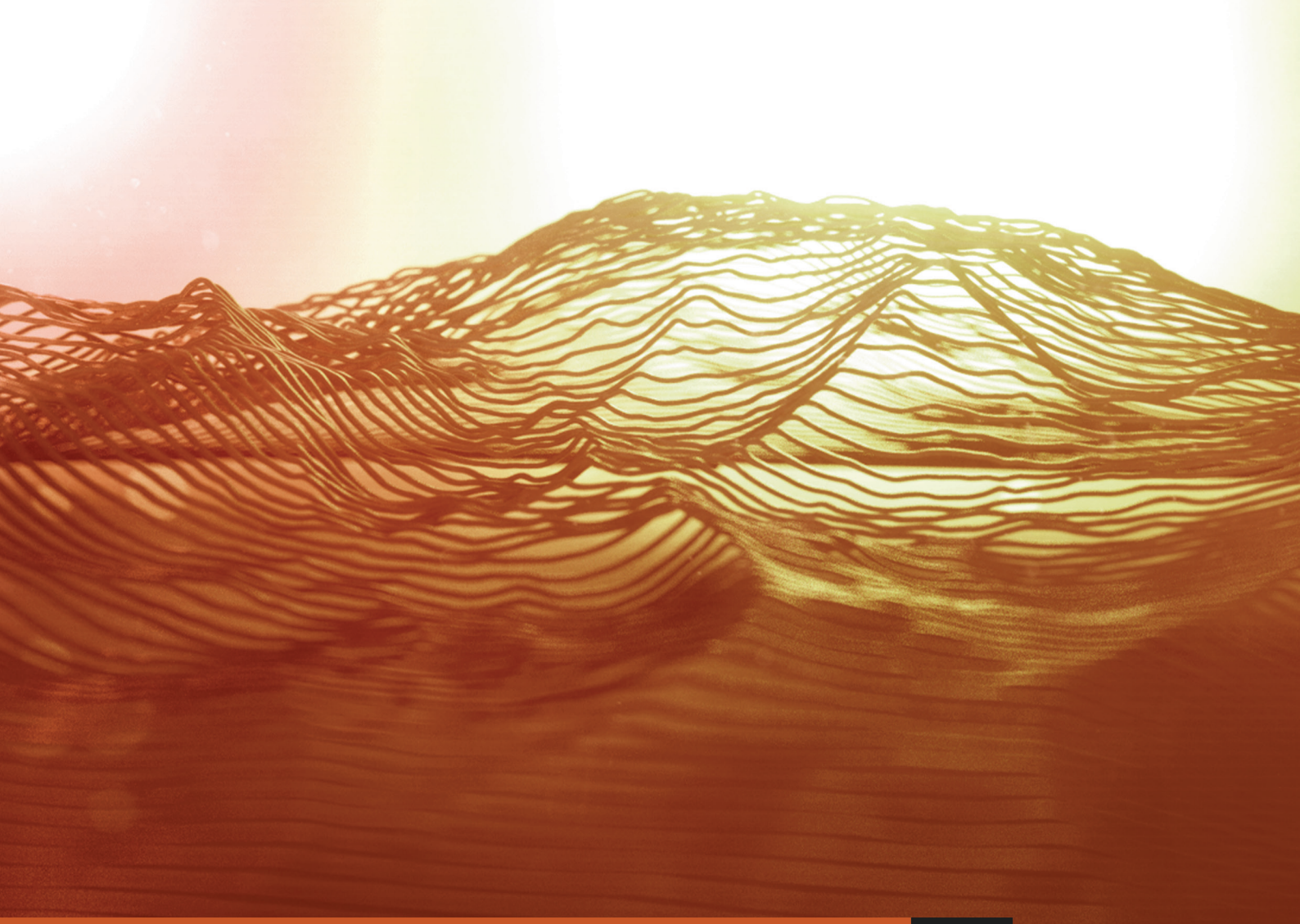

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LOCAL RESEARCH LOCAL SOLUTIONS

Volume III

TECHNOLOGY & PUBLIC SERVICE DELIVERY

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Edited by Nadeem Ul Haque and Faheem Jehangir Khan

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PART I

TECHNOLOGY & PUBLIC SERVICE DELIVERY

Research Papers

ELECTRONIC VOTING MACHINES FOR PAKISTAN: OPPORTUNITIES, CHALLENGES, AND THE WAY FORWARD

Hina Binte Haq, Syed Taha Ali and
Maryam Zafar Usmani

ABSTRACT

This paper is an attempt to structure the ongoing debate around electronic voting machines (EVMs) and election technology in Pakistan and ground the discourse in research, international best practices, and expert guidelines. EVMs have been used in different countries since the 1960s and have proved to be highly controversial. A concerning trend has emerged over the last two decades in those various developed countries, including Ireland, the Netherlands, and Germany, which have phased out or terminated their EVM deployment over concerns about voter privacy and election integrity. At the same time, the deployment of EVMs in developing countries, such as India, Brazil, Venezuela, and the Philippines, has yielded mixed results. There is, therefore, an urgent need to decipher this trend such that we may maximise the gains from these technologies and avoid mistakes made by other countries.

Moreover, revolutionary new technologies have emerged in recent years, which enable citizens and observers to verify and audit election results. Technologies such as end-to-end verifiable voting and risk-limcognition of the unique challenges in adapting these methodologies in developing countries such as Pakistan. There is a need to make these technologies accessible to election stakeholders and to precisely identify the critical research gaps and challenges we need to address in Pakistan. This paper draws together these complementary lines of inquiry and provides a comprehensive vision for election technology in Pakistan

We also present recommendations to address these challenges at every stage. The accompanying roadmap spells out these recommendations in the form of concrete detailed steps that stakeholders need to take. This paper provides a framework for such efforts and is supported by a detailed roadmap which describes the key steps that stakeholders need to take to successfully deploy EVMs and election technology in Pakistan.

1. INTRODUCTION

Elections in Pakistan suffer from poor execution, persistent rigging and fraud, and a pronounced lack of transparency. Polls are routinely contentious and frequently result in political deadlocks, street protests, and violence. Such instances undermine citizens' confidence in elected leaders and negatively impact civic participation and trust in democracy (FAFEN, 2018).

Major rigging allegations in the general elections of 2013 resulted in mass protests and a public sit-in by a major opposition party. Lasting over four months, this was the longest protest in Pakistan's history and caused estimated losses of over USD 5 million (Hussain, 2020). Election watchdog body FAFEN reported electoral illegalities and irregularities at over 21,000 polling stations in the 2013 General Elections (FAFEN, 2013). Almost a decade on, nothing much has changed. In recent by-polls in Daska, 20 election presiding officers were abducted, and the Election Commission of Pakistan (ECP) declared the poll results null and void (Ebrahim, 2021). Appendix A gives a quick summary of how general elections in Pakistan have routinely been contentious. It also gives a brief overview of the key irregularities reported.

In this context, the government's recent push for electoral reforms is a welcome step to restore citizens' confidence and trust in elections. Election technology, such as electronic voting machines (EVMs), result transmission system (RTS), and Internet voting have documented benefits in curbing fraud. However, these technologies are prone to fail and may even result in disastrous election day outcomes if deployed without careful research and homework.

The international experience has documented considerable benefits of using EVMs. EVMs dramatically reduce the time and manual effort required for vote tabulation and result reporting and significantly mitigate certain types of electoral fraud. EVMs also provide accurate counts by eliminating spoiled ballots. Certain countries document that the adoption of EVMs improves voter turnout, empowers marginalised communities to vote, reduces electoral expenses, and may even correlate with improved governance.

The disadvantages are also considerable. For instance, EVMs are closed systems, prone to malfunction, and can be easily hacked. Although EVMs counter certain types of electoral fraud, they may open the door to new and more dangerous attacks. Voters might find EVMs difficult to use. EVMs can be very costly and can necessitate further significant costs in infrastructure and logistics.

We have significant examples of countries including the Netherlands, Ireland, Kenya, Venezuela, and Russia, where election technology adopted in haste proved controversial, and in some cases, it failed outright or was aborted. Our own experience with developing a homegrown internet voting solution for overseas Pakistani in 2018 illustrates this point. An expert audit commissioned by the Supreme Court of Pakistan identified critical vulnerabilities in every major component of this system (Internet Voting Taskforce, 2018), re-endorsed by Minsait, which also undertook an audit of the same system in 2021 (Minsait, 2021). Likewise, the mysterious failure of the result transmission system during the general elections of 2018 cast a cloud of suspicion on the election results (Thomas & Khuhro, 2018).

Critics have repeatedly noted that mainstream discussion on election technology lacks essential depth and rigour (Gul, 2021; Express Tribune Editorial, 2021; Dawn Editorial, 2021) and ``add little value to the general populace's understanding" (Bari & Muhammad, 2021). Prior reports have also emphasised our lack of critical expertise regarding election technology and urged stakeholders to invest in this domain to prevent such incidents in the future. Deploying election technology is a large-scale exercise, which will likely cost tens of billions of rupees. Therefore, we cannot afford to make decisions without high-quality research, clear thinking, and rigorous debate.

The primary contribution of this paper is structuring the debate around EVMs and grounding it in verifiable facts and international best practices to effectively "separate the wheat from the chaff." We address fundamental questions: What are the pros and cons of EVMs? Should we deploy EVMs in Pakistan? What are the key challenges

we can expect? How do we address these challenges? In this paper, we argue that these negatives of EVMs can be effectively mitigated using a two-pronged approach:

- By adopting state-of-the-art technologies, such as End-to-End Verifiable (E2E-V) voting and Risk Limiting Audits (RLAs), which are specifically designed to audit EVMs and ensure the integrity of their results. There is, unfortunately, yet very little awareness of these technologies and their revolutionary potential in our electoral reforms discourse in Pakistan.

- By exercising due diligence, applying international best practices, strengthening the overall elections ecosystem, developing procedural mechanisms, and applying appropriate checks and balances at every stage. Unfortunately, there is no global standard or formula for deploying EVMs, and each country must carefully adapt these machines according to their unique ground realities and build a supporting ecosystem.

Our second contribution, therefore, is to provide election stakeholders with essential insight into new election technologies and to demystify their workings. We provide a detailed layman-oriented description in this report. Third, we provide a framework within which to develop, try, and deploy EVMs in Pakistan. We explicitly spell out the technological, human, and sociopolitical challenges we expect and present concrete recommendations to address them. This section of the report is supplemented by a roadmap document which details key steps we need to undertake to successfully introduce EVMs in Pakistan.

Similar feasibility reports and studies have been commissioned numerous times in other countries (e.g., Estonia (The General Framework of Electronic Voting and Implementation Thereof at National Elections in Estonia, 2019); Finland (Vaalit, n.d.), NAS (Committee on Science, Technology, and Law et al., 2018) Norway (Ministry of Local Government and Regional Development, 2006), but to the best of our knowledge, we are the first to conduct a technology-focused study, specifically for a developing country. Developing countries present unique challenges in election technology adoption, which are rarely recognised and remain to be comprehensively addressed in election policy or research. We believe this document will also be useful and informative to other developing countries considering electronic voting machines.

We are optimistic that this study will clarify the debate around EVMs, provide stakeholders with actionable information to start this national project, and contribute to public confidence in election technology in Pakistan.

2. BACKGROUND

The Road to Electronic Voting Machines

In its earliest consideration of the subject, in 2009, the Election Commission of Pakistan (ECP) commissioned a study to assess the feasibility of electronic voting machines (EVMs). The subsequent report recommended that the "use of electronic voting and counting technologies be pursued further, although a final decision on the national adoption of these technologies will remain pending" (the Election Commission of Pakistan, 2010). In 2011, the ECP evinced interest in Indian EVMs and even requested a demonstration (India Times, 2011), but later relinquished the idea as any such association may prove controversial. The ECP also asked interested vendors to manufacture the EVMs according to certain approved specifications. Other interested parties such as academic institutions (COMSATS) and vendors (TIP, KRL, NIE, Smartmatic, and Indra) were also invited to demonstrate their models of EVMs. In 2012, the EVM presented by COMSATS was given a field test in a few polling stations in by-elections in Multan (Jafri, 2012).

In 2014, the ECP announced its intention of shifting to EVMs in a couple of years. It also presented demonstrations of EVM prototypes to political parties and representatives of the media at an event organised for this purpose. A demonstration was staged for the Parliamentary Committee on Electoral Reforms (PCER), which remained ambivalent on the use of the EVMs and asked the ECP to come up with concrete and secure proposals for the same (Correspondent, 2014).

In 2015, the ECP held a field test of the biometric voting machines (BVMs) EVMs during by-elections in NA-19, Haripur. The machines verified only 46% of the 15,723 votes cast through BVMs. The reported reasons for failed verifications were the unavailability of fingerprints in the NADRA database, invalid or blocked CNICs, and fingerprint detrition (Sadaqat, 2015).

After the promulgation of the Election Act 2017, an EVM pilot was conducted in NA-4 by-elections. The ECP officials said more than 100 electronic machines would be used in more than 100 polling booths of 35 polling stations (Imran & Bari, 2017). However, the details of the pilot are not available publicly. Furthermore, ECP made efforts to acquire EVMs from Smartmatic that ran up to a few thousand dollars per unit (Correspondent, 2017).

The PTI also had another longstanding demand to enfranchise the diaspora, for which it had submitted multiple petitions. (Bhatti et al., 2018). Consequently, an internet voting (IV) system was developed by NADRA (on the orders of the Supreme Court in early 2018), for overseas Pakistanis, in 10 weeks, for Rs. 150 million (Bhatti, 2018). This system was not deployed in the 2018 General Elections due to security concerns highlighted by the IVTF (Internet Voting Taskforce, 2018) constituted by the Supreme Court to undertake an audit of the iVote system. The system was later piloted in the October 2018 by-elections in 35 constituencies. Another pilot was conducted in December 2018 by-elections in 1 constituency. The overseas votes of both pilots were incorporated in the final tally. The elections had a very low overseas voter turnout of around 1% with only 7,538 votes cast in both the by-elections. This deployment cost approximately Rs. 95 million (Election Commission of Pakistan, 2018). EVMs pilot project report was presented in the National Assembly (NA) and Senate in January 2019. Their discussion in parliament, however, remained pending for 2 years. In 2021, directed by the PM, the Ministry of IT (MoIT) hired Minsait as a consultant to audit the internet voting system. The Spanish firm reiterated the IVTF's concerns and said the internet voting system did not meet international standards and the recommendations of the IVTF had not been incorporated in any manner (Minsait, 2021).

The issue of electoral reform resurfaced in late 2020 when the PTI government expressed their intention to introduce electronic voting "to ensure free and fair elections." The coming months saw hostility between the government and the ECP, specifically in the aftermath of the senate elections in 2021. President Arif Alvi promulgated an ordinance to amend Section 94 and Section 103 of the Elections Act 2017 without extensive consultation with the opposition and the ECP. This amendment directs the ECP to enfranchise the overseas Pakistanis as well as begin the procurement to conduct general elections using the EVMs (Naqvi & Lodhi, 2021). The opposition disagreed with this decision, citing that technology would only be used to manipulate and rig the elections, with the premise that the staged failure of the Results Transmission System (RTS) in 2018 was also done to manipulate election results (Chaudhry, 2021).

Among the technology-related concerns of the ECP is the premature internet voting provision for overseas Pakistanis and binding ECP to procure EVMs without determining if these would prove useful in combating rigging. The ECP also fears the proposed amendments such as the proposed role of NADRA in preparing electoral rolls will dilute its constitutional powers and shift them to NADRA which is part of the federal government and not an independent body like the ECP (Correspondent, 2021). The ECP has since formed a technical committee to evaluate the proposal of EVMs on technical, legal, and financial aspects (Khan et al., 2021).

Literature Review

There is a considerable body of research on the application and challenges of electronic voting technology in the developing world, which is relevant to our purposes. This includes feasibility studies (Maphunye & Kealeboga J, 2019), holistic frameworks (Osho et al., 2016), cost-benefit analyses (Okoro & Ephraim, 2016), and adoption studies (Alomari & Mohammad Kamel, 2016; Agbesi & Samuel, 2018). Some studies focus on specific topics such as the economic determinants of voter behaviour (Oganesyan & Rafael, 2014) or technical concerns (Jillbert et al., 2003; Akinyokun & Olukayode Nicholas, 2020). There are case studies on e-voting in individual countries (Aranha et al., 2018; Herstatt et al., 2014; Inuwa et al., 2015) and efforts to adapt insightful metrics, such as the E-Voting Readiness Index, to the developing world (Aljarrah et al., 2016) (Maleti et al., 2019).

Other work produced by indigenous researchers (Arooj et al., 2016; Solehria et al. 2011; Khan et al. 2011;

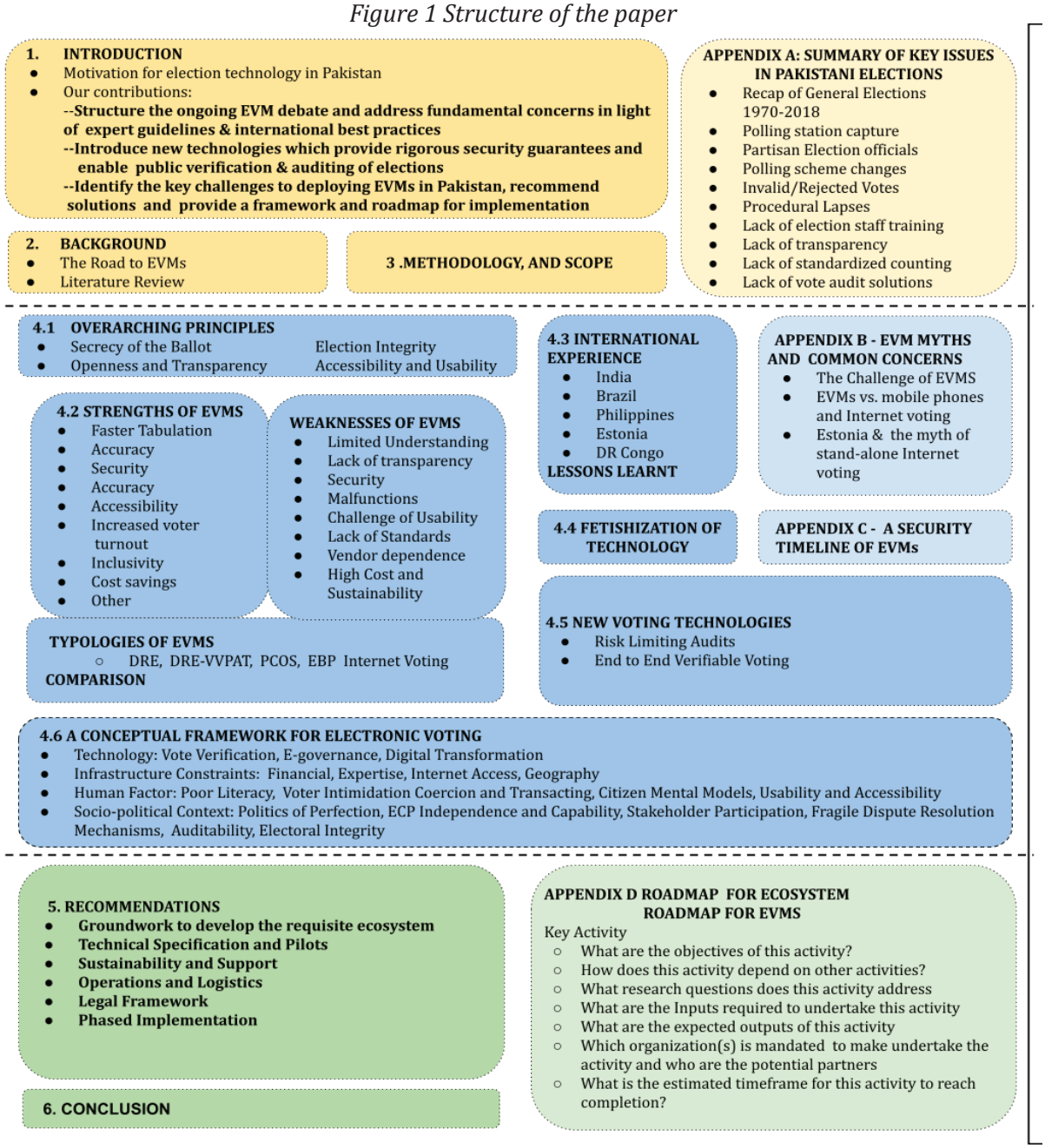
Khawaja et al. 2016; Ghaffar et al. 2017) attempts to approach the subject, but there is a lack of an in-depth study.

There is also a wealth of supplementary material for practitioners (Reynolds et al., 2008; Goldsmith et al., 2013). Internationally, there are numerous studies, recommendations, and handbooks providing general guidelines, introducing best practices, and standards in the context of e-voting. These include reports by the National Academy of Sciences (National Academies of Sciences & Engineering, and Medicine and others, 2018), Council of Europe (Council of Europe, 2016), International Idea (Introducing Electronic Voting: Essential Considerations, 2011), Carter Center (Center & Carter, 2012), Ace Project (ACE, 2020), etc. However, there is a lack of work that focuses on the unique social, economic, and political predicament of Pakistan. We explore these themes in more detail in the following sections.

3. METHODOLOGY AND SCOPE

This paper follows the structure depicted in Figure 1. The findings are divided into six main sections, each supplemented with appendices of relevant material.

Figure 1 Structure of the paper



First, we define the overarching principles that should govern the initiative to shift to EVMs.

In the second part, we note documented strengths and negatives of the EVMs and present a comparative summary of common EVM models deployed in developing countries.

Third, we present case studies of countries such as India, Brazil, and the Philippines, followed by the lessons to be learnt from these deployments.

Fourth, we highlight common pitfalls, explaining the phenomenon of the "fetishisation of technology" and how it distracts stakeholders from rigorous assessments and stringent checks and balances in the overall ecosystem, rendering election processes even more vulnerable than they were without technology.

Fifth, we describe the novel concept of public verifiability and how risk-limiting audits and verifiable voting can mitigate outstanding security concerns regarding the EVMs and ensure trust in poll results.

Sixth, we present a holistic framework to identify the challenges to address as we move toward the EVMs. Our national discourse to date has focused primarily on EVM units, and there is, unfortunately, very little recognition of the enormous task of building a supportive ecosystem for EVMs. This ecosystem is critical to the success of the overall project and the effort and costs involved in setting it up can easily dwarf that of procuring the EVMs themselves.

We also present recommendations to address these challenges at every stage. The accompanying roadmap spells out these recommendations in the form of concrete steps that stakeholders need to take. The roadmap lists key activities, including research assessments, pilot studies, hackathons, and demos, and suggests timelines, references, and resources at every step and highlights dependencies and concerns. We also identify critical research gaps to be addressed.

There is very little existing research in this domain and this section highlights our novel research contribution. To compile data for this section, we studied election technology deployments in India, Brazil, the Philippines, and various African countries. We initiated conversations with key stakeholders in Pakistan, including the ECP, the Ministry of Science and Technology, NADRA, the Ministry of IT & Telecommunications, and the National Institute of Electronics. We interacted with international EVM vendors including Smartmatic, Dominion, Indra, and Miru and participated in demos of their machines. We consulted international election technology experts and academics working in this domain. We also participated in seminar programs organised by civil society, election activists, and field workers in India.

We also specify the limitations of our study. Our paper is essentially a position paper, which advocates the use of cutting-edge election technologies in Pakistan. It also demonstrates their security properties and describes the way forward. We do not claim to answer all the questions regarding EVMs. Instead, we envision our contribution as the first and foundational step toward a culture of research to support election technology in Pakistan.

There are considerable research concerns that still need to be addressed, which we describe in the following sections and the roadmap. There are also questions about the EVM design, feature specifications, user interface, usability studies, procedures and protocols, legal issues, costing analysis, and concerns related to the ecosystem and infrastructure. Most of this work is unique to Pakistan and it has never been done before.

4. FINDINGS AND DISCUSSION

This paper follows the structure depicted in Figure 1. The findings are divided into six main sections, each supplemented with appendices of relevant material.

Overarching Principles

Here we define the overarching principles that should guide the deployment of electronic voting machines in

Pakistan. For successful deployment, it ne eds to be ensured that the following principles are not forgone:

Secrecy of the Ballot: A transition to an electronic voting system should not compromise ballot secrecy. The right to a secret ballot is etched in the Universal Declaration of Human Rights (Article 226), and the Elections Act, 2017 (Section 94, Elections Act, 2017).

Election integrity: The new system should have stringent checks and balances that ensure that election integrity is not compromised. Auditability measures need to be integrated into the election procedures, such as public ceremonies, EVM inventory, functioning and log audits, cryptographic checks for verifiability, and paper trails, to name a few.

Openness and Transparency Engaging stakeholders at every step of the decision-making process is necessary. The ECP needs to maintain transparency in all their undertakings. A key feature is to democratise the debate around EVMs, as the US civil rights icon, Bayard Rustin stated, "If we desire a society that is democratic, then democracy must become a means as well as an end." (Making Real the Promises of Democracy, 2020)

Accessibility and Usability: The upgraded election process should be a service to citizens. It should increase transparency as well as accessibility and usability for voters. Thus far, there has been no study that indicates how the voter experience in Pakistan could be altered with the introduction of electronic voting machines. Pilots offer a good opportunity to collect data for such studies. Given the lingual diversity within Pakistan and the low literacy rate, it is important to develop a system that does not discourage or hinder voters from voting due to their linguistic background or low literacy. Accessibility extends the concept of usability to differently-abled citizens. Special provisions need to be made for such voters, which ensures ballot secrecy and election integrity.

Sustainability refers to the practical concerns and costs of deploying EVMs. Pakistan is a developing country and efforts should be made to emulate the model of India and Bangladesh, which chose to invest in indigenous expertise and developed low-cost machines suited to their environments. Moreover, EVMs should be usable for at least three to four election cycles, which necessitates that the technology is broadly aligned with future trends and innovations.

It is important to develop an appreciation of these properties among the stakeholders and the different requirements they entail in an electronic voting system. Researchers have identified that some of these properties have an inherent conflict with other properties. For the avid reader, we discuss this in detail in *Appendix B*.

Conventional Electronic Voting Machines

Strengths and Weaknesses

Electronic voting encompasses any system in which the casting of a vote, the recording of a vote, or the tallying of the votes is done through electronic means. These processes may further be aided by information and communication infrastructure for the transmission and dissemination of results.

EVMs are gaining popularity in developing nations. While India, Brazil and the Philippines boast a country-wide deployment that is now at least a decade old in each of these countries, Namibia has recently become the first African nation to transition to EVMs. Paraguay, Panama, Bangladesh, and Mexico have all begun to experiment with electronic voting machines.

This section discusses documented pros and cons of EVMs. The strengths of electronic voting mainly deal with electoral efficiency and improved security due to reduced human intervention:

- *Faster Tabulation and Reporting of Results:* EVMs provide a dramatic reduction in the time required for vote counting and result tabulation. In the Philippines, in recent elections, two-thirds of the election results were counted and transmitted within 2 hours after polls closed (Manila & The Philippines, 2016). Automation also eliminates much of the manual effort required to count votes. In Indonesia, in the 2019

polls, in the laborious vote counting process over five hundred and fifty poll workers passed away due to exhaustion and thousands more were hospitalised (Endy Bayuni, 2019). This has propelled Indonesia to consider electronic voting machines for future elections. EVMs can play a significant role in such an environment to reduce human effort.

- *Accuracy* EVMs provide a more reliable and accurate tabulation of results by eliminating human error in recording and counting votes. Spoilt ballot papers can considerably skew the outcome of an election. In General Elections 2018, the number of spoiled votes exceeded the margin of victory in over 30 constituencies (FAFEN General Election Observation 2018 Result Assessment and Analysis, 2018). Researchers document that human error in hand counts can be up to 2 per cent (Ruth & Hodges, 2012). Such procedural and counting errors in the 2018 general elections led the ECP to order a recount in 70 constituencies (FAFEN General Election Observation 2018 Result Assessment and Analysis, 2018).

- *Security:* Conducting the typical paper-based election exercise involves a lot of human resources in the order of hundreds of thousands of workers. These workers have to be trusted to not manipulate the results. EVMs take away the power from polling station officials by automating the process of recording the votes and counting the votes, reducing polling station fraud significantly. In India, electronic voting has set about a marked reduction in election-related corruption and fraud, especially in areas with high political volatility, where repolling and recounts were routine due to allegations of rigging (Debnath et al., 2017). The faster tabulation process also significantly reduces the time window within which rigging can be undertaken.

- *Accessibility:* Electronic voting machines offer new opportunities to provide voters with multilingual support with the press of a button. EVMs can also be designed with increased accessibility options, including audio aids, Braille support, and other technologies for people with disabilities.

- *Increased Voter Turnout:* In certain cases, the introduction of EVMs has been reported to increase voter interest and participation. For instance, the Philippines witnessed a historic voter turnout as 81% of the registered voters cast their votes in 2016 when electronic voting was adopted (Kagawaran, 2022). This has been linked to increased user satisfaction and better overall user experience, which leads to increased voter trust and confidence.

- *Inclusivity* Studies on elections in India report that EVMs empower women, scheduled castes, and other marginalised communities to cast their votes and participate in the political process (Somanathan & Madhavan, 2019; Debnath et al., 2017).

- *Cost Savings:* Although the initial transition to EVMs requires huge capital investment, studies from Estonia and Brazil indicate that operational costs of elections decline considerably in the long run due to decreased human resource requirements and not requiring to print ballot papers, to name a few. Moreover, countries such as India have devised effective strategies that include developing very low-cost hardware-based machines and staggering national elections over a longer time to reduce operational costs.

