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Digital and Technology

# The Contribution of Digital Technologies to Service Delivery: An Evidence Review

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# THE CONTRIBUTION OF DIGITAL TECHNOLOGIES TO SERVICE DELIVERY: AN EVIDENCE REVIEW

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# Abbreviations

| | |
|---|---|
| ADB | Asian Development Bank |
| CAI | computer-assisted instruction |
| CAL | computer assisted learning |
| EMR | electronic medical record |
| EHR | electronic health record |
| FHW | frontline health worker |
| HMN | Health Metrics Network |
| IADB | Inter-American Development Bank |
| IAI | internet-assisted instruction |
| ICT | information communication technology |
| ICT-CFT | ICT Competency Framework for Teachers |
| LCR | learner-to-computer ratio |
| LMICs | low- and middle-income countries |
| mERA | mHealth evidence reporting and assessment |
| MMS | multimedia messaging service |
| PISA | Programme for International Student Assessment |
| OLPC | One Laptop per Child |
| PIRLS | Progress in International Reading Literacy Study |
| RCT | randomised controlled trial |
| SMS | short message service |
| TIMMS | Trends in International Mathematics and Science Study |
| UIS | UNESCO Institute for Statistics |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |

# 1  Introduction

The explosion in digital connectivity, globalisation and the rapid growth in digital technologies over the last two decades has revolutionised the way that businesses perform and compete globally. Governments around the world have been put under strong pressure to transform themselves into electronic governments, in recognition of the efficiencies brought about by the appropriate use of information communication technologies (ICTs) in businesses and the need for development (Ahmed, Markkula and Oivo 2013; Bwalya and Mutula 2014; Gauld, Goldfinch and Horsburgh 2010). The aim has been to maximise the state's capacity to serve its stakeholders: namely citizens, business, employees and other government and non-government agencies (Fang 2002). E-government or digital government has been a significant feature of public sector reform in recent years in both developed and developing countries with a substantial amount of resources dedicated to the development of necessary systems and infrastructure. Yet the transformational potential of digital for development risks not being replicated in the real world. Large-scale and sustainable use of ICTs for education is not yet being realised in developing countries, despite the fact that digital technologies have the potential to reduce costs and strengthen education systems. In the field of health care, mHealth systems are reaching significant scale in many developing countries but there is still a lack of concrete evidence with which to fully assess the economic impact of these technologies.

This report explores and assesses the evidence for the impact and use of digital technologies in development, identifying cross-cutting themes that are important for use, implementation and scale-up. These include funding and infrastructure, policy commitments by government, skills and leadership.

A 2016 UN report identifies six key areas of e-government (health, education, social, labour, finance and the environment) and of these, the most developed dimensions in terms of e-government (as measured by percentage of use) are health, education and finance (UN 2016). While adoption levels are lower in the least developed countries, the same areas of health, education and finance see the highest levels of use. The scope of this report is, therefore, to understand the impact of digital technologies and e-government on two areas of service delivery, namely health and education in developing countries. This focus on health and education reflects the significant levels of investment and the extensive bodies of research and evidence in these fields. Whilst other areas of digital service delivery are undoubtedly significant, the conclusions and findings from these two areas provide generalizable insights for digital development more broadly.

## 1.1  E-government

The effectiveness of digital service delivery for education and health in developing countries should be understood against the backdrop of the broader evolution of e-government globally. This encompasses not only the scope of e-government initiatives, but also technological shifts such as the rapid spread of mobile technology which have impacted on the platforms used for dissemination and engagement.

While initial e-government initiatives were aimed at automating public sector processes and streamlining services within and across government organisations, the focus has increasingly shifted to the provision of seamless information flows and the facilitation of collaborative decision-making (Mahmood 2014). This has resulted in a conceptual shift towards a view of e-government as a means to enable whole-of-government service

delivery, policy integration, and increased transparency and accountability through the use of open government data and participatory service delivery and decision-making (UN 2016).

According to the 2016 UN report on e-government, most of the 193 member states of the United Nations who had an online presence by 2014 continued to make efforts to automate core administrative tasks, to improve the delivery of public services and to promote transparency and accountability (UN 2016). Although there are significant variations in e-government development between regions and income, the survey shows that most countries are moving towards higher levels of e-government development. In addition, the process of developing e-government has been shifting from a staged linear progression towards non-sequential, overlapping and connected building blocks that allow for leap-frogging and quick wins. In 2016, 142 countries enabled citizens to create personal online accounts, 114 to file income taxes online, and 97 to register a business, all of which has increased since 2014. However, as of 2016, significantly fewer countries were offering online application for birth (55 countries), marriage (53 countries) and social security benefits (63 countries) (*ibid.* 2016).

E-government is not limited to web-based government but encompasses the full range of ICTs, including radio, television, and telephones (fixed and mobile). The advancement of web 2.0 and the rapid spread of mobile phones have enabled the development of what is described as 'mGovernment' (Al-Huan 2012; Bwalya and Mutula 2014; Mahmood 2014). Mobile phones, reaching almost four fifths of the world's people, provide the main form of internet access in developing countries and the increasing trend in mobile technologies and applications is driving innovations that reach the poorest and most vulnerable (ITU 2016; UN 2016). According to the 2016 UN survey, 99 countries are now using responsive web design (RWD) technology for their national portals (22 from Africa, 21 from the Americas, 26 from Asia, 24 from Europe and 6 from Oceania), allowing government portals to be accessed from a multitude of devices (UN 2016).

But while ICTs can improve the efficiency of public service delivery and administration in a multitude of ways, success in implementing e-government depends on a variety of external factors. These include a favourable policy environment, digital inclusion, availability of and access to infrastructures, and digital literacy and skills among citizens (Archmann and Castillo Iglesias 2010). The World Bank argues that e-government can positively impact government transformations and service delivery, provided it is used to support organisations or systems that are legitimate, effective, transparent and participatory (World Bank 2016).

## 1.2   Structure of the report

This report covers the following topics: Section 2 looks at evidence and research in ICTs and education in developing countries: the ICT for Education ecosystem, the impact of ICT on learning, curriculum issues, teacher training, infrastructure, and new trends in technology and education. Section 3 looks at evidence and research in health service delivery and management in developing countries, covering health information systems, telemedicine and mHealth. Section 4 then draws on the previous two sections to assess what lessons we might learn from this research on the use of digital technology in health and education, including factors affecting implementation, scale-up and sustainability. These factors include issues such as security and privacy, infrastructure availability and policy commitments. Finally, Section 5 concludes the report with some overarching reflections on the future of ICT interventions in health and education in developing countries.

## 1.3  Methodology

In order to understand the impact of digital technologies on education and on health and nutrition service delivery, we reviewed secondary literatures. This review was informed by targeted searches of electronic databases (such as Pubmed and Google Scholar search engine) to identify peer-reviewed articles as well as related books and reports. We also checked bibliographies for evidence identified from the electronic databases and we located additional evidence. A search was also conducted to identify reports from different governmental and non-governmental organisations and international bodies such as UNICEF, UNDP, and so on.

The search included variations of the key terms: 'Digital technology', 'ICT', 'Information Communication Technology', 'eGovernment', 'Digital Government', 'eHealth', 'mHealth', 'Health', 'Nutrition', 'Service Delivery', 'Education', 'eLiteracy', 'eLearning' and other related terms.

The focus of the search was limited to developing countries. Only evidence published in the English language was considered. Studies and reports published beyond 2010 were included. However, we have also considered some evidence published before 2010 where it was deemed necessary. A narrative approach was chosen for the evidence synthesis.

# 2 Education

Global economic competition and the growth of knowledge societies have forced governments around the world, particularly in developing countries, to assure educational opportunities for all. These factors have also placed increasing emphasis on the need to ensure that people are information-literate (Tinio 2002). At the World Education Forum 2015, governments and policymakers from all over the world reaffirmed the vision that the worldwide movement Education for All initiated in Jomtien in 1990 and reiterated in Dakar in 2000 (World Education Forum 2016). The new vision of 'ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all', in line with the Sustainable Development Goals (SDGs), has underlined the importance of harnessing ICTs to strengthen education systems, knowledge dissemination, information access, quality and effective learning, and more effective service provision particularly in marginalised societies and groups. Emphasis has also been placed on promoting the use of ICTs, particularly mobile technology, for literacy and numeracy (*ibid.* 2016). However, the large-scale and sustainable integration of ICTs in the education system is yet to be realised in developing countries. A better understanding of ICTs in education and how they are integrated across national education systems must be a priority.

It is now widely accepted that access to ICTs in education can have a multiplier effect by helping individuals to compete in a global economy, by enhancing learning and creating a skilled workforce, by reaching learners in rural and remote regions, by improving teachers' training, and by minimising costs associated with the delivery of traditional instruction (Bladergroen *et al.* 2012; Souter *et al.* 2014; Tinio 2002; UIS 2014; UNESCO 2011a). The benefits are amplified by the availability and increase in Open Education Resources (OER), distance education programmes, and mobile and personal technology platforms. These have the potential to overcome geographical barriers, promote increased efficiency and enable easy and cheap sharing of content and collaboration among networked groups of people.

However increased expenditure on ICT in education is not necessarily achieving the expected benefits. Concerns related to the measurement of ICT in education, its usage and potential outcomes, including retention and learning achievements are being raised (UNESCO 2011a). The One Laptop per Child (OLPC) programme typifies these challenges. This programme saw 2 million laptops distributed in 40 countries with minimal impact on enrolment and test scores in maths and language. This shows the need for ICT in education initiatives to be complemented by appropriate pedagogy, institutional readiness, teacher competencies and long-term financing in the local context, in order to be truly effective (Beuermann *et al.* 2013, 2015; Cristia *et al.* 2012; Melo *et al.* 2014; Mo *et al.* 2013).

The following sections describe the use and impact of implementing ICTs in education in the formal education system, of distance learning, and of mobile learning in developing countries.

## 2.1 The ICT for Education ecosystem

A review of ICT for Education initiatives in South Asia recommended the ICT for Education ecosystem that pulls together different elements in an integrated manner, supported by a robust and flexible policy framework (InfoDev/World Bank 2010). In this ecosystem, the ministries of education, ICT and infrastructure are urged to work together to provide integrated policy guidance that is translated into initiatives by both public as well as private providers, through different mechanisms. These initiatives focus on critical elements of

capacity building, content development and monitoring and evaluation strategies, which together would result in improved teaching and learning outcomes for children. The ecosystem also highlights the need to consider critical factors such as detailed implementation plans, financial allocations, institutional capacity, and also community demand for ICTs that need to be effectively integrated in the education system. In addition, governments need to acknowledge the variability and boundaries of the different sectors and make policy decisions on the basis of what is best for the ecosystem as a whole.

