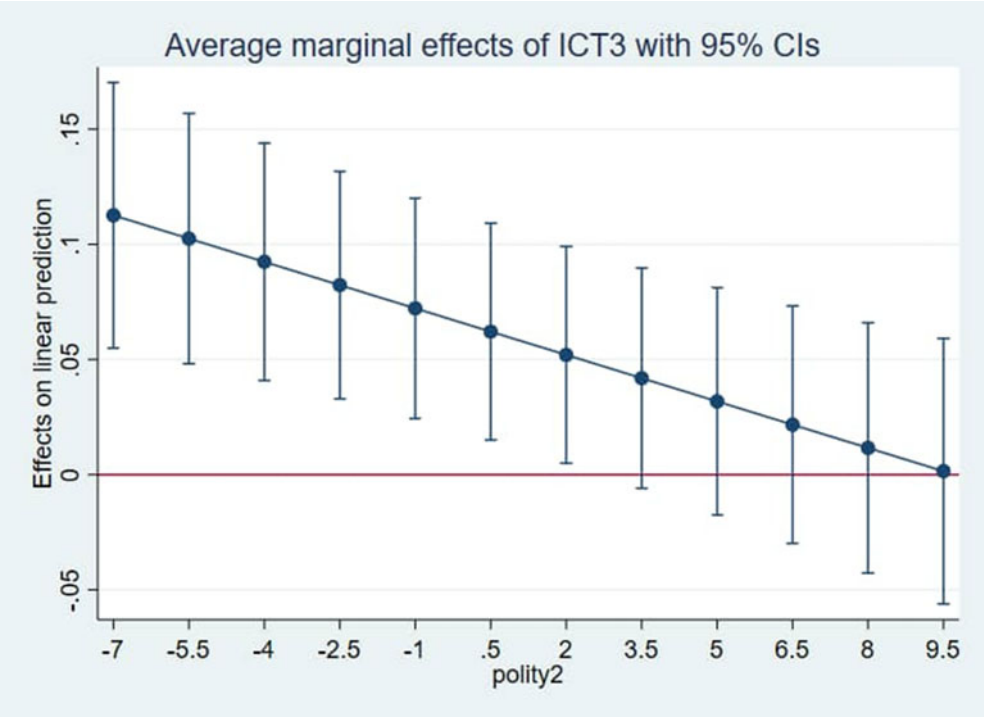

Figure 7. Marginal effects of democracy on relation between fixed phones and early child health.
Source: Authors.

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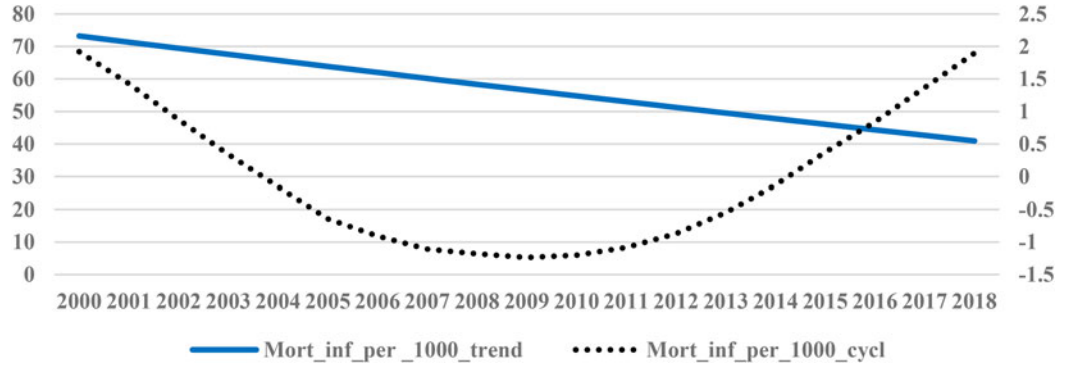

Figure 8. Decomposition of infant mortality variable using the HP filter.
Source: Authors.