- *Other Positive Indicators:* The introduction of EVMs has also evidenced certain positive social indicators. The introduction of EVMs in some regions correlates with improved governance and increased electoral competitiveness. This pattern is highlighted in research which indicates competitive electoral races In Brazil infant healthcare outcomes noticeably improved because of the cost savings due to EVMs (Fujiwara & Thomas, 2015). In India, electronic voting correlated with an improved overall supply of electricity and a decline in crime in some regions (Debnath et al., 2017).

Despite demonstrated benefits, EVMs have several disadvantages, which have resulted in several technologically advanced countries, including Germany, Ireland, and the Netherlands discontinuing EVMs.

- *Limited Understanding for the Public:* The ability to understand the inner working of EVMs requires technical knowledge, which is o nly possessed by a small fraction of the electorate. It was due to this

reason that the German Supreme Court ruled the use of EVMs as unconstitutional, requiring that "essential steps of the voting and of the ascertainment of the result can be examined reliably and without any specialist knowledge of the subject" (The Wire, 2021).

- *Lack of Transparency:* Arguably the most problematic aspect of popular EVM types is that they are technically black boxes that do not give stakeholders transparency into their inner workings. Other problematic aspects are limited audit and forensic capabilities. This is, unfortunately, due to the inherent tension that exists between voter privacy and election integrity (Orcutt, 2016). Individual ballots must be anonymised to safeguard voter privacy, and this leaves them vulnerable to rigging and manipulation. A recent report by the Citizens' Commission on Elections, an Indian civil society organisation, comprising contributions by international authorities in elections security, concluded that the Indian EVMs, due to a lack of transparency in their present form, are "near-fatal for electoral democracy" (CCE, 2021).

- *Security:* While EVMs are known to reduce polling station frauds, they also create new vectors for rigging elections. EVMs are, unfortunately, very easy to hack and present an opportunity for large-scale manipulation of election results without leaving any physical trace. Almost every EVM that has been analysed has been successfully compromised by researchers to leak sensitive vote information and alter vote counts, including various machines certified and used in the US, Brazil, the Netherlands, and India. The premier hacking symposium DEFCON runs an annual election technology hackathon called the Voting Village. In the 2020 Voting Village event, over a hundred certified electronic voting machines were hacked. The organisers of the event noted in their report "As disturbing as this outcome is, we note that it is at this point an unsurprising result" (Newman, 2019).

- *Prone to Malfunction:* EVMs occasionally suffer serious technical difficulties due to extreme weather conditions and unexplained circumstances, which can frustrate voters and delay results. In the 2018 midterm elections in the US, ballot tabulators could not read ballots due to humidity in North Carolina and Alabama (NBC News, 2018). In New York City, election officials stated that rain had wet the ballots and caused scanning machines to jam. In India, 3-10% of voting machines are known to fail mock polls held before field deployment (POONAM AGARWAL, 2019). In polls in 2018, the Election Commission of India had to provision 15 per cent of extra EVMs during polls to compensate for faults because of extreme heat, light, and dust. (CCE, 2021)

- *Challenge of Usability:* EVMs may be challenging to use in developing countries like Pakistan. Usability is also a complex topic and there are several facets to consider. For instance, usability generally correlates with computer literacy and technical skills within the citizenry, the scope and effectiveness of voter education and outreach efforts and is typically assisted by piecemeal and gradual deployment strategies (ODIHR, 2013). The physical design and the voting protocol of EVMs must be adapted to cater to voters. A wide range of factors must be carefully considered, including the legibility of text on the machines, the time it takes to cast a vote, how the machine deals with unintentional undervotes, etc. Adapting EVMs to the unique ground realities of a developing country like ours will likely require considerable research and pilot testing.

- *Lack of Standards and Certifications:* There are no clear and authoritative standards or certifications for EVMs as there are for various other technologies. The reason is that EVMs are a complex phenomenon that must be adapted to the unique ground realities of every society. A whole host of socio-political, cultural, logistical, and financial considerations come into play. Attempts to transplant election technology on a large scale without rigorous homework are quite likely to fail and incur heavy political and financial costs, as observed in Ireland (Wrong, 2013) and Kenya (Melia & Byrne, 2012).

- *Vendor Dependency and lock-in:* A lack of self-sufficiency in election technology has been known to create situations where national election management bodies became dependent on vendors or technologies, with a possible risk of compromising electoral processes. Moreover, EVMs typically contain electronic, or software components sourced from different countries, and this dependency can pose potential security risks to elections.

- *High Costs and Sustainability Concerns:* Many developing countries lack the resources for expensive EMV deployment and often depend on international donors for financial assistance and engage international consultants to provide technical expertise. This situation can be costly and its sustainability is questionable in the long run, thereby preventing countries from developing indigenous capacity. Moreover, EVMs manufactured in foreign countries or containing vital parts sourced from such countries raise important issues about the security and trustworthiness of these machines and concerns about foreign interference. Such concerns have recently been raised in the US by the three largest EVM vendors, Dominion Voting Systems, Hart InterCivic, and Election Systems & Software, who have sought explicit guidance from the Department of Homeland Security and supporting legislation, regarding their dependency on components manufactured by companies based in or having links with China and Russia (Ross, 2020; Alexa Corse, 2019).

- *Wholesale Rigging:* Indeed, manipulating on a large scale is extremely difficult with paper ballots, as each attack is geographically limited. Influencing, modifying, or destroying a considerable number of votes requires significant resources, time, and money, and is likely to generate witnesses and tangible proof. In comparison, the electronic voting process is completely opaque to the typical voter, more error-prone than many believe, and much, far more vulnerable to undetectable large-scale attacks.

Typologies of Electronic Voting Machines

In this section, we describe the electronic voting options available. We briefly describe each system and share the experiences of developing countries with the system, including the country's process of implementation, successes with the system, and main challenges that arose.

As paper ballots were blamed for persistent fraud, the turn of the century saw the adoption of voting machines. The US was the first to use mechanical lever voting machines back in 1890. By the 1960s they were used by more than half of the US voting population. The 60s saw the first use of the machine-readable optical scan or mark-sense voting systems in which votes are recorded through marks made on the ballot card. The system uses a light beam to scan the marked paper ballots and tally the results. Another popular technology in the 60s was punch card systems, in which voters marked their vote by using a punch device to punch a hole in the ballot card. Tabulation was later done by a computerised counting machine. The increasing sophistication of computer technology saw the first electronic voting system delivered to the Utah State Legislature in 1970. (Electronic Voting | US House of Representatives: History, Art & Archives, 2022)

Since then, technology has advanced, and various types of electronic voting machines have been developed. In this section, we give an overview of the different types of voting machines being used around the world, along with details about where they are deployed and estimated costs. We follow it with brief case studies.

Precinct Count Optical Scanning (PCOS) Machines: In Precinct Count Optical Scanning (PCOS) machines, voters cast their votes on ballot papers that are specifically designed to be input into the PCOS machine. These ballot papers can be marked using pens or electronic markers. The marked papers are fed to the Optical Mark Recognition (OMR) based device, which scans each ballot and counts the votes for each candidate. This technology is similar to that used to mark standardised tests. The marked ballots are generally counted at the precinct where they were cast, however, they can be gathered at a centralised counting location. The Philippines has a country-wide deployment of PCOS systems, where each PCOS Machine it procures from Smartmatic, has an estimated price of around 1,600 USD (Gotinga, 2015).

Direct Recording Electronic (DRE) Voting Machines: DRE machines use a screen as an output device that shows the candidates. This screen display is accompanied by buttons and/or a touch panel, which are used as an input device as well, used to cast votes. The machine directly records these cast votes in its memory. DRE voting machines do not produce a physical printout of the vote. Therefore, the voter has no guarantee that their vote was recorded as cast. The machine may transmit individual votes or vote totals. The saved voting data can be transmitted via the internet, the detachable memory components or through printed ballot paper. These are the primary machines used in Brazil. The cost of each machine is estimated to be approximately USD 700 (Jokura, 2021).

Direct Recording Electronic with Voter Verified Paper Audit Trail (DRE-VVPAT) Voting Machines: These machines have a screen or a display that shows the potential candidates to the voters. This display is accompanied by buttons and/or a touch panel, which are used as input devices used to cast votes. The machine directly records these cast votes in its memory. DRE-VVPAT voting machines also produce a physical printout of the vote. This paper trail, formally called VVPAT, is meant to serve as physical proof of the votes that have been cast. The voter can view the Voter Verified Paper Audit Trail (VVPAT) to make sure the vote was cast as intended and put it in a sealed ballot box. DRE-VVPATs are used extensively in the USA and nationwide in India for national-level elections. DRE-VVPATs used in India cost USD 660 approximately (Press Trust of India, 2014).

Table 1 Comparison of EVM Typologies

Comparison Metrics, with paper-based voting as the baseline	PCOS	DRE	DRE VVPAT	Electronic Ballot Printers	Remote Internet Voting	E2E-V Voting
Counting and Tabulation Speed Increased	Yes	Yes	Yes	Yes	Yes	Yes
Improved Accuracy of Results	Yes	Yes	Yes	Yes	Yes	Yes
Flexibility to adapt to various electoral systems	Yes	Yes	Yes	Yes	Yes	Yes
Simplification of Ballot Paper Design	No	Maybe	Maybe	Maybe	Maybe	Maybe
Increased Ease of Access to System	No	Maybe	Maybe	Maybe	Yes	Maybe
Increased Voter Turnout	Not affected	Not affected	Not affected	Not affected	Yes	Not affected
Accessible to Mobile Voters	No	No	No	No	Yes	No
Usability	No	No	No	No	Maybe	No
Reduction in Polling Station Fraud	Yes	Yes	Yes	Yes	Not affected	Yes
Greater accessibility	No	Maybe	Maybe	Maybe	Yes	Maybe
Multi-language support	No	Yes	Yes	Yes	Yes	Yes
Elimination of Rejected/ Spoilt Ballots	Yes	Yes	Yes	Yes	Yes	Yes
Reduced Voter Coercion/ Buying	Not affected	Not affected	Not affected	Not affected	No	Not affected
Increases Openness and Transparency	Maybe	No	Maybe	Maybe	No	Yes
Easily understood by non-technical people	Maybe	No	Maybe	Maybe	No	No
Maintains Secrecy of the vote	Maybe	Maybe	Maybe	Maybe	No	Yes
Secure against outsider attacks	Maybe	Maybe	Maybe	Maybe	No	Yes
Secure against insider attacks	No	No	No	No	No	Yes
Low-cost introduction and maintenance	No	No	No	No	Yes	No
Infrastructure/environmental requirements	No	No	No	No	Maybe	No
Do e-voting standards exist	No	No	No	No	No	No
Possibility of meaningful recount and audit	Yes	No	Yes	Yes	No	Yes
Independence from Vendor	No	No	No	No	No	No
IT security requirements easy to achieve	No	No	No	No	No	No
Software Independence	No	No	No	No	No	Yes
Machine Malfunctions	Frequent	Frequent	Frequent	Frequent	No	Frequent
Cryptographic Verifiability	No	No	No	No	No	Yes

Electronic Ballot Printers: The voter marks his choice using a button on the machine itself, which produces a token, or a paper printout of the vote. This printed ballot is then placed in a ballot box either automatically by the voting machine or manually by the voter. At the end of polling, all the tokens/ballots are manually counted. This option is being explored by Bangladesh, where it is expected to cost USD 2,400 per machine (Irani, 2018).

Remote Internet Voting: This system uses the internet to relay the vote to a centralised tallying server. The voters vote in an unsupervised environment such as home or public computers and devices, and voting kiosks set up for this purpose. Due to infrastructural, financial, literacy, and societal challenges, no developing country has implemented internet voting. Currently, Estonia is the only country in the world that uses internet voting for politically binding national-level elections (e-Estonia, 2017).

Comparison

In this section, we compare the strengths and weaknesses of various electronic voting machines. There is no such thing as a perfect electronic voting system. The following table summarises the common strengths and weaknesses of several electronic voting methods in comparison to paper-based alternatives. An improvement over the paper-based system is indicated by a 'Yes' while the impairment of a function is indicated by a 'No.' If the function or property remains unaffected it is indicated by 'Not affected,' while if the outcome is dependent on the specifications of the model of EVM, it is represented by a 'Maybe'.

International Experience with Voting Technology

India: DRE with VVPAT

India first introduced EVMS in 1982 in 50 polling stations – suspending its use two years later when the Supreme Court specified the need to amend the Representation of People Act. From 1988 to 1992, the foundational institutional structures and legislations were established to make the use of EVMs in elections a reality. In the subsequent years, the technology was tested with the first pilot implemented in the state assembly elections in 1998 in a few constituencies. Thereafter, the ECI conducted a phased implementation of the EVMs in subsequent assembly elections. By 2003, all by-elections and state elections were held using EVMs, and a nationwide roll-out followed in the 2004 General Elections (History of EVM, 2022).

In 2011, the prototype of the EVM and VVPAT system was demonstrated and the first field trial was conducted. Based on the trial, the system was reviewed and revised in 2012 and a second field trial was conducted. Finally, in 2013, the design was approved and legal amendments were passed to enable the use of VVPAT with EVMS. The deployment of the VVPAT was conducted in phases as well, with the nationwide roll-out in the parliamentary general elections of 2019.

Due to the phased introduction of EVMs, researchers were able to establish clear linkages between the introduction of EVMs and the decline in election-related corruption and fraud, enfranchising of the marginalised segments of the society, and a more competitive electoral process (Debnath et. al, 2017).

Importance of local context

Ballot stuffing, among other election frauds, was endemic in Indian elections. The Indian EVMs were designed to add a barrier to "stuffing" the EVM, by allowing only 5 votes to be processed per minute.

What makes it a success?

- Government support for election technology and public confidence in ECI as an independent body has been foundational in the journey to make election technology a success in India.

- Despite criticism and lawsuits challenging e-voting in India, there has not been any substantial proof of the failure of EVMs to provide free and fair elections, and the problems are often overshadowed by the prevailing perception that benefits are far greater. The VVPAT technology has alleviated concerns surrounding the potential for fraud and manipulation.

- ECI is intentional in its communication with voters and voter education mechanisms, which has also been crucial in improving voter acceptance of the new technology.

- To address infrastructural challenges, election management challenges, and cost limitations, and to ensure efficient use of EVMs, ECI conducts elections in multiple phases across the constituencies.

Challenges

So far, cybersecurity has not been given primary importance by the ECI and Indian voters alike. The premise is that the EVMs are stand-alone machines without any network connectivity, such as the internet. Likewise, in recent years, citizen bodies and the electorate have stressed that the voter registration system needs to be updated to make it more transparent. Recently, civil society has also urged the uptake of state-of-the-art technologies, such as E2E-V voting and RLA (CCE, 2021) to increase transparency.

Brazil: DRE

Timeline

The TSE (Tribunal Superior Electoral) began the computerisation of Electoral Justice in 1986, starting with the electronic registration of voters. Like the case of India, Brazil's strategy for the implementation of electronic voting spanned over multiple years, starting with civic information as well as usability and feasibility studies in 1986. This was followed by a decade of efforts involving capacity building within the TSE. Trials of electronic voting machines in the Brazilian environment began in 1996, which involved various quality control exercises and multiple revisions to the system, followed by the nationwide roll-out in 2002 (The History of Electronic Voting — Superior Electoral Court, 2022).

Public Security Tests and Pre-election Audits

The Brazilian Superior Electoral Court (TSE), the EMB of Brazil, has complete ownership of the source code used in the EVMs. Legally, the TSE is required to make the final source code available to the political parties and the Brazilian Bar Association (OAB) at least 120 days before an election for inspection and audit. There have been some indigenous researchers that have attempted to conduct somewhat of an independent audit since 2001. Furthermore, the OAB also outsourced the audit of the source codes in 2004. However, due to the limited capacity of the OAB and political parties, the stakeholders were unable to effectively examine the technology in subsequent years.

Following a petition in the Brazilian Supreme Court, which raised the concern about the public not vetting the EVMs and their source code, the TSE has organised hackathons, commonly known as "The Public Security Tests (TPS)." These events are restricted and only the researchers that are approved by the TSE can assess the system, find, and report vulnerabilities and recommend improvements. The need for these events arose after two political parties filed an appeal before the Court of Justice regarding the impossibility of verification of the security system of e-voting. The TPS is conducted in phases, starting a year before the elections. In the first round, researchers and experts find and report issues in the source code. Thereafter, the TSE has six months to resolve the issues identified by the experts in the EVM. Regarding the recommendations from the inspection phase, it is at the discretion of the TSE whether it is willing to incorporate them in the current election cycle. After revisions to the system, if any, the researchers are invited to re-test the system. (Silva, 2020)

The TSE also authorizes another audit procedure by the name of "parallel vote." Two EVMs are randomly selected in each state a day before the election and checked to see if they produce the same results. However, some experts have criticised the parallel vote as they claim it is possible to manipulate the system between the parallel vote and election day (Introducing Electronic Voting: Essential Considerations, 2011).

What makes it a success?

- The voting system has consistently improved over Brazil's election cycles through Public Security Tests (TPS) – most notably in terms of the source code running on the machines. The TSE has been intentional in its effort to constantly improve the voting system, which may be the reason for the success of the Brazilian e-voting experience.

- The procurement process legally followed by the TSE centralised the development of electoral hardware and software. The software is designed and developed internally by the TSE, while it sends its team to the hardware production facility to oversee manufacturing. In addition to the EVM itself, for which the TSE solicits bids as per its specification of the security architecture, election-related apps are also developed by their in-house teams.

Challenges

The biggest issue with the Brazilian mode of EVM is the lack of a paper trail or VVPAT. This restricts any kind of auditing and recounting activity. Consequently, candidates are unable to successfully challenge any election results. In the cases where the election results have been challenged and called to a comprehensive audit, the TSE demands over USD 1 million to fund the recount.

Further, the TSE has, in some election cycles, not made the final version of the EVMs available for audit by OAB, political parties, and experts. Due to the continued lack of a) TSE's transparency, and b) a stakeholder consensus on auditing mechanisms, future election results will be subject to further contention.

The Philippines – PCOS

Timeline

The Commission on Elections (COMELEC) initiated discussions to automate the election process in the Philippines in 1992, and the first nationwide use of voting technology was in 2010. The lengthy transition from manual to automated elections entailed multiple revisions to the legislation through deliberations and a structured and inclusive process. Although some provisions had been questioned to be ambiguous, most stakeholders found there to be a solid legal foundation for conducting automated elections.

However, the COMELEC faced a multitude of implementation challenges in the decade before its first nationwide rollout. While COMELEC was authorised to implement the automated process in the 1998 elections, due to the lack of preparation, time, and funding, it was only used in 4 constituencies. Further, in 2001, the COMELEC's negligence in addressing civic education required for the new election process led to the unintended disenfranchisement of nearly 3 – 6 million voters (Filipinas Heritage Library, 2021).

First nationwide roll-out: The Aftermath – the need for capacity building

Although the technology was tested, shortly before election day in 2010, 75,000 PCOS machines were found to be incorrectly configured. COMELEC assigned resources on a large scale to address this problem, extending till the end of election day (International IDEA 2011: 22).

Election day itself posed challenges for the voters. To curb costs, COMELEC reduced the number of polling stations by 75%, resulting in overcrowding and long waiting times for the voters (Carter Center Limited Mission to the May 2010 Elections in the Philippines, 2010).

In its first nationwide use of voting technology in 2010, electoral protests and complaints increased unexpectedly. Compared to the previous years, the defeated candidates filed more cases to COMELEC. The complaints encompassed issues such as inaccuracy in vote counting, misreading of ballots by the optical-scan machines, errors in transmission and consolidation of results, faulty rejection of ballots, non-implementation of security measures, and manipulation of optical-scan machines and/or compact flash cards. However, due to insufficient and inadequate evidence or procedural inconsistencies, many cases were dismissed. Party observers lacked the adequate technical skills for observing the technology and, hence, did not have the knowledge to identify the evidence needed to support their claims. These events also highlight the importance of courts having the technical capacity to effectively rule on technology-related cases (National Democratic Institute, 2022).

Additionally, the results of the random manual audit were also unavailable weeks after the election, creating further mistrust in COMELEC and the technology. Similar problems occurred in the 2013 elections, after which VVPAT technology was introduced. However, COMELEC purchased new PCOS machines for this purpose, since the previously acquired machines were incompatible with VVPAT (Introducing Electronic Voting: Essential Considerations, 2011).

Post-election Audit Process

The Poll Automation Law in the Philippines stipulates that "there shall be a random manual audit in one precinct per congressional district randomly chosen by the Commission on Elections (Comelec)." After the 2019 Philippines Elections, the Random Manual Audit (RMA) Committee reported a 99 per cent accuracy rate between the results of the manual audit and the Automated Elections System (AES). The manual audit was conducted in 711 out of 715 clustered precincts. While the COMELEC declared the election a success, the AES Watch (election watchdog organisation) declared it the "worst" as their experts suggested that the precinct sample size should be raised from 700 to 2,500 for real accuracy, which the RMA Committee failed to do (Patinio, 2019).

What makes it a success?

- Transparency as a key factor in the acceptance of results: In the 2016 elections, the source code was audited for over seven months by political parties, authorities, and election watchdogs. It was also certified by an independent US-based company. Field monitors (technical staff documenting election day system issues) were also recruited by COMELEC on election day and the media was granted full access to the documentation.

- Audit mechanisms: The 2016 elections generated one of the largest paper-audit trails, with nearly 43 million voter-marked ballots and their corresponding voter receipts. The Random Manual Audit confirmed the election results with 99.8 per cent accuracy.

Estonia – Internet Voting

Timeline

Discussions surrounding internet voting in Estonia began in 2001, followed by legislation enabling the effective use of the technology. In 2003, the National Electoral Committee (NEC) locally contracted a firm to develop their electronic voting system that used smart cards and electronic signatures. This was followed by trials of the system in a consultative referendum in the capital city of Tallinn in 2004.

The Estonian solution has been the most technologically advanced, and trusted internet voting solution, and has been used as one of the voting channels since 2005. While mail-in and on-site paper ballots are also available during elections, Estonia has observed an increase in the use of the internet voting system. In addition to ensuring a secure, secret, and transparent vote, the i-voting solution has also proven to be cost-efficient, inclusive, and convenient.

Since the introduction of i-voting in Estonia, voter participation has risen continuously. The 2019 Parliamentary

Elections saw online participation increase by 40% compared to the elections in 2015 (World's Most Hi-Tech Voting System Raises Cyber Defences, 2019).

What makes it a success?

Estonia's e-governance, infrastructure, and public trust: Estonia has been developing its digital infrastructure since the 1990s and has provided e-government services since 1999. The government also developed and issued electronic resident identification cards in 2001, and deployed internet voting in 2005. Given the NEC's technological capacity, expertise, transparency and compliance with election principles, public trust in the internet voting technology is naturally high.

Democratic Republic of Congo: Electronic Ballot Paper

Timeline

The Congolese Electoral Commission (CENI) adopted the Electronic Ballot Printer (EBP) technology in the 2018 national and concurrent elections, to reduce fraud and manipulation. CENI acquired three machines for public demonstration and information dissemination in 2017, and two of the three machines experienced issues post-demonstrations (Ross & Lewis, 2018).

The CENI faced immense opposition to the decision of adopting the EBP for the 2018 elections, on both the national and international fronts, for all the right reasons (Clooney & Prendergast, 2022). The EBP machines have been problematic since their demonstration. DRC also lack the required infrastructure since most remote areas have power supply issues. The literacy rate of the electorate is also low. The voters also discovered that CENI did not have the technical capacity to understand and inspect the software, source code, and database, which intensified opposition. This led to the arson of a storage facility of the EBP machines 10 days before the elections (Paravicini, 2018).

Reasons for failure

CENI pursued to implement this technology in a short time frame, with little consideration for the legal framework and public acceptance. The implementation was rushed, and public perception was mismanaged, which led to increased conflicts in the country.

Lessons Learnt

- Planning and implementation should not be rushed, and time should be built-in in the pre-election phase for systems review, revisions, and retesting. From its decision to deploy election technology to its first use in elections, DR Congo took only a year to acquire, test, and review the technology, and to build the ecosystem supporting it. It is evident that their EMB failed to do so effectively. The ECP should plan for a timed and phased implementation to realise the benefits and limitations of the system.

- Thorough legislation and regulation are required to enable the use of EVMs. In most countries, it has taken years of careful, thorough, and constant revision of legislation, following trials and retrials of technology, well in advance of a nationwide transition to electronic technologies.

- Invest in capacity-building efforts. The example of the electoral complaints filed by political parties in the 2010 Philippines elections is quite relevant to highlighting the capacity voids that can be created in the adoption of election technology. The required expertise and skills at every level and function of the ECP need to be identified and assessed, and a comprehensive recruitment and training plan needs to be developed.

- The TSE practices can also be reviewed to review options for capacity development. Aside from the localised training, the TSE regularly invests in its staff by providing international training and following

IFES training guidelines.

- Technological specifications for EVMs should account for the ability to accommodate anticipated future technologies. COMELEC purchased the PCOS machines in 2010 for EUR 120 million (International IDEA 2020: 46). However, the purchased machines were not compatible with the VVPAT technology that was required post-2016 elections, rendering them useless post-2016. An investment of such immense scale needs to be well-thought-out, and the timelessness of the technology needs to be addressed in the planning phase.

- Since the Estonian government had a highly developed digital infrastructure for its public services prior to the introduction of election technology, the electorate had built an inherent trust in the NEC's abilities to implement it. Learning from Estonia's experience, the ECP needs to digitise its internal processes, at the least, to show the electorate that it has the expertise to oversee the deployment of EVMs in future elections.

- Stakeholder acceptance is crucial for election results acceptance. The experiences in DR Congo and Kenya show that an understanding of the technology is essential for stakeholder acceptance of the technology, which is essential in establishing the legitimacy of the election processes.

- Transparency measures need to be established for building trust and understanding of the system.

- Information for the voters and voter education mechanisms are needed as per the local needs. A major factor in EVM acceptance in India is the exposure to the technology ECI has provided to the electorate. As part of its civic education efforts, the ECI also took prototypes of EVMs for a demonstration to the public, and dummy EVMs to be tested by the public.

- While costs are an important consideration, it is important not to compromise on the system quality and requirements to reduce the budget. In 2019, new regulations required COMELEC to procure the system and logistics at the lowest bid, which compromised the quality and compatibility of the acquired technology with the existing systems.

Fetishisation of Technology

Most election management organisations (EMBs) now utilise some form of technology to try to improve election operations. From basic office tools and websites to complex biometric voter registration databases, voting systems, electronic voting, and internet voting.

Technology has often been introduced as a panacea for this issue of trust. Several countries, including Brazil, India, Namibia, Nigeria, and Venezuela, have adopted electronic voting machines, and the Philippines and Mongolia have deployed automated counting systems. Other countries including Argentina, Kenya, Bangladesh, Indonesia, Pakistan, Panama, Ghana, Kyrgyzstan, and Kazakhstan have begun experimenting with the technology.

The results from the international experience are mixed. Reported improvements in India include a significant decline in electoral fraud in some regions, a more competitive electoral process, and increased participation of marginalised groups in society (Somanathan & Madhavan, 2019; Debnath et al., 2017). Automated counting in the Philippines corresponded with record turnouts of over 81% (Team & Web Development, 2021) and a dramatic reduction in the time taken to compile and finalise election results (Manila & The Philippines, 2016).

However, there are frequent irregularities that undermine trust in technology. In 2017, the Supreme Court of Kenya nullified election results citing irregularities in the result transmission system (Burke, 2017). Similar concerns were raised by opposition leaders in Pakistan in 2018 when the results transmission system broke down inexplicably on election night (Wasim & Saadat, 2018). In Azerbaijan, the introduction of a smartphone app in 2013 to report election results backfired when it released the election results the day before the actual election (Bigg, 2013).

There has also been a backlash against voting machines. In India, numerous incidents were reported in different polls where machines recorded votes in favour of the ruling party, no matter which choice the voter made (Sinha, 2019). In 2018, the introduction of untested voting machines in the Democratic Republic of Congo was strongly opposed by opposition parties, and thousands of machines were subsequently destroyed in an act of arson (Paravicini, 2018).

Researchers have sought to explain these "unintended consequences" of election technology in terms of a "fetishisation of technology" (Cheeseman et al., 2018), or a silver bullet (DR, 2011), which distracts stakeholders from rigorous assessments and stringent checks and balances in the overall ecosystem (Barkan & Joel D, 2013). Paradoxically, this lack of attention can render election processes even more vulnerable than before.

In this scenario, it is helpful to differentiate between electoral efficiency (speed, accuracy, and elimination of 'rejected votes') and electoral transparency as two desirable yet distinct outcomes of using election technology (Yard & Michael, 2010). Unfortunately, in most deployments of election technology, there is a marked tendency to prioritise efficiency over transparency and favour a "black box'" approach, which concentrates trust "away from the many" and into the "hands of the few." We anticipate that E2E-V voting systems - by incorporating security and integrity as core design features of the system - can potentially redress the balance between electoral transparency and efficiency.

New Election Technologies

End-to-end Verifiability

Conventional electronic voting machines are black boxes, and they lack the transparency that is the cornerstone of an effective voting solution. End to End Verifiable (E2E-V) voting systems are a promising new paradigm in the world of electronic voting that provide voters strong cryptographic guarantees that the vote was cast as intended, recorded as cast, and tallied as cast. Every individual can rigorously audit every essential step of the election process, with a smartphone and internet connection available to them. All of this can be achieved without compromising ballot secrecy. Moreover, no voter can demonstrate to a third party which candidate they chose to vote for. It makes the entire election life cycle auditable by third parties, the voters, and the election administration alike, and provides strong cryptographic security guarantees every step of the way. The voter does not have to blindly trust the voting system, polling officers, or election authorities regarding the integrity of the election. If there is any malfeasance or rigging, it will be exposed by the protocol itself.