## Figure 2.1   ICT for Education ecosystem
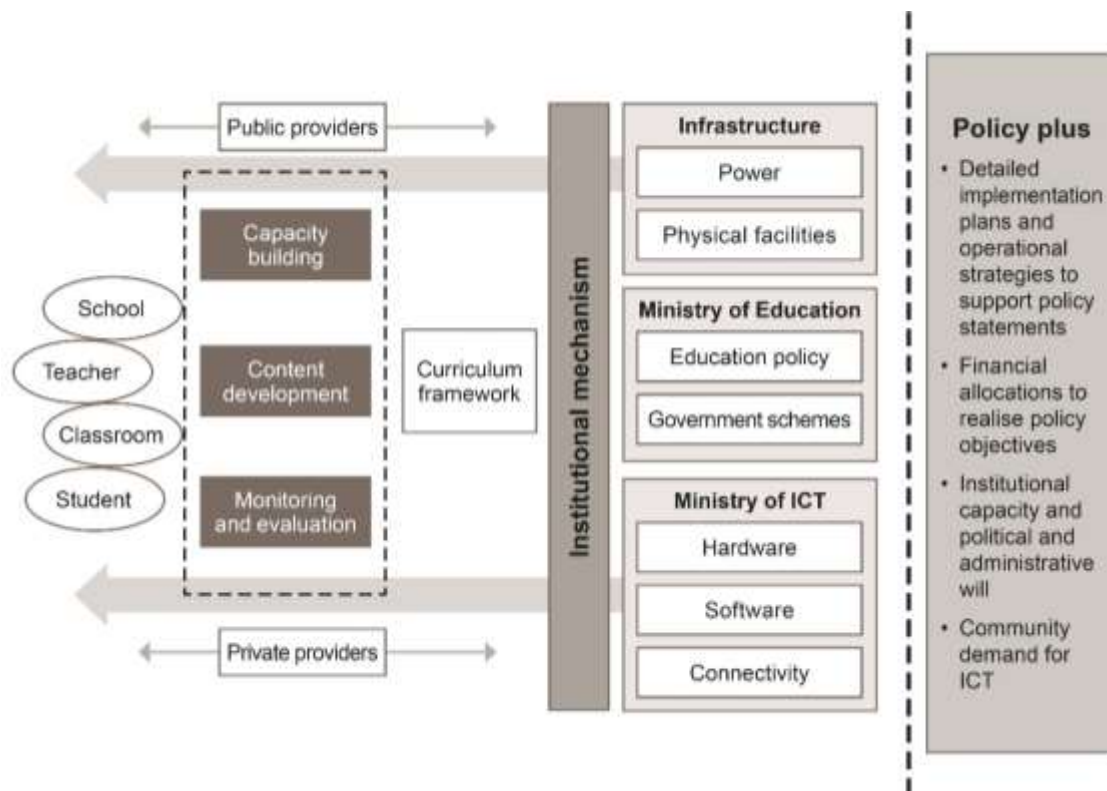


*Source*: Adapted from InfoDev/World Bank (2010).

## 2.2   Impact of ICT on learning and achievement

There is a pervasive belief that ICTs are powerful enabling tools that enhance students' skills through changes in the teaching process and improvement in school management practices (Ortiz and Cristia 2014). ICTs are seen to influence and change traditional methods of teaching and learning to a more innovative one. They are thought to empower teachers and learners and transform the instructional process from a highly teacher-dominated to a student-centred one, which results in increased learning gains for students (Brown *et al.* 2010; Trucano 2005). This section explores the evidence base for the impact of ICT in education and in particular the findings from recent reviews and experiments in evaluating learning outcomes in developing countries.

The current evidence base does not provide conclusive evidence of the links between access to and use of ICT, and impacts on students' learning outcomes; moreover the evidence is also mainly from developed nations with little relevance for developing nations (Brown, McCormac and Zimmermann 2010). Empirical studies, the majority of which lacked rigorous evaluation methodologies, have shown an inconsistent relationship (pro, contra or none) between the availability or use of ICTs and student learning (Brown *et al.* 2010; Trucano 2005; UNESCO 2011a). The OECD's Programme for International Student

Assessment (PISA), the International Association for the Evaluation of Educational Achievement's (IEA) Trends in International Mathematics and Science Study (TIMMS), and the Progress in International Reading Literacy Study (PIRLS) are among the most reliable sources of information on access, use and outcomes in this domain.

In 2014, Skryabin *et al.* used TIMMS 2011, PIRLS 2011, and PISA 2012 to investigate how national ICT development level and individual ICT usage influenced achievements in reading, mathematics and science for 4th and 8th grade school students. According to the findings, while the national ICT development level was a significant positive predictor for individual academic performance in all subjects for all grades, the influence of individual-level ICT use was mixed across different student groups and subjects, depending on the ICT usage type. Consistent positive influences for the two types of ICT usage (at school and at home) were discovered for all three subjects at 4th grade but for 8th grade students ICT usage at school showed a negative influence while use of ICT at home for working on school-related tasks showed a positive influence (Skryabin *et al.* 2015).

Two other studies analysing ICT use and learning outcomes using the PISA data set indicate that gaming was the only activity for which a positive coefficient between PISA test scores and intensity of use is consistently found. For the other activities, the measures of intensity tend to be negatively correlated with students' PISA test score with the negative effect being strong for activities that are related to using ICT in schools – such as the creation of content and knowledge, and problem-solving activities (Biagi and Loi 2013; Zhang and Liu 2016). However, the PISA data set is limited in terms of geographical coverage and reliability, and its inadequacy regarding current classroom practices.

Other work has focused specifically on developing countries. Evans and Popova (2015) reviewed six systematic reviews and meta-analyses conducted between 2013 and 2014 that examined interventions to improve learning outcomes in low- and middle-income countries. Their review recommended information technology interventions that provide information about school quality, or even basic infrastructure (such as desks) to achieve the greatest improvements in student learning. The positive impact of technology was identified particularly by three studies: McEwan (2015), Conn (2014) and Kremer, Brannen and Glennerster (2013). McEwan (2015) reviewed 77 randomised trials that evaluated the effects of school-based interventions on learning in developing country primary schools and found computer-based interventions to be the most effective. Conn (2014) conducted a meta-analysis of 12 types of education interventions that are effective in sub-Saharan Africa. His analysis reveals that interventions in pedagogical methods, particularly interventions that employed adaptive instructions (either computer-assisted learning programmes or pedagogical methods) had a higher effect size on achievement outcomes. Among the different adaptive instruction techniques, computer-assisted learning programmes had the highest effect size.

However, there are variations in findings between the studies included in the reviews. For example, the OLPC programme in Peru had little or even negative effects on student learning (Cristia *et al.* 2012). Similarly, an experiment to assess the effectiveness of OLPC (with an additional remedial tutoring software and training) in migrant schools in Beijing showed that the programme improved student computer skills by 0.33 standard deviations, maths scores by 0.17 standard deviations and also improved self-esteem (Mo *et al.* 2013).

There are also a considerable number of randomised experiments that evaluate computer assisted learning (CAL) programmes in developing or rural economies. For example, a randomised experiment evaluating CAL programmes in rural schools in Shaanxii, China indicated improvements in maths scores by 0.16 standard deviation and found positive impacts in both 3rd and 5th graders (Mo *et al.* 2014). Similarly, game-based CAL programmes that focused on teaching Chinese and maths improved the test scores of the

students receiving the treatments (Lai *et al.* 2012, 2013). Another CAL programme focusing on teaching maths in India during and after school increased maths scores. The impact was larger among children in the bottom tertile of the achievement distribution than for those in the top tertile. Also the initial gains remained significant for targeted children even after one year of the programme (Banerjee *et al.* 2007).

However, a similar evaluation of an initiative in Guayaquil, Ecuador, did not find the same impact on lower-achieving children. In this initiative schools received basic infrastructure for computer labs, four computers per school, computer-aided instruction to facilitate students' learning in language and maths, and training for teachers and administrators (Carrillo, Onofa and Ponce 2010). The impact was much larger for those students at the top of the achievement distribution. The programme had a positive impact on maths test scores and a negative but statistically insignificant effect on language test scores.

A few recent studies have also examined the effect of home computers on children's outcomes. Malamud and Pop-Eleches (2010) used a regression discontinuity design to examine a Romanian government programme which provided vouchers to buy home computers for children in poor families. They found that home computers led to lower school grades but higher cognitive skills and computer skills and fluency. However, the presence of parental rules regarding computer use and homework mitigated the effects of computer ownership, suggesting that parental monitoring and supervision may be important mediating factors. Evaluation of the OLPC programme in Peru that provided a home computer found no impacts on academic achievement in maths and language standardised tests but observed some positive impacts on the use of that particular computer and cognitive skills (Beuermann *et al.* 2015; Cristia *et al.* 2012).

Ortiz and Cristia reviewed the impact of technology programmes that aim to raise student learning through improving instruction in developing countries. They included 15 experimental studies published between 2007 and 2012 and used meta-analytic techniques to inform differences in academic or digital, general, cognitive and socioemotional skills between programmes that either guided the use of technology or not. Their review revealed that, in general, programmes had a significant positive impact on the average score in maths and language. In addition, programmes that guided the use of technology produced learning benefits four times greater in terms of academic skills than those that did not guide it. Notably, most of the studies that guided the use of technology did not measure impact on cognitive or digital skills and instead particularly focused on measuring academic skills (Ortiz and Cristia 2014).

Findings from these reviews also indicate that pedagogical interventions or computing interventions generally are not inherently more effective than others unless they are well implemented and affect students' learning experience (Evans and Popova 2015). Murnane and Ganimian (2014) found that computer-assisted learning programmes are ineffective when instruction is not tailored to each student's level of knowledge, when technology distribution is unaccompanied by training (Cristia *et al.* 2012); when computers substitute useful instructional time during school hours (He, Linden and MacLeod 2008) or home study (Beuermann *et al.* 2015; Cristia *et al.* 2012; Malamud and Pop-Eleches 2010); or when the intervention is not integrated by teachers into their instructions (Barrera-Osorio and Linden 2009). In addition, the reviews also fail to provide evidence about the trajectory of longer-term learning impacts (Evans and Popova 2015).

## 2.3   Monitoring and evaluating the integration of ICT in education

The integration of ICT in education not only affects educational systems but also all the actors in the education system who need to adapt to new methodologies and techniques

and to change attitudes. At the time of writing there is a lack of comprehensive studies that provide clear information on the impacts of ICTs on teaching and learning; on the multifaceted interactions between various types of ICT implementations; and on the effects of factors such as school-based intervention, socioeconomic status and expenditure. These gaps in assessing the impacts of ICTs hinder the work of policymakers who intend to develop evidence-based strategies and regulatory measures for effective ICT implementation, to verify that the activities and resources meet the objectives of the initiative before gaining scale, and to make necessary changes or implement corrective measures (OECD and Joint Research Centre—European Commission 2010; Ortiz and Cristia 2014).