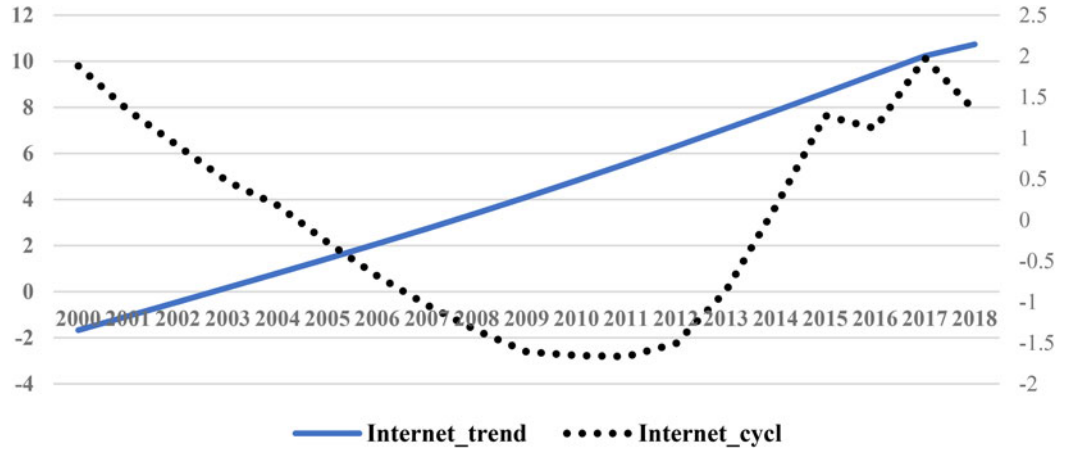

Figure 9. Decomposition of the internet variable using the HP filter.
Source: Authors.

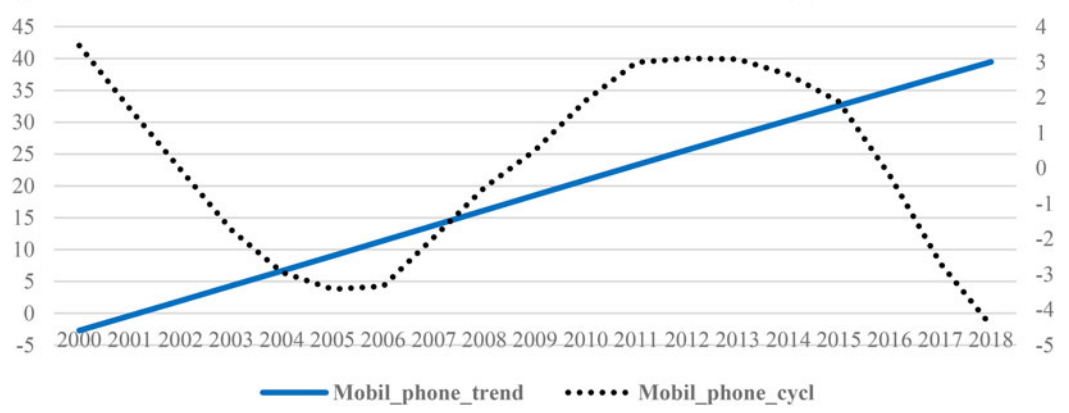

Figure 10. Decomposition of the mobile phone variable using the HP filter.
Source: Authors.

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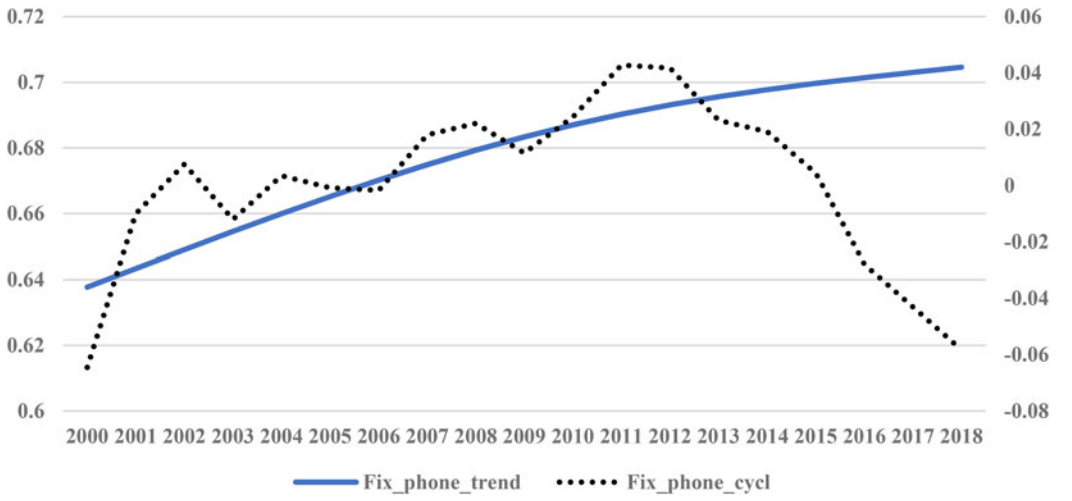

Figure 11. Decomposition of mobile phone using the HP filter.
Source: Authors.