This is a revolutionary remodelling of the conventional voting machines, the inner workings of which are largely opaque to voters and lack effective auditing mechanisms. The cryptographic algorithms are well known and publicly available, for any technically sound third party to independently check and verify. It has often been touted as the de facto holy grail of electronic voting (e-Estonia, 2017). Various pilots have also been conducted in the UK (Hao et al., 2020) and are now being deployed in binding political elections on a small scale (for instance, in intra-party elections in Israel, in mayoral elections in Maryland, the US (Zagorski et al., 2013), in state elections in Victoria, Australia (Burton et al., 2016), and at the county level in gubernatorial elections in Texas (Acemyan et al., 2014). Estonia also deploys an E2E-Voting system for its nationwide parliamentary elections, the first deployment being in 2019 (e-Estonia, 2019).

These systems have also gained trust and recognition from the National Academy of Sciences (The National Academy of Sciences, 2018), international researchers, experts, industry, and technologists (Inspector General, 2021). Recently, E2E-V voting has garnered immense interest from technology giants, and various large-scale commercialisation efforts are underway. Among these is Microsoft's partnership with Smartmatic, a leading vendor of election technology. Hart InterCivic, Dominion, and others are also set to trial E2E-V voting systems.

Similar sentiments have also recently been voiced in the developing world, namely Brazil (Aranha et al., 2018), Pakistan (IVTF Report, 2018), and India (CCE, 2021), where security professionals, researchers, and civil society organisations have urged election authorities to explore the adoption of E2E-V voting systems in elections to enable transparency and restore the credibility in electoral processes.

India's Election Commission, in partnership with IIT-Madras, has been conducting extensive research on E2E-V voting. Plans for pilots are underway and there is an increased awareness within the public about the benefits that E2E-V voting systems offer. A pilot was intended for last year's municipal elections in Hyderabad. Additionally, public awareness is high. As a report from the Citizen Commission of India explains, conventional electronic voting machines have "defects that appear to be near-fatal to electoral democracy." The report further notes in favour of E2E-V voting systems "Wouldn't it make sense if elections embodied democratic ideas as well? Why not create a system that allows individual citizens to independently verify and audit elections – to ensure that the votes they cast genuinely count?"

E2E-V Voting systems are orthogonal to the EVM typologies discussed above. Researchers have proposed systems that work in cohesion with PCOS machines (Scantegrity), and DRE VVPAT (StarVote), and add transparency, auditability, and verifiability to such machines. E2EV systems for paper-based voting have also been proposed. However, the usability issues make it nearly impractical for use in political elections.

Such systems would eliminate electoral fraud by enabling voters to verify not only that their vote is cast as intended, but also correctly recorded and counted, something that neither traditional paper ballots nor electronic systems are currently capable of delivering. In theory, the simplest way to achieve such a goal would be to publish voters' names and their choices, but this would contradict the principle of ballot secrecy. In Table 1 we directly compare EVM typologies with E2E-V Voting systems. It is evident that E2E-V Voting systems are superior in terms of increased openness and transparency, maintaining the secrecy of the ballot as well as providing security against insider and outsider attacks. They provide for a meaningful recount and audit assisted by the VVPAT as well as cryptographic auditability and verifiability. They are also software independent, i.e., an undetected change or error in its software cannot cause an undetectable change or error in an election outcome.

We provide a primer on E2E-V voting technology next.

Primer On End-To-End Verifiable Voting

This section presents a primer on E2E-V voting systems (Ali & Murray, 2016) intended for a non-technical audience. We motivate the case for their application in Pakistan. The explanation is intended to eschew the technical concepts and present them in a way that is understood by the non-technical audience. We purposely omit cryptography-heavy descriptions and processes and try to convey the intuition and rationale behind the design of End-to-End Verifiable (E2E-V) voting systems. E2E-V voting systems are a promising new paradigm in the world of voting systems that provide voters with strong cryptographic guarantees that their vote was cast as intended, recorded as cast, and tallied as cast (Ali & Murray, 2016). Three guarantees it provides are:

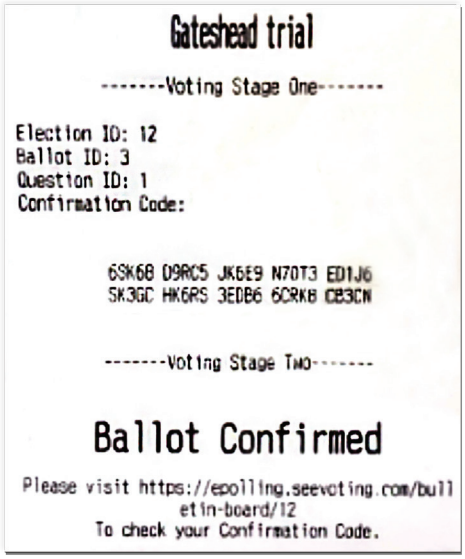
- Individual verifiability, which empowers any voter to confirm and verify that the votes cast by them are correctly included in the set of votes cast.
- Universal verifiability, which empowers any voter to check and endorse that all the votes in the ballot box have been counted with fidelity
- Additionally, eligibility verifiability guarantees provided by this class of voting systems help voters verify that all votes cast were cast by registered voters.

We walk the reader through what an experience with E2E-V voting would look like:

The voter, Ali, visits the polling stations on the day of the election and presents identification information to help authenticate himself as an eligible voter. At the polling booth, Ali marks the option for his candidate by either touching or pressing a button on the voting machine. The machine records and encrypts his vote and provides him with a paper trail, just like a traditional EVM, but with one notable difference, i.e., it also prints and provides him with a receipt to take home, a small slip bearing a unique serial number and a verification code consisting of a string of random-looking characters, a cryptographic commitment to his vote. This receipt allows him to later ascertain that the vote cast by him has been accurately processed and included in the tally. However, the receipt

does not reveal Ali's choice of candidate and he cannot use it to sell his vote or be coerced into voting for a particular candidate. The receipt for the pilot of an E2E-V voting system in Gateshead, the UK is shown in Figure 2 below. The receipt includes a random verification code that is analogous to the tracking ID allocated to track shipments through courier services.

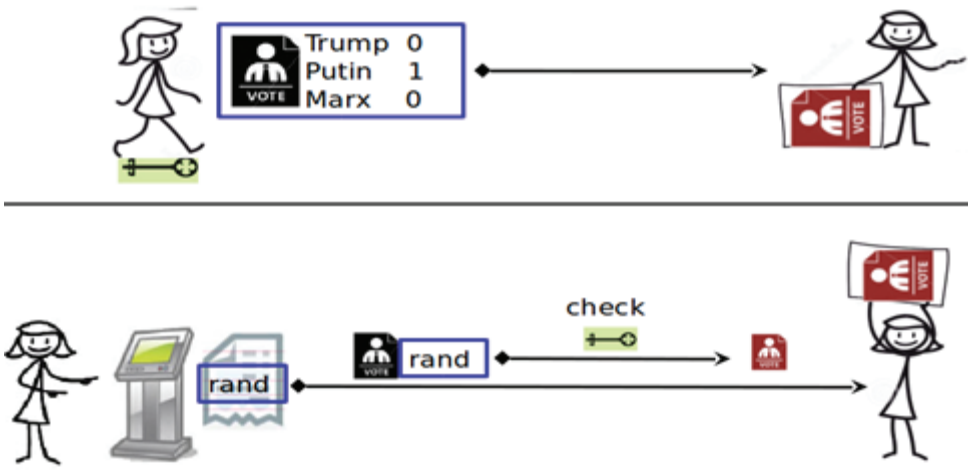
Figure 2 Example Receipt from E2EV Voting Trial in Gateshead, UK



However, Ali may suspect the machine is malfunctioning or has been tampered with. In this case, he avails an option to force the machine to reveal the cryptographic parameters it used to encrypt his vote, shown by the random number rand and the key in Figure 3 below. This step effectively "spoils" his ballot but allows him to double-check that the machine is operating correctly. He can repeat this step several times until he is ready to cast his vote. In the parlance of E2E-V voting systems, Ali is now confident that his vote has been cast as intended. Ali takes the receipt home, shown in red in Figure 3 below.

This step is important because in India voting machines are known to be rigged in such a manner that the choice of a candidate selected by the voter is shown on the voting machine screen but the vote is still cast for a different candidate.

Figure 3 E2E-V Voting: Cast as Intended

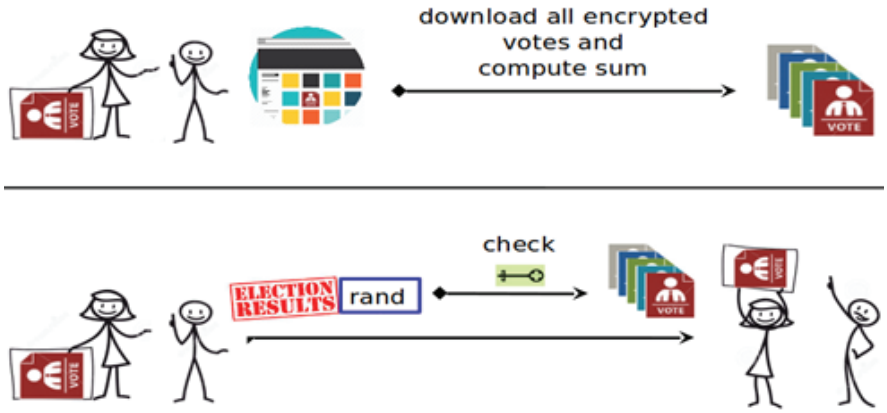


After the polls close, election officials upload copies of all receipts to the election website. Ali navigates to his receipt using the serial number. If anyone has tampered with his vote, he can detect it by comparing the receipt to the physical copy he holds in his hand and can file a complaint using his physical receipt as hard evidence. By independently verifying the encryption he gains confidence that the machine has encrypted his vote correctly, and that "his vote has been recorded as cast." Statistical analyses indicate that if a mere fraction of voters were to check their votes in this way, they would detect any attempt at large-scale vote tampering with very high likelihood.

Figure 4 E2E-Verifiable Voting: Recorded as Cast

E2E-V voting systems usually employ two key techniques to tally results in a privacy-preserving manner. Systems such as Pret 'a Voter and Scantegrity rely on mixnets to anonymise and decrypt cast votes, which are then added. This approach, exemplified by STAR-Vote, employs homomorphic encryption to aggregate encrypted votes and decrypt only the tally. Both processes offer voters and observers cryptographic or mathematical proof of correct operation. Ali can use these proofs to verify that "his vote has been tallied as recorded".

Figure 5 E2E-V Voting: Tallied as Cast



Cryptographic primitives that enable this are sophisticated but not incomprehensible. Patriotic citizens with programming skills could spend some time writing this software, which is essentially an independent audit. QR codes, smartphone apps, and mobile SMS services may simplify this process considerably. These E2E-V voting or simply "verifiable voting" technologies are being developed for use with electronic voting machines and online voting.

An end-to-end voting system prototype may be developed using the open-source SEAL by Microsoft (Microsoft SEAL, 2022).

Risk-Limiting Audits

Election procedures and controls implemented throughout the election life cycle are meant to guard against undetected human error, intentional malfeasance, and voting system malfunctions that may cause harm to the integrity of the election outcome. Another such critical component of a transparent election is a risk-reducing post-election audit. Post-election audits, as the name suggests, occur after the voting period ends and before certifying the results of an election.

Post-election audits are statistical tests that reduce the risk of an erroneous election outcome. They help identify anomalous tallies and give election officials time to make amends before the election results are certified. Post-election audits are public ceremonies to which invitation is extended to the public, civil society, and media. Such public ceremonies can also be live-streamed. They are a very effective measure to increase voter and stakeholder confidence in the outcome of elections and raise the perception of electoral integrity. The process is summarised in Figure 2.

The idea is to build trust in systems that have become less transparent as they are more mechanised. In 2012, a municipal election in Palm Beach County, Florida, conducted a post-election audit. The audit identified a discrepancy between the reported results and the audit-based results. This led to the identification of a bug in the election management software, which was attributing voters to the wrong candidate. The results were consequently officially corrected.

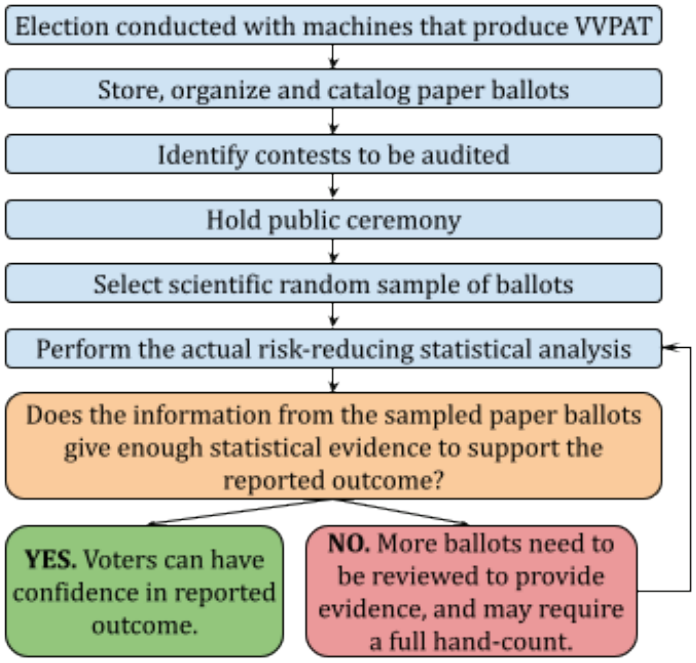
Risk Limiting Audits begin with a small number of randomly selected ballots. They continue to scrutinise an increasing number of ballots, selected at random. This step is repeated until there is enough statistical evidence that a manual counting of all the votes cast will not change the outcome (IFES, 2021).

Risk-limiting audits are more time- and cost-efficient than hand-count audits. By the end of this, there is either a quantifiable level of confidence that the election outcome is correct or quantifiable evidence of an error that can then be corrected by a full hand count.

Risk-limiting audits have been recommended by numerous international bodies such as the Senate Select Committee on Intelligence (Brennan Center Quick Take, 2018), the National Academies of Sciences (National Academies of Sciences & Engineering, and Medicine, 2018,), the American Statistical Association (Alexandria, VA (PRWEB), 2010), and Brennan Center for Justice (Howard & Rosenzweig, 2021), among others.

In Pakistan, there are no post-election audits conducted by default. It is only when a petition is filed against the election outcome that an audit or a recount may be ordered. Although risk-limiting audits are specifically tailored to work with EVM-based systems, there are other post-election audits found in the literature that can be undertaken in paper-based systems.

Figure 7 Risk Limiting Audits



We walk the reader through risk-limiting audits with an example.

Primer On Risk Limiting Audits

If the initial count of votes is produced by EVMs, then risk-limiting audits can be deployed to increase confidence in the results produced. A risk-limiting audit initially takes a small number of ballots, which humans count and check against the initial outcome. If a discrepancy is found, then the sample of ballots is increased until there is a statistical proof that the initial outcome was correct. Otherwise, the wrongly reported outcome is rectified. However, a prerequisite for an effective risk-limiting audit is a VVPAT (Voter-verified paper audit trail), as the tally produced by the machine will be checked against this VVPAT to ensure that the outcome correctly reflects the voters' choice.

There are many methods to conduct risk-limiting audits each catering to the specific needs of different electoral systems. We describe a simple "ballot-level risk-limiting comparison audit" that is compatible with the electoral system in Pakistan. In a ballot-level comparison audit, polling staff count a randomly drawn sample of ballots. Any discrepancy between the EVM reported percentage and the audit percentage will lead to another round of audit with a larger randomly drawn sample of ballots. This continues until there is a convincing proof that a manual count of all the votes will lead to the same outcome as was originally reported. We walk through an example adapted from seminal work by Lindeman and Stark (2012). We begin with defining some relevant terminology.

Ballots cast, b, refers to the turnout in terms of the total votes cast in an electoral race.

Margin of victory, MOV, refers to the difference in votes between the victor and the losing candidate. A separate MOV may be calculated between the winner and each of the losing candidates.

Diluted margin, m refers to the smallest reported margin of victory as a proportion of the total number of votes cast.

Risk limit, r, refers to the greatest probability/chance that a wrong outcome is not detected.

Random sample, n, of ballots is drawn to comply with the statistical notion of randomness.

Outcome refers to the winners and not the actual vote totals. A wrong outcome, therefore, implies the initially reported outcome conflicts with the outcome of a full count during the audit.

Additionally, when manual counts are conducted there could be two types of errors:

An understatement is the total number of votes by which the audit results report fewer votes for the winner. This means that the reported MOV is smaller than the actual margin of victory between the winner and every loser. Identification of understatements benefits the already reported winner and solidifies his victory.

An overstatement is the total number of votes by which the audit results report more votes for the winner. This means the MOV is inflated between the winner and one or more losing candidates.

2-vote overstatement, o2, is an event when the ballot cast in favour of a losing candidate is attributed to the reported winner; 1-vote overstatement, o1, is an event when the ballot cast in favour of one losing candidate is attributed to another losing candidate; 1-vote understatement, u1, occurs when the minimum number of candidates in the race are three and a vote for the winning candidate is attributed to a losing candidate; 2-vote understatement, u2, is an event when the electoral race is between two candidates and the ballot cast in favour of the reported winner is attributed to the losing candidate.

The audit begins in full public view. The polling officials draw a random sample of VVPAT, based on the MOV.

These are manually reviewed to identify any conflict between the outcome reported by the EVM and the actual outcome. The risk limit needs to be defined in the legal framework. For our example, we set the risk limit to 10%. Suppose the audit has inspected a sample of n ballots. The audit can stop when

$$n \geq \frac{4.8 + 1.4(o_1 + 5o_2 - 0.6u_1 - 4.4u_2)}{m}. \qquad (1)$$

Both overstatements and understatements being errors alter the requirement for further ballots to be drawn. As an understatement adds to the votes of the winners it means fewer additional ballots need to be drawn. The opposite happens with an overstatement, which attributes a winner for one of the losing candidates to the winning candidate, and the number of additional ballots to be drawn increases. However, the increase and decrease are not by equal amounts, as is evident from their coefficients in Equation 1 above. The increase is greater than the decrease.

Let us suppose that in an election race there were 10,000 ballots cast. According to the results reported by the EVM the winner obtained 4,000 votes, while the first runner-up obtained 3,500.

For this contest MoV= 4,000-3,500 = 500 votes.

The diluted margin = (4000 – 3500)/10000 = 5%

We sample single ballots incrementally. Here, the polling audit staff will randomly select a ballot out of the ballot box and manually ascertain if the results reported by the EVM are in line with that of the drawn ballot. If there is only one error in the first 80 votes and this error is a 1-vote understatement then, u1 = 1 and o1, u2, and o2 are all zero. At this point, the condition in equation one is satisfied:

$$80 \geq \frac{4.8 - 1.4 \times 0.6 \times 1}{5\%}. \qquad (2)$$

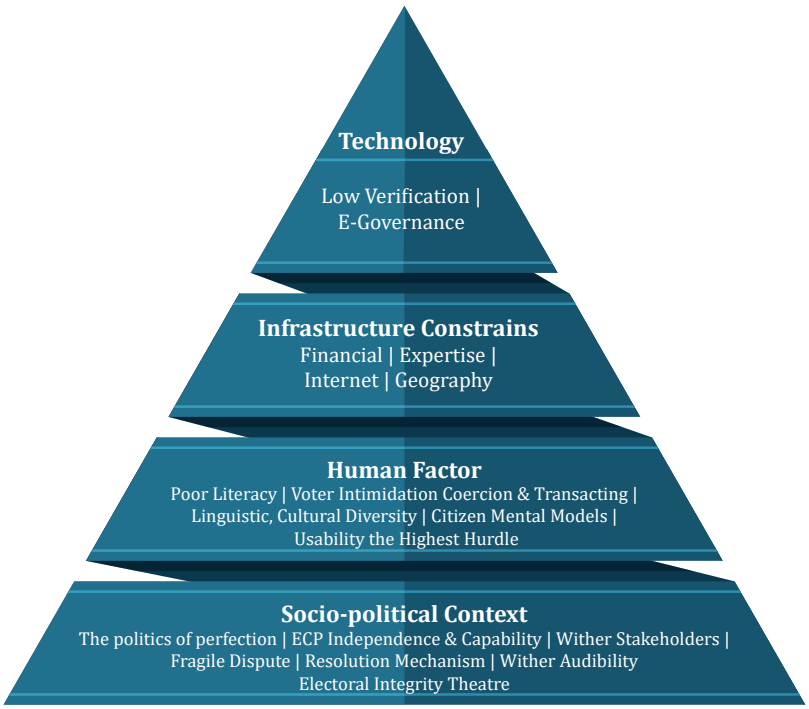
There is no need to draw further ballots. However, a repeat of the audit can be undertaken with a more stringent risk limit. The confidence in the outcome is greater if fewer errors are found as compared to if many, but equal numbers of overstatements and understatements are found. If a lot of errors are being reported then it is at the discretion of the auditor to terminate the audit and begin an exhaustive manual count of all the ballots cast in the electoral race.

Arlo (Arlo, 2022) and Bravo (Lindeman et al., 2012) are a couple of open-source and free software to help conduct these audits cheaply and quickly, in the hope of increased adoption by EMBs worldwide.

A Conceptual Framework for Election Technology

Literature suggests that "A voting system is only as good as the public believes it to be" (McGaley et al., 2003). The perception of fraud can be just as detrimental to the credibility of an election as the actual fraud itself. Researchers have described the perceptions of electoral integrity around the world. Pakistan ranks 118th with a low PEI Index of 47 points (Norris et al., 2019). The goal of E2E-V voting is to provide transparency to the voters which, in turn, will improve voter trust, electoral integrity, and perception thereof. We define the challenges along the lines of the pyramid of trust that we propose to help understand the distinct factors that contribute to building trust in electoral systems.

Figure 8. Conceptual Framework for Election Technology



Technology

E-Governance and Digital Transformation: E-voting is a cornerstone of e-governance. Pakistan is at a nascent stage of e-governance and digital transformation, with traditional methods of service delivery dominant, especially in the public sector. Estonia began its online voting initiatives only after widespread use and gradual growth of pre-existing services in areas like social security, taxation, and property registration. As of now, over 99% of public services can be performed online. Through these measures, Estonia in a year saves over 1,400 years of human effort (e-Estonia, 2017). The success of Estonia's internet voting system is also attributed to the extensive digital infrastructure that supports it.

The ECP needs to develop a cybersecurity strategy and undertake rigorous cyber hygiene exercises within all its departments. It needs to bring itself at par with international standards concerning cybersecurity. A step toward this is to obtain ISO-27001 certification. EMBs are increasingly becoming the target of cyber threats. Hackers and crime gangs have been targeting EMBs worldwide with a 3-fold increase in attacks since 2015. One such incident involves a ransomware attack on the Caribbean EMB, which had to pay ransom in bitcoins to gain access to its data (Commonwealth Secretariat, 2020). A Computer Emergency and Response Team (CERT) should be established within the ECP to handle any untoward incident.

Low Verifiability Rates The provision in E2E-V voting systems that permits every participant in the vote to check and verify their vote is revolutionary. However, there is a dire need to motivate voters to exercise this option. So far, in all the pilots and deployments it has been observed that the rate of verification is very low. An even lower percentage of people identify and report differences in their vote and the one cast by the machine (Moher et al., 2014). Chipchase and Jan (2005) observed that non-literate populations avoid complex functions and this reinforces the assumption that if a step is optional, it will be skipped (Ellison & Carl, 2003). Technical solutions for this exist in literature where receipts can be bundled, or linked in chains, where the verification of each vote implicitly verifies the bundle of votes or the votes in the chain (Ali, 2016).

Infrastructure Constraints

Financial Cost: Financial cost calculation must occur early in the process so that stakeholders fully grasp the

criteria on which they are making their judgments. Although E2E-V voting may offer greater financial gain in the long run over many electoral cycles, the upfront investment related to system development, security procedures, testing, promotion, and voter education campaigns is significant. Another approach could be to start with traditional EVMs and then use the Scantegrity approach, and implement E2E-V voting on top of existing DRE-VVPAT machines. This can be done easily through modularity in the EVM design. Such modularity will increase the lifetime of the EVMs and make sure they do not have to be scrapped.

Utilities: There is a lack of utility provisions, such as electricity, telecommunications, and robust broadband internet service. The internet penetration is 54%. Even where such capacities are available in Pakistan, they are primarily concentrated in urban centres (almost ⅔ of all internet users are based in urban centres), with negative implications for widespread deployment of the E2E-V voting systems, which require a bulletin board to ensure individual and universal verifiability.

Transport and Geography: A significant operational challenge, rarely recognised in the existing studies, is the diversity of geographic terrains. The polling stations are set up in far-flung areas, which are sometimes only accessible by foot. Thus, the machines need to be rugged, weather resistant, sealed from insect infestation, and capable of lengthy periods operating on battery power. In some countries, there might even be a delay between the casting (and recording) of a ballot, the return of the equipment to a location with connectivity, and the votes being centralised, before verification is even possible. How these delays create opportunities for malfeasance needs to be studied.

Human Factor

Voter Intimidation Coercion and TransactingL Voters in the developing world are more likely to cast votes based on sects, castes, tribes, and political affiliations, while those in the developed world based on a thorough, logical, and comparative analysis of the contesting politicians (Bossuroy & Thomas, 2007). Pakistan is no exception. Accordingly, E2E-V voting awareness campaigns must ensure that voters understand and appreciate that the receipt does not reveal their vote, in order not to exacerbate an already serious problem. Another drawback is that of discarded receipts or receipts that the voter has been coerced to give up.

Linguistic, Cultural Diversity: Pakistan is marked by their linguistic diversity (dialects may change every few miles) (Weber et al., 2017), ethnic diversity, and varying cultural constructs (Alesina et al., 2003), which requires the need for localisation of both the voting system and the accompanying receipts and verification mechanisms.
Citizen Mental Models: There is a need to educate the voters on the paradigm of E2E-V voting. It has been reported in the literature that voters' perception of a voting system is based on how-to-vote procedures (Acemyan et al., 2015). It is necessary to formulate mental models for E2E-V voting to help all stakeholders including voters, election officials, and judiciary to foster an understanding of this novel paradigm, as unverified assumptions may hinder stakeholder acceptance (Zollinger et al., 2019). Citizen awareness programs through various media, public demonstrations, operating phone helplines and awareness sessions, etc., should be undertaken. These can be targeted to help remove mismatch, impart clarity to voters in their pre-existing mental models and overcome cognitive barriers (Kshetri & Nir, 2007).

Usability the Highest Hurdle: E2E-V voting systems are weak from a usability perspective (Acemyan et al., 2018) and they have been known to confuse voters (Schneider et al., 2011; Acemyan et al., 2014) even in the developed world. In E2E-V voting systems, usability considerations include a voter's ability to cast their vote effectively and, more crucially, their ability to complete the verification procedure. Extending low literacy HCI recommendations (for voters in traditional electronic voting) to the E2E-V voting scenario is not trivial.

A preliminary assessment of prominent E2E-V voting solutions discovered that voting took about twice as long with each system, and a huge proportion of the voters failed to independently use the systems to cast their vote with each of the systems, many of whom were unaware of the error they made (Acemyan et al., 2014).

Several technical alternatives, such as simplifying security features or improving voting systems to ease individual vote verification, have been proposed (Nandi et al., 2010; Ryan & Peter YA, 2011; Dechand et al., 2016; Perrig et

al., 1999; Olembo et al., 2013; Azimpourkivi et al., 2020). It is necessary to study how these can be adapted for Pakistan.

Social and Political Factors

A supportive sociopolitical environment considerably aids in the deployment of e-voting and can even temporarily mask initial implementation difficulties. In this section, we explore how Pakistan's volatile socio-political setting puts it at risk of an unfavourable outcome of the deployment of EVMs.

ECP Independence and Capability: According to an IFES report "Challenges with the ECP's full exercise of its mandate had implications for the integrity of elements of the election process" (IFES, 2014). The introduction of E2E-V voting in such a scenario may result in increased doubts over electoral integrity. It is vital to maintain the ECP's central role in addressing the deployment of any contemporary IT solutions for the election process, as it is the only organisation tasked with administering them. It is important that the ECP is provided with the autonomy and regulatory teeth it requires for this huge undertaking and not operate under political influence and fear.

The ECP also needs to undergo major restructuring and reforms at all levels of its institution. This will require a dedicated long-term multidisciplinary effort, for which constituting an R&D cell is the first step. Under the umbrella of the R&D Cell, a long-term research and development agenda should be formulated. In countries with a reputation for electoral innovation, such as Estonia, Brazil, India, and Australia, election management bodies typically partner with leading universities to undertake research. This point has been raised numerous times in expert reports and official proceedings over the last decade. The ECP itself has tried to initiate steps in this direction. Unfortunately, none of these efforts has been fully pursued.