Educational interventions need to explicitly monitor intermediate results (for example, change in educational practices) and assess impacts, whereas at the system level public policies should be based on a diagnosis of key indicators essential for making informed decisions (Ortiz and Cristia 2014).

The types of data and indicators needed for monitoring and evaluation of ICT in education depend on the development status of a country and the stage the country is at, in terms of the diffusion of ICT in education. Countries in the early stages require information on underlying infrastructure (including electricity and internet connections); on access to different types of ICT-assisted instruction; and on training levels of teachers, to give them basic ICT skills. When infrastructure has been established, new needs arise such as information on management of pedagogical innovation, adaptive and inclusive curricula, organisational change, sustainable technical support and continued staff development. Finally, in the most advanced stage of ICT use in education there is a need for information on enhancing student outcomes and the effects on economic productivity (ITU 2014).

## Figure 2.2 Information needs at different levels of ICT penetration in education over time
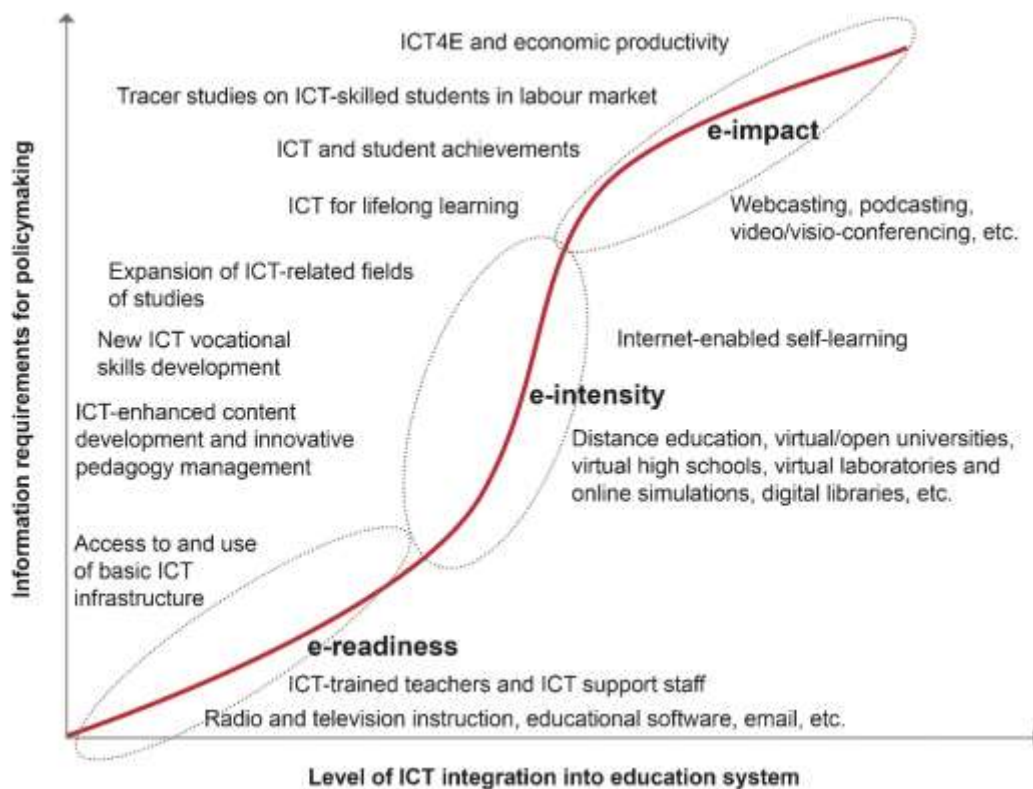


*Source*: Adapted from ITU (2016) and UIS (2014).

The knowledge base on use and impact of technology in education for both developed and developing countries is quite limited in scope and focuses primarily on the input (number of devices, for example) rather than on the process or output (effect on student performance, for example) (Pedró 2012). At a project level, approaches used to monitor and evaluate the activities and impact of projects in developing countries differ. Therefore consensus on conceptual frameworks to help guide such work and enable cost-benefit analysis in an appropriate manner would be very useful (Trucano 2005). In addition, there have been few global initiatives to identify, define and normalise indicators that assess the integration of ICT in education, resulting in incomparable data and indicators. As mentioned earlier, the PISA, TIMMS, and PIRLS are among the most reliable sources of information that provide comparative pictures of access, use and outcomes across several developed and developing countries, although they are limited in geographical scope and use varying indicators and definitions. Other data collection efforts in developing regions include those conducted by the World Bank and the Asian Development Bank (ADB) in Asia (ADB 2012; InfoDev/World Bank 2010) and in Latin America and the Caribbean (Hinostroza and Labbe 2011). The World Bank's System Assessment and Benchmarking for Education Results (SABER) initiative and the Inter-American Development Bank (IADB) are currently focusing on a compilation of detailed information about technology policies in education, mostly from a qualitative perspective (Ortiz and Cristia 2014; UIS 2014).

Recognising the need for a common set of indicators, the International Working Group on ICT Statistics in Education (WISE), led by the UNESCO Institute for Statistics (UIS) is working to improve the availability and quality of ICT data and indicators, particularly in developing countries. In 2004, the Partnership for Measuring ICT for Development was formed to develop comparable data and indicators for monitoring World Summit on Information Society (WSIS) goals. As part of this process, UIS has released a *Guide to Measuring ICT in Education*, which identifies sets of core and supplemental indicators utilised as part of its Regional Questionnaire on Statistics of ICT in Education (UIS 2014). Some valuable work which provides a comparative perspective of the integration and access to ICT in education as part of these efforts includes the UNESCO Institute for Statistics' regional data collections in Latin America and the Caribbean (UIS 2012), a few selected Arab States (UIS 2013), Asia (ADB 2012; UIS 2014; UNESCO and KIST 2013) and sub-Saharan Africa (UIS 2015).

The data gaps in the integration of ICT in education remain unaddressed due to the methodological challenges and the scale of the efforts required to address them (Pedró 2012). Measuring progress in the area of ICTs in Education will require a balance between identifying global quantifiable information to monitor international goals and taking into account the diversity of circumstances among countries in terms of stage of development, infrastructure, income and socioeconomic factors. Therefore, a mixed-methods approach that combines empirical work, large-scale surveys and direct observations may be more appropriate, particularly in developing countries (Pedró 2012).

## 2.4    Teacher-training and ICTs

Teachers are the most important influence on classroom learning. They facilitate the integration of technological materials in the classroom and create a favourable environment for developing teaching practices that exploit the comparative advantages of technology. Therefore, a fundamental issue is whether teachers know how to use ICT effectively in their teaching. In recent years professional development and developing teachers' digital capabilities have been recognised as crucial to help them incorporate technology into learning. However, there has been limited research on appropriateness, amount, content, duration and affordability of teacher training. Technology in education programmes have used both in-service and pre-service training activities led by a facilitator outside the classroom, as well as direct pedagogical support in the classrooms to improve teachers'

capabilities. Furthermore, recurring training may be required to keep up with evolving technologies and related skills. In support of such efforts, the UNESCO Regional Office in Bangkok has gathered case studies of pre-service courses on 'Education Technology' to equip teachers with the relevant knowledge, skills and tools to effectively use ICT in the classroom (UNESCO Bangkok 2013).

However, despite significant growth of programmes to integrate technology into education in developing countries, teachers still make little use of computers. There are several reasons for this, including adoption of policy without investing in the necessary resources or acceptance by all the actors in the education sector, particularly teachers; resistance from teachers and their unions, specifically in countries with an ageing, underpaid teacher workforce; and inadequate training and preparation.

Another barrier to the meaningful integration of ICTs in education in developing countries is the lack of alignment between what funders and project implementers intended, and the social meanings that educators assign to the technology. Studies conducted in under-resourced schools in Cape Town show that, although educators appreciate the value of ICT in education and are willing to adopt it, they also feel that they lack the capacity and support to achieve that goal effectively. The studies also show that global discourses on ICT may deny teachers in disadvantaged communities the power to voice the challenges they face when integrating ICTs into their teaching processes (Bladergroen *et al.* 2012).

Other factors that influence ICT use in the classroom are adequate support from administrators, directives to teachers to use ICT, appropriate ICT skills and knowledge as well as adequate resources. In Honduras, a survey of teachers' perception of ICT revealed that, although they are convinced that the technology gives students access to better sources of information, 46 per cent think students will use the computer mainly for playing (Bruns and Luque 2015). The perception is also negative regarding the impact of the introduction of technology to their work: about 40 per cent believe that computers increase their workload, reinforcing the idea that some policies that incorporate technology in the classroom need to provide teachers with sufficient resources, guidance, support and motivation for their proper use.

The UNESCO ICT Competency Framework for Teachers (ICT-CFT) (2011), developed by UNESCO and several partners, aims to inform policymakers on how to help students and teachers utilise technology effectively and develop ICT skills (UNESCO 2011b). This has been used as a conceptual reference for the development of national ICT teacher competency frameworks in countries such as Guyana, Nigeria and Tanzania (Broadband Commission 2013).

Surveys conducted in several regions provide indicators on the 'proportion of ICT-qualified teachers in schools' and the 'proportion of teachers trained to teach subjects using ICT'. Findings reveal that in both developed and developing countries, a lack of trained teachers presents significant challenges in terms of adapting national curricula to meet the challenges of the information society (ITU 2014). Although developed countries have greater proportions of trained teachers than developing countries, most countries, regardless of economic position, have trained 10 per cent or fewer teachers to be ICT-qualified for delivering basic computer skills or computing courses (*ibid.*). However, the proportion of teachers trained to teach using ICT varies much more widely. But developing countries face particular challenges in providing an adequate supply of trained teachers, in the absence of a strong policy environment and essential school infrastructure.

## 2.5   Content and curriculum issues

The integration of ICT in education is achieved either by studying ICT as a separate subject and/or by using ICT as a teaching or learning tool in other subjects. However, in many developing countries, the lack of appropriate and relevant educational content or resources in a format that makes them easily accessible and relevant to most teachers and learners is an important inhibitor to ICT use in schools (Trucano 2005). Teachers and learners have problems in using ICT unless electronic educational resources are directly related to the curriculum, and to the assessment methods used to evaluate educational outcomes, especially standardised testing (ADB 2012; Trucano 2005).