While it seems intuitively clear that no smoothing technique should be equally well applicable to all types of trended macroeconomic data, the HP filter is universally used in macroeconomics to extract a trend component from a time series (De Jong and Sakarya, 2016). The method continues today to be very widely adopted in academic research, policy studies, and analysis by private-

Table 8. Estimates using the HP filter

Estimation technique: 2SLS			
	Dependent variable: infant mortality rate		
Variables	(1)	(2)	(3)
Internet	0.0617* (0.034)		
Democracy	0.0447* (0.026)	−0.0165 (0.026)	0.0078 (0.029)
Internet × democracy	−0.0183* (0.010)		
Mobile phone		−0.0821** (0.039)	
Mobile phone × democracy		0.0045 (0.007)	
Fixed_phone			0.0932 (0.165)
Fixed phone × democracy			−0.0049 (0.026)
GDP	0.0131 (0.104)	0.0419 (0.107)	−0.1453*** (0.037)
Electricity	0.6818*** (0.081)	0.6666*** (0.082)	0.4214*** (0.047)
Current health expenditure	0.0010 (0.011)	0.0008 (0.011)	−0.0080 (0.008)
Constant	−0.6689 (0.591)	−0.3701 (0.560)	1.6557*** (0.271)
Observations	665	664	664
Countries dummies	Yes	Yes	Yes
Number of ID	48	48	48

Source : Authors.

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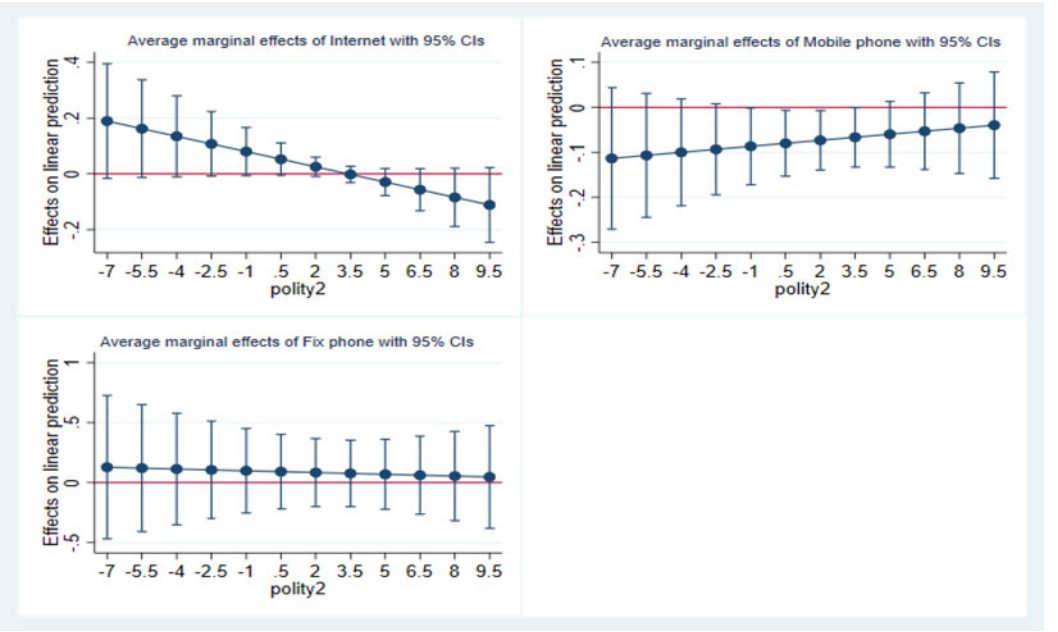

Figure 12. Marginal effect after the a HP filter application on ICT and infant mortality.
Source: Authors.

sector economists (Hamilton, 2017). We use this technique to decompose observed ICT and infant mortality series into trend and cycle. Figure 8 shows the result of the decomposition of infant mortality in trend and cycle components while Figures 9–11 show trend and cycle components of the internet, mobile phones, and fixed phones variables, respectively. In this section, only the cycle component of these variables is used for analysis.

Table 8 reports estimates of infant mortality after applying the HP filter. The results show that among ICT variables, only the coefficient of the mobile phone variable retains the negative sign and remains significant. This effect is independent of the state or the level of democracy. However, its interaction with democracy is not significant. The coefficient of fixed telephone is no longer significant and the one of internet changed to become positive and significant. Moreover, only the internet and democracy interaction coefficients are significant.