Figure 9. Over the last decade numerous expert reports and official proceedings have asked the ECP to set up a dedicated research unit

Legal Framework: A restructuring of the legal framework is also required with the introduction of electronic voting systems. It is necessary to ensure that the confidentiality of the vote is maintained and identity data is disassociated. The legal framework should provide for ample auditing of the election outcomes as well as the processes that lead to those outcomes. It also needs to specify the course of action in case a discrepancy in results

arises during audits or some irregularities in the process are discovered. The election authority must ensure that technology has undergone certification. The law needs to identify those institutions that can provide certifications. The law also needs to decide how long the certification period will be and the requirements for the certification. Legal provisions regarding the logistics such as transport and storage of EVMs and resident data need to be provided, such as the time period for retaining data, how data is deleted, how it is backed up, and what to do in case of data loss. If voter identification is done through biometric data of voters, then the law needs to bring data under the umbrella of a data protection act. Whether the source code of the EVMs and associated technology will be made open source or not needs to be spelt out in the law. This will also dictate the level of access and information that is available to stakeholders for scrutiny.

There needs to be a thorough analysis of what audit reports and forensic investigation data can be collected from the electronic voting system. In case the election results are challenged in court, what kind of evidence is admissible in court needs to be assessed apriori.

In the case of E2E-V voting, it should be binding on the ECP to issue a receipt to every voter, upload all the receipts on a bulletin board within a stipulated time frame, verify the results through the software provided to observers, make the software open source, share the public cryptographic parameters, and conduct risk-limiting audits, without which the security guarantees of E2E-V voting systems become moot. The election day integrity measures and procedures also need to be updated according to the new electronic system.

Fragile Dispute Resolution Mechanisms: In Pakistan, disputes over election results often act as triggers for mass protests, violence, political deadlock and animosity, often bordering civil war. Following the 2013 elections, PTI chairman Imran Khan ordered an investigation into electoral improprieties in 4 constituencies. However, it took a sit-in of over four months to institute a Judicial Commission that discovered over forty flaws in the handling of election results. IFES summarises "for decades, the executive branch has manipulated the election law to increase its control over the process and there has been resistance from a range of sectors to reforming the current framework. The legal framework is also mostly silent or unclear about the processes by which complainants file grievances and the ECP investigates and rules on these complaints. The lack of specificity leads to inefficiencies, limited transparency, an increased chance of malpractice, and great confusion. More could be done by the ECP to remedy the legal vacuum or to take on the responsibility of adjudication." (IFES, 2014)

It is necessary to ensure that the introduction of electronic voting does not exacerbate dispute resolution problems. Similar incidents are common in developing countries. For instance, in Kenya, the lack of awareness among many individuals and observers about how digital processes truly function made it incredibly difficult to distinguish between false and credible assertions. (Cheeseman et al., 2018). Similarly in Brazil researchers have noted that "important judicial decisions are not based on scientific research; they are often based on the personal opinions of judges who have no understanding of (election) technology" (Aranha et al., 2018). Accordingly, for disputes involving technologies, defining the requirements for the admissibility of evidence, and training the judiciary to handle the intricacies of electronic voting systems based on digital evidence are of utmost importance.

Electoral Integrity Theatre: The security guarantees of E2E-V voting systems become moot if the verification step is not undertaken and the system is not auditable. If legislatures in developing countries cannot draft and pass laws that are sufficiently detailed to address both core and ancillary processes (such as risk-limiting audits and electoral dispute resolution), E2E-V voting risks becoming nothing more than the electoral equivalent of "security theatre" (Schneier & Bruce, 2021). To quote Park et al., “Auditability alone isn’t enough” and ``must be accompanied by auditing to be effective”. (Park et al., 2021). Without auditability, paper trails are “ornamental”.

The Politics of Perfection: Many electronic voting efforts in developing nations have been launched without a solid research base or a strategic plan in place first (Hapsara et al., 2017). Despite developing countries taking the lead in e-voting deployments, there is little discussion and dialogue about E2E-V voting systems. The Venezuelan government calls its voting system “the most perfect voting system in the world” (Machin-Mastromatteo & Juan D, 2016), while India's EMB angrily reacted to the reasonable analysis of its EVM (G.V.L. N. Rao, 2010). Similarly,

in August 2021, the Minister for Science and Technology, reiterated that the EVM developed by MoST cannot be hacked. Can developing countries that see their EVM systems as "perfect" even begin to accept the need to evolve towards E2E-V voting and evidence-based elections?

Wither Stakeholders: The majority of stakeholders have strong opinions regarding electronic voting. There is a dire need to involve these stakeholders from the outset, which is the opportune time to let the stakeholders express their concerns, as well as ensure their concerns are addressed in the process of introducing electronic voting.

5. RECOMMENDATIONS FOR EVM ROADMAP

In this section, we formulate actionable recommendations based on our findings. The recommendations are accompanied by a roadmap in Appendix F that may serve as a guide in the implementation of these recommendations.

Groundwork to develop the requisite ecosystem

- We recommend the ECP constitute a steering committee, which will serve as a structured body to provide leadership, governance, and oversight for this endeavour. The next logical step is to establish a research division within the ECP to provide high-quality research for technological, legal and policy decisions. The ECP needs to undertake a gap analysis to identify the limitations in its capacity that may hinder the project from achieving its objectives. An action plan should be developed to bridge these gaps.

- We recommend that the ECP solicits stakeholder input at the early stage of the project to develop trust in the voting system. The ECP should seek to engage and consult stakeholders such as political representatives, civil society, activists, and technologists, and seek their input at every stage of the deployment process. At every step, the ECP needs to maintain transparency in its conduct. This can be achieved by setting up active working groups and organising outreach efforts such as public calls for comments and organising seminars, invited talks, demos, and hackathons. The ECP should also actively conduct knowledge mobilisation and build linkages between itself and research bodies, the private sector project partners, and international EMBs.

- We recommend the ECP assess the readiness of the country to transition to EVMs. This needs to be assessed specifically from a technological and infrastructure perspective. For instance, the readiness to indigenously manufacture EVMs. Critical national infrastructure such as election technology should not be outsourced. Critical EVM hardware and software components should be manufactured within Pakistan to give ECP greater oversight and control over the process. Countries much like our own, including Brazil, India, and Bangladesh, have successfully innovated EVMs as per their own needs within their limited resources.

- We recommend the ECP devise a digital transformation strategy to modernise the ECP and its systems to the point where they can successfully launch and manage large-scale EVM deployments. This would involve upgrading internal systems, digitising existing processes, hosting dedicated data centres, and developing policies and processes to support the new infrastructure and safeguards against technology failures.

- We recommend the ECP on an urgent basis develop a cybersecurity strategy to counter attacks on its IT infrastructure. It should identify and work towards implementing international information security standards such as ISO/IEC 27001. The ECP should also undertake periodic and comprehensive risk assessment audits. It should also prepare for any untoward incident either by developing an in-house capacity for cybersecurity emergency response and recovery or seek active assistance from national cybersecurity agencies and specialist bodies.

- We recommend that the ECP pay special consideration to measures to foster social support and trust. This includes targeted strategies such as media strategy, active voter engagement strategy, strategy for public

oversight, strategy to fight disinformation, technologist involvement strategy, effective communication plans for election day and post-elections processes like audits, election petitions, and dispute resolution.

Technical Specification and Pilots

- We recommend ECP define baseline security requirements for EVMs. This study, referred to as a threat model, should precisely define the security issues and vulnerabilities on the ground that we expect to address using EVMs.

- We recommend that ECP analyses the suitability of popular EVM types for use in Pakistan. Given the different characteristics and benefits of each type of EVM, it is important to assess how each performs on the ground in Pakistan. We recommend that the ECP procures multiple units of each EVM type and pilot them. It is important to know which EVM type and interface our citizens find easiest to use and is most conducive to enfranchising them. This will be an extensive exercise examining a range of factors, including security, usability, costs, logistics, storage, and handling requirements.

- We recommend that the ECP researches and devises voter verification strategies, such as multi-finger authentication, computer vision solutions, tokens, and smart cards. The ECP's earlier pilot of biometric verification machines noted a significant failure rate of 54%. This was due to scanning issues, environmental or lighting conditions, and poor quality of fingerprints due to injuries, or calluses due to intensive manual labour.

- We recommend ECP undertake multiple large-scale pilots in a mix of urban and rural areas to ensure a representative cross-section of the electorate is covered. The ECP may commence large-scale procurement and nationwide deployment after a sufficient number of successful pilots.

Sustainability and Support

- We recommend that the ECP develops a comprehensive strategy for supporting technologies such as result transmission system (RTS). Procedures must be devised to transfer the results from the EVMs in a safe, secure, and timely manner. The RTS should be rigorously stress-tested and be piloted alongside EVMs multiple times to identify potential integration issues.

- We recommend ECP develop sustainability strategies for EVMs and supporting technologies. As a developing country, we must seek out cost-effective options and utilise our resources effectively. We should try to "future-proof" our EVMs, such that they have a lifetime of at least 2 to 3 election cycles.

- We recommend that the ECP develops comprehensive standards and testing and certification protocols for EVMs. These processes must be designed to give stakeholders greater transparency into the state of the machines.

- We recommend that the ECP organises hackathons for EVMs and solicit feedback from the international and local election technology community to identify vulnerabilities and provide stakeholders with greater transparency. We recommend that the ECP engages third-party technical experts and consultants periodically to analyse the security properties of EVMs.

Operations and Logistics

- We recommend that the ECP develops comprehensive storage and transport facilities and protocols for EVMs. EVMs will likely require fleets of customised trucks or large vehicles to transport EVMs between storage sites and polling booths on election day. For this purpose, the ECP should develop detailed standards and SOPs to store and transport EVMs, as devised in countries like India and Brazil. We recommend that the ECP devises stringent protocols for accessing, handling, and maintenance of EVMs that can be rigorously monitored and policed.

Legal Framework

- We recommend that the ECP identifies the issues with the current legislation and introduce legislation to support EVMs:
    - Voting laws should not be so specific that they hinder innovation, nor should they be so generic that they leave room for lingering litigation.
    - The law should provide for conducting pilots for risk-limiting audits and end-to-end verifiable voting.
    - Also, the law should have provisions for technology trials and certifications, identifying authorised certifying institutions and establishing the certification standards.
    - There should be laws that mandate the pre-audit and post-audit of EVMs and supporting equipment. Election laws will need to specify requirements and standards for auditing mechanisms.
    - The law should provide for efficient dispute resolution under the new voting modality.
    - The law should provide for what constitutes admissible evidence in court
    - The law should specify rules for source code access.
    - The law should update procedural checks according to the updated voting mechanism.
    - The law should specify which data protection law voter data fall into and what recourse is required in case of a breach.
    - The law should specify procedures and access to observers and political party representatives.

Phased Implementation

- Planning and implementation should not be rushed, and time should be built in the pre-election phase for systems review, revisions, and retesting. From its decision to deploy election technology to its first use in elections, DR Congo took only a year to acquire, test, and review the technology, and to build the ecosystem supporting it. It is evident that their EMB failed to do so effectively. The ECP should plan for a timed and phased implementation to realise the benefits and limitations of the system. The timeline as recommended by international experts and their guidelines should be respected. As an NDI report notes, "The timeframe for consideration and possible adoption of electronic voting and counting technologies is an issue that needs to be carefully considered. It is easy to underestimate the time that proper consideration and implementation can take, even for a pilot project. A full assessment of electoral requirements; availability of technologies; and identifying benefits and challenges of using such technologies can take many months. Once suitable technologies are identified, they must be procured – ideally and initially on a small scale – for a pilot. When pilots are held, a full and thorough evaluation of the process must be conducted before any plans or decisions are made for further implementation." (National Democratic Institute, 2013)

6. CONCLUSION

We started by defining the context of electoral issues in Pakistan. We then delineated our finding that any shift towards electronic voting machines should be guided by the overarching principles of secrecy of the ballot, electoral integrity, openness and transparency, accessibility and usability, and sustainability.

In the second part, we noted documented strengths of EVMs, such as faster tabulation with greater accuracy, reduction in polling station fraud, increased voter turnout and accessibility, inclusivity, and long-term cost savings. On the flip side, we also discussed the potential weaknesses such as lack of transparency and limited understanding of the voters, information security concerns, malfunctions, usability, lack of standardisation, sustainability, and high initial costs. We presented a comparative summary of common EVM models deployed namely PCOS, DRE, DRE-VVPAT, EBP and emote internet voting.

We then presented case studies from India, Brazil, Philippines, Congo and Estonia, followed by the lessons to learn from these deployments: avoid rushed implementation, undertake phased implementation, ensure timely regulatory and legislative support, invest in capacity building efforts, anticipate and leave room for future improvements, do not undermine the importance of supporting digital infrastructure, build stakeholder acceptance and transparency measures, engage in rigorous voter education and acceptance efforts, and lastly, do not compromise quality to appease the budget.

We highlighted common pitfalls, explaining the phenomenon of the "fetishisation of technology" and how it distracts stakeholders from rigorous assessments and stringent checks and balances in the overall ecosystem, rendering election processes even more vulnerable than they were without technology.

We described the novel concept of public verifiability and how risk-limiting audits and verifiable voting can mitigate outstanding security concerns regarding EVMs and ensure trust in poll results.

We presented a holistic framework to identify the technical and human factors, socio-political, challenges and infrastructure constraints to address as we move toward EVMs. Our national discourse to date has focused primarily on EVM units, and there is, unfortunately, very little recognition of the enormous task of building a supporting ecosystem for EVMs. This ecosystem is critical to the success of the overall project and the effort and costs involved in setting it up can easily dwarf that of procuring the EVMs themselves.

There is very little existing research in this domain, and we believe it is the first comprehensive document of its kind on the EVM discourse in Pakistan.

We also presented recommendations to address these challenges at every stage. The accompanying roadmap spells out these recommendations in the form of concrete detailed steps that stakeholders need to take. The roadmap lists key activities, including research assessments, pilot studies, hackathons, and demos and suggests timelines, references, and resources at every step and highlights dependencies and concerns. We also identified critical research gaps to be addressed. The ECP in collaboration needs to ensure the synergy of people, processes, and technology. It should evaluate, manage, and mitigate risks at every stage. There should be a steady progression toward adopting election technology propelled by careful research and deliberation so that unfavourable outcomes can be avoided. However, "We must not ... make the mistake of placing our faith in technical solutions to political problems. When opposition parties and donors invest in the transformative power of new scientific advances, they often overlook the fact that even the most advanced forms of election technology rely on human programming and management. And there is nothing about digital technology that means that those who use it are likely to be any more trustworthy or fair" (Cheeseman et al., 2018).

As John Githongo, Kenya's former anti-corruption tsar has put it, "You cannot digitize integrity" (Cheeseman et al., 2018).

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APPENDIX A

Summary and Recap of Key Issues in General Elections

Pakistan, with its 200 million citizens, ranks 6th in the world in terms of population. It has an electorate of 118 million voters (ELECTORAL ROLLS, 2021). However, elections here are routinely contentious and frequently result in political deadlock, street protests, and violence.

Before 1970, Pakistan had no national direct elections. Unfortunately, in the aftermath of the first-ever general elections in 1970, the political situation escalated into a civil war that led to the creation of East Pakistan. Democracy returned to the country in 1972, with Zulfiqar Ali Bhutto instated as prime minister (PM). General elections were held again in 1977, with Pakistan People's Party (PPP) winning handily. However, the accusations of rigging by the opposing Pakistan National Alliance (PNA) resulted in turmoil and violent protests, leading to martial law under General Zia-ul-Haq, which lasted over a decade. Thereafter, PPP and PMLN took turns to form government in 1988, 1990, 1993, and 1997 but none could complete its turn. Martial law returned in 1999 under General Musharraf. The next general elections happened in 2008 when the PPP formed the government. But keeping its tradition of electoral violence, in the run-up to the elections Benazir Bhutto was assassinated at a political rally. After obtaining the majority of seats in the elections, the PML (N) formed the government in 2013. This was the country's first transfer from one civilian government to another, and it was an important step forward for democracy. However, major rigging allegations in the general elections of 2013 resulted in mass protests and a public sit-in by the PTI. Lasting over four months, this was the longest protest in Pakistan's history, causing estimated losses of over Rs 1.5 billion (Imran & Bari, 2020). Following the 2018 elections when PTI came into power, the failure of the RTS (automated results management system) led to widespread accusations of fraud and irregularity by the opposition, making the General Elections 2018 controversial (Wasim & Khan, 2018).

In the 11 general elections Pakistan has conducted since independence, hundreds of lives have been lost as incidents of election-related violence, gun, and bomb attacks, sparked by the perennial mistrust in the credibility of elections, routinely mar the election discourse.

Systemic corruption and procedural inefficiencies run rife in the electoral system. And the current paper-based elections present the perfect means to exploit these systemic issues. According to FAFEN's report, election malpractices and major election day irregularities include:

- Partisan election officials campaigning for a certain party or candidate.
- Polling station captures by unauthorised individuals.
- Voters trying to cast multiple votes or ineligible parties trying to cast votes.
- The percentage of spoiled/rejected votes far exceeding the normal range of 2 to 3 per cent, and often greater than the margin of victory.
- The lack of publicly official documents from all polling stations on the ECP website.
- Last minute changes in polling scheme.
- Preventing or restricting observers from observation
- Unofficial breaks in voting as well as extension in polling hours.
- Lapses in following procedures, such as failure to seal ballot boxes.
- A Lack of basic training of the election staff regarding how to correctly fill critical forms.
- A lack of transparent and standardised counting procedures.
- A lack of vote audit solutions and a lack of robust dispute resolution mechanisms.
- Violence, voter intimidation, bribery and coercion, and barring women from voting.
- Minimal security deployment outside polling stations.

APPENDIX B

EVM Myths and Common Concerns

The Challenge of Using Electronic Voting Machines: EVMs are a unique case. The fundamental requirement of the secrecy of the ballot means that the identity of the voter needs to be stripped from the vote itself. This severely limits auditing and accounting activities. Most other IT systems rely on rigorous logging of events and an audit trail to track and monitor any transactions and activities performed. Until recently, separating the voter's identity from the cast vote meant that there was no way to ascertain if the vote was indeed counted in the final tally as cast by the voter. Consequently, voting systems have relied on indirect proofs through paper trails and strict procedural checks and balances. Without such procedures incorporated with the introductions of EVMs, the process could be rendered more vulnerable than it was in paper-based systems. The fundamental difficulty in designing EVMs is reconciling the conflicting requirements of process openness and vote secrecy. As we discuss in our paper, new election technologies such as end-to-end verifiable voting resolve this dilemma.

The most striking example of this is the friction between ballot secrecy and election integrity. The name of the voter is stripped from the vote to ensure ballot secrecy. However, this same act makes it very difficult to track the vote and ensure that it has not been modified. Similarly, stakeholders can inadvertently take electoral efficiency to mean electoral transparency. Michael Yard of IFES notes "This is not to say the efficiency in elections is, in itself, a bad thing; on the contrary, it is only when efficiency comes into conflict with transparency that it becomes undemocratic." (Kreigler, 2011) A narrow focus on efficiency can result in the deployment of "black box" components that "lead to more efficient development and employment", but these risks transferring power "away from the many" into the "hands of the few" (Cheeseman et al., 2018).

As a baseline, to justify the use of EVMs for elections in Pakistan, we should identify a system that, at the very minimum, provides significant advantages over paper-based elections. These advantages could be in terms of superior security, greater transparency, reduced election costs, simplified logistics, etc. These benefits need to be documented and spelt out explicitly in rigorous cost-benefit analyses. In the absence of a rigorous assessment, the introduction of technology "may create significant opportunities for corruption that (among other things) vitiate their potential impact... precisely because the new technology tends to deflect attention away from more 'traditional' strategies, the failure of digital checks and balances often renders an electoral process even more vulnerable to rigging than it was before" (Cheeseman et al., 2018).

Banking vs Voting - Election Security is Unique

One of the most frequently asked questions in the debate around internet voting is that in a world where online banking and commerce applications are pervasive, why can citizens not vote online? This question raises a valid point, i.e., if we can trust the internet with our monetary transactions, then why not vote? Banking and e-commerce applications are critical and organisations go to great lengths to secure them. Regardless, cybercrime related to such breaches amounts to a staggering $ 6 trillion annually and is expected to rise to $10 trillion by 2025 (Morgan, 2021). Such breaches have been accepted as the cost of doing business, a stance which is unacceptable when it comes to elections and democracy.

Furthermore, the techniques that are used to secure our monetary transactions cannot be extended to internet voting. For instance, maintaining thorough records and fine-grained audit trails of every transaction is routine in financial institutions. However, maintaining any information such as the vote and the identity of the voter is in direct violation of the principle of the secret ballot. Similarly, financial institutions have recovery protocols, such as reversing transactions, blocking stolen cards, compensating customers, etc. However, in the case of internet voting and elections, there is no way to undo a miscast vote or compensate a voter. The nature of elections is also far more sensitive than that of a financial transaction. Therefore, the USA classifies election infrastructure as critical national infrastructure. The incidence of election tampering raises serious questions over national sovereignty and seriously impacts citizen confidence.

Estonia and the Myth of Stand-alone Internet Voting

To allay a few of the concerns listed above and to diminish their impact, internet voting can be run in parallel to paper-based or internet voting systems giving the voters the choice to cast their vote. This is true for Estonia, the only nation to deploy remote internet-based voting on a national scale. However, it provides internet voting as an alternate channel and voters may cast their vote using the paper-based system in the polling station. Voters may cast multiple votes and the paper-based vote would override the internet-based vote. This is done to ensure if a voter has been coerced to vote a certain way, he/she can still salvage their vote.

APPENDIX C

Security Timeline of Electronic Voting Machines

2003 – Diebold hack: In early 2003, activists found a version of Diebold's software on an unprotected server, where anyone could download it. This server was used by Diebold employees to update the software on its machines. In addition to this security breach, the code, itself, had many security flaws. Researchers evaluated the penetrability of this software aided by the voting machine source code that was available on the internet. In their findings, they reported multiple vulnerabilities and deemed the system as unreliable and subject to abuse.

2004 – Voter Verified Paper Trails: In 2004, Nevada became the first US state to require all electronic voting machines used for federal elections to produce voter-verified paper trails and it became the first state in the U.S. to produce a paper trail of electronic ballots.

2005 - The Commission on Federal Election Reform recommends DREs to include VVPAT (Voter Verified Paper Audit Trails): The Commission on Federal Election Reform releases the report "Building Confidence in U.S. Elections," which makes the recommendation to include VVPAT for increasing trust in elections and improving election administration.

2005 – Black Box Voting, demonstrates hackability of the Electronic Voting Systems (Hursti hack): When invited by the Leon County supervisor of elections, Black Box Voting, an election watchdog, set up a demonstration of the Diebold machines. Computer security experts, Harri Hursti and Herbert Thompson, were able to compromise the central vote tabulator of the Diebold machines and alter the results of a mock election without any evidence of interference. During the attempt, Hursti discovered that Diebold's machines allowed negative votes, and changed the votes using only a memory card, producing a "one-step hack" that could alter the central tabulator as well as the voting machine results to produce matched results.

2006 – Black Box Voting Highlights Electronic Voting Machines "Backdoors": Black Box Voting, in collaboration with Harri Hursti performed another penetration attempt on Diebold voting machines in Utah. Hursti found backdoor channels that make it possible for malicious software to be installed as early as the machines are manufactured.

2010 - National Database on Voting System Failures and Vulnerabilities Issued: This report highlighted that even though electronic voting machine failures have been documented time and again, no concrete step has been taken to improve the security of electronic voting machines. The report attributed this partly to the lack of legislation in this regard, as vendors are not legally obligated to report security vulnerabilities and past breaches to the election authorities.

2012- Voting Machine Malfunctions in the 2012 Presidential Election: In Pennsylvania, at least two electronic voting machines were recorded switching votes from Obama to Romney. According to the founder of the watchdog group Verified Voting, this appeared to be a classic case of "vote-flipping," which in most cases is a result of improperly calibrated machines. Additionally, the elections were also rife with long waiting times with machine breakdowns in Virginia, causing 3–5-hour long lines leading to extended polling hours. Machine malfunctions were also reported in Georgia, South Carolina, Ohio, Colorado, and Wisconsin.

2013- NYC returns to Lever machines: The NY State Legislature in 2013 authorised the return to the lever machines for the primary and any ensuing runoff. These lever machines were acquired in the 1960s, and they replaced the $95 million electronic voting system because of the chaos that ensued in the 2012 election, as described above.

2017 – US Department of Homeland Security categorizes elections as "critical infrastructure": Prior to the USA 2016 federal elections, the information technology infrastructure of several state-level and local election management bodies became victims of cyberattacks (purportedly of Russian origin). As a result, in January 2017, the Department of Homeland Security (DHS) declared the election infrastructure a part of the nation's critical infrastructure. Under the designation, the DHS assists, on a priority basis, that election officials can request to reduce both cyber and physical risk to their election systems.

2018- National Academy of Sciences Report calls for Verifiable Voting and Risk Limiting Audits: According to the 2018 National Academies of Sciences, Engineering and Medicines report, the current state of election technology fails to guarantee vote secrecy, security, and verifiability. It suggested that the voting machines that do not provide a VVPAT should not be certified to be used in any future elections. The report also recommended the states start trialling E2E-V voting systems and mandate risk-limiting audits before the certification of election results.

2018 -Internet Voting Task Force report calls for Verifiable Voting in Pakistan: IVTF report urges election authorities to explore the adoption of E2E-V voting systems in elections to enable transparency and restore the credibility of electoral processes, specifically in the context of internet voting for overseas Pakistanis.

2018 – Estonia commits to Verifiable Voting: Estonia expresses its resolve to deploy verifiable voting in the next nationwide elections.

2018 – Annual DEFCON Voting Village: This event has gained recognition for being the only public forum in the USA where hackers get unrestricted access to voting machines to discover vulnerabilities in the equipment. In 2018, the Voting Village made available over 30 electronic voting machines, most of which are still deployed for elections in the USA. According to the event's report, the participants were able to effectively breach the machines within minutes, revealing the inherent vulnerabilities in the electoral system and raising awareness about election security issues.

2019 – Estonia deploys Verifiable Voting in national elections: Estonia becomes the first and only country in the world to deploy nationwide internet voting. It also became the first nationwide deployment of verifiable voting for binding national-level elections.

2019- Microsoft partners with Galois to develop open-source E2E-V Voting Software: In 2019, Microsoft, in partnership with Galois, announced ElectionGuard, an open-source collection of modules that can be integrated to form an election system based on E2E-V Voting, and support risk-limiting audits that help assures the accuracy of elections.

2020 – Risk Limiting Audits implemented in multiple states in the U.S.: In the U.S., a small community of practitioners has worked to convince legislators and administrators to adopt the practice in several states. According to recent figures, more than 60 pilot RLAs have been conducted in the U.S.A., while around 8 U.S. states have made the use of RLAs mandatory. In 2020, 15 U.S. states implemented RLAs post-elections, with Virginia, Atlanta, and Pennsylvania, confirming the results of the elections with the successful execution of their statewide risk-limiting audit. The audit in Virginia confirmed the results of the presidential election and senate race with over 99% confidence.

2021-CCE report on Indian elections, calls for Verifiable Voting and Risk Limiting Audits Citizens': The Commission on Elections (CCE) Report on Indian elections declared that DRE-VVPAT voting machines currently deployed in India are not verifiable. Hence, they do not fulfil the requirements of free and fair elections. Additionally, even though VVPAT is installed in every EVM, the votes are not audited before declaring the results,

exposing the elections to serious fraud. It emphasised the importance of RLA and E2E-V voting to demonstrate the validity of election results and to increase trust in the democratic processes.

2021 – Microsoft announces Verifiable Voting partnership with Galois, Dominion, Smartmatic, Hart InterCivic, Clear Ballot: In June 2021, Hart InterCivic and Microsoft entered a partnership to integrate ElectionGuard software into Hart's Verity voting systems, making it the first major voting machine manufacturer in the U.S. to provide end-to-end verifiability to voters.

Table 2 A Security TimeLine of EVMs

2003	Diebold Hack
2004	Voter Verified Paper Trail compulsory in NEVADA
2005	The Commission on Federal Election Reform recommends DREs include VVPAT
2005	Black Box Voting demonstrates "Hursti Hack"
2006	Black Box Voting exhibits Electronic Voting Machines' "Backdoors"
2010	National Database on Voting System Failures and Vulnerabilities Issued
2012	Numerous Voting Machines Malfunction in Presidential Election
2013	NYC returns to Lever machines
2017	The US Department of Homeland Security categorizes election infrastructure as "critical infrastructure"
2018	National Academy of Sciences Report calls for E2E-V Voting and Risk Limiting Audits
2018	Internet Voting Task Force report calls for E2E-V Voting in Pakistan
2018	Estonia commits to E2E-V Voting
2018	Annual DEFCON Voting Village, hackers compromise all machines
2019	Estonia deploys E2E-V Voting in national elections
2019	Microsoft partners with Galois to develop open-source E2E-V Voting software
2020	Risk Limiting Audits implemented in multiple states in the U.S.
2021	CCE report on Indian elections, calls for E2E-V Voting and Risk Limiting Audits
2021	Microsoft announces E2E-V Voting partnership with Galois, Dominion, Smartmatic, Hart InterCivic, Clear Ballot

APPENDIX D

Roadmap

In this section, we outline the actions required to implement the recommendations we have suggested. The first step to developing this roadmap was the assessment and analysis of the existing systems and information, and studying international best practices. The roadmap interventions are drawn from the gaps and barriers we identified during our study. We recommend intervention for the Ecosystem, R&D Cell and the EVM exercise are given under separate roadmaps below. A nationwide EVM deployment is a complex endeavour, and we highlight activities that must not be skipped on this journey. The purpose of this roadmap is to help achieve a full-scale EVM deployment by General Elections in 2028.

There is limited groundwork towards achieving a country-wide deployment of EVMs. The capacity of the institutions mandated to undertake this task is sub-optimal. Similarly, government and infrastructure support are lacking. This document aims to support this process. Our engagement assumptions include a buy-in of all relevant stakeholders, adequate availability, and allocation of resources.