In order to achieve effective integration of ICT into teaching and learning across the curriculum various actions need to be considered. These include (ADB 2012; Ortiz and Cristia 2014):

- development of advanced curriculum documents, with clear and practical guidelines of the curriculum content of ICT or its cross-cutting use in pursuit of subject-specific learning outcomes and skills development;
- rapid development of e-learning materials in local languages, including encyclopaedias, manuals, textbooks, guides and videos;
- introduction of new assessment regimes that reward the achievement of specified subject ICT skills;
- provision of software to support teaching and learning processes such as productivity applications, platforms and virtual simulators;
- software for education management information systems, or EMIS.

Adaptation and digitisation of educational content is a lengthy and expensive process, often requiring donor support and public–private partnerships. Also, the development of culturally appropriate digital content is best achieved when local knowledge is combined with international skills and experience, and in the presence of mechanisms to evaluate the appropriateness of the contents (Trucano 2005).

## 2.6   Integrating ICT through policy and formal commitment in curricula

Policies are usually thought of as strategic statements, action plans, programmes or projects that not only provide a context for change and articulate a vision but also guidance on the mechanisms and resources by which the vision is to be realised. Strategic policies in different countries have been found to promote investment in educational ICTs in mutually reinforcing ways, in order to achieve the following:

- support economic growth and prepare a future workforce;
- promote social development by creating an environment that shares knowledge, fosters cultural creativity, increases democratic participation and makes government services more widely available among all population groups;
- advance pedagogical reform that emphasises understanding of key concepts and the ability to apply those to solve complex, real-world problems (UNESCO 2011a).

Surveys conducted by UNESCO and the World Bank (InfoDev/World Bank 2010; UIS 2012, 2013, 2014, 2015; UNESCO 2011a) provide us with an idea of the policy situation in various countries and help in assessing countries' efforts to embark on educational reform through the implementation of ICTs in education (UIS 2014). So, for example, findings from Asia indicate that the majority of responding countries have a stand-alone, sector-wide ICT in Education plan and this includes developed and developing economies (UIS 2014). Although India had drafted an ICT in Education policy in 2009, the federal nature of the

government requires individual states to develop plans to carry out policy that is set at the federal level (InfoDev/World Bank 2010). However, in a majority of states in India, ICT in Education is mentioned only in IT policy documents (InfoDev/World Bank 2010). In Latin America and the Caribbean, 31 of 38 countries have either a national policy or plan, or a regulatory institution or a set of regulatory provisions (UIS 2012). The 2013 estimates from five Arab states (Oman, Qatar, Palestine, Egypt, Jordan) show that all five not only have a written policy and plan for the integration of ICT into education, but also have created regulatory provisions and institutions to ensure that ICT-assisted educational reform takes place and is monitored and evaluated (UIS 2013).

For a myriad of reasons, implementation of ICT policies in education has been found to be challenging or has been unsuccessful, particularly in the developing country context. Reasons include:

- Policies created without any resources or guidance, or insufficient elaboration to bring about change. Policies are usually symbolic acts aimed at satisfying the needs of certain stakeholders (Elmore 2004).
- Resistance from teachers or school management.
- No explicit link to pedagogy or instructional practices.
- Lack of programme or resources to implement the policies, or lack of monitoring and evaluation (UNESCO 2011a).

A few key questions that must be answered in analysing and developing policies is whether the components of the policy are aligned with the national educational vision; whether the policies include measurable goals, implementation strategies, a timeframe and costing; and whether the policy has a plan on how to monitor and evaluate the implementation of the policy (UNESCO and KIST 2013). Country analysis of policies and their development process provide us with information not only about the varying phases of development and implementation in each country but also provide us with guidance and lessons learnt regarding appropriate policy development (InfoDev/World Bank 2010; UNESCO 2011a; UNESCO and KIST 2013).

For example, in 2013, policy and infrastructure analysis for Asia revealed Singapore to be in an advanced phase followed closely by Malaysia, whereas Thailand, Vietnam and Indonesia were considered to be at an implementing phase, and Myanmar, Lao People's Democratic Republic (PDR) and Cambodia in the entry phase (UNESCO and KIST 2013). Robert Kozma (UNESCO 2011a) presents a conceptual tool for developing policies – the knowledge ladder – that focuses on four approaches: basic education, knowledge acquisition, knowledge deepening, and knowledge creation. Each of them has different implications for the different education system components, namely the educational policy, teacher professional development, classroom pedagogy, curriculum, assessment, school organisation and administration, and ICT use.

## 2.7    ICT in national curricula

The early integration of ICT into the school education curricula through formal recommendations not only assists in facilitating its entry into educational institutions but also acts as a lever to develop digital literacy and empower young people throughout their education (UIS 2014). Curricula that include courses on basic computer skills and use ICT for the instruction of other subject areas such as mathematics, natural sciences, social sciences, reading/writing and literature, or second languages, are considered to be a reflection of policies that advocate for ICT in education (UIS 2015).

The findings from developing countries are varied, with some countries explicitly including recommendations for ICT-assisted instructions in national curricula while other countries

have a more generalised set of recommendations not specific to the type of ICT to be supported, the subject area, levels of education (i.e. primary, lower secondary and upper secondary) or duration of use (UIS 2012, 2013, 2014, 2015). For instance, more than half of the countries surveyed in Asia recommend integrated objectives or courses on basic computer skills or computing at primary, lower secondary and upper secondary levels of education, regardless of whether it is achievable in all schools (UIS 2014). Singapore and Japan are examples of countries that have adequate resources to meet objectives, while a country like Bangladesh faces challenges to universalise access to basic computer skills or computing in schools. In countries like Armenia, Bhutan, Lao PDR and the Philippines, basic computer skills and computing are emphasised in lower secondary education, while in Cambodia, Myanmar, Nepal and Sri Lanka this occurs in upper secondary education.

## 2.8 Infrastructure to support the integration of ICT in educational institutions

Effective implementation of ICT in educational institutes requires a series of infrastructure elements to be in place for teachers and students to work adequately. These include: devices to support learning (like radio, television, computers, tablets, digital whiteboards, cameras and video players, and smartphones), connectivity to the internet or an internal network, and finally resources for the normal functioning of the devices, such as electricity, adequate physical space, furniture, security measures and technical support (Ortiz and Cristia 2014).

The physical environments where computers are used are usually divided into two models: either through computer labs or through use of a laptop by each student through all subjects. Most IT and education policies advocate the introduction of ICT as a subject in the curriculum especially in secondary and higher education followed by the corresponding establishment of computer laboratories. However, these laboratories are often criticised for providing limited hours of access, concerns with hardware and software maintenance, limited or slow internet access, and limited use in other subject areas apart from ICT (InfoDev/World Bank 2010; Ortiz and Cristia 2014). Therefore, although computer laboratories are considered as solutions to address limited resources, stakeholders need to focus on the curriculum, content, capacity building and support services to ensure that these laboratories translate into a learning space across the curriculum (InfoDev/World Bank 2010).

Although the promotion of OLPC programmes aimed to achieve learner-to-computer ratios of 1:1, few countries have been able to attain this (UIS 2012). In the absence of 1:1 learner-to-device ratios, computer laboratories (including mobile laboratories) may help to fill this gap by playing an important role in managing and organising how and when children use ICT-assisted instruction.

### 2.8.1 Learner-to-computer ratio

The learner-to-computer ratio (LCR) provides an estimate of the average number of learners sharing a single computer for pedagogical use in national education systems (UIS 2009). It is an aggregate measure of the digital divide, irrespective of the type of school, and should be analysed in the context of parallel use of other, non-computer ICTs in schools – especially radio and television. Often, national-level LCRs mask internal digital divides or sub-national differences. Survey findings from the UNESCO Institute for Statistics indicate that computer resources are greatly overstretched in low- and middle-income countries with LCRs being greater than 100:1. This is the case in a number of countries in Asia such as Indonesia (136:1), the Philippines (412:1 at the primary level), and Nepal (>500:1) (UIS 2014); also in the Dominican Republic (122:1) and Paraguay (130:1 in primary level) in Latin America and the Caribbean (UIS 2012); and in Niger (>500:1 in lower secondary),

Madagascar (>500:1 in lower and upper secondary), Guinea (>500:1 in primary, lower and upper secondary), and Lesotho (>500:1) in sub-Saharan Africa (UIS 2015).

The LCR in schools with computer-assisted instruction (CAI) is another indicator that presents information on how computer resources are distributed among schools with computers for pedagogy (UIS 2009). For example, in Iran, the national LCR for primary education of 83:1 indicates relatively low access for students. However, considering that in Iran just 46 per cent of primary schools offer CAI, a primary LCR in schools with CAI of 18:1 indicates a distribution that is more conducive to learning.

## 2.8.2  Computer-assisted instruction

CAI is an interactive learning method where teachers or pupils use a computer to present instructional material or learning-oriented tasks, monitor learning and help in selecting and accessing additional material in accordance with individual learner needs (UIS 2009). The proportion of schools offering CAI in the country is a measure of the overall presence and availability of CAI in schools and primarily depends on the availability of computer and other basic infrastructure in the schools. For example, low- and middle-income countries such the Dominican Republic in Latin America, Bangladesh, Myanmar and Nepal in Asia, Madagascar, Niger and Lesotho in sub-Saharan Africa, reported having either no or fewer than 15 per cent of schools with CAI which can mostly be attributed to the scarcity of computers (i.e. high LCRs) or the absence of other infrastructures such as electricity in their schools (UIS 2012, 2014, 2015). CAI is primarily offered through one-to-one computing models or through the use of computer laboratories in developing countries. In most countries CAI and laboratories are intertwined, being equally available in schools in Kyrgyzstan (86 per cent), Azerbaijan (84 per cent), Maldives (40 per cent), and in secondary education in Bhutan (66 per cent) and the Philippines (87 per cent) (UIS 2014). For countries where the proportion of schools offering CAI is greater than those with computer laboratories, CAI is also delivered through mixed models that make use of multiple locations including classrooms, libraries, and so on (ITU 2014). Examples of this are Iran, where 46 per cent and 76 per cent of primary and secondary schools, respectively, offer CAI, while no primary schools and only 43 per cent of secondary-level institutions have laboratories; Sri Lanka, another example, provides CAI in 60 per cent of all schools but has laboratories in just 34 per cent of schools (UIS 2014).