Figure 12 plots marginal effects of the ICT effect on infant mortality when democracy values change. For weak values of democracy, the internet has a positive effect on infant mortality. Such a result could find explanations through female participation in labour market that increases with internet diffusion (Nkoumou Ngoa and Song, 2021), given that women's employment decreases the quantity of time mothers spend with their children (Basu and Basu, 1991; Bui *et al.*, 2018). However, this positive marginal effects of internet on infant mortality are decreasing with democracy. From the value 3.5 of the democracy index, that ranges from −10 to 10, the marginal effects of the internet on infant mortality become negative. This result confirms the positive role of internet in early child health when the democracy environment improves and becomes better.

6. Conclusion

In this article, we attempted to examine the effect of ICT on early child health and the way democracy modifies this effect. We used data from 51 African countries spanning the period 2001–2019. The first step of this paper was to explain how ICT could be a contributor of health

https://doi.org/10.1017/S1744133123000269 Published online by Cambridge University Press

in general and early child health in particular. The theoretical interaction between ICT, democracy, and health has also been shed light. Before estimating the model using the 2SLS method, the HP filter was applied. Findings document that the extension of mobile phone significantly contributes to the improvement of early child health in Africa. This effect is indifferent to the state or the level of democracy. Also, the internet diffusion plays a positive role in early child health when the democracy environment improves and become better. These results suggest that digital inclusion policies and democracy be fostered to support health care programmes and improve early child health in African countries.

Competing interests. None.

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Appendix

Table A1. List of countries

Algeria, Angola, Botswana, Burundi, Cameroon, Comoros, CAR, Djibouti, Gabon, Equatorial Guinea, DRC, Congo, Benin, Burkina Faso, Cape Verde, Ivory Coast, Egypt, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea Bissau, Kenya, Liberia, Libya, Madagascar, Malawi, Mali, Morocco, Mauritius, Mozambique, Niger, Nigeria, Uganda, Sao Tome and Principe, Senegal, Sierra Leone, Sudan, Togo, Lesotho, Namibia, Eswatini, Africa South, Tanzania, Chad, Tunisia, Rwanda, Somalia, Zambia, Zimbabwe.

Source: Authors.

https://doi.org/10.1017/S1744133123000269 Published online by Cambridge University Press

Table A2. Description of variables

Variables	Description	Sources
Infant mortality rate	The number of infants dying before reaching 1 year of age, per 1000 live births in a given year.	WDI (2020)
Neonatal mortality rate	The number of neonates dying before reaching 28 days of age, per 1000 live births in a given year.	WDI (2020)
Under-five mortality rate	The probability per 1000 that a newborn baby will die before reaching age 5, if subject to age-specific mortality rates of the specified year.	WDI (2020)
Internet	Internet users (per 100 people).	WDI (2020)
Mobile_phone	Mobile-cellular subscriptions (per 100 people).	WDI (2020)
Fixed_phone	Fixed-cellular subscriptions (per 100 people).	WDI (2020)
Electricity	The percentage of population with access to electricity.	WDI (2020)
GFCF	Gross capital formation as a share of GDP.	WDI (2020)
Education	Gross secondary school enrolment rate.	WDI (2020)
Health_expenditure	Level of current health expenditure expressed as a percentage of GDP.	WDI (2020)
Regime duration	Gives information on the number of years so the regime to survive.	Data of Political Institutions (2018)
Democracy	Provides information on the level of democracy corrected by the dictatorship. The values of this variable vary between −10 and +10, which are the best scores for characterising a political regime.	Polity IV Project Online (2018)
Women political empowerment	Index developed by Sundstrom *et al*. (2017), based on the legislative presence of women and the distribution of political power by gender.	Varieties-Democracy (2020)
Ethnolinguistic fragmentation	Average value of five different indices of ethnolinguistic fractionalisation. Its value ranges from 0 to 1. Index of ethnolinguistic fractionalisation in 1960, which measures the probability that two randomly selected people from a given country will not belong to the same ethnolinguistic.	La Porta *et al*. (1999)
Rule of law	The confidence level of citizens, the respect of contracts, of police and courts jurisdictions, the perception of crimes and violence. Values range from −2.5 (low) to +2.5 (high).	World Governance Indicators (2020)

Source: Authors.

Cite this article: Nkoumou Ngoa GB, Song JS (2024). Early child health in Africa: do ICT and democracy matter? *Health Economics, Policy and Law* **19**, 92–118. https://doi.org/10.1017/S1744133123000269