Table 3 Roadmap: Ecosystems for EVMs in Pakistan

Roadmap: Ecosystem for EVMS in Pakistan								
Key Steps	Document / Activity	Objective(s)	Dependencies	High -Level Goals / Issues to be Addressed	Requirement(s) & Input(s)	Output(s)	ECP's partners	Timeline / Duration * **
1	Establish Steering Committee	Set up a structured body to provide leadership, governance, and oversight for this project	-	1. Define the primary goals for this project 2. Translated these goals into actionable activities 3. Define key milestones 4. Precisely define key human, financial, infrastructure, and technical resources for this project 5. Identify stakeholders, their roles, and inputs	Stakeholder consultation necessary for this step Seminars and round-table discussions with stakeholders to define composition and terms of reference (ToRs) for this body	An empowered and representative Steering Committee which includes members from various stakeholder bodies	1. Political parties 2. Civil Society 3. Academia	0-1 month (1 month)
2	R&D Cell	Establish a Research division within the ECP to provide high-quality research inputs for policy decisions	-	Setting up R&D Division: 1. Structure the division 2. Initiate the hiring process 3. Set up dedicated office space 4. Procure and setup essential equipment 5. Staff orientation and training	Stakeholder consultation necessary for this step Potentially study other such dedicated efforts in Estonia, the United States, Brazil, etc.	R&D Cell should issue a detailed Activities roadmap for the year ahead	1. Academia 2. Donor bodies 3. Technical bodies, e.g., IT boards, NADRA, etc.	1-2 months (1 month)

3	Stakeholder Consultation and Outreach	To achieve stakeholder consensus on the deployment of election technology	[1][2]	1. Structure the mainstream discourse 2. Secure essential inputs from stakeholders regarding benefits, objections, and concerns regarding EVMs 3. Inform stakeholders regarding international practices 4. Demo and pilot new technologies for stakeholders 5. Advance the debate on EVMs 6. Set up working groups and subcommittees with stakeholder representatives to draft policy proposals	-	A wide-ranging and structured forum for consultation with stakeholders with a detailed activities program	1. Political parties 2. Civil society 3. Academia 4. Donor bodies	3-4 months (1 month)
4	Capacity Building	Develop capacity within ECP to successfully deploy election technology	[1]	1. What is the current capacity of the ECP and election-associated institutions vis-à-vis electronic election administration? 2. Identify critical gaps within ECP which need to be addressed 3. Develop an action plan to address these gaps 4. Set up a specialised project management unit to address these gaps	1. Qualifications/training/capacity requirements for the type of e-voting system 2. Current structure and capacity limitations of ECP in light of the capacity requirements for every stage of technology deployment 3. Study international practices in capacity building through literature review and/or collaborative learning groups with other EMBs	Recruitment and development of 1. Project Management Team 2. Communication expert/team 3. Technical Specialists 4. Implementation specialists/team 5. Training Specialists 6. Legal experts 7. Evaluation Commission (with a security expert, election expert, and local authority) 8. Training/Skills and Needs Assessment 9. Identify existing training or courses (local/international) 10. Action plan with timelines	This process should be driven by a dedicated project management division overseen by the Steering Committee	3 months onwards (ongoing)
5	E-Voting Readiness Strategy	To assess the ecosystem gaps (social, political, technical and legal requirements) to introduce EVMs in Pakistan	[1][2][3]	1. Define precise requirements needed to shift to EVMs. Researchers have devised various metrics to gauge the suitability to introduce electronic voting. However, these metrics are primarily applicable to developed countries with far fewer voters. We need to adapt these for Pakistan. 2. Where do we stand in terms of these requirements? 3. What actions need to be taken to achieve this shift?	Extensive consultation with stakeholders .1. Examine similar models devised for EU countries, Netherlands, UK, Russia, etc. 2. Examine attempts to devise similar models in Kenya, Indonesia, Jordan, etc. 3. Examine international election technology experiences and failures in the developing world	A report detailing specific metrics which need work to introduce electronic voting technology successfully in Pakistan. This will include social, political, technical, and legal determinants	Stakeholders, including political parties, civil society, and academia	3-4 months (1 month)

6	A Digital Transformation Strategy for ECP	To secure elections infrastructure within Pakistan in line with international standards	[1] [2] [3]	1. To upgrade ECP's internal systems 2. To improve existing processes within ECP to support EVMs 3. To develop new supporting infrastructure and policies to support EVMs 4. To develop safeguards against technology failures observed in the past (RTS/RMS) 5. To set up dedicated digital resources within ECP, e.g., datacenters	Survey strategies employed in Brazil, Estonia, India, Australia, etc.	A detailed plan for digital transformation within ECP with milestones and timelines	Help may be sought from government technical bodies, e.g., IT boards, NADRA, etc.	3-5 months (3 months)
7	A Cybersecurity Strategy for ECP	To secure elections infrastructure within Pakistan in line with international standards	[1] [2] [3] [4] [6]	1. To identify international standards for elections systems 2. To incorporate transparency checks 3. To develop appropriate incident response and mitigation strategies 4. To determine relevant organisational-level security certifications	This document directly depends on the Digital Transformation Strategy Survey strategies employed in Brazil, Estonia, India, Australia, etc.	A detailed plan for cybersecurity readiness within ECP with milestones and timelines	1. Ministry of IT&T 2. Ministry of Science and Technology 3. Private sector cybersecurity firms	6-7 months (2 months)
8	Public Engagement	1. Increase the public's trust in elections and educate the voter about election processes and election security 2. Provide oversight and control to the Pakistani society (experts, Civil Society Organisations, activists, voters) to foster social support and trust	[1] [2] [3] [4] [5]	1. Media strategy for public engagement 2. Active voter engagement strategy 3. Strategy for public oversight 4. Social involvement strategies to target disinformation 5. Technologist involvement strategies audit source code and system vulnerabilities, hackathons 6. Voter engagement strategies, to improve transparency on election day (e.g., inviting the public to be poll workers) 7. Effective communication plan on election day (e.g., live election portal) 8. Communication strategy for transparency in post-elections processes like audits, election petitions, and dispute resolution	1. A public survey can be administered to identify the perception of electronic voting and ECP's capacity, to identify trustworthy sources of information for different segments of society, and modes of information consumption 2. Comparative analysis of international experience regarding measures taken to a) ensure the e-voting system is transparent and b) determine outreach and education strategies that can be implemented within multiple target groups (e.g, senior voters, disabled voters, women, rural, urban, etc.)	1. Voters have adequate knowledge of how the overall system works 2. Voters comfortable with how to vote 2. Voters understand the reason for the adoption of the technology and the security measures undertaken to ensure the integrity 3. Appropriate response to media or other stakeholders' narrative of the election technology 4. Voter's knowledge of capacity building and other efforts undertaken by the ECP to ensure successful implementation	CSOs, NGOs, and media experts	4 months onwards (ongoing)

Table 4 Roadmap: R&D Cell

Roadmap: R&D Cell								
Key Steps	Document / Activity	Objective(s)	Dependencie	High-Level Goals / Issues to be Addressed	Requirement (s) & Input(s)	Output(s)	ECP's partners	Timeline***
1	Building Linkages and Knowledge Mobilisation	To develop a strong research culture to provide critical support for the election's ecosystem in Pakistan	-	1. To identify and build linkages between research bodies and project partners to address knowledge gaps in Pakistan 2. To conduct symposiums, seminars, and outreach efforts on election technology and policy 3. To conduct hackathons and demos of election technology 4. To build international linkages 5. To foster indigenous expertise in election technology, policy, law, etc.	The R&D Cell should ideally have an Advisory Board comprising local and international experts to advise on these matters 1. Launch research grants programs 2. Organize seminars and symposiums 3. Undertake observation trips to observe foreign elections	1. High-quality research to inform elections policy and address local problems 2. Tech transfer efforts	1. Donor bodies: UNDP, IFES, etc. 2. Research partners – PIDE, HEC, NCCS, MoST, etc. 3. Research-intensive universities 4. Foreign election management bodies	2 months

Table 5 Roadmap: Electronic Voting Machines for Pakistan

Roadmap: Electronic Voting Machines for Pakistan								
Key Steps	Document / Activity	Objective(s)	Dependencies	High-Level Goals / Issues to be Addressed	Requirement(s) & Input(s)	Output(s)	ECP's Partners	Timeline / Duration ***
1	Threat Model for Electronic Voting Machines in Pakistan	Precisely define baseline security requirements for EVMs in Pakistan	-	1. Describe the ecosystem of Pakistan's voting system - list key actors, processes, and data units 2. Describe current threats to the existing voting system 3. What are the key procedural and process inefficiencies and shortcomings? 4. Differentiate between procedural and technological resolutions to these threats 5. What is the feasibility of using EVMs in Pakistan? 6. Is electronic voting at least as reliable and secure as paper-based elections? 7. Is it in compliance with the fundamental principles of elections? 8. Do the benefits of EVMs outweigh the drawbacks? 9. Does the cost-benefit analysis indicate a favourable outcome?	*Stakeholder consensus is essential for this report* 1. An investigation of failures and irregularities in the General Elections of 2013 and 2018 2. Threat models for similar environments, e.g., India/ Bangladesh/ African countries	The study clearly defines the threat model and inefficiencies in the electoral system in Pakistan that will be addressed by EVMs There also needs to be concrete remedial procedures suggested for each of these issues, along with a holistic perspective specifying how they have been handled in other countries	1. Academia 2. Donor bodies 3. Technical bodies, e.g., IT boards, NADRA, etc	2-4 months (3 months)

2	Vulnerability Analysis of MoST EVM	To undertake a rigorous security analysis of the prototype EVMs developed by MosT	[1]	Detailed analysis of prototype machines developed by MoST considering: 1. security properties 2. international best practices 3. suitability for Pakistan 4. cost-benefit analysis 5. It would be instructive to pilot this EVM in small-scale elections, if possible, to assess usability and logistics.	1. Detailed specifications document 2. Details of manufacturing and supply chain	The study gives a complete picture of the pros and cons of MoST EVM	1. Academia 2. Donor bodies 3. Technical bodies, e.g., IT boards, NADRA, etc.	5-6 months (2 months)
3	Vulnerability Analysis of Smartmatic	To undertake a rigorous security analysis of the EVMs acquired from Smartmatic	[1]	Detailed analysis of EVMs acquired by Smartmatic 1. Security properties 2. International best practices 3. Suitability for Pakistan 4. Cost-benefit analysis 5. It would be instructive to pilot this EVM in small-scale elections, if possible, to assess usability and logistics.	1. Detailed specifications document 2. Details of manufacturing and supply chain	The study gives a complete picture of the pros and cons of Smartmatic EVMs	1. Academia 2. Donor bodies 3. Technical bodies, e.g., IT boards, NADRA, etc.	5-6 months (2 months)
4	Comparative Analysis of Popular EVM Models for Pakistan	Detailed comparison of 3 popular EVM types across various metrics to judge suitability for local deployment	[1]	Three popular EVM models for developing countries (India-button-press, Brazil-keypad, Iraq/Philippines-scanning) 1. Investigate security properties and vulnerabilities for each model. 2. Investigate on-ground operational requirements for each EVM model (transport, storage, handling, configuration, maintenance, etc.) 3. Conduct pilots for each model to measure usability. Pilots should be conducted in non-political elections (e.g., organisational polls, trade bodies, bar associations, etc.) Care must be taken to ensure statistically significant results. 4. Formulate dispute-resolution strategies for each model 5. Investigate the legal framework for each model 6. Detailed cost-benefit analysis for each model (including overall costs for logistics, handling, manpower)	The availability of prototypes of each of the machines 1. Specifications documents for each EVM type 2. Security analyses from the research literature 3. Reports from existing pilots and deployments	The study gives stakeholders a comprehensive picture of the pros and cons of each EVM type as well costing figures Existing pilot studies and reports prepared in-house by ECP are typically not of high quality, they lack rigorous security and statistical analysis. It is highly recommended they partner with a research organisation for this exercise or train their staff in the required skills.	1. Academia 2. Donor bodies 3. Technical bodies, e.g., IT boards, NADRA, etc.	7-8 months (2 months)
5	Deployment Study for E2E-V Voting in Pakistan	Investigate and adopt verifiable voting for local deployment	[1] [2] [3] [4]	1. Pilot EVMs with verifiable voting in non-political settings (bar association polls, chambers of commerce, etc.) 2. Investigate on-ground operational requirements 3. Studies to investigate citizen mental models for verifiable voting systems 4. Formulate dispute-resolution strategies	Development of a prototype 1. Develop or procure EVMs with verifiable voting capability specifically for this exercise 2. Prior research work on verifiable voting trials,	Study to examine the feasibility of verifiable voting in a local setting, as well as measure verifiability rates, and check how citizens understand this	1. Academia 2. Donor bodies 3. Technical bodies, e.g., IT boards, NADRA, etc.	6-11 months (6 months)

				5. Investigate the legal framework 6. Trial different technical options for bulletin board - e.g., Internet-based bulletin board, SMS service, etc. 7. Trial different code visualisation options - e.g., alphanumeric text, images, emojis, etc.	measuring verifiability rates, and mental models can help with developing a template for this exercise, but care must be taken to adapt to our ground realities, e.g., language, culture, etc.	technology and derive mental models		
6	Deployment Study for Risk Limiting Audits in Pakistan	Investigate and adapt RLAs for local deployment	[1] [2] [3] [4]	1. Pilot RLAs in existing polls (by-elections, LG polls, etc.) - multiple pilots for different RLA methodologies 2. Investigate on-ground operational requirements 3. Studies to investigate citizen mental models for RLAs 4. Formulate dispute-resolution strategies 5. Investigate the legal framework	Personnel will have to be trained to run RLAs and E2E-V Voting systems. 1. RLA-based research literature 2. RLA schemes proposed for Indian EVMs	1. Document that serves as a guide for RLA inclusion in the electoral framework 2. Practical guide on how to conduct RLA	1. Academia	6-11 months (6 months)
7	Voter Verification Mechanisms	Feasibility study of various options (biometrics, smart cards, CV techniques)	[1] [2] [3] [4]	What are the false acceptance and false rejection rates of each of the voter verification technologies? How do these vary for the population of Pakistan? What is the relative cost of each of the options for voter	1. Specifications documents for each voter verification mechanism 2. Security analyses from the research literature 3. Reports from existing pilots and deployments 4. There is extensive literature that explores access controls such as biometrics, smart cards, tokens etc	The study gives stakeholders a comprehensive picture of the pros and cons of each voter verification mechanism as well costing figures	1. Academia 2. Donor bodies 3. Technical bodies, e.g., IT boards, NADRA, etc.	6-8 months (3 months)
8	EVMs in Pakistan: Specifications and Requirements	Define technical and functional specifications and processes for EVMs to be deployed in Pakistan	[1] [2] [3] [4] [5] [6] [7]	This phase describes the proposed EVM 1. Map security properties of EVM to threat model [1] 2. Describe detailed technical and functional specifications of the proposed EVM 3. Describe workflow and processes for deployment and elections 4. Describe workflow and processes for storage, maintenance, and handling 5. Describe security checks and audit processes 6. Include measures to incorporate future technology (e.g., citizen smart cards) 7. Describe RLA and verification processes 8. Propose dispute resolution strategies 9. Propose changes to the legal framework	Stakeholder consensus is essential for this report 1. [1] [2] [3] [4] 2. Research Literature	First iteration on technical Specifications including functional requirements, non-functional requirements hardware and software requirements This documentation must be of high quality and conform to appropriate international standards for technical documentation	1. Research-intensive organisations (e.g., universities) 2. technical organisations with small-scale manufacturing capability (e.g., NIE)	12-13 months (2 months)

9	Prototype EVM	Develop prototype EVM	[1] [2] [3] [4] [5] [6] [7]	Develop prototype EVM for pilot purposes and also address further questions: 1. Derive precise costing figures for manufacturing/procuring EVMs 2. Document production supply chain and procurement/manufacturing processes 3. Are there security threats in the supply chain? 3. Can the EVM design be modified to further improve security and/or reduce costs without impacting functionality? 4. Devise adequate Quality Assurance checks and processes	[1] [2] [3] [4] Research Literature	A report evaluating the prototype and whether the goals were met or not	1. Research-intensive organisations (e.g., universities) 2. technical organisations with small-scale manufacturing capability (e.g. NIE)	14-16 months (3 months)
10	Pilot Studies	Conduct multiple pilots using new EVMs	[1] [2] [3] [4] [5] [6] [7] [8] [9]	Pilot the proposed EVM in non-political and political settings: 1. Collect feedback on usability 2. Record the performance of these machines in the field 3. Observe process flow and procedures to propose improvements 4. Modify EVMs or processes in response to feedback from 1, 2, 3 5. Undertake multiple pilots in rural and urban areas to derive statistically significant results which reflect Pakistan's diverse population.	Stakeholders must be regularly briefed about the outcomes of these trials, ideally at every iteration. The pilot must be evaluated on multiple dimensions such as technical, social, legal, usability, and process efficiency. For this formal observation of the pilots is necessary, so that by the end there is enough data to decide on the outcome	Series of pilot processes to fine-tune EVM design and workflow and operational procedures for the field	-	16-18 months (3 months)
11	Feedback and Improvement	Incorporate changes to rectify the issues identified in the EVMs in the first pilot before going into production	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10]	1. What were the limitations and weaknesses evident in the electronic voting machine and associated processes? 2. What was the end users, i.e., the voters' perspective?	A survey consisting of diverse stakeholders, a public call for comments, engaging with academia, media and collecting as much feedback as possible	A document that defines the changes that need to be made in the EVM to overcome the issues faced in the first pilot	1. Research-intensive organisations (e.g., universities) 2. Technical organisations with small-scale manufacturing capability (e.g., NIE)	18-19 months (2 months)
12	Second Round of Pilots	To iron out any remaining issues after the first round of improvements made according to the feedback received	[1] [2] [3] [4] [5] [6] [7]	1. What are the remaining limitations, and weaknesses in the system? 2. Do we need to go for another round of changes in specifications?	Stakeholders must be regularly briefed about the outcomes of these trials, ideally at every iteration changes made,	Series of pilot processes to fine-tune EVM design and workflow and operational procedures for the field	-	20-21 months (2 months)

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			[8] [9] [10] [11]	3. What are the outstanding challenges that can be left for the next iteration	further observation from the second pilot	A report evaluating the prototype and whether the goals were met or not		
13	The second round of feedback and Improvement	Incorporate changes to rectify the issues identified in the EVMs in the second pilot before going into production	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12]	1. What were the limitations and weaknesses evident in the electronic voting machine and associated processes? 2. What were the end user, i.e., the voters' perspectives?	A survey consisting of diverse stakeholders, a public call for comments, engaging with academia, media and collecting as much feedback as possible	A document that defines the changes that need to be made in the EVM to overcome the issues faced in the first pilot	1. Research-intensive organisations (e.g., universities) 2. technical organisations with small-scale manufacturing capability (e.g., NIE)	22-23 months (2 months)
14	Hackathons Source code review	To gain public trust Identify security loopholes	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13]	Has the EVM been subjected to scrutiny by the public, technologists, and international experts?	EVM prototype	Possibility of EVM being hacked and new security issues and bugs identified	Media, Election Observer Groups	16-17 months 20-21 months (2 months each)
15	Election System Certification	Election System Verification	[1] to [14]	Under what parameters were the Security Claims Validation, Testing Rules Determination, and System Audit, Compliance and Certification performed?	Finalised Electronic Voting Machine	Approval of statutory body that machine is fit to be deployed	-	22-24 months (3 months)
16	Procurement	Tendering and Production	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15]	Has the tendering process occurred according to rules and regulations? How to avoid vendor dependence and lock in? Should there be a single vendor or multiple vendors? What are the evaluation parameters to vet the vendor? How to vet the supply chain of the vendor? How do we ensure production in the stipulated time? Who will perform the quality checking? Who will perform a third-party audit? Does the ECP send its technical team to the vendor to oversee the manufacturing process? What happens if the vendor fails to deliver the machines in the stipulated time?	Call for Tender	Delivery of EVMs	Vendor	24-42 months (18 months)

17	System Integration	To ensure the different components (RTS, RMS, Voter Verification, ECP Management Portal) of the election systems function together seamlessly and satisfy the design properties and characteristics of the system	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15]	Are the different components of the ecosystem compatible with each other? Does the system work together as a whole without technical glitches? Have some mock elections been conducted to simulate an election day exercise? Are the interfaces of a component of a system in conflict with another? does the integration of a system create any new security loopholes?	RTS, RMS, EVMs, Voter Verification Module, ECP Election Management Portal, Voter Rolls	The end-to-End running electronic voting system	1. Research-intensive organisations (e.g., universities) 2. technical organisations with small-scale manufacturing capability (e.g., NIE)	24-26 months (3 months)
18	Infrastructure, Operations and Logistics	To ensure adequate infrastructure, logistics, and operational support are available to make the EVM deployment a success	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15]	How have internal regulations been changed to cater to EVMs? What are the methods to ensure inventory control of EVMs? How is it ensured that machines remain functional, and have not been tampered with? What are the protocols for the movement and transport of EVMs? What training programs are to be undertaken for the Election officials? What are the long-term goals in terms of improving infrastructure and communication support? Have the ownership, roles and responsibilities been defined? what measures have been taken for the physical security of assets? Are there adequate disaster management and recovery protocols in place?	A comprehensive and holistic guide to the electoral lifecycle with the introduction of EVMs that details when they will be procured, stored, and used.	A handbook of policies, procedures, guidelines, and internal regulations by which election officials can operate and be held accountable	Law Enforcement Agencies	24-29 months (6 months)
19	Updating Legal Framework	Identify and Outline: 1. the enabling legislative amendments 2. key elements of regulations governing the details of the e-voting system	[1] [2] [3] [4]	Identify legislative, regulatory and procedural elements pertaining to the electoral system, including, but not limited to: - Authority for elections authorities to create procedures for electronic voting - Physical aspects of the electronic voting system - Provisions for trials, pilots, and certification - Audit requirements before and after the election - Provisions for scrutineers	Stakeholder consensus is necessary 1. Analyze and define the allowances and limitations of the current legislation and regulation with respect to electronic voting 2. What aspects need to be defined in the legislative and regulatory environment that	Effective Legal Framework to oversee Electronic Voting Machines based elections	Election Law Experts, Election Observation Bodies	22 months onwards (ongoing)

				- Means of authenticating/ identifying voter - Procedural requirements on election day(vote invalidity, vote count, etc.) - Dispute resolution mechanisms and training of judiciary - Anti-corruption legislation for electoral staff - Defining Admissible evidence - Access to source code - Data governance, ownership, security, storage and retention - Transparency - Electronic voting offences and related law enforcement - Communication with stakeholders - Provisions and protocols for election observation	will ensure the validity of the election results 3. Comparative study of e-voting elements in enabling legislation and regulations in other countries			
20	Monitoring, Evaluation, and Innovation	Continue efforts to resolve residual issues To ensure continued electoral innovation and avoid stagnation	[1] to [19]	What are the unresolved issues? What is the latest research in terms of technology that needs to be studied to be able to incorporate into the system	The feedback from real election deployments, voters, media, election observers and judiciary	Upgraded system based on the feedback received	1. Academia 2. Donor bodies 3. Technical bodies, e.g., IT boards, NADRA, etc.	30 months onwards

*Many of these activities are independent of each other and may be undertaken in parallel as denoted in the timeline.
**This depends on the availability of qualified personnel in the R&D wing, as well as the resources and facilities available.
***Pilots are subject to scheduling of by-elections

TRANSFORMING PUBLIC SECTOR THROUGH E-GOVERNANCE: A CASE STUDY OF KHYBER PAKHTUNKHWA

Shagufta Aman

ABSTRACT

Under the motto, 'Technology is Our New Ideology,' Khyber Pakhtunkhwa's two-time elected Pakistan Tehreek-e Insaaf (PTI) provincial government is undertaking several key governance reforms for digitising service delivery in various government departments. Taking the two key departments of education and health as case studies, this research investigates how service delivery is impacted through digitisation, what influences are generated on organisational culture and in what manner it affects citizens' trust in the provincial government. It attempts to do so from the perspective of public service providers, i.e., the bureaucracy and end users, i.e., the public (school and college students and hospital patients). The study employs both qualitative and quantitative methods to reach its findings. The findings of the study suggest that significant digital interventions were made by the provincial government in both education and health sectors; the Covid 19 emergency provided a big push for the digitalisation of government services. These interventions are driven by first, the desire to generate policies based on evidence-based data and second, to optimise the efficiency, transparency and accessibility of public services. Most of the education e-initiatives focus on online admissions, computer labs and smart boards for classroom management, biometric attendances for teachers and students, digitisation of schools and colleges data, dashboard creation to monitor the institutions, NTS computer-based testing for recruitment, e-learning portals and the system of e-transfers. In health, initiatives include disease surveillance and data generation from the field, online access to pathology reports, biometric attendance for para-medical staff, electronic record systems, or the hospital management information system (HMIS), E-Vaccs, telemedicine departments in hospitals and data generation from hospitals and BHUs through the Independent Monitoring Units. The findings of the study suggest that the ICT-induced impacts on service delivery have from a service provider's perception induced greater efficiency, transparency, and accessibility; however, from the end user's perspective, significant constraints remain. The absence of a critical thinking approach behind technology introduction has led to the underperformance of various ICT initiatives. Additionally, there is a propensity of significant groups being left out, either due to the non-availability of resources, such as computers, and the internet, or lack of digital skills and awareness among the end users. The digitisation measures are also steered towards greater government control and less public participation in policy-making, making it as Chadwick and May (2003) suggest a model of managerial government. The findings also suggest that ICT-induced transformations in bureaucracy's organisational culture have led to veiled resistance and scepticism of the ICT-introduced reforms from the service provider's end. The enquiry into how far the ICTs build people's trust in government shows a higher percentage of satisfaction in health digitisation initiatives and comparatively a far lesser proportion of faith in the educational sector digital reforms.

1. INTRODUCTION

Governance in modern times has undergone significant changes in terms of policies and practices, especially those designed to increase citizen participation in broader political processes. The evolution of governance practices in the 20th century and that of the 21st are made possible primarily through growth in modern means of communications and technology. The state today is heavily reliant on information and communication technology (ICT) tools to undertake its responsibilities. This form of governance which relies on electronic communication devices, computers, and the internet to provide services to the people and engage them in the sphere of politics is termed 'e-governance'. The ICT revolution is reshaping the concept of governance in Pakistan, where government bodies, political parties, pressure groups and other institutions are increasingly using the ICTs to engage people in the sphere of politics and governance. The sub-national governments in Pakistan, including the government of Khyber Pakhtunkhwa, are undertaking many e-governance reforms in its various departments, to provide efficient, transparent and inclusive services in the province.

Pakistan was introduced into the e-governance system comparatively late than its regional compatriots. It was in the year 2000 (August) that the government came up with its first 'National IT Policy and Action Plan' for inducting IT tools in government agencies; 2.6 million PKR were allotted in 2001 to promote 'e-governance in the country' (Ghayur, 2006; p. 1016). This was followed by the establishment of the Electronic Government Directorate (EGD) inside the Ministry of Science and Technology for initiating projects and providing guidelines and standards for software development and related infrastructure. By 2005, the 'E-Government Strategy Five Year Plan,' approved by the National E-Government Council (NEGC) provided for introducing e-applications in all government agencies, delivering efficient, cost-effective, e-services to citizens and ensuring transparency and accountability in decision making (Ilyas, 2016: pp. 57-58). Very soon the mantra, 'e-governance for good governance' as the basis for transparent, accountable, efficient and participatory service delivery was getting attention from the policy makers in the field (Ghayur, 2006).

The Pakistan Tehreek-e-Insaaf (PTI) government in Khyber Pakhtunkhwa under its motto 'technology is our new ideology,' claims to take a broader view of e-government to mean not just automation of government departments, but also using technology to provide the public 'a central point of access to government services', thereby placing communities and individuals in 'responsive networks of knowledge, service, trust and accountability' (G of KP DoIT website, n.d). The completed and ongoing e-government projects are focused on creating IT infrastructure and IT training, Online Hospital Management Information System (HMIS), Virtual Teachers for Schools, the establishment of science and computer labs in schools, system analysis and re-engineering programmes for recruitment and promotion in schools (G of KP DoIT 'Completed Projects', n.d.), touch screen computers for learning of sciences subjects (Naveed, November 29, 2016), and the online college admission system for public sector colleges (Mustafa, June 23, 2017). While these digitisation engagements are supposedly enhancing people's trust in government, there is a need to understand how these are improving the efficiency, transparency and inclusivity of services in the province, with what impacts the bureaucratic culture.

2. LITERATURE REVIEW

The use of technology is today seen as an offshoot of direct democracy in politics. The internet provides a timeless and space-less paradigm of politics (Castells, 2000). Many developing countries have embarked upon the journey of e-governance believing that ICT has the power of reshaping governance. As such, technology has been credited with the renewal of democracy and is termed an 'instrument of democratic liberation' (Chadwick and May, 2003; p. 272). The use of the internet as an active agent for participation in the political process has been defended on several counts. The internet provides a medium for participation in the political process, whilst maintaining the secrecy of their private identities; the subjects could otherwise be discriminated against by the state as being incapable of participating in mainstream politics (Smith, 2015). 'Internet subjects' can even challenge the traditional representative democracies, which are subject to the limitations of size, place, and scale. The internet can give more freedom in terms of participation in political debates and decision-making. Andrew Chadwick in his book Internet Politics terms the introduction of ICT in governance as the 'renewal of democracy' and calls it an 'instrument of democratic liberation' (Chadwick, 2006).