## 2.8.3  Internet-assisted instruction

Internet-assisted instruction (IAI) refers to an interactive learning method using the internet to deliver instructional materials on a computer or through other devices, in accordance with learners' pedagogical needs (UIS 2009). IAI is considered to develop autonomy in research activities and information literacy skills by transforming learning from a teacher-centred to a student-centred process. In most developing countries, integration of IAI has been typically slower than CAI due to the lack of formal policy commitments, lack of curricula adapted to using the internet, inadequacy of supporting infrastructure (devices, adequate connectivity, and so on) and lack of effective teacher training (ITU 2014). Internet access, particularly fast broadband connection, is still a challenge for many countries, especially in rural or isolated areas, which inhibits the use of IAI (ADB 2012; InfoDev/World Bank 2010).

While IAI was universally available in many upper middle and high-income countries, it was rare in low and middle-income countries. For example, in Asia IAI was uncommon in the Philippines (8 per cent in 2012) and Sri Lanka (18 per cent in 2011); in Latin America and the Caribbean, IAI was uncommon in the Dominican Republic (12 per cent), Ecuador (18 per cent), Guyana (13 per cent) and the Turks and Caicos Islands (7 per cent) (ITU 2014). Despite availability of electricity in Kyrgyzstan and Azerbaijan schools, in 2012 IAI was available in only 6 per cent and 27 per cent of schools, respectively, due to the lack of

internet service providers, high connectivity costs and/or low school budgets (ADB 2012; ITU 2014).

### 2.8.4 Radio and television

Although radio and television (live and off-air) are regarded as 'older' or more traditional ICTs, they can play an important role in connecting schools, especially where there is a lack of qualified teachers and more advanced forms of ICT are absent. They are known to be effective in delivering educational content at a large scale and low cost especially to children and adults who have dropped out of school, allowing them to follow curricula from a distance; and by providing otherwise unavailable instructions in rural and remote areas (InfoDev/World Bank 2010; ITU 2014; Trucano 2010, 2014).

Examples of such radio and television-mediated education include Mexico's long-standing distance education programmes for secondary and high school students *Telesecundaria*, the ECCA distance learning and teaching programme for adults in Cape Verde, and the use of a community-based radio network for development and learning in the Solomon Islands (IDB 2014; Ortiz and Cristia 2014; Trucano 2010, 2014; UNESCO Institute for Lifelong Learning 2014).

In some developing countries in Asia, the use of radio and television-assisted learning in the form of dedicated educational channels or programmes is more widespread than newer forms of technologies. These include countries such as Nepal (e.g. Radio Sagarmatha), Sri Lanka (e.g. Radio Kothmale), Afghanistan (e.g. Educational Radio and Television), Samoa, India (e.g. Gyan Darshan I & II, Toppers, Tata Sky Fun Learning) and the Philippines (KcH) (InfoDev/World Bank 2010; UIS 2014).

Despite the positive impact at low cost demonstrated by these programmes in some very challenging educational environments, they are often dismissed as being 'successful pilot projects at scale'. The reasons for this include shifts to the use of digital technologies, abandonment of programmes when a government changes, institutional constraints making it difficult to sustain these programmes once a large donor leaves, and a lack of support from political elites as these programmes are mainly directed towards poor and marginalised communities.

## 2.9 New trends in technology in education

The tablet explosion is one of the most important technology trends in education and has resulted in large-scale purchases of such devices for use in schools outside industrialised, 'highly developed' countries over the past few years. These include the FAITH project in Turkey that aims to purchase 11 million tablets and 450,000 interactive whiteboards, and plans by the Brazilian government to distribute 500,000 tablets to teachers (Ortiz and Cristia 2014; Trucano 2015).

However, like the use of other educational technologies, the evidence base on tablets' impact on learning when used in schools is weak and derived from studies conducted in developed nations (Trucano 2015). A recent systematic review reporting use of tablets by primary and secondary school children across the curriculum, with a particular emphasis on learning outcomes, found mixed results (Haßler, Major and Hennessy 2016). Among the eligible studies, 16 reported positive learning outcomes, five found no difference and two showed negative learning outcomes. The review concluded that, while tablets can viably support children in completing a variety of learning tasks, the fragmented nature of the current knowledge base and the scarcity of rigorous studies make it difficult to draw firm conclusions and generalise findings.

Using mobile phones for educational purposes is another trend. Smartphone penetration in developing countries is accelerating, offering students a variety of options for learning and interacting in the education process. While some pilot initiatives are under way to explore how effectively mobile technology can be used in the education space, the use of mobile phones has been predominant in informal education programmes – such as for promoting adult literacy, disseminating information for farmers and fishermen, support services in education programmes, and distance learning programmes. Mobile devices are a way for people to access information outside formal education contexts, in a personal and immediate way.

Given the limitation of the screen size and the amount of data being exchanged, mobile phones are not utilised extensively in actual educational content delivery in formal education. A few pilot experiences in Afghanistan, Ghana and Uganda suggest that certain applications related to text messages can stimulate student motivation and participation in training programmes for work (Raftree 2013). Since this is a rapidly evolving scenario in terms of innovations in devices and options for connectivity and data exchange, some of these constraints might be overcome in the foreseeable future and therefore mobile technology remains a possible option to be leveraged in the education space.

The big business of using education technology or use of ICT in the classroom, and their exponential growth is making it difficult even for developed and technology-oriented schools to prioritise future ICT investments. These technological innovations may not be very relevant to the needs of poorer countries at this stage of their development. For example, in developed countries, the installation of interactive whiteboards or cloud computing has become common, and although there are obvious cost and infrastructure constraints, it is also clear that many middle-income and even developing countries are taking an increasing interest in interactive whiteboards and other new technology developments. The wish to be perceived as being at the 'cutting edge' of new technology, regardless of the national cost implications, teacher-training issues, maintenance problems, and impact on student learning is creating a growing gap between developed, developing and transitional economies.

# 3    Health service delivery and management

In the post-2015 development agenda the concept of 'good health' is shifting from an absence of disease and prevention of premature mortality to a more positive and inclusive focus on creating and maintaining good health and wellbeing (The World We Want 2030, 2013). Health systems are expected to adapt in order to address social, cultural, environmental, economic and political determinants of health; to take into account the multidimensional aspects of increasing equity; to ensure universal health coverage and access to comprehensive services through all stages of life; to promote efficiency; to prevent exclusion; and to protect people from poverty caused by excessive health care expenses (AbouZahr 2012; The World We Want 2030, 2013). Health policymakers, donors, programme implementers and managers worldwide, and especially in developing countries, are therefore looking for innovations in health technologies, services, monitoring and evaluation, and information systems. Not only should these innovations promote high quality and affordable health care to diverse population groups in remote and resource-constrained environments, but should also be cost-effective and scaleable (Lewis *et al.* 2012; Piette *et al.* 2012; Shuvo *et al.* 2015; The World We Want 2030, 2013).

Digital technologies can address some of the challenges of dysfunctional health systems in terms of the availability, quality and financing of health care. They have been used to prevent, assess, inform and treat health behaviours and deliver services in resource-constrained health markets over the last two decades (Borrelli and Ritterband 2015). The mounting interest in the potential of ICT in low- and middle-income countries (LMICs) has been made possible by the preponderance of the internet and mobile phones and low-cost communication infrastructure across LMICs (ITU 2016; WHO 2011). Use of ICTs, under the two umbrella terms eHealth and mHealth, aims to revolutionise health care by improving its timeliness, patient-centredness, efficiency, effectiveness, equity and safety.

The term eHealth gained popularity in the late 1990s to describe internet medicine and everything related to computers and medicine (Eysenbach 2001). Usage of the term has varied from a narrow scope using the internet for health to a broad scope that includes all electronic and digital processes in health (Meier, Fitzgerald and Smith 2013). The WHO defines eHealth as the use of ICTs for health and mentions that despite controversies there is wide agreement on a core principle presented by Eysenbach in 2001: that eHealth represents 'a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology' (Eysenbach 2001; WHO 2006).

Tools for eHealth such as computers, mobile phone-based health (mHealth) applications, telemedicine systems, or eLearning programmes, satellites, internet, cloud computing, software, and other digital platforms are designed to improve health system management and service delivery, and to support behavioural changes related to public health priorities and disease management. However, many approaches in the eHealth field, particularly in low- and middle-income countries, are still at a relatively new or pilot stage of implementation. Very few programmes have demonstrated a potential to be scaled up, with limited studies demonstrating their relevance, applicability or cost-effectiveness.

In this review we focused on evidence for the impact of ICT in three broad categories: (1) health information systems; (2) telemedicine; and (3) mHealth. We reviewed them to understand their use, impact on health outcomes and understand the challenges that hinder utilisation, scale-up and sustainability.

## 3.1 Health information systems

Globally, reliable and timely health information is an essential foundation of public health and health systems, especially when funding allocation decisions need to be made with limited resources (HMN and WHO 2011; WHO and HMN 2008). The ability to monitor and steer progress towards the Sustainable Development Goals will therefore depend on the availability of comprehensive health information systems. According to the Health Metrics Network (HMN), a health information system is 'an integrated effort to collect, process, report and use health information and knowledge to influence policy-making, programme action and research' (WHO and HMN 2008). The aim of a health information system is to assess trends and health system performance, using data from either population-based sources (census, civil registration, population surveys) or institution/facility-based sources (health and disease, service and resource records) (*ibid.*).

Since 2000, there has been significant growth in the use of ICT to enhance the capacity and performance of health information systems, with countries in the high- and upper/middle-income groups being notably more advanced than those in the lower middle- and low-income groups (HMN and WHO 2011; WHO 2006). However, evidence of what works best to improve care is debatable, as only a few rigorous evaluations have been conducted (Chib, van Velthoven and Car 2015; Higgs *et al.* 2014; Lee *et al.* 2016; Scott and Mars 2015). Examples of studies that have shown a positive impact in low- and middle-income countries include the use of laboratory reporting tools for management of tuberculosis in Peru (Blaya *et al.* 2011), and the use of Open Medical Record System's (OpenMRS) Electronic Medical Record for HIV care in Rwanda (Amoroso *et al.* 2010) and Kenya (Were *et al.* 2011).

Many LMICs are using technology to improve health management and information systems. Study findings from Uganda, Kenya and Malawi indicate improved timeliness and completeness in reporting of routine outpatient, inpatient and health service usage data compared to other existing systems (Chaulagai *et al.* 2005; Kariuki *et al.* 2016; Kiberu *et al.* 2014; Mphatswe *et al.* 2012). However, challenges remain, including inaccuracy and timeliness of data reporting, lack of computers and poor access to the internet, lack of training of newly deployed or recruited staff, interrupted electricity supply to computers and lack of qualified staff to operate the computers, among others. For example, a study on the development of the national health information systems in Botswana, revealed a lack of central coordination, weak leadership, weak policy and regulatory frameworks, while inadequate resources limited development of the national health information systems (Seitio-Kgokgwe *et al.* 2015).

Digital innovations can also improve civil registration and vital statistics systems' performance but a review of 58 studies of such interventions suggested that most of the projects were pilots with issues of scalability and systems integration rarely being addressed. Most lacked a rigorous assessment, meaning they had limited usefulness (AbouZahr *et al.* 2015).

Large-scale electronic medical record (EMR) and electronic health record (EHR) systems projects have been implemented in many countries. Studies reveal the following barriers and challenges to implementing EHRs in sub-Saharan Africa and other LMIC regions:

- lack of clinical trials;
- a tendency to report positive impacts;
- infrastructural barriers such as reliable power, connectivity and networking capabilities where EMRs are deployed;
- human resource barriers such as high staff turnover, absence of local technical support and low levels of computer literacy;

- organisational barriers such as lack of local information system leadership or coexistence of multiple co-deployed systems without coordinated leadership;
- limitations of currently available EMR systems such as bugs, missing features and poor performance contributing to user resistance;
- a lack of ethically grounded EMR policies or policies that appropriately address security and privacy issues in developing countries.
(Fernández-Alemán *et al.* 2013; Jawhari *et al.* 2016; Were and Meslin 2011)

The review of health information systems indicates that ICT provides an opportunity to strengthen data collection and transfer, as well as to process, analyse and communicate the results. However ICT should not be seen as a magic bullet, but rather as a valuable tool to enable system development and transformation (HMN and WHO 2011). The lack of common data architecture and standards disrupts interoperability between different data systems. Addressing this issue would mean that the increasing diversity of actors and resources contributes evenly and in a sustainable manner to resolving the information gaps at country and global levels (*ibid.*). Good legal foundations are essential to ensure security and privacy of personal data and to set standards for database interoperability, confidentiality, data protection and personnel clearance.

## 3.2   Telemedicine

Telemedicine – which literally means 'healing at a distance' – is used throughout the world to increase patient access to medical information and health care, and to improve patient outcomes (WHO 2010). Telemedicine applications are broadly classified into two basic types according to the immediacy of the interaction (or response) aspects in the telemedicine service – *synchronous* and *asynchronous*. The *synchronous* approach gives the opportunity to refine details and provide clinical decision or advice within the tele-consultation session. In contrast, the *asynchronous* service overcomes the constraints of limited bandwidth and is efficient when the task does not require to-and-from interactions, or relies on direct interaction with the patient throughout (Wilson and Maeder 2015). Asynchronous telemedicine involves the exchange of pre-recorded data between two or more individuals at different times and at the convenience of the participating parties whereas real-time or synchronous telemedicine requires the involved individuals to be simultaneously present for immediate exchange of information, as in the case of video consultation (WHO 2010; Wilson and Maeder 2015). This section explores the reach and success of telemedicine projects both in LMICs and in humanitarian networks.

There has been substantial progress in the implementation of telemedicine in Latin American countries. Several countries in Latin America have already deployed national telemedicine projects such as Brazil, Colombia, Ecuador, Mexico and Panama while in several other countries such as Bolivia, Costa Rica, Cuba, El Salvador, Guatemala, Peru and Venezuela, the deployment is in the early phase (dos Santos *et al.* 2014). An example of an effective, technically feasible and economically viable project is the Telehealth Network of Minas Gerais – a large, public, state-wide telehealth system that supports primary care professionals in remote regions of the Brazilian state of Minas Gerais in cardiology combined assistance and in-service education with simple and inexpensive technology. Minas Gerais invested about US$9m and achieved estimated cost savings of US$20.08m in five years. It covers around 9.2 million inhabitants or 47.2 per cent of the population and performs a daily average of 1,450 remote echocardiograms and 77 teleconsultations (Alkmim *et al.* 2012).

The majority of telemedicine projects in Asia show little evidence of sustained programmes (Scott and Mars 2015). The telemedicine market in India has witnessed spectacular growth in recent years and both government and the private sector have been actively participating in tele-health programmes (Mishra, Singh and Chand 2011). However most of these

activities are struggling to achieve scale and sustainability (Carroll and Horton 2013; Mohan *et al.* 2012; Prathiba and Rema 2011; Singh and Das 2010; Vinekar *et al.* 2014). None of the programmes has been adopted into the health system and the activities are primarily supported by agencies such as the Department of Information Technology and the Ministry of Health and Family Welfare.

Only a few initiatives in sub-Saharan Africa have been successfully integrated into routine clinical practice, and published data on their use are sparse (Mars 2013). In some countries such as Ethiopia and South Africa there is significant progress in telemedicine while in countries such as Burkina Faso and Nigeria the progress is slow (Wamala and Augustine 2013). Challenges are both technological such as lack of infrastructure and the lack and high cost of connectivity to host telemedicine projects, and non-technological such as poverty, lack of human resource and capacity development, lack of political support, and funding (Mars 2010; Wamala and Augustine 2013). However, tele-education has been a successful use of ICT in health in Africa, including projects such as Fundamentals of modern telemedicine in Africa, Réseau en Afrique Francophone pour la Télémédecin and the PAN African e-health programme (Mars 2010, 2013; Wamala and Augustine 2013).

Work has also been done looking at the adoption of telemedicine in nine humanitarian networks. Broadly speaking they were found to be improving access to care in the developing world. However sustainability factors varied between networks, and included institutional anchoring, organisational models, technical and clinical solutions, clinical quality and benefits to patients, exit strategy, availability of coordinators, the training of experts, a lack of infrastructure and equipment, and most importantly, funding (Wootton *et al.* 2012).

A review of factors that hinder or support implementation of cross-border telemedicine services worldwide in the last two decades grouped these factors under the following headings (Saliba *et al.* 2012):

- **Legal:** uncertainty around liability of health professionals; ensuring clinical governance and informed consent, data security and confidentiality.
- **Sustainability:** the need for long-term financing on a large scale; start-up and maintenance costs; the need for well-designed formal evaluations including cost-effectiveness; integration into the broader health system; building on national telemedicine services; and combining top-down and bottom-up approaches.
- **Cultural:** language; trust between professionals/patients; trust at the organisational level; overcoming resistance to technology.
- **Contextual:** knowledge of local infrastructure and resources.

## 3.3    mHealth

WHO's Global Observatory for eHealth (GOe) defines mHealth or mobile health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices (WHO 2011).

### 3.3.1  mHealth applications and use

Labrique *et al.* (2013) presented a list of 12 common mHealth and ICT applications which included client education and behaviour change communication, sensors and point-of-care diagnostics, registries and vital events tracking, data collection and reporting, electronic health records, electronic decision support, provider-to-provider communication, provider work planning and scheduling, provider training and education, human resource management, supply chain management, financial transactions and incentives (*ibid.*). Similar categories were used by WHO, m-Health Alliance and Columbia University and

others to report on mHealth applications: health call centres, emergency toll-free telephone services, managing emergencies and disasters, mobile telemedicine, appointment reminders, community mobilisation and health promotion, treatment compliance, mobile patient records, information access, patient monitoring, health surveys and data collection, surveillance, health awareness-raising, and decision support systems (Mechael *et al.* 2010; Haas 2016; WHO 2011).

These applications employ one or more mobile functions such as short message service (SMS), interactive voice response, multimedia messaging service (MMS), audio, and/or video communication, images, camera, digital forms, mobile web, mobile apps (calendar, dashboards), GPS etc. to achieve the desired objectives (Labrique *et al.* 2013).

**Figure 3.1   Member states reporting at least one mHealth initiative, by WHO region**
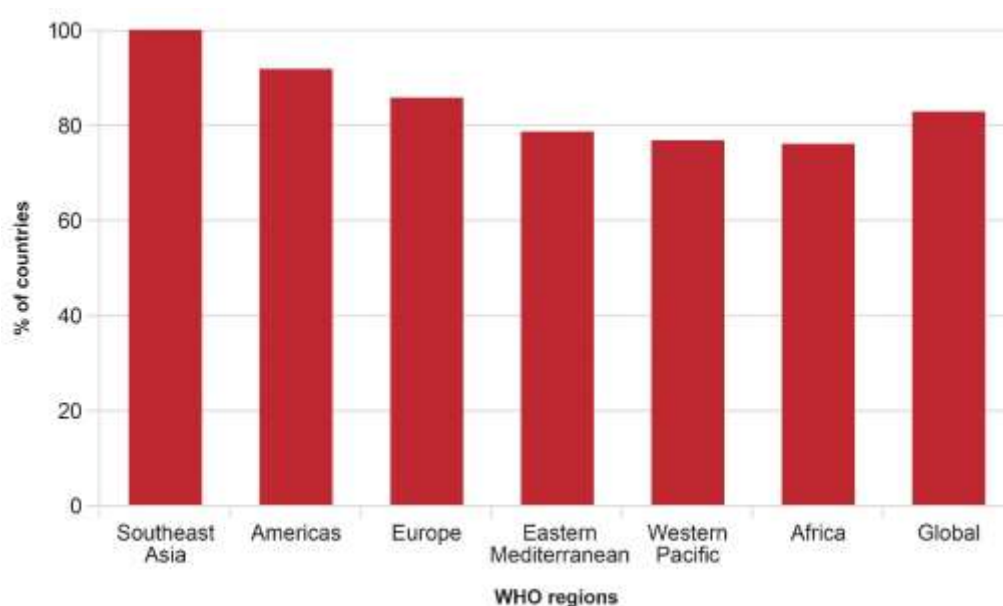


*Source*: Adapted from WHO (2011).

The mHealth Global Observatory survey reports mHealth to be an approach with global appeal, with at least 75 per cent of participating WHO Member States from each region reporting the presence of one mHealth initiative. Countries in the African region reported the fewest initiatives, while those in the Southeast Asia region reported the most. The most frequently reported mHealth initiatives globally were health call centres/health-care telephone helplines (59 per cent), emergency toll-free telephone services (55 per cent), emergencies (54 per cent), and mobile telemedicine (49 per cent).

### 3.3.2  Evidence for mHealth initiatives

There is a growing body of research indicating the potential of mHealth interventions for improving health in LMICs with a few recent systematic reviews exploring the impact of mHealth on health outcomes. While previous reviews were primarily disease-specific, recent ones focus on exploring the impact of mHealth interventions on maternal, newborn and child health outcomes, on health-care service delivery, health behaviour change or disease management.

The results from a few of these reviews are summarised below.

**Community health workers in low- and middle-income countries (Källander *et al.* 2013)**
The most commonly documented use of mHealth was one-way text message and phone reminders to encourage follow-up appointments, healthy behaviours, and data gathering. The authors concluded that there were few rigorous outcome evaluations of mHealth in low-income countries, and constituted mainly project process and uptake documentations; most were evaluations of small-scale pilot studies that were not designed to demonstrate an impact on behaviour change or health.