A further aspect of ICT in politics is that it has lowered the cost of communication between the government and citizens and revitalised the representative system by opening up channels to those who traditionally were not allowed to participate or had constraints of leaving their homes. Among many other advantages of e-government are enhanced efficiency and competence, saving of time, improved communication and coordination between governments, businesses and citizens, public facilitation through online access to services, greater transparency and more accountability (Joseph, September 2015). However, the meaningful use of the internet and the ICT for democratic governance depends on the ability of the governments to devise and implement appropriate policies for citizens' participation. Some believe that digital government can 'enhance or erode democratic processes', arguing that this will depend not only on the use of the latest technology but also on 'policy choices, management strategies and cultural responses' (Dutton, 1999). The ends for which IT is used and citizens' access to it will determine the influence of technologies in democracy and politics in the real sense (Wilhelm, 2000; p. 149).

Some of the published literature suggests that ICTs can be effectively utilised to enhance the dissemination of information, ameliorate public service delivery, ensure governmental accountability, and bring inclusiveness in terms of citizens' participation in governance, thereby enhancing the citizens' trust and confidence in the government (OECD., 2003; Tsankova, 2010; Bhatnagar, 2014; UNDESA, 2018; Anderson, 2009; and Carlo Bertot et al., 2010). It is assumed that the use of ICT tools in the public sector will enhance efficiency, policy effectiveness and democratic values (OECD, 2003). Here, e-governance is believed to be a 'good management' strategy and a step towards the 'New Public Management' (NPM) process in this information and knowledge society (Tsankova, 2010). Bhatnagar (2014) argues that since governments are the largest providers of information and services to the people, therefore, their outdated methods of service delivery results in corruption and inefficiency. He suggests that well-designed e-governance projects with process reforms that target enhanced transparency and accountability reduce the discretion vested with civil servants and in turn help enhance efficiency and lower corruption (Bhatnagar, 2014; p. 23). As contended by Rana et al., public organisations in democracies are programmed to deliver services to the citizens and the more the level of accountability, the more efficient public service delivery will be (Rana et al., 2019). ICTs are argued to ensure transparency, particularly, by granting the citizens access to crucial policy-related information and allowing them to keep a check on the government. The ICTs encourage citizens' participation in governance through an exchange of knowledge, ideas and experiences between them and the government; in this capacity, e-governance is an enabler for the citizens of a state (UNDESA, 2018, p. 5).

It was more than a decade ago that Thomas Barnebeck Anderson (2009) talked about the introduction of the ICT system in the tax departments of the non-OECD countries aimed at reducing contact between the tax collectors and taxpayers and doing away with the opportunities for pay-offs; findings suggested that the use of ICTs (between 1996 to 2006) did reduce corruption in these countries. Similarly, India's online property record system, the Philippines and Chile's e-procurement systems, the US government websites containing information access to data on government expenditure, and the file tracking systems are all examples of e-government usage for reduced corruption and increased transparency (Bhatnagar, 2003; and Anderson, 2009). Subhash Bhatnagar (2003) argues that ICT initiatives may reduce corruption and ensure transparency by providing information on government rules, citizens' rights, government decisions and actions, and by the monitoring of government actions, spending and evaluation of government performance. However, as argued by scholars, cultural influences can prove a daunting challenge to government openness and the anti-corruption therein (Carlo Bertot et al., 2010). The ICT intervention in transparency is more evident in countries with a tradition of openness. Therefore, it is argued that *'ICTs can be used to promote transparency in cultures that have a tradition of government openness'* (Carlo Bertot et al., 2010; p. 268). Other compatible evidence is more challenging. In a survey conducted on 1,200 government officials across 70 countries on the issue of how digital technology was transforming the public sector operations and service delivery, an overwhelming majority argued about digital interventions having a major impact on the governments, but a clear majority or around three-fourths of the respondents argued that such digital technologies were disrupting the public sector. It is interesting to note that most of these governments where surveys were conducted were in the early stages of this journey. Not to mention the fact that around 70 % of the government officials accepted that they lagged behind the private sector in e-service delivery. The study also indicated two drivers for this transformation: cost and budgetary pressures; and citizens' demands (Eggers and Bellman, 2015).

As identified in the literature, the e-government service delivery initiatives in the developing countries have run into many problems, including the lack of political support, issues of digital divide, deficient human resource, and inadequate infrastructure in Kazakhstan (Bhuiyan, 2010); low levels of awareness, poor quality of information, concerns about security of personal information affecting public intention to use e-government services, fewer technological infrastructures, poor IT literacy, organisational characteristics and collaboration with other organisations in Pakistan (Rehman, Esichaikul & Kamal, 2012; Qaisar & Khan, 2010); high illiteracy rate, a lack of ICT infrastructure, low levels of awareness, funding, and commitment on the part of government officials and leadership in Nepal (Sharma, Bao, & Peng, 2014); the lack of coordination, sparse information sharing, low ICT literacy and e-government awareness in Afghanistan (Samsor, 2021); and deficiency of IT infrastructure, low levels of IT knowledge, and little trust in public data protection and information security in Kuwait (Al-Mutairi, Naser & Fayez, 2018). There is an acknowledgement in the literature that developing countries have suffered from high levels of failure with e-government experiments, especially in the formative stages, which mainly resulted from 'reality gaps' between the 'e-readiness' of government organisations and 'large design' ideas of the governments (Heeks, 2001). Hence, there is an emphasis on building institutional and technological infrastructure, awareness levels and commitment on the part of leaders, as well as the development of adequate human resources and provision of effective legislative support (Heeks, 2001) to make e-government initiatives work without many setbacks and constrictions.

3. RESEARCH SCOPE

Problem Statement

While revolutionary steps in e-governance are being undertaken by the provincial government in Khyber Pakhtunkhwa, there is a need to understand how such e-governance practices in public management are changing bureaucratic culture and ensuring efficient, transparent and inclusive service delivery in the Khyber Pakhtunkhwa province. It is further needed to analyze how far the citizen's trust in government is impacted through digitised service delivery. There is hardly any in-depth academic research on digitalisation's impact on service delivery in Khyber Pakhtunkhwa. This necessitates a thorough investigation of how bureaucratic culture and practices are changing and which problems are limiting the effectiveness of ICT tools of governance. Unless bureaucratic adjustments to technology influences are not researched, it will be difficult to realise the goals of efficient service delivery and grievance redressal, which are the essence of a rational bureaucratic system.

Research Question

How service delivery in education and health is being transformed through ICT interventions in Khyber Pakhtunkhwa?

Research Objectives

- To investigate the use of ICT tools by the Khyber Pakhtunkhwa Government in education and health.
- To explore how far digitisation has impacted the bureaucratic culture by generating efficient, transparent and accessible services.
- To understand how public perception and trust in government is changing with the digitisation of service delivery.

Justification

Digitisation is perceived to enhance the bureaucratic efficiency, accountability, transparency, and accessibility of service provision in Pakistan. The ICT interventions in Khyber Pakhtunkhwa need to be analyzed for the perceived impacts on improved service delivery. Already, International Financial Institutions are emphasising e-governance tools for improved service delivery. For example, the World Bank's report, 'Pakistan@100: Shaping the Future' recommends essential e-governance reforms to ensure citizens' accountability of service providers and e-procurements for transparency and reduced corruption (World Bank, March 18, 2019). For this,

technology holds the key. Health and education are the most essential services, whose transparent provision can improve public perception of the government. Modern economists consider education and health as the keys to improving human capital and increasing the economic output of the nation (Almendarez, 2013). Though Pakistan's public health spending of under 2 % of the budget is very meagre, however, it is believed that the introduction of e-health initiatives at the tertiary and basic levels will produce positive outcomes for ensuring a healthy population (Naseem et al., 2014). Similarly, investment in formal education is seen as an investment in human capital and more worthwhile than the physical capital of a nation (Psacharopoulos & Woodhall, 1985). The issues that keep children out of school in Pakistan including, poverty combined with 'low quality of education, traditional style of teaching and corporal punishment, long distances to schools and high student-teacher ratio' (Aly, Feb 2007, p 36), can be addressed through ICT interventions. ICT interventions are, therefore, crucial for keeping governance malpractices under check and providing efficient, transparent, and inclusive services to all people. The citizen's trust in government is impacted through digitised service delivery, building the foundation of a strong democratic culture

4. METHODOLOGY

Since the research objectives are exploratory and analytical, therefore, a mixed method (MM) of data collection from qualitative as well as quantitative sources were utilised. The research is evidence-based and exploratory because it explores the use of various ICT tools by the Khyber Pakhtunkhwa government for service delivery. It is analytical because such ICT interventions were analysed to understand in what manner service delivery is becoming more efficient, transparent and inclusive and what if any organisational and cultural changes are taking place in the provincial bureaucracy. And by way of extension how far the public trust in the government is changing with ICTs. The basic premise behind using MM research design is that combining more than one type of data source under multiple research phases (Creswell and Plano Clark, 2011, pp. 7-11) provides a fuller understanding of the research problem than a single or mono-method approach (Guest, Greg & Fleming, Paul, 2015; pp. 581-610).

Qualitative Research Methods

Qualitative research methods drew on secondary as well as primary sources. In secondary data, books, journals, reports and newspaper articles, and official documents were accessed, including the Khyber Pakhtunkhwa ICT policies and other related policy outlines. The primary data was collected through qualitative semi-structured in-depth interviews from official respondents (BPS 17 and above executive officers who were involved in policy making and execution) selected through purposive sampling from two sets of government departments. Firstly, from the provincial government, IT-focused departments,[1] including Science and Technology & Information Technology department (ST&IT), Performance Management and Reforms Unit (PMRU), and Khyber Pakhtunkhwa Information Technology Board (KPITB). Secondly, from the provincial government's education and health departments. In education, the Khyber Pakhtunkhwa Elementary and Secondary Education Department (KPESED), Education Monitoring Authority (KPEMA), and Khyber Pakhtunkhwa Higher Education Department (KPHED) and in health, Directorate General Health Services, Health Department, Lady Reading Hospital (MTI), Peshawar and Ayub Teaching Hospital, Abbottabad were targeted for interviews. The reason for choosing education and health departments was that many of the key ICT interventions here are highly publicised by the provincial government. These departments are primary service providers to the people and people's perception and trust in government are most significantly impacted by how these departments perform their functions. Since the goal of qualitative research is the attainment of saturation, therefore around 25 interviews/ FGDs were conducted from the above-mentioned departments. All interviews were audio-recorded with the permission of the respondents except for 3, who did not permit us to audio-record the interviews with them. In these cases, the information was recorded through descriptive field notes. Analysis and synthesis of the interviews helped find further themes/patterns that emerged in participants' experiences and connections between the experiences. See Appendix A for education interview questions and Appendix B for health interview questions arranged thematically. The respondents were also given a consent form (See Appendix C for the Consent Form). See Table 1 for details on research data collection.

[1] The IT departments generate, facilitate, promote and regulate e-government activities in the different government departments at the provincial level.

Table 1: Details of Research Data Collection

Data Collection	Education Department s KPESED & KPHED	Health Department	IT-focused Departments: ST&IT; PMRU; KPITB	Total
Interview	4	7	3	14
FGDs	6	1	4	11
Survey sites	8	2	-	10
Survey respondents	201 (Approx. 100 each from schools and colleges	104	-	305

Quantitative Research Method

For quantitative research, a survey questionnaire was used to collect data from a sample size of 305 respondents. The rationale for choosing a 300-sized sample was to represent in equal numbers the end users from secondary level education (schools), higher level education (colleges), and major tertiary hospitals. The aim was not only to understand the penetration of ICT tools among end users, i.e., students and patients, but to know how far service generation through ICTs had increased citizens' trust in the provincial government. The standard method for learning public perception and thinking is survey research (Morgan, 1997). The survey questionnaire had three parts. Part one related to demographics; part two included questions about access to digital tools, awareness about e-government initiatives, and the use of these initiatives; and part three had a Likert scale section to understand the impacts of ICT tools and citizens' trust in the government. This survey was uploaded on Kobo Toolbox, data generated were processed through the SPSS software and generalisations were derived.

Since the research focused on performance and service delivery through ICTs in 2 critical government departments, therefore the site selections were made keeping in view these service-providing departments. Two major districts of Khyber Pakhtunkhwa, including Peshawar and Abbottabad districts were chosen for data collection. In education, a total of 8 institutions representing secondary and higher secondary (4) and college education (4) were selected from Peshawar and Abbottabad which had the highest enrolments of students. Out of each set of 4 institutions, 2 were boys and 2 represented girls' institutes. Around 25 respondents were chosen from each of the 8 survey sites, bringing the number of total respondents to around 200; around 100 from schools and around the same number from colleges. Systematic random sampling techniques were adopted to select respondents in schools and colleges. In health, one tertiary hospital in Peshawar-Lady Reading Hospital Medical Teaching Institute (LRH-MTI) and one in Abbottabad- Ayub Teaching Hospital (ATH-MTI) were chosen because these provide health care services to thousands of patients daily. A total of 100 surveys were conducted: 50 from each hospital site. The survey respondents were primarily either patients or their relatives who accompanied them to hospitals for seeking medical treatment. In the case of hospitals, the convenience sampling method was used following the Mall Intercept Survey Technique to collect data through face-to-face interaction. The enumerators filled in the questionnaires in Kobo Toolbox software uploaded on tablets.

Theoretical Framework

The literature on digital governance outlines two broad approaches for identifying the relationship between technology and society; Technological Determinism and Social Constructivism/ Social determinism (Winner, 1980; Chadwick, 2006; Johnson & Wetmore, 2009). The technological determinists argue that technology is an autonomous and powerful force, which determines society by producing direct and inalterable social changes. In this argument, technology follows a linear path of progression, uninfluenced and unrestrained by social and political forces and compels people and institutions to behave in certain ways (Johnson & Wetmore, 2009). In the opinion of Langdon Winner, artefacts have political qualities perceived in their specific design, history, use and arrangement, which in turn establishes patterns of power and authority in society (Winner, 1980). *"The things that we call technologies are ways of building order in our world. Many technical devices and systems contain the possibilities for ... ordering human activity... technologies influence how people are going to work, communicate, travel, consume and so forth..."* (Winner, 1980; p127). The social constructivists, on the other hand, contend that

technology does not follow a natural or logical order of progression, rather it is controlled by man. They maintain that society through interest groups, laws, economy and political decisions shapes and controls the design, production, and dissemination of technology; even the users of technology interpret and reinterpret technologies by using them for purposes for which they were not designed (Johnson & Wetmore, 2009). To them, there are different ways in which technology and society are interwoven, for example, technology can be used by employers to subvert the autonomy of employees; it can reinforce or break down racial classiclassification; and can be associated with lofty goals like equity, security and progress (Johnson & Wetmore, 2009).

In another line of argument, Andrew Chadwick contends that sticking to any of the two assumptions or approaches is problematic. He asserts that it is too convenient to assume that the effects of technology on society can be understood just by examining its innate properties. Similarly, it is equally problematic to assume that features of technology have no bearing on how it may be used politically. A more balanced position would be to recognise that technologies have political properties, simultaneously placing their use in the political context (Chadwick, 2006). He examines the influence of communication technologies on power, citizen participation, political parties, pressure groups, democracy, public bureaucracies, social movements, and internet-enabled citizen activism, as well as discusses the issues of governance, political apathy, surveillance, privacy and security. He contends that internet technologies are being used by civil society and governments simultaneously to posit their point of view; the flow of information is quick and cheap but is restricted by government surveillance and public apathy (Chadwick, 2006). Like Winner, who believes that some artefacts are inherently political shaping the patterns of power and authority in society, Chadwick understands new communication technologies as 'political artefacts,' which exist in a political context. He assumes that the 'politicisation of the Net' arises from the nature of the technology itself and that it, in part, structures a society's social and political action (Winner, 1980, p 122; Chadwick, 2006, p 20).

In the realm of e-governance, Andrew Chadwick and Cristopher May (2003) identify three models of e-interaction between states and citizens. The three heuristic models of interaction include the Managerial model, the Consultative model and the Participative model. The Managerial model is characterised by the provision of information to the public more efficiently through the use of ICTs. The Consultative model focuses on communication between citizens and government; particularly, communicating the opinion of citizens to the government directly without involving intermediaries. In the Participative model, the citizens are truly active and participate in government affairs. However, this interaction and participation take place through multiple associations, actors and platforms. Therefore, this is a multi-directional interactive model (Chadwick & May, 2003). By using Chadwick and May's 'Managerial, Consultative or Participative Model of Interaction,' we can develop an understanding of how far participative the practice of e-governance in Khyber Pakhtunkhwa is and to what extent it follows the general path of information dissemination alone and discourages an active engagement of citizens in consultation and participation. For example, the facility of citizens' online complaints can hardly be termed 'consultative', as the public may communicate grievances to the department concerned and give feedback on government response to grievance redressal, however, the aspect of citizen's consultation in making and running the different applications remain absent. Therefore, we come to Chadwick and May's argument that democratic interaction is being sidelined by managerialism.

5. RESEARCH FINDINGS

ICTs in Education and Health: Changing the Face of Service Delivery

All the official respondents from the two Education Departments of KPESED and KPHED and the Health Department and Directorate General of Health Services underscored the importance of ICTs in the light of the necessities of current times and expressed their confidence in the current provincial government possessing enough enthusiasm and innovation to bring ICT induced changes in service delivery. The following major ICT interventions were identified in the education and health sectors through interviews.

Education and Digital Interventions by the Khyber Pakhtunkhwa Government

S #	ICT initiatives in Public Schools/ Colleges	Merit	Beneficiary
1	Biometric attendance system for teachers in 60-70 % of schools	Ensures efficiency and accountability; Teacher attendance improved by 95% To help solve the issue of teacher absenteeism in schools and colleges Introduced in 288 colleges, out of a total of around 300 colleges. Limited to 60-70 % of the schools. The system also extended to all education offices including DEO offices in districts.	Citizens/ Government
2	e-Transfer launched on September 1, 2021	Ensures transparency through zero political interference	Teachers/ Administration
3	NTS for teacher's appointment started in 2013	Ensures transparency through merit-based appointments NTS computer-based testing for the recruitment of teachers was started in 2013. NTS aims at ensuring transparency in the appointment process of the teachers and therefore, such appointments supposedly also ensure meritocracy.	Citizens
4	Online Admission System in colleges- Administered in 303 colleges; The system extended to newly merged districts	Ensures transparency & efficiency. 50,0000 online applications; The system claims to have not only saved the government money on unnecessary printing of prospectus, etc. but also created additional income for other more necessary expenditures required in colleges. Cited as the best project and a success story by officials, the system being also extended to Merged District Colleges in 2020.	Citizens
5	Online Teacher Training Online training for teachers undertaken by KPESE in collaboration with American Board Teaching Certification.	Improves efficiency The HETTA provides mandatory training to college teachers also necessary for their promotions. The Covid emergency transferred their training to online mode, using Zoom. This improved efficiency of teachers training in two ways: first, the institute trained more teachers than it could train physically, i.e., 1800 teachers, which was 6 times greater than in the pre-pandemic era; second, only 45 % of the stipulated 100 % budget for physical training was spent on online one.	Teachers/ Administration
6	Online Teacher's Review Students to participate in online Teacher's Review and complaints system in colleges through the MIS system.	Ensures efficiency and transparency.	Citizens

S #	ICT initiatives in Public Schools/ Colleges	Merit	Beneficiary
7	The file tracking system in HED through HEMIS EMIS was established in 2005 in KPHED. It has automated all official correspondence for rapid information flow and timely decision-making and stores all information regarding colleges, including its staff and other concerned information.	Ensures efficiency. The HEMIS officials noted a 'File Tracking System' already in vogue in the HED, where files are monitored and tracked through a centralised dashboard and the file is disposed of by officers within 7 working days	Administration/ citizens
8	Provision of One Screen Smart Boards in 60-70% of the higher secondary schools Total schools = 767 [Boys = 491 & Girls = 276]. Teachers were given at least a three-time training for using smart boards.	Ensures quality & efficiency in teaching and learning Subject contents in higher secondary schools are placed on a digital platform accessible to teachers and students alike. Officials spoke enthusiastically about smart board technology intervention in schools.	Administration/ citizens
9	Provision of IT labs with IT teachers 60-70% of higher secondary schools have running IT labs; Students are exposed to computer literacy starting from grade 6 and onwards. At the colleges, 492 labs were launched in 303 colleges by the KPHED	Ensures digital skills & quality. The hiring of qualified computer teachers and lab in-charge	Administration/ citizens
10	Early Age Programming and IT Essentials Initiated in 2017, children of government schools learn coding and programming in selected urban schools	Ensures Digital Skills. A 13-year boy from Mansehra won an international award Grade 7 and 9 students taught computer coding in the already established IT labs. In Phase I, 3,000 students learned programming and coding skills in 60 public schools of 14 districts.	Citizens
11	Khyber Pakhtunkhwa Learning Portal-(Digital Learning Platform) by KPESED	Ensures accessibility. The ubiquity of this portal allows access to children living even in the remote regions of the country Encourages students to use digital materials to enhance their knowledge; Teachers and parents can also access this portal. Around 287 animated videos dubbed in Urdu and Pashto for students of Grade 1-10 mostly cover topics related to Math, General Knowledge and Sciences.	Citizens
12	Development of school websites	Ensures accessibility and information. Parents can enter their CNIC, and parents can get information about their child's syllabus, results, teachers etc.	Citizens

S #	ICT initiatives in Public Schools/ Colleges	Merit	Beneficiary
13	KPESE – Virtual Teacher, EMIS An app developed in 2020 with 10,000+instals Virtual teacher Question and answer is a digital avenue website provided on KPE&SE	Ensures efficiency. 'Virtual Teacher Question Answer Forum' on Google Play Store to increase conceptual knowledge of students in Science and Math subjects. The 'KPESE YouTube Channel: Learn Today, Lead Tomorrow' (August 2020) channel was forced out of operation by YouTube because of copyright issues.[2]	Citizens
14	Another app launched in April 2021, KPE&SE HRIS, EMIS is a human resource information system with 100,000+ installs	Ensures better communication. It was a digital platform for human resources of the government departments	Administration
15	Camera scanners on college gates	Ensures security and monitoring; will help to monitor the entry and exit of people.	Citizens
16	Digital Library Colleges connected with HEC digital library	Colleges connected with HEC digital library provide college students access to soft copies of books, journals and other reading material.	Citizens

Several apps were launched by KPESED on Google Play Store in 2020 under different names, including, Books App, Virtual Teacher, HRIS, SQMI, e-Transfer etc. Most of the apps had low app ratings with complaints of the app not working properly, being too sluggish, being time-consuming, non-user interface etc. (see **Appendix D**).

Health and Digital Interventions by the Khyber Pakhtunkhwa Government

S. #	ICT initiatives in Public Tertiary Hospitals	Merit	Beneficiary
1.	Tele-rounding • Initiated during the Covid-19 pandemic, Intensivists from the USA do tele-round of patients in ICU/ check their vitals. They check the patient's pathology & radiology reports /doctor & nurses notes	Quality Health care provision/ Efficiency in Health care	Public and paramedics
2.	Tele-medicine • Initiated during the Covid-19 pandemic, the creation of a telemedicine dept. inside LRH • Linking doctors & psychologists with patients through video links • Emergency services through phone Prescriptions on WhatsApp	Quality Health care provision/ Efficiency and accessibility in Health care provision, especially during a pandemic	Public & paramedics
3.	Sehat card Plus program -a health insurance card (collaboration of KP Government, State life cooperation of Pakistan and the German KFW Bank) • Free in-patient health care facility provided to 7.2 million families in KP • Maximum limit of 1.0 million per family per year	Inclusivity and Accessibility for all	Public

[2] The click on the webpage redirects to the YouTube page where it is mentioned that this account was terminated because of multiple third-party claims of copyright infringement regarding material on the website. See (https://www.youtube.com/channel/UCiHheDKhebGDZv51eGEjGbQ).

S. #	ICT initiatives in Public Tertiary Hospitals	Merit	Beneficiary
	• The annual cost of the programme billion Around 520 public and private hospitals are contracted across KP to provide healthcare facilities		
4.	Sehat Sahulat mobile application • Access to all contracted hospitals near the patient • Provides treatment history Patients can send their Health-related complaints	Accessibility issues addressed	Public
5	Lodging online complaints of panelled hospitals; Sehat card plus hospital complaints can be lodged on the Khyber Pakhtunkhwa Health Department website	Accountability & Transparency	Public
6	Free corona testing at Call 1700 for citizens	Efficiency and Accessibility	Public
7	Android Tablets in BHUs • 1000 android tablets to be installed in BHUs • Regular surveillance updates of diseases Development of a unified dashboard, reporting on all kinds of diseases	Efficiency	Health Administration
8	District Health Information System (DHIS) • DHIS is an open-source software platform for reporting, analysis and dissemination of data for all health program • DHIS - 2 will address the issue of constant surveillance of diseases 43 diseases selected as "priority diseases"	Efficiency, prompt response to disease outbreaks	Health department
9	Electronic Record System in tertiary hospitals • The online file of a patient but only accessible to doctors No networking with other hospitals	Efficiency	Doctors and patients
10	Health Management Information System- HMIS - Paperless system • Online pathology reports • Filmless radiology • Repository of record of patients • hospital financial records • Digitised HR & procurement system • Death & Birth certificates issued online Online doctor's appointment for Inpatient care (not available for OPD)	Cost Efficiency, time-saving, resource-saving, transparency, ease of service accessibility, online accessibility of services to patients and citizens	Administration & public
11	IMU - KP became the first province to establish an Independent Monitoring Unit (IMU) under the Health Department in 2016 • to collect and share health data, • monitor the performance of public sector health facilities and Share the information with the public through its website	Transparency, Efficiency in decision making	Administration & Public
12	IMU Health KP (Health and Fitness App) IMU Health KP App available on the Google play store has been launched by KPITB in 2019 with 100+ installs	Accessibility and inclusivity	Public

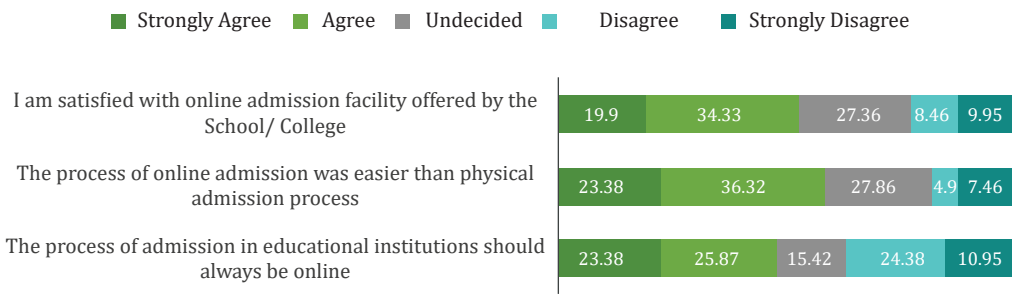
Transforming Public Service Delivery in Education and Health: 'Is Technology the Silver Bullet?'

ICTs & Efficiency in Service Delivery
'Efficiency is the hallmark of Bureaucracy' (Max Weber)

The education and health department officials spoke enthusiastically about ICTs improving the efficiency of service generation. In education, it was argued that ICTs improved the standard of education in government schools, with some designating the digitisation programme as primarily an 'efficiency programme'. They argued ICTs to be 'good management tools' which allowed them to continue official correspondence and coordination in off timings too. Since human interventions in official working had been reduced and human discretion could, therefore, be avoided in official businesses (KPE&SED and KPHED officials). This ensured quick disposal of work. The officials saw digitisation as improving the efficiency of their department's functioning in terms of time-saving and speedy disposal of work. One example here was the HEMIS in the HED, which was established in 2005 had automated all official correspondence for rapid information flow and timely decision making; it also stored all information regarding colleges, including the staff and is tasked with the completion of a file tracking system (KPHED officials). However, there was also the backup of all the information on paper. In the context of a well-developed Learning and Management System (LMS), for increasing student-teacher e-learning and interaction capacities and online classes, especially in the pandemic times through Zoom and Google Meet, it came to light that the system was not well developed enough to enable college teachers to upload presentations etc., for students access; or manage attendance of students online, reflected on a dashboard; however, tenders for a well-developed LMS system were reportedly underway. Other ICT initiatives praised by the officials for improving public sector education provision included the smart board technology in schools, the computer labs and IT experts in schools and colleges, the appointment of school teachers through computer-based NTS tests, teachers online training, digital learning portals for schools, biometric attendance for teachers and online admissions for colleges (Education Department Officials).

If we look at the efficiency-related claims of the education department officials and try to compare them with the responses from the end users, we realise that survey results indicate some digital interventions to be incredibly popular, probably because they are now mandatory, for example, the online admission system for colleges. Around 55 % students of the students showed their satisfaction and 60 % thought of it to be easier than physical admission (Figure 1).

Figure 1: Student's Satisfaction Level with Online Admission System



Similarly, other steps such as computer education in schools and colleges elicited a higher response of around 58 % receiving some computer exposure in schools and colleges. The computer skills learned in these classes included MS Word (44%), MS Excel (22%), and computer programming (16%) (Figure 2). However, an alarming number of students (41.29%) stated that they learned no skills, which suggests a less meaningful exposure to computer literacy in schools and colleges. Additionally, only around 50% expressed satisfaction with the infrastructure in computer labs (Figure 3).