**Health-care quality for non-communicable diseases in LMICs (Peiris *et al.* 2014)**
Their findings revealed that most studies focused on text messaging systems for patient behaviour change, and few studies examined the health systems strengthening aspects of mHealth. There was limited literature reporting clinical effectiveness, costs and patient acceptability, and none reporting equity and safety issues.

**mHealth strategies used by frontline health workers (FHWs) in developing countries (Agarwal *et al.* 2015)**
Applications for which mobile phones were used by FHWs included data collection and reporting, training and decision support, emergency referrals, work planning through alerts and reminders, and improved supervision of and communication between health-care workers. Findings reveal that with adequate training (which mainly ranged from a few hours to a week), FHWs were able to use mobile phones to enhance various aspects of their work activities. In addition, the review revealed that mobile-based data collection improved promptness of data collection, reduced error rates and improved data completeness, and two randomised controlled trials (RCTs) provided evidence that regular SMS reminders and use of mobile-based decision-support systems may improve the adherence of the FHWs to treatment algorithms (Mitchell *et al.* 2013; Zurovac *et al.* 2011).

**Nutrition-related behaviour change in LMICs (Barnett *et al.* 2016)**
This review found only ten studies on the use of mobile phones to improve infant and child feeding practices or hygiene behaviours, with only two of them (Flax *et al.* 2014; Jiang *et al.* 2014), both RCTs, aimed at triggering behaviour change. Although interest is growing in the use of mobile phones for nutrition behaviour change interventions in LMICs, hard evidence is very limited, often based on anecdotal findings, methodologically weak and lacking any theoretical plan to guide the design of the interventions. In addition, most of the reviewed studies did not consider the environmental context of the m-nutrition intervention, and hence the ability of participants to adopt the behaviours.

**A heuristic of inputs-mechanism-outputs as a tool to categorise mHealth studies in developing countries (Chib *et al.* 2015)**
This review reveals that mHealth studies in developing countries mainly concentrated on pilot projects, implementation evaluations and studies with undefined design or interviews that adopted a deterministic approach to technological inputs.

Despite the limitations, a few common conclusions were drawn by the authors of the reviews. Certainly, there is encouraging evidence particularly on the supply-side of health-care systems. Although evidence of the benefits of mHealth is increasing, for policymakers and planners wishing to make informed choices about mHealth investments, studies must be of high quality, undertaken in resource-limited settings as well as in high-income countries, and must consider interventions that combine mHealth and conventional approaches (Hall *et al.* 2014; Lee *et al.* 2016). Authors agree that there remains a need for more rigorous measurement of performance and outcomes (Braun *et al.* 2013; Catalani *et al.* 2013; Chib *et al.* 2015; Higgs *et al.* 2014; Lee *et al.* 2016; Tao *et al.* 2015; Hall *et al.* 2014; Free *et al.* 2013, 2010; Peiris *et al.* 2014; Mookherji *et al.* 2015; Chib 2013).

Catalani *et al.* (2013) argue that an implementation science agenda will drive the field towards more rigorous approaches to monitoring and evaluation, operations research, and impact evaluation, necessarily moving the literature from mostly descriptive studies to more quasi-experimental and experimental designs and with quantifiable economic, clinical and long-term patient-centred health outcomes. When RCTs are not feasible or ethical, more rigorous quasi-experimental studies and further grounding and analytical rigour in qualitative studies will be needed. In addition, Chib (2013) argues that an appropriate mix of quantitative and qualitative methodologies will better inform academics and policymakers particularly when investigating sensitive sociocultural topics, such as gender relations within an entrenched power structure, or the issue of sexual and reproductive health.

The existing literature also provides little or no evidence around costs of implementing interventions and measuring efficiency or benefits. Hence, authors agree that cost-effectiveness analysis should be incorporated to inform policymakers and planners to assist them in deciding the value of national implementations and to make operational decisions about using mobile technology to deliver programme targets (Braun *et al.* 2013; Mookherji *et al.* 2015).

In addition, mHealth research projects were found not only to be under-theorised but included ambiguous descriptions of interventions and their mechanisms, hindering interpretation, replication, scaling and effective translation of the research to practice (Catalani *et al.* 2013; Chib *et al.* 2015; Higgs *et al.* 2014; Lee *et al.* 2016). Only a few studies used theory or methodological designs (often borrowed from different disciplines, with no dominant theory) to explain use of mobile phones for health-care needs or connections between particular development processes and health outcomes (Catalani *et al.* 2013; Chib *et al.* 2015). In cases where behaviour-change theories were used they failed to account for context such as culture and gender, which are essential for evaluating factors that influence how and why interventions work (Barnett *et al.* 2016; Chib *et al.* 2015).

In order to improve completeness of reporting of mHealth interventions, the WHO mHealth Technical Evidence Review Group developed the mHealth evidence reporting and assessment (mERA) checklist consisting of 16 items, i.e. a minimum set of information needed to define what the mHealth intervention is (content), where it is being implemented (context), and how it will be implemented (technical features), to support replication of the intervention (Agarwal *et al.* 2016). The aim is that the use of these guidelines will standardise the quality of mHealth evidence reporting, and indirectly improve the quality of mHealth evidence.

### 3.3.3 Taking mHealth solutions to scale: enabling environments and successful implementation

Although the majority of mHealth interventions are currently pilot projects or are implemented at a limited scale, a growing number of mHealth systems are reaching significant scale and/or are being adopted by national governments (Haas 2016). Interventions at scale are defined as 1 million or more users if the application is patient-/population-facing, and 1,000 or more users if the application is health system-facing (Levine *et al.* 2015; Haas 2016). They include the following examples:

- RapidSMS-MCH for improving maternal and child health in Rwanda (used by more than 45,000 community health workers);
- MomConnect in South Africa (adopted and led by the Ministry of Health);
- Ananya in Bihar, India (currently serving a population of more than 104 million, and planned adoption by the Ministry of Health and Family Welfare);
- TIBU in Kenya (linked with national health information system) and SMS for Life in Tanzania (Levine *et al.* 2015).

Factors that need to be considered for ensuring sustainability and successfully scaling up mHealth innovations include collaboration and partnerships, financing, literacy and cultural issues in trust and acceptability, and technical considerations such as interoperability, security and privacy (Källander *et al.* 2013).

Lemaire (2011) presents a set of best practices and recommendations (programmatic, operational and policy) to grow a project beyond a successful pilot phase and to achieve scale-up, which include:

- planning for scale-up and sustainability on a large scale from the beginning;
- identification of real needs and demands of target beneficiaries, local health priorities and to understand the local landscape (existing players and solutions, policies, local settings and practices, etc.);
- in the area of implementation: identification and collaboration with organisations with existing similar initiatives for deeper impact;
- aligning the mHealth programme with the local and national health priorities and any existing health information systems, engaging end-users to ensure uptake;
- securing buy-in from different stakeholders, collaboration with local implementation partners and establishment of strategic partnerships to support scale-up of the project;
- performing monitoring and evaluation and assessments of impact using meaningful, measureable metrics.

Tomlinson *et al.* (2013) recommend reviewing existing standards for research, conducting efficacy and effectiveness trials, implementing interventions guided by a plausible theory of behaviour and factorial design to test multiple features, establishing an open mHealth architecture and cooperation between governments, funders and industry to set standards before scaling up an mHealth project.

This review shows both the breadth of the term telemedicine and the scarcity of evidence on its effectiveness in developing countries. There are few cost-utility and cost-effectiveness studies, leading de la Torre-Díez *et al.* (2015) to conclude that there is a lack of concrete evidence with which to fully assess the economic impact of telemedicine, eHealth, and mHealth systems. However the economic stakes are very high: the telemedicine market is expected to grow to US$55.1bn by 2021 (bcc Research 2016). The aim for policymakers in developing countries should be to use the lessons learnt from current use, barriers and solutions to invest wisely in the identification, demonstration and implementation of technologically appropriate solutions that are effective (Scott and Mars 2015).

# 4 Lessons learnt on use of digital technology in health and education/ factors affecting implementation, scale-up and sustainability

This section highlights issues that are significant to use, scale-up and sustainability of projects using ICT to provide health and education services.

## 4.1 Funding

In any e-government implementation scenario involving delivery of services such as health and education, the funding model used and the cost incurred in conceptualisation, design, implementation and evaluation defines the likely levels of sustainability that it will achieve (Bwalya and Mutula 2014). Lack of adequate financial resources and inaccurate or lack of cost-benefit analysis can limit the flow of investment at the levels necessary and derail future e-government service delivery implementation and innovation. Many e-government projects in developing countries have failed because they have replicated funding models from the developed world.

Emerging funding models for financing e-government applications require that implementation should be self-sustaining through successful business models that employ an appropriate mix of public and private partnerships and alternative or diversified revenue sources (Bwalya and Mutula 2014; Lemaire 2011; Shuvo *et al.* 2015).

In addition, there is a need to complement these funding models with informed design for monitoring and evaluation strategies and a need to consider context-aware adoption models. In many African countries e-government initiatives, such as the Health Management and Information system in The Gambia, are funded by donors, which are hard to sustain and more likely to fail (Sander, Bell and Rice 2005). Lewis *et al.* (2012) analysed 176 Center for Health Market Innovations programmes in eHealth in LMICs and identified persistent reliance on donor funding to be a major impediment to reaching scale. Finally in education, the ICT4E survey conducted in India and South Asia indicated that in order to sustain ICT for Education activities it is essential to provide and sustain ICT infrastructure in schools, especially through public–private partnerships (InfoDev/World Bank 2010).

## 4.2 System interoperability

Ensuring seamless data flow between different standalone systems across different organisations is key in designing successful e-government service delivery platforms (Bwalya and Mutula 2014). But to make sure that diverse systems and organisations communicate and work together it is necessary to have highly integrated and interoperable systems which are also relevant and workable in the local context. This requires establishment of and adherence to open standards and architectures (Bwalya and Mutula 2014; Fishenden and Thompson 2013; Haas 2016).

For example, Fishenden and Thompson (2013) argue that future public services will depend on the evolution of global, internet-enabled, digital platforms, with two distinctive technical and commercial features. Firstly, the use of open standards and architectures will allow government to become technology- and vendor-agnostic. Secondly, over time, open standards and increased market choice will drive both innovation and progressive convergence on cheaper, standard 'utility' public services. This could enable the disintegration of traditional 'black boxed' or siloed technologies and services and

development of an innovative and cost-effective marketplace for these services (Estrin and Sim 2010; Fishenden and Thompson 2013; Tomlinson *et al.* 2013).

According to Bwalya and Mutula, the development of context-aware interoperability frameworks is a very urgent matter since there are no globally agreed semantics to aid such efforts. Despite the urgency, the literature on eHealth reveals that very few efforts are being made to allow for interoperability and in creating a robust platform to allow for exchange of accurate and reliable information between various mHealth and health information system platforms.

To facilitate collaboration across 14 sites in ten different sub-Saharan African countries and different languages and governmental systems, the Millenium Village Project (MVP) eHealth architecture was built using a free/libre open source software for health care (FLOSS-HC) platform. It has focused on the use of open and international standards, where possible (Kanter *et al.* 2012). Estrin and Sim mention that an open mHealth architecture around shared data standards and the global communication network is available that could facilitate scaleable and sustainable health information systems provided that governments, non-government and commercial bodies collaborate intensively to set standards and create a self-governing commercially viable ecosystem for innovation (Estrin and Sim 2010; Tomlinson *et al.* 2013).

## 4.3   Level of evidence

The importance of research and evaluation for scalability, transferability and continuing quality improvement cannot be overemphasised: evidence on impact and cost-effectiveness is vital to justify investments in health and education programmes that use ICTs. However the current knowledge base on use and impact of technology in education and health for developing countries is limited in scope, lacks rigour, focuses primarily on the input (number of devices, for example) rather than on performance or outcome (effect on student performance in education or decrease in mortality in health) and does not take into account the socioeconomic context of the particular country or region (Chib 2013; Pedró 2012).

There is also a lack of theoretical frameworks or models to guide future developments (Bwalya and Mutula 2014; Higgs *et al.* 2014; Lee *et al.* 2016; Shuvo *et al.* 2015). In the field of education, there is a lack of comprehensive and well-designed studies on the impacts of ICTs on teaching and learning; on the multifaceted interactions between various types of ICT implementations; and on the effects on factors such as school-based intervention, socioeconomic status and expenditure (OECD and Joint Research Centre–European Commission 2010). These gaps in assessing the impacts of ICTs hinder the work of policymakers who are trying to develop evidence-based strategies and regulatory measures for effective ICT implementation. These gaps also make it harder to verify that the activities and resources meet the objectives of the initiative before scaling up, and to make necessary changes or implement corrective measures (Aranda-Jan, Mohutsiwa-Dibe and Loukanova 2014; Bloomfield *et al.* 2014; Ekeland, Bowes and Flottorp 2012; Higgs *et al.* 2014; OECD and Joint Research Centre–European Commission 2010; Ortiz and Cristia 2014; Shuvo *et al.* 2015).

## 4.4   Security and privacy

Information security and privacy issues are a growing area of importance in the implementation of e-government. Many governments, particularly in developing countries have not yet put in place laws, policies and standards for privacy protection and information access which makes for a challenging environment for e-government implementation (Bwalya and Mutula 2014). The emergence of mobile phones and tablets as ubiquitous information management and service delivery platforms for eHealth and eLearning

reemphasises the need for protecting privacy and security and reinforcing trust in digital information platforms. E-Health policy issues in the developed world relating to data security, data quality, licensure, patient confidentiality and privacy may act as major impediments in the developing world as well (Scott and Mars 2015). The implementation of electronic patient records and health information systems, increased regulation, provider consolidation and the increasing need for information exchange between patients, providers and payers, all indicate the need for better information security (Appari and Johnson 2010). Globally only around one third of WHO Member States have specific legislation to protect the privacy of information held in an electronic health record and such legislation has been found to be more common in high- and middle-income countries than in low-income countries (WHO 2012).

## 4.5   Infrastructure availability

Although access to technology and technological infrastructure is a prerequisite for ICT innovations in health and education, coverage and reliability are major challenges. The integration of technology into education in developing countries, and particularly in rural areas has been slowed by the lack of supporting infrastructure such as devices, and adequate connectivity (ADB 2012; InfoDev/World Bank 2010). International Telecommunications Union (ITU) figures (2016) show that only one out of seven people in the least developed countries are using the internet. While 53 per cent of people globally do not use the internet, that proportion rises to almost 75 per cent of people in Africa. In addition, mobile-broadband networks (3G or above) reach 84 per cent of the global population but only 67 per cent of the world's rural population (ITU 2016). Even for those with technology and access, poor general and technological literacy means use is limited. For women and the poor, these issues of access and use are exacerbated. In India, for example, 42 per cent of women targeted by an mHealth intervention had to rely on their husbands due to device and textual literacy barriers (Balasubramanian *et al.* 2010).

## 4.6   Policy commitments

An important aspect in the sustainable success of e-government initiatives or ICT initiatives in health and education is a formal commitment from the government. The right policies and strategies for the development of ICT, e-government, and eHealth or ICT in Education, with proper emphasis on reducing inequalities and creating a constructive legal and regulatory environment, can play a big role in creating an enabling environment for promoting the adoption of technologies and thereby extending their benefits.

According to WHO, the most favourable approach to the implementation of eHealth at the national level is to have a framework of strategic plans and policies which lay the foundations for development (WHO 2006). These plans and policies should create an enabling environment to protect citizens, promote equity, observe cultural and linguistic issues in cyberspace, ensure interoperability and allow for capacity development so that all citizens can access eHealth solutions (*ibid.*). Although a country may not have a clearly stated eHealth policy, it may be part of larger e-government policy or part of social welfare or health policy, or there may be a telemedicine or telehealth policy or an eHealth roadmap or strategy (Mars and Scott 2010).

According to the third global survey on eHealth 2015, about 58 per cent, 66 per cent, and 22 per cent of the responding states reported respectively an eHealth, a health information system and a telemedicine policy or strategy at the national level. In addition, variations were seen on the availability of legal frameworks to eHealth. For example, 78 per cent of the responding countries said that there was a policy or legislation that protects the privacy of personally identifiable data of individuals irrespective of whether it is in paper or digital format, whereas 54 per cent of countries mentioned having a policy or legislation that

protects the privacy of individuals' health-related data held in an electronic health record (EHR); and 22 per cent said they had one that governs the sharing of digital data between health professionals in health services in other countries through the use of an EHR (WHO 2015). Scott and Mars (2010) argue that considering the complexity of cross-border eHealth, it is better to have clear eHealth policy documents and to make certain that these are aligned with, and are identified in related health, education, ICT, and e-governance policy and strategy. In addition they also advocate that developing countries should strive for 'glocal' eHealth policy tailored to the specific needs of a given locality and population but that would facilitate countries to benefit from eHealth in a borderless global environment (Mars and Scott 2010; Scott and Mars 2015).

While standalone ICT in education policy documents are most effective in bringing about a transformational change in the education system, surveys have found that policies vary between countries by level of specificity and are expressed within references to ICT in Education sector strategy policy documents and plans or references to the education sector in national cross-sector ICT policy documents and plans (InfoDev/World Bank 2010; UIS 2012, 2013, 2014, 2015; UNESCO 2011a). Surveys in sub-Saharan Africa reveal that while some countries have specific ICT in education policy and plans, others such as Cameroon, Comoros, Congo, Guinea, Lesotho and Madagascar do not have any such policies (UIS 2015).

Effective partnership and collaboration between public, private and nonprofit sectors are required for successful ICT interventions delivering education and health services by helping to fund and develop, implement, or scale activities. Hence, government stewardship is needed to provide oversight to public–private partnerships that facilitates large-scale interventions by bringing together diverse health or education, technology and media stakeholders including regulators, development and non-governmental organisations, commercial enterprises, and beneficiaries.

The review, however, suggests that in order to inform policymakers and influence policy decisions for deployment and scale-up of ICT in health and education, more comprehensive and rigorous empirical evidence on the social and economic benefits are needed.

## 4.7   Human factors: awareness, skills and leadership
People are central to the adoption of ICT-based products and services in health and education; changes in strategies, structures and form of service delivery must be accepted by the service providers (namely health-care professionals and educators/teachers). They not only must learn new skills in computer and web technologies but also must adapt to new organisational and managerial competences and leadership necessary for the changes in working methods and job roles.

In the context of education, teachers need not only to know how to instruct pupils to use ICT effectively, but they also need to be trained to use ICTs themselves. How this is achieved varies from one country to another, given the widely disparate policies and curricula on how best to integrate ICTs and apply them in the classroom, as well as differences in teacher training programmes and professional development. Studies show that while some educators appreciate the value of ICT in education and are willing to adopt it, they also feel they lack capacity and power to voice the challenges in integration while others are less motivated and resist its integration as they feel computers increase their workload (Bladergroen *et al.* 2012).

Findings also reveal that in both developed and developing countries, a lack of trained teachers presents significant challenges and although developed countries have greater proportions of trained teachers than developing countries, most countries, regardless of

economic position, have trained 10 per cent or fewer teachers to be ICT-qualified for delivering basic computer skills or computing courses (ITU 2014).

Similarly, for eHealth, the role of individual capacity is vital, including educational background, training and work experience as well as team coordination, and availability of technical and administrative support as critical components for large-scale implementation (Alwan, Awoke and Tilahun 2015; Lluch 2011; Nuq and Aubert 2013; Olok, Yagos and Ovuga 2015; Scott and Mars 2015; Shuvo *et al.* 2015; Sukums *et al.* 2014). Also of importance are issues such as resistance to new technologies and the need for research about health worker benefits, and incentives for increasing use and compliance (Lluch 2011).

# 5  Conclusion

The review provides evidence on the use of ICT in education and health and identifies seven cross-cutting themes that are important for use, implementation and scale-up.

- Funding
- System interoperability
- Level of evidence
- Security and privacy
- Infrastructure availability
- Policy commitments
- Human factors: awareness, skills and leadership

Although the use of ICT in health and education is being increasingly advocated to address systems challenges in LMICs, most solutions, expertise and research originate in developed countries and are made to fit in environments that are essentially different and challenging. An alternative approach could be to innovate using solutions that are appropriate to the local context.

With the rapid growth of ICT interventions in health and education in developing countries, there is an urgent need for evidence of its impact to justify and guide the investment of resources in such systems. Despite increases in evaluations in recent years, most large implementations have little or no evaluation data, are concentrated in developed countries, have focused on process indicators rather than outcomes, and are performed mostly by academic groups. Focus should be placed on including evaluations as part of the implementation and be adopted by organisations implementing or funding such systems.

In recent years there has been a rush to seek simple quick fixes in new technologies. A better approach in future is to start with the identification of the problem and possible solutions; this process must also determine if including ICT can facilitate an optimal solution and help resolve the problem. If technology is part of the solution then a step-by-step approach is needed which integrates all parts of the system through design, implementation and scaling. Successful approaches require a holistic strategy that will guide innovation to address evidence-based needs and result in broader user adoption.

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