Figure 2: Student's Response to Skills gained from Computer Classes

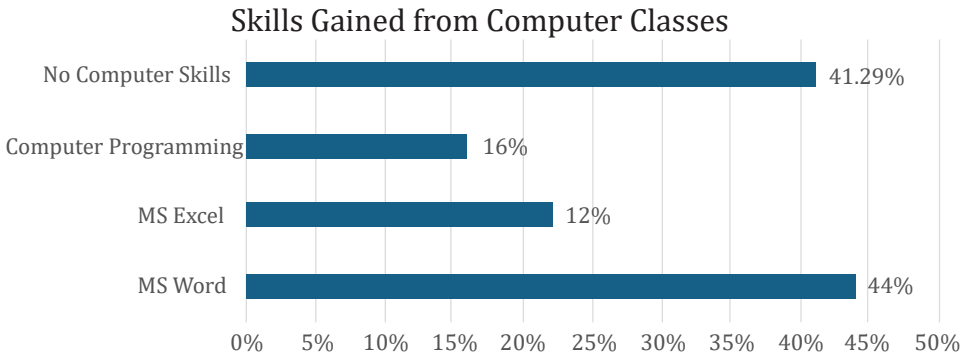
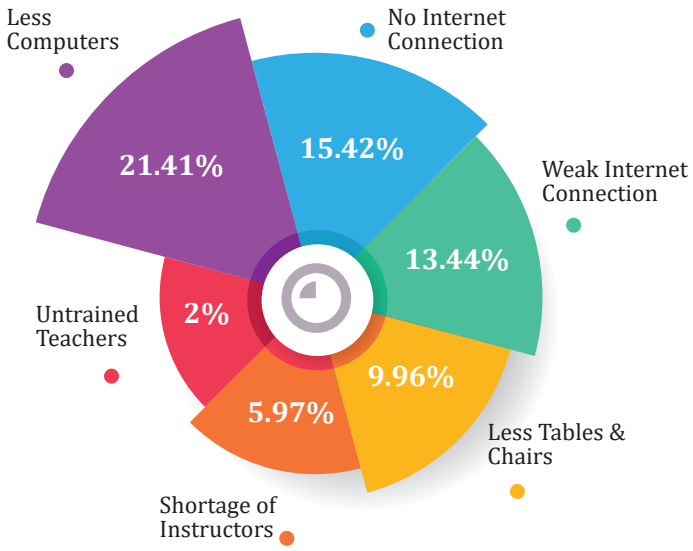


Figure 3: Deficiencies in the IT Lab pointed out by Students



For most other digital interventions, unfortunately, the survey response from the end users was not very encouraging, for example, in the case of smart boards, a staggering 80 % of students said they were not taught regularly on them (Figure 4) and a majority of 55 % also showed a likeness for conventional white boards for learning purposes (Figure 5). This is despite the great emphasis from officials, it was also reported from other sources that around 70% of smart boards installed in schools were not being used by the teachers; the reason being a limited two-day training could not give them enough expertise or enthusiasm to handle such boards for undertaking successful teaching (Ashfaq, September 5, 2016).

Figure 4: Smart Boards and Student Learning

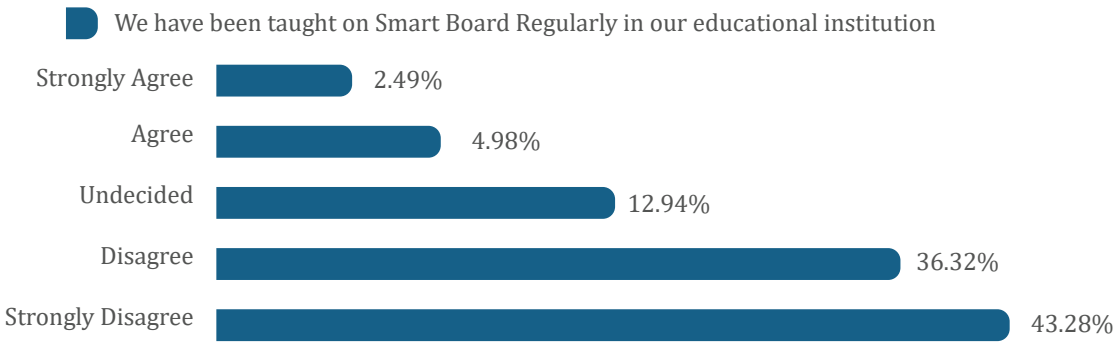
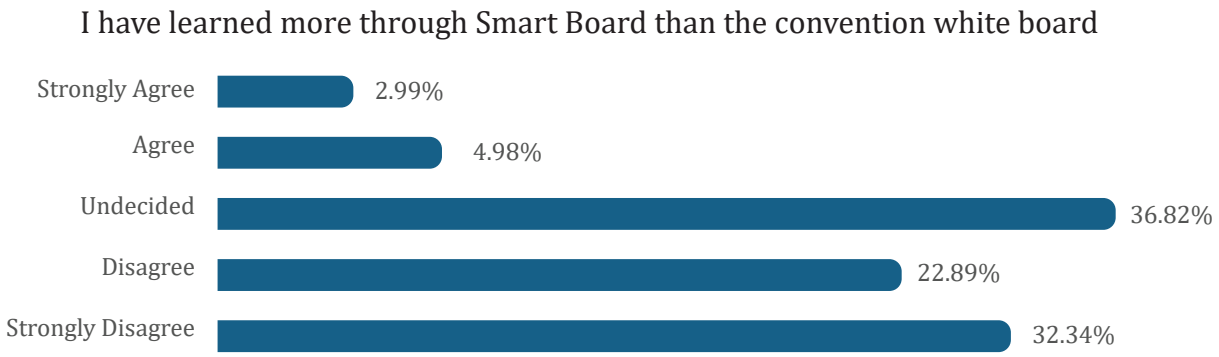
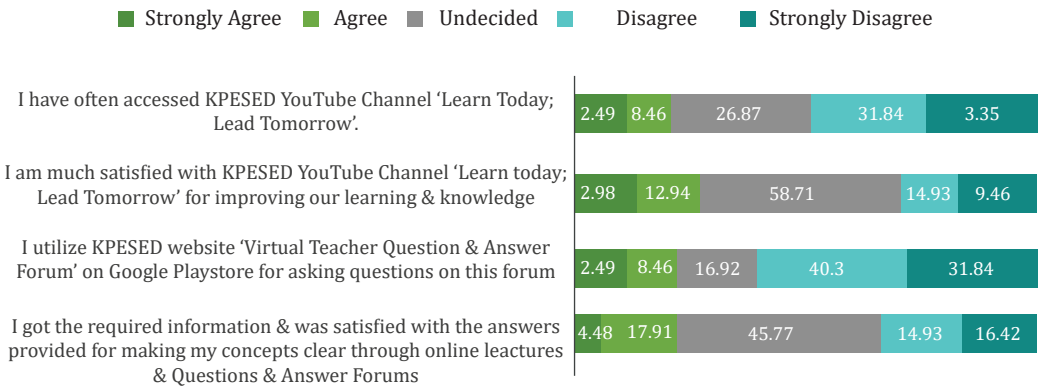


Figure 5: Student's survey response to Smart Board and Learning



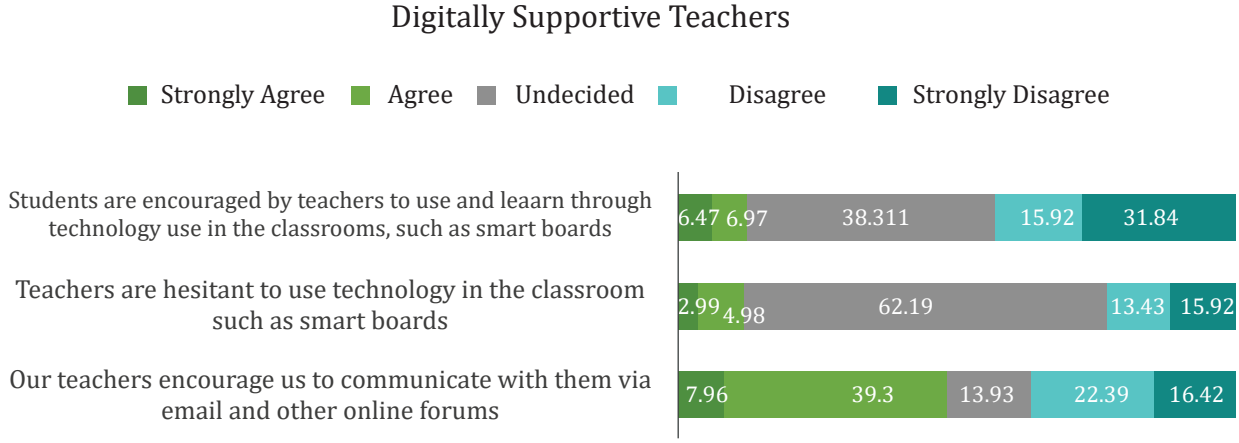
Another dismal performance area is that of digital learning platforms. The results of the surveys show that there was a lack of awareness about the online digital e-education programmes among most students (see Figure 6).

Figure 6: Students' response to Digital Learning Programs



It is the entwined forces of teachers, students and the school environment that can help produce digitally supportive schools and colleges. However, if the teachers are hesitant to use technology in the classroom (such as smart boards), then the students will also lack the confidence to use technology. A large percentage of students (62%) remained undecided over their teacher's reluctance to use technology (Figure 7). This is probably because around the same number earlier did not have exposure to smart board teaching technology.

Figure 7: Student's Response on Whether the Teachers Were Digitally Supportive or Not

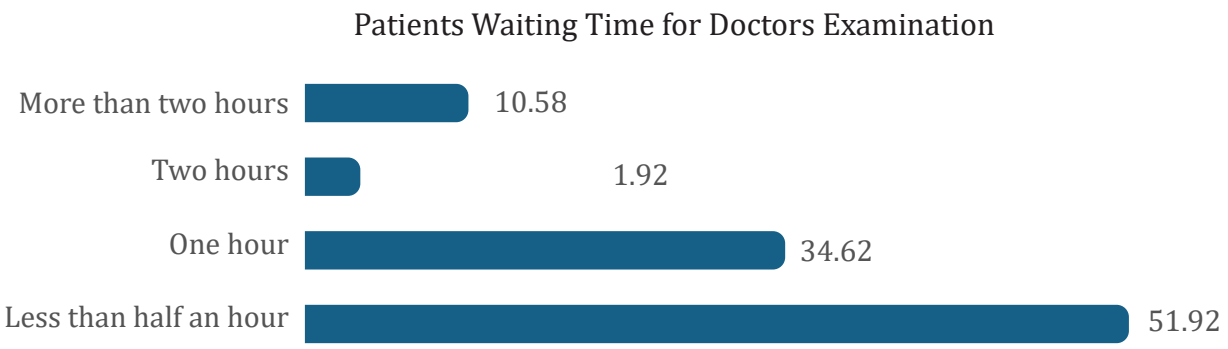


In the realm of health services generation too, digitisation was argued to have brought greater efficiency in the working of the hospitals and the health department's response to disease emergencies. The bureaucracy reported the use of real-time data on Covid through the ICTs speeded up the process of decision-making in the health department. Efficiency is also seen in the timely and effective response to disease outbreaks by the government. Here the officials made comparisons with the earlier manual data entry practice and the resultant belated government response. The ICTs helped identify health emergencies due to real-time data reporting; made mandatory for doctors to report within 24 hours of the spread of different infectious diseases. Digitisation saved the costs incurred on X-RayY printing and multiple visits in case of non-accurate scanning, saving patients from harmful radiation exposure. Similarly, the radiology report as soon as it goes through a C.T. scan can be viewed by the consultants; thus, time wastage is avoided. Only X-Rays were not directly uploaded, only when required, which again saves time and film costs; this also ensured the element of accuracy and digital X-Rays could also be zoomed in on the screen to help reach a correct diagnosis.

The IT officials in hospitals reported productivity of teamwork improved especially in the public sector hospitals as a result of IT interventions. The DHIS official also informed us about making key performance indicators to measure the efficiency of different hospitals in the province; these performance indicators displayed on the dashboard could be monitored to understand how hospitals were performing. However, reservations were expressed about the electronic monitoring system of diseases (primarily run by the Health Department) for not being very successful due to the wastage of resources on separate reporting and indicators of different diseases, which necessitated the appointment of multiple programme coordinators (Health Department Officials). There was also stress that such efficiency is generated when there is effective monitoring and reporting on ICT tools usage and the tendency to reprimand and punish those who are not effectively utilising the same (Health Department Officials)

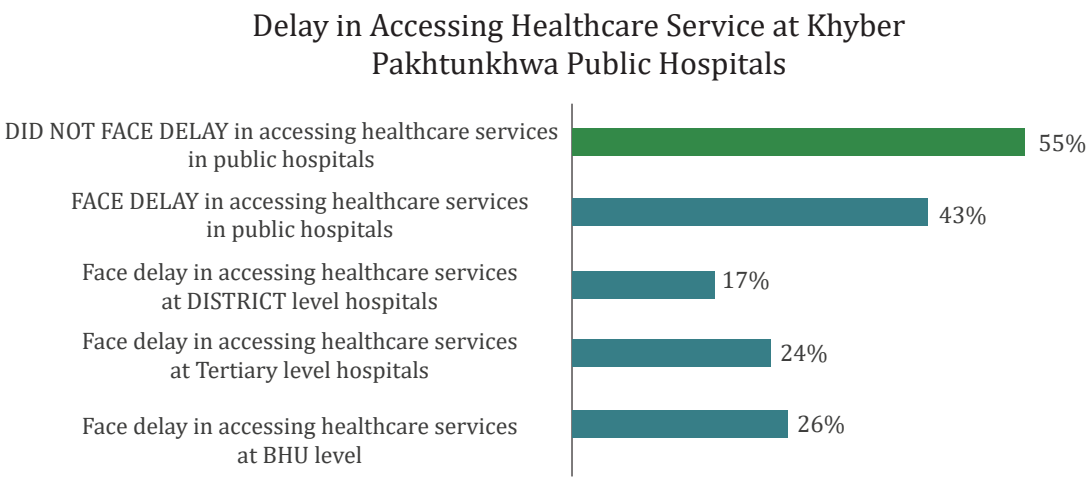
The IT tools reportedly were making health service generation in hospitals faster. However, despite the promise of efficiency, the survey results from end users show that, on average, 48% of the patients had to wait for an hour or more to be examined by the doctor after taking the slip (parchi) for OPD services (see Figure 8).

Figure 8: Survey response showing patient's waiting for doctor's examination



When patients were asked if they faced a delay in accessing healthcare services in the Khyber Pakhtunkhwa public hospitals, around 43% reported that they faced a delay of some sort in accessing healthcare services at different levels of government healthcare facilities (Figure 9).

Figure 9: Patients' response to delays faced in accessing healthcare services in public hospitals in Khyber Pakhtunkhwa



ICTs and Transparency in Service Generation

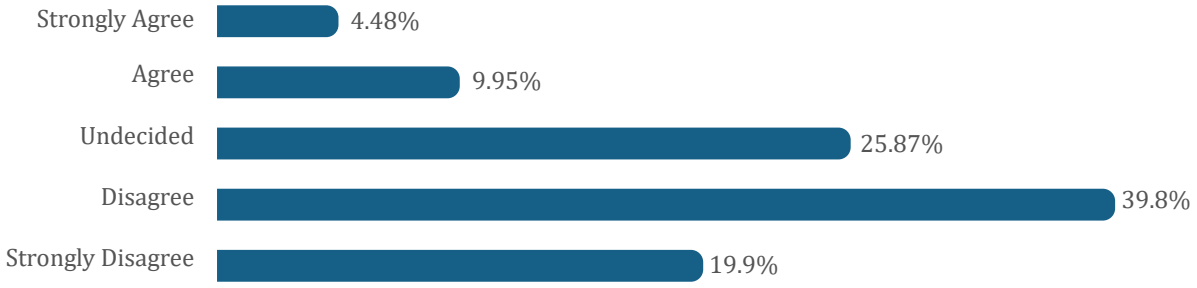
Access to information and transparency is one of the themes of digital government and researchers agree that in the information society of today, governance involves critical aspects of how information is collected, analysed, used, and disseminated (Dawes, 2009; Scholl, 2006 & 2014). Internet portals of the government institutions help reduce perceptions of corruption against the government and its institutions (Garcia-Murillo, 2013) and government institutions' strong web presence also ensures transparency and citizen participation (Jones, 2011). In the realm of transparency and accessibility to data in education as well as health, most of the data and information available on the KPHED as well as the KPESED website is outdated, dating back several years, which shows a clear failure to provide up-to-date information to the citizens frequently. This is also true for the health department as well as the teaching hospitals and other levels of hospitals and BHUs lacking well-developed and interactive websites with related information.

In the realm of transparency in education, one of the most recently introduced (September 2021) digital interventions is that of 'e-transfers;' with claims to 'revolutionise teacher transfers,' pave the way for quality learning, and ensure zero political interference in postings and transfers of school and college teachers. It is also publicised as a grievance redressal mechanism for teachers to submit their grievances online (KPESE Department GoKP, n.d.). The officials from education talked in length about the biometric attendance system for teachers introduced in around 288 colleges (out of 313) and around 60-70 % of the schools. All education offices including DEO offices in districts also reportedly had bio-metric attendance systems. Official interviews confirmed that biometric attendance in schools brought down teacher absenteeism; teacher attendance improved by 95%. DEO's regular school visits are uploaded and ranked on District Performance Evaluation Scorecard monitored by the respective secretary and chief secretary. Resultantly, teachers' punctuality improved as a result of reporting real-time data to the DEOs office. Similarly, the employment of school teachers through computer-based National Testing Service (NTS) tests for recruitment in government schools, not only supports the use of technology for employment but also makes the process transparent. The NTS system was claimed by officials to be 100 % transparent, also bringing political interference down to zero (Education Department Officials).

However, a monthly government report from January 2020, declared the performance of teachers, students, and relevant staff in Khyber Pakhtunkhwa's 347 higher secondary schools as well as in district education offices as unsatisfactory and used the term 'very discouraging' for teachers in some schools of district Peshawar, as well as other districts. It was reported that the teachers remained absent from duty after registering their bio-metric attendance (Yousafzai, February 9, 2020). The survey results show that the majority of the students (60%) believe the biometric attendance of the teachers helped solve the issue of teacher absenteeism. However, a small

number of students (26%) were not sure. Add to it those who disagree, and we have around 40% of students who think otherwise (Figure 10).

Figure 10: Biometric Attendance of Teachers and Improvement in Teacher Absenteeism

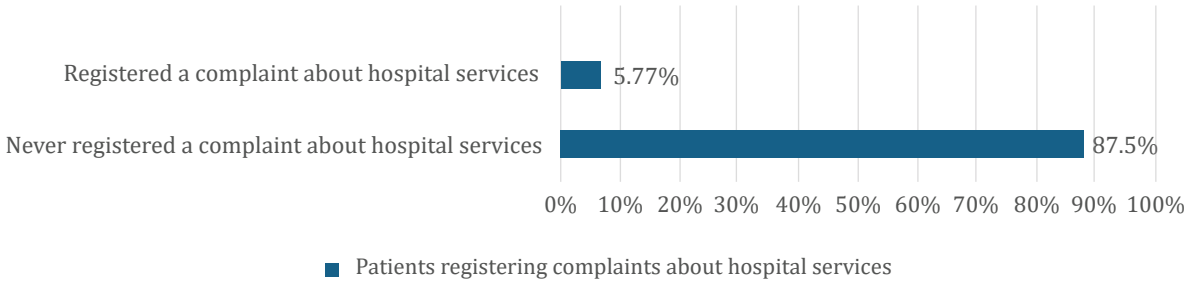


The results generated from the survey further show that a clear majority of 71.15% of students responded as being unaware of any online feedback system for evaluating teacher's performance, nor had they ever given their feedback on teacher's appraisal. Similarly, students also expressed that they were not allowed to give their feedback on the school/college administration performance either (83.58%).

In the domain of digital health and transparency, the officials' reported ICTs were not only improving the quality of health care but also sped up the process of catching leakages within the health system. The biometric attendance of doctors and paramedics was ensuring their timely presence in hospitals. There was the added aspect of service generation becoming more transparent and accountable in hospitals. The IT director of LRH reported that the patient's test result as well as treatment was now time-bound electronically. The X-ray results getting mixed up (this happened in the manual system) was also put to rest with the digital X-ray machine. The system of bar-code which is machine-readable, avoided such errors, resolving issues of 'health data manipulation.' The diagnosis also being more accurate as digital X-rays could now be evaluated by the doctor from close angles through the facility of zooming in. The digitisation of patient record underway in the medical record numbers (MRN) system, will help the government to hold the local BHU responsible for not treating the local patients for simple ailments and forwarding them to big hospitals in cities.

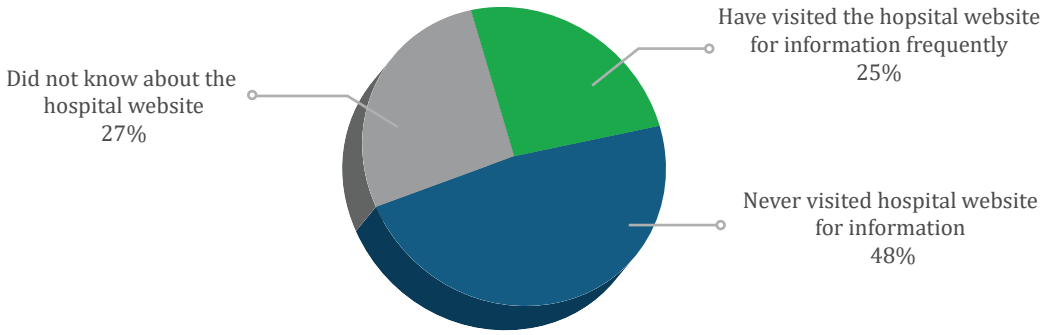
The public tertiary hospitals also ran an online complaint system for patients to record their grievances. However, quantitative survey results indicate that none of the patients accessed the online complaint registration system of the hospitals. The survey respondents when asked if they ever had registered a complaint about the hospital services, 87% of the respondents stated that they never had lodged a complaint about the hospital services. The 5.77% who had registered their complaints had done so by writing to the hospital administration (see Figure 11)

Figure 11: Complaint registration about health services



Even though both the LRH and the ATH hospitals had adequate website presence, which provided ample information about the hospital services, the doctors available in each ward, the number of departments, staff, beds, the OPD timings, Sehat Card Plus services, online doctor's appointment (only in LRH MTI, Peshawar), information about different lab tests and reports available etc., still, 48% of the respondents had never visited the hospital website for any sort of information. Around 26.92% remained undecided implying they did not know about the existence of any hospital website (See Figure 12).

Figure 12: Survey results showing the percentage of patients visiting the hospital website

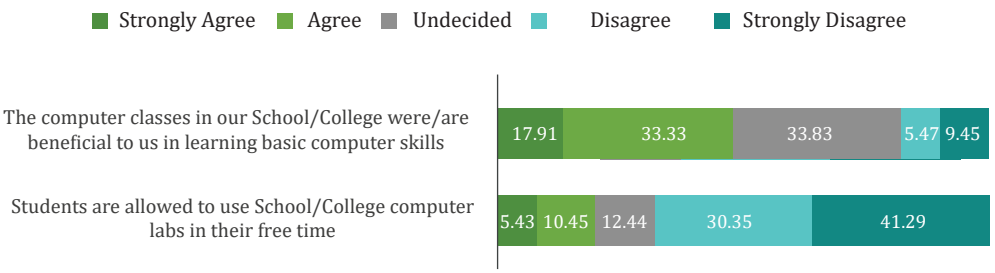


ICTs and Accessibility in Service Generation

Inclusivity through e-education was linked with infrastructure facilities available in schools and colleges and the financial resources available to the parents. The education department officials argued that e-education programmes can improve the quality of education for all only when it is accessible to children. An important aspect of inclusivity was that mostly underprivileged children were studying in public sector schools, which meant that they lacked the resources to afford digital gadgets for utilising online sources of knowledge. Inclusivity is also hindered by around 30 to 40 % of the secondary and higher secondary schools lacking any computer labs and smart boards. The situation for the middle schools is not very encouraging. A 2019 Express Tribune report cites 8,000 middle schools in Khyber Pakhtunkhwa not possessing any IT lab, or IT teachers, despite computers being one of the 9 core subjects there. This meant around 100,000 students in such schools faced such shortages (Haroon, August 17, 2019).

The survey results on accessibility to computer classes show that a majority (58%) conceded to receiving some sort of computer classes at their schools and colleges. Among the group who received computer education, a majority (51.24%) agreed that the computer classes they received in their schools/colleges were beneficial to them in learning basic computer skills. However, around 34% of the students were undecided on the benefits of computer classes and a small number (14.92%) thought computer classes to be ineffectual (see Figure 13). An alarming revelation was that a considerable percentage of students (42%) had never received any kind of computer education at all.

Figure 13: Computer Classes and Student's Accessibility Issues



When students were asked in the survey if they were allowed to use school/college computer labs in their free time, a majority (71.64%) responded in negative and 12.44% were unclear whether their school/college would allow them to use the computer labs when they needed to use it. This shows that our schools/ colleges are quite far away from being 'digitally supportive,' a concept introduced by Wastiau et al., (2013) who argued that state-of-the-art ICT structures along with the opportunity to access it were imperative to help improve digital competencies among students and ensure 'digitally confident students.'

Inside the schools too, certain policies hamper the accessibility of the students to computer education. For example, as suggested by interview respondents, students were exposed to computer literacy from grade 6 (middle schooling) and onwards. On further query, it was revealed that computer science was not compulsory but an optional one left to the choice of students to choose from among Arabic, Pashto and other languages. The officials informed that hardly 15 to 20% of children in public sector schools could benefit from digital education initiatives as a majority of the students came from poor families. A look at the graph (Figure 14), shows the income disparities of children studying in public sector schools and colleges, which in turn leads to disparities in accessing digital devices and tools (Figure 15). The officials rightly argued that unless the end users, i.e., the students in public sector colleges and universities are not facilitated with the provision of cheap internet packages, mobiles, and laptop devices, the students will fall behind in education as compared to the private schools and college students. In a survey done by the HEMIS in colleges to gauge the level of preparedness of students in Khyber Pakhtunkhwa for online classes (availability of 3G 4G services, laptops, etc.), it was revealed that only 5 % could confirm the availability of these facilities.

Figure 14: Average Family/ Guardian Income of students studying in Khyber Pakhtunkhwa Government schools and colleges

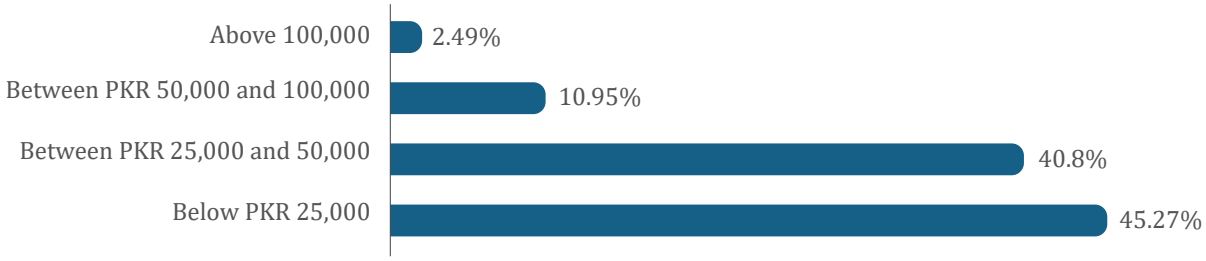
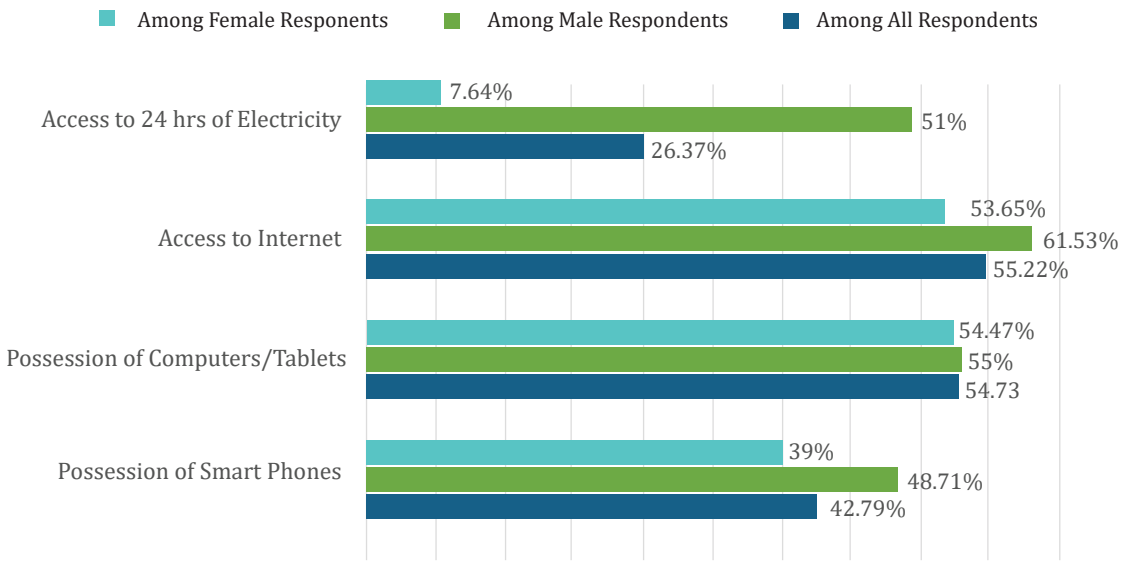


Figure 15: Access to Electronic Devices/ Internet/ Electricity (Students in KP Higher Secondary Schools & Colleges – Peshawar & Abbottabad



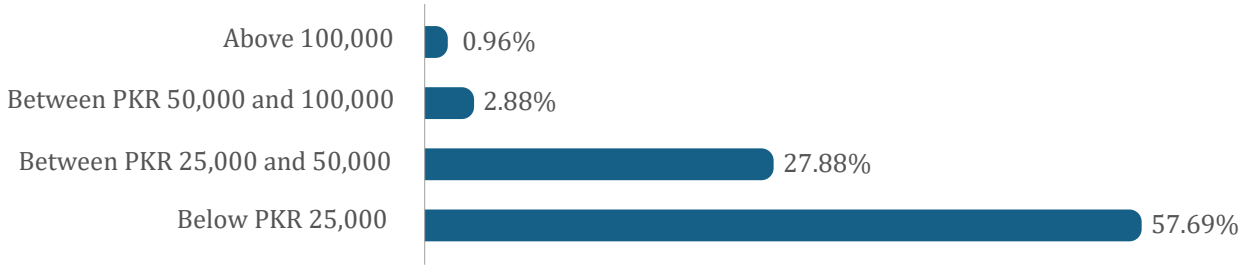
As opposed to the west, where the social structure is there to support digital transformation, Pakistan not only lags in social structures conducive to digital transformation, but the use of the internet and information and communication technologies is also somewhat abstruse. The access of the majority of students in Khyber Pakhtunkhwa schools and colleges to the internet (55.22%), as shown by the survey data, displays the fast diffusion of internet among the Generation Z (Figure 15). However, this increasing internet penetration does not promise transformation in the real sense, and neither does it closes the gap of the digital divide among the different social groups. The females have even lesser access to digital devices and internet connections. The accessibility issues are correlated with the use of online forums by students to communicate with their teachers. The majority of the students (64%) agreed to have used some form of an online forum to communicate with their teachers and the most widely used was WhatsApp (65%) (Figure 16). However, around 34% of the students had never used any online means to access their teachers. This is despite around 43 % possessing smartphones and 55 % having either computers or tablets.

Figure 16: Online Forums of communications between teachers and students in public schools and colleges

The overarching dependence of teachers and students on WhatsApp to deliver lectures and communicate shows the low level of teachers' and students' confidence in their digital competencies and the inability to use more formal means of communication and lecture-delivering forums such as Zoom, Google Classroom, etc. It also indicates the incapacity of the school/ college strategies to support ICT integration in teaching and learning that was promised by the education department officials through the introduction of the LMS in schools and colleges.

In digital health and accessibility, officials argued that the very fact that the government charged just Rs. 20 as token money for OPD services in public hospitals is a pro-poor policy that increased poor patients' accessibility to these hospitals. The quantitative survey analysis brings home the point that the public hospitals are visited by mostly very poor patients with a majority (57.69%) having an average income of less than Rs. 25,000 (see Figure 17)

Figure 17: Average Income of patients visiting Khyber Pakhtunkhwa Government Public Hospitals

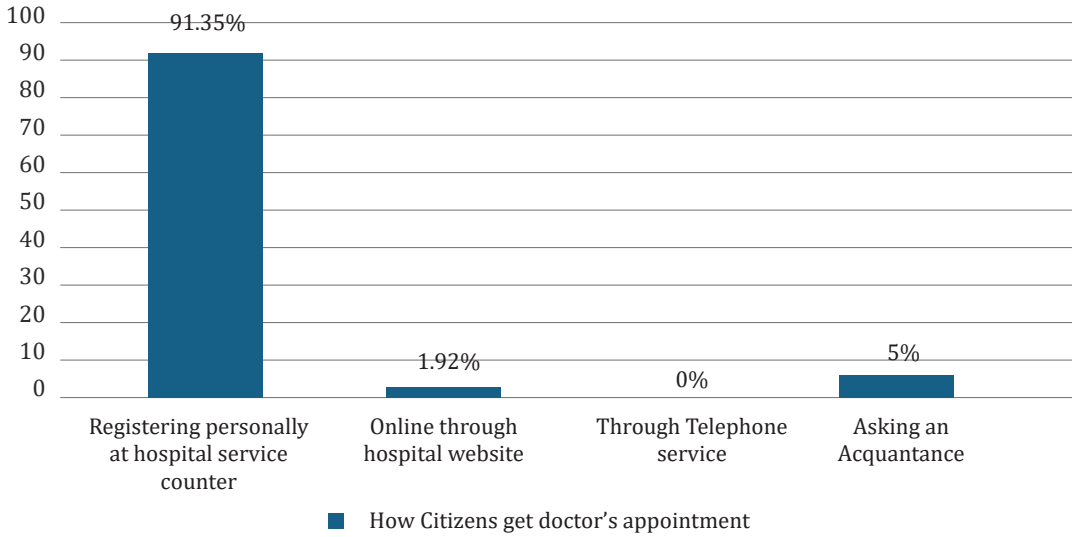


Accessibility (in terms of expenses) of poor patients was further increased with the lower cost of tests, resulting from the digitisation of films in radiology. The inclusivity issue was somewhat addressed through the government's 'Sehat Sahulat Card' that made health care affordable for patients by providing support to health care expenses of patients in hospitals that were near to their places, which also prevented overcrowding in main

hospitals in cities. According to officials, health care was becoming more inclusive and accessible through online services, such as online doctor appointment facilities and patient access to medical data online. It was revealed that the patient had only access to his pathology reports, which he could download at his convenience in his home (Health Department Officials).

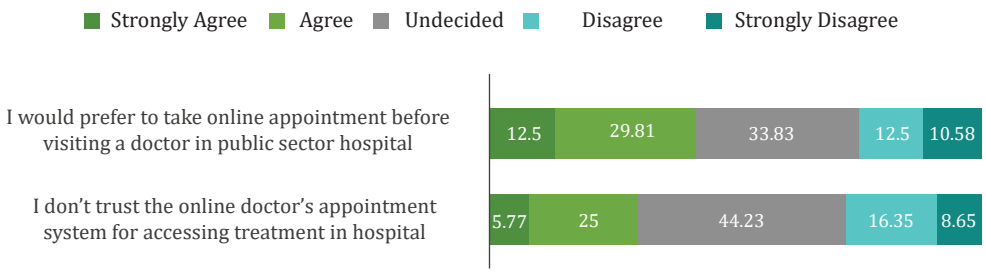
However, the patient's use of ICT tools for health services was hampered by traditional ways of accessing health care services. The patients, as argued by the health officials, still preferred to access health care in public sector hospitals physically, because of the existing culture of in-person visits to hospitals and because of their low educational levels, which hampered knowledge of and usage of ICT tools. The survey outcomes also showed that the majority of patients accessed the doctors through forums other than online. This was also because the online doctor's appointment option on the hospital website is meant for the inpatient department (IPD) and it was not functioning for OPDs conducted in the morning. The online appointment system is available only for Institutional Based Practice (IBP) of doctors under the Khyber Pakhtunkhwa Government Medical Teaching Institutions (MTI) Reforms Act 2015. When asked about the mode of getting doctor's appointments, a considerably high majority (91.35%) stated that they do not get doctor's appointments either online or through telephone service, instead they preferred to go to the hospital and register personally through 'parchi' in hospital OPDs (see Figure 18).

Figure 18: Mode of doctor's appointment



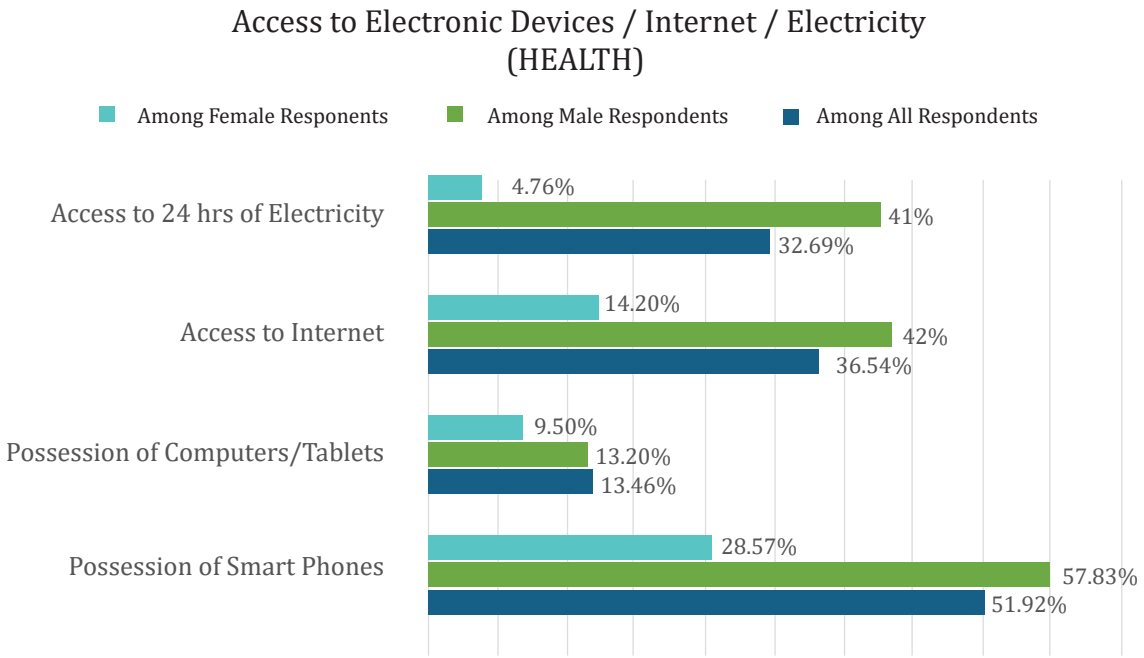
The issue of doctor's online appointments is an important part of a hospital's online presence. Survey results showed that 30.77% did not trust the online doctor's appointment system for accessing treatment in a hospital, and most respondents (44.23%) were undecided and could not make up their minds as to trust the system of online appointment or not. Only around 25% of the respondents showed their trust in the online doctor's appointment system (Figure 19).

Figure 19: Survey response to online doctor's appointment



The survey showed interesting results on the issue of online access to medical reports. Most of the respondents (46.15%) were undecided on whether the public hospital should provide them online access to their medical records, including test reports. However, 44.23% of the respondents reported that they would like the hospital to provide them with online access to their medical records and test reports. For inclusivity and marginalised population's coverage in health, there was optimism among officials that ICTs can achieve these goals provided the local BHUs are equipped with proper infrastructure and internet availability was ensured to connect patients with hospital consultants. On the end user's side, the accessibility issue was hampered by citizens' access to electronic devices, internet facilities and electricity (see Figure 20).

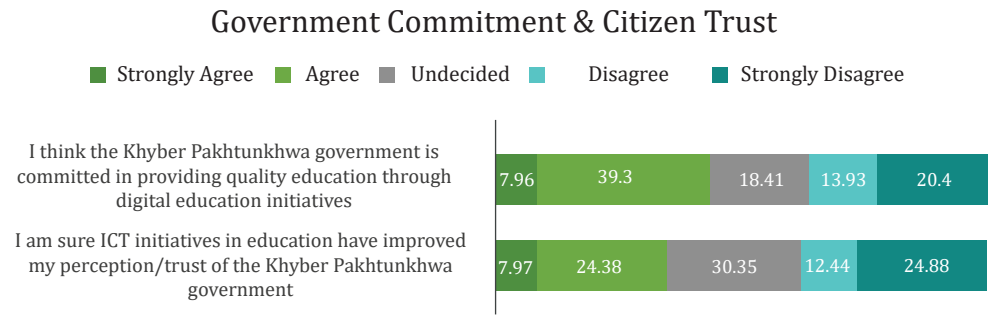
Figure 20: Survey outcome showing patient's access levels



ICTs, Service Delivery in Education and Health and Citizen's Trust

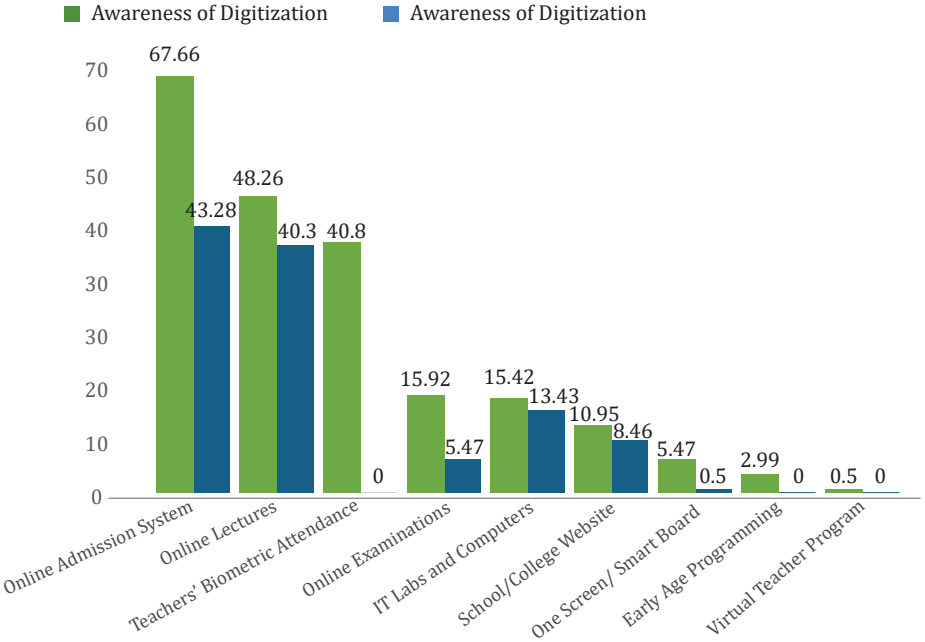
In most democracies, citizens are said to be disconnected from mainstream political processes (Stoker, 2006). There are low levels of satisfaction and trust in governments as well as politicians (Hay and Stoker 2009). Hence, one way of building citizens' trust in government is by engaging them in policy-making through ICT interventions. From the service provider's perspective, almost all the official respondents in education, as well as health, were confident that the delivery of services through ICT tools had markedly improved citizen trust in the government. Thus, technology is argued to have removed public apprehensions, thereby building trust among citizens. The survey results show that a majority of the students (47.26%) believed that the government was committed to providing quality education through digital education initiatives; although around a quarter of them (34.33%) were still apprehensive about it. Whether the introduction of ICT initiatives in the education sector helped build the trust of the people in their government shows a mixed result. Only around 32.35% of students trusted the government's digital initiatives in education (Figure 21). Governments usually adopt initiatives in bona fide, however, several hurdles demean the efforts of the government. A discursive and systemic approach is needed in solving the issues related to digital education.

Figure 21: Survey results showing student's perception of Khyber Pakhtunkhwa Government's commitment to digital education initiatives and level of trust in the government



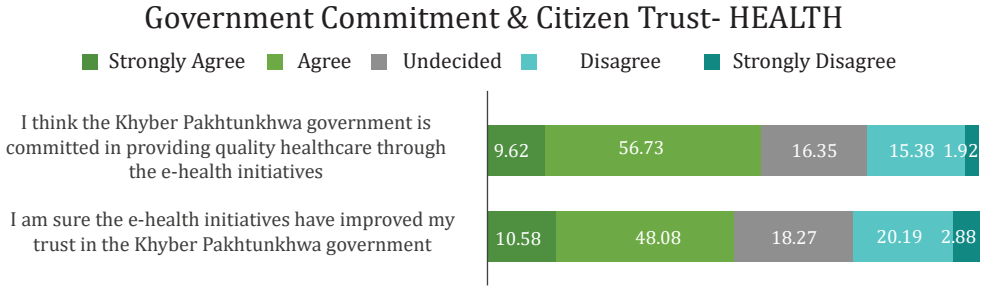
The citizen's perception of their government performance is also related to their level of awareness about their government policies and the resultant use of those services by the citizens. The survey results show that although a majority of respondents displayed awareness about the digital initiatives of the Khyber Pakhtunkhwa government in education, however, this did not correspond to the effective use of these initiatives (see Figure 22).

Figure 22: Level of Awareness About Digital Initiatives in Education & the Highest Used Digital Tools



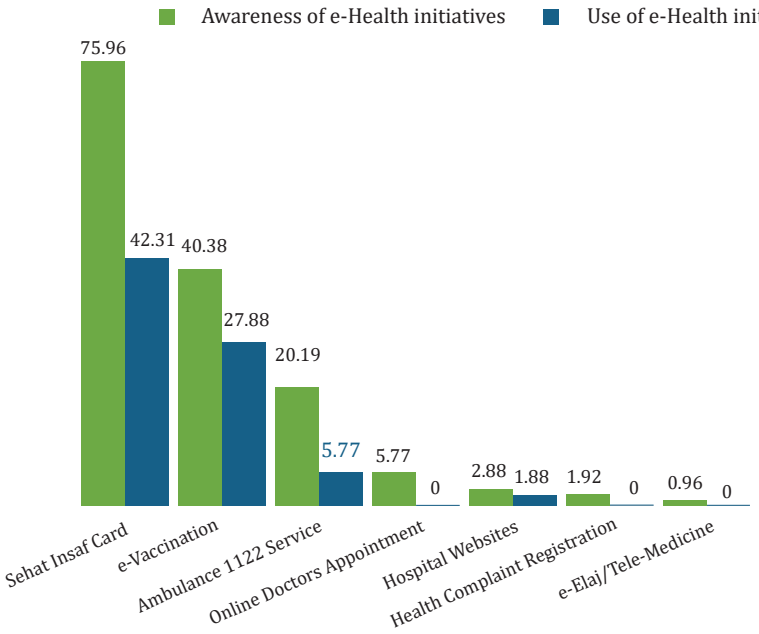
In health too, the officials responded positively in the context of people's trust improving in the government with the use of ICTs for service provision, even though they admitted having no direct mechanism to measure public trust. Others believed that people's perception of the government was improving, albeit slowly. The survey results also showed that the majority of respondents (58.66%) were certain that e-initiatives improved their trust in the government, and around 67% believed that the government was committed to providing quality e-health services (see Figure 23). This is a greater percentage as compared to education sector figures.

Figure 23: Survey results on E-Health and Citizen's trust in Khyber Pakhtunkhwa Government



The health officials showed their concern about the lack of awareness of the use of e-services among the end-users. However, the survey responses show that most of the respondents (83%) were one way or another, aware of the e-health initiatives introduced by the Government of Khyber Pakhtunkhwa, although their usage of the same lagged behind their awareness levels (Figure 24).

Figure 24: Level of Awareness of the e-Health Initiatives & Use of e-Health initiatives



Issues Hindering e-Government Efforts in Education and Health

There is hesitancy, scepticism, and latent resistance among the bureaucrats about the digitisation initiatives and related impacts. For example, some believe online education cannot be a replacement for interpersonal and face-to-face teaching. Others display overt technological shyness by arguing, "… personally I think people do not like the use of ICT tools." Still others contend, "it is not an easy job…it involves many factors…it is not just technological change, but also a behavioural one." Some also give the example of e-office to argue that technology was ineffective because of its "complicated nature"… "You will have to scan documents and then officials would write on them and then it would go to the other higher official in a long chain but writing comments on such files is a complicated business." Therefore, a lack of skills was indicated to be the main concern. Officials also lamented the fact that most people who were oblivious to the potential and importance of ICTs were occupying the strategic policy-making level posts inside the government. In health too, though high levels of enthusiasm were reported for ICT tools among the service providers, however, change management issues were also reported. For example, hesitancy on the part of hospital staff in using computers, which was reportedly being overcome through regular IT training. Some officials admitted that the e-file system was not running very effectively in the education department, because of clerical staff's unfamiliarity with the system. This was probably because the in-service training for these clerical staff was not properly managed. The organisational culture in schools was reportedly changing due to repeated teacher training imparted to teachers in schools where smart boards and computer labs were introduced. "… the teachers are no longer afraid of using ICT tools in teaching. People's expertise with the software is improving…" said one official. The NTS-based appointments and higher levels of education among teachers were also helping to reduce technological shyness.

Some of the officials linked change management issues in education to the ICT savviness of their secretary-level bosses, giving examples of how some of them through persistent direction and monitoring were adamant about making the ICT interventions a success. A few also argued that there is less bureaucratic hesitancy for such ICT initiatives that do not involve drastic policy changes. Officials also mentioned technical issues and glitches resulting from the first-time usage of ICTs to conduct official business, such as online meetings during Covid 19 emergency; to quote one official, "*I haven't attended even a single online meeting that did not run into problems.*" In health too, technical glitches were reported to be impacting the systematic entering and use of data in some

cases. Issues of internet connectivity at local levels also delayed the process. The context of outdated machines which did not support ICT initiatives in health was also pointed out as one aspect of the problem. The deficiency of technical staff, especially data entry operators (DEOs)' at district-level BHUs was also reported. Despite resistance to ICTs, a technology culture was being developed in some areas because of the mandatory nature of work, such as the district education officials (DEOs) must regularly log in and report to their bosses and in case of non-communication, are reprimanded. Similarly, the case of e-transfers shows that since there is no alternate way of registering transfer cases for school and college teachers except online; therefore, it has now become mandatory. The same stands true in the case of mandatory online college admissions in Khyber Pakhtunkhwa.

In the case of financial obstacles, there was some hesitation on the part of top-level bureaucrats to admit the lack of resources from the government side. However, we can assume that they did not want to annoy their political bosses by issuing such statements that could be traced back to them. Others who were serving in the middle and lower cadre of bureaucracy were more open to the fact that ICTs could improve service delivery further provided more resources were made available. Some officials downplayed the lack of resources aspect to emphasise the lack of vision of policymakers, which results in a waste of money. In health, lack of finances was argued as a long-standing issue which meant the government always provided finances less than the demand, although some argued investment was undertaken in critical e-health fields. Shortage of funds made the government take recourse to donor funding; such programmes initiated by the government and run by the donors initially for 5 to 6 years are reverted to the government and got 'political ownership,' once it generates a demand among the people. For provincial government spending on education in the last five years, see Table 2.

Table 2: The Khyber Pakhtunkhwa Government Expenditure on Education (2015-2020)

Years	Total Expenditure
2015-16	112,231
2016-17	136,121
2017-18	142,643
2018-19	152,711
2019-20	46,249

Source: Pakistan Economic Survey 2020-21. Government of Pakistan, Finance Division. Page 206. Retrieved December 2021 from https://www.finance.gov.pk/survey_2021.html

The provincial government websites are not interactive as far as the public is concerned. A website may serve multidimensional purposes. However, the Khyber Pakhtunkhwa government websites are focused on information sharing or policy presentation and service delivery. Many of these are not fully modernised; the outdated data on the websites provide little information to citizens. Some websites do show proactive disclosure of budget estimates (such as the ST&IT department) but mostly it is not current or contains information on the remunerations of the officials only. Similarly, attempts to avail the services portal links show errors or the contents don't get displayed. The use of websites as a deliberative or co-production channel (Lee-Geiller & Lee, 2019) is, therefore, overlooked. Citizens passively receive information or services but are denied feedback mechanisms, resultantly, the consultative feature of the websites is ignored. The primitive nature of government websites is further impaired by the poor internet services in Khyber Pakhtunkhwa.

The e-government initiatives make use of ICT tools and applications, which necessitates the availability of high-speed internet and access to mobile devices by the public for effective utilisation of public services. Given the fact that the majority of the Khyber Pakhtunkhwa population (83.1%) lives in the rural areas and a quarter (16.9%) in the urban areas (PBS, GoP, 2017), only around 15.1% of the rural population has access to internet connection and 41.9% urban residents have internet availability (ASER, 2019). The survey results also underscore the issues of lack of access to mobile devices by the public. In the year 2020, Pakistan imported 24.51 million phones, compared to the locally manufactured capacity of 13.05 million (Arab News, January 25, 2022). Add to it the 'regulatory duties' (between 32% to 240%) that were imposed by the Federal Board of Revenue (FBR) on the import of mobile phones in 2021 (Rana, July 2, 2021). Additionally, the Government of Pakistan

imposed a 17% tax on mobile phones in the Supplementary Finance Budget on January 15, 2022. The newly imposed tax led to a price hike of approximately 30% above the original price (Digital Rights Monitor, January 22, 2022) of these phones, deviating from the government vision of a 'Digital Pakistan.' The non-affordability of cell phones coupled with the non-availability of internet connection is the key restraint for citizens to utilise online public services. The once-upon-a-time rendition of access to technological devices being a luxury has undergone significant change, especially in the Covid-19 emergency period. 'Digital Pakistan,' therefore, needs 'digital access,' which is only possible with affirmative digital policies that ensure digital access and reduce the digital divide in the country.

Discussion on ICTs and Service Delivery in Education and Health

The Khyber Pakhtunkhwa Government's ICT-driven interventions are promoting values of efficiency, transparency and inclusiveness in service provision. Efficiency in service delivery in terms of better management of resources, quick delivery of services and provision of quality services; transparency as openness of government information to the general public; and justice as the value-ethic of government agencies is shown in its principle of inclusivity - the ability to provide services to all regardless of their language, religion, culture, ethnicity, area of habitat, political affiliations and above all their social condition. An in-depth search for reality as to whose interest these ICT technologies serve and who is excluded or included is critical. Just as Kühn (2019) is worried about the dominant narrative in education technology of finding out and implementing universal technological solutions supported by the inventions of Silicon Valley. He calls these narratives deterministic in their approach. This deterministic approach encourages forces other than our free will to govern our behaviour; the Khyber Pakhtunkhwa government's digital policy narrative about its capacity of transforming the government 'apparatuses,' mechanisms and processes, are regulating and supervising our actions/behaviours over which we have no control. Canguilhem 'recognises the logical primacy of the abnormal over the normal' (Pasquinelli, 2015); adopting his stance, one can say that the manual disposition of work by bureaucracy has become 'abnormal' according to the 21st century reinventing government narrative of David Osborne and Ted Gaebler. So, to bring this 'abnormal' to 'normal', digital interventions are necessary. Digitisation hence becomes the new normal; any defiance will be regarded as abnormal. This brings us to what the technological determinists would say that technology compels people and institutions to behave in certain ways (Johnson & Wetmore, 2009).

The Khyber Pakhtunkhwa ICT Policy (2015-16) underscores the importance of a technology-driven and efficient service delivery paradigm for public accessibility (citizen-centric government), and not only promises efficiency, transparency, accountability, and effectiveness but also increased citizen interaction with government (responsive government), all to be achieved through effective use of ICTs. The newer version of this ICT Policy (KP Digital Policy 2018-23) talks about improved service delivery through such digital technologies that will bring innovation, improve digital literacy and skills, and ensure the inclusion of women, youth and marginalised groups. Similarly, the Good Governance Strategy (2018) is further supported by five pillars, which include open government and transparency, public service delivery, citizen participation, performance and accountability, and ideas, innovation, and technology. A thorough analysis of these government policy papers reveals that these documents largely represent the social constructivist view on technology being neutral and driven by our subjectivity, i.e., technology will reflect the way we envision it. If we understand technology to uplift people's lives or end discrimination based on gender, and social class, technology will benefit the people; it will be as we think of it. If, on the other hand, we use technology to strengthen the position of power, for example, by the bureaucracy, we will end up using ICTs to that end. Technology is something that we can mould and shape according to our values, our own social needs, and to that social requirements. Persons in power can use it either to retain and strengthen their power positions or to benefit the common people.

Technological interventions in service delivery have implications for both the education and health sectors. These ICT interventions have the power to determine the behaviour of teachers, students, patients, and other end-users. For example, the biometric attendance of the healthcare staff and the teachers has made their presence obligatory for delivering services; the introduction of an e-file tracking system has sped up file disposal within 7 working days; the NTS system has led to the hiring of more educated and skilled personnel on merit; the

online admission gives ease of access to students, also brings transparency in admissions; the e-vaccinations, tele-rounding and telemedicine interventions help improve citizen's health; the electronic pathology reports give easy online access to patients; teacher's online lectures and communication with their students during Covid 19 helped improve student learning positively; and other digital interventions aiming to increase efficiency, transparency and accessibility in service delivery. However, these are not without limitations. The impact on the people, however, as empirical findings show is limited by their inability to access these e-government facilities.

ICTs have no doubt improved bureaucratic processes and practices, giving them a positive power to serve the people in a more transparent, efficient, and inclusive manner. While efficiency improved the structures, processes and practices of the bureaucracy, transparency has made the power of bureaucracy visible, exposing the entire processes and practices to the public. If there is a lack of transparency in bureaucratic practices, it is because of human error. Technology is impartial and, therefore, inclusive as it cannot identify gender, class, or ethnic group. It is open for all to use. It is the cultural elements that at times restrict females from the use of technology. Similarly, the socio-economic limitations can stop the poor from accessing these services as they cannot afford to buy the gadgets necessary to utilize these e-services. This means that socioeconomic and cultural constraints restrict the use of technology, making it exclusive. Therefore, in a society embedded with socio-economic disparities, the introduction of technology will increase the depth of such differences. The differences in gender, class, and region will intersect with the new differences created by technology – the gaps created by technology haves and have-nots; this will create deep fissures in society and discourage the fair use of ICTs. The survey results (Figure 3.3 & 8.3) also underscore the accessibility issue of citizens to electronic devices, internet facilities and electricity for availing public service delivery options. There is not only a digital divide but also a lack of digital skills both on the part of the service providers and the end-users.

We can argue in line with Karl Marx, who in his book 'The Poverty of Philosophy' (1847) says, '*The Hand-mill gives you society with the feudal lord: the steam-mill, society with the industrial capitalist;*' the digitisation phenomenon which has gone global gives us yet another kind of class -the class of 'digital elites.' The novel 'digital elites' who not only own digital devices but also know how to use technology skillfully and access public services. The digital divide that created the digital elites deepens the divides further. The new technologies such as e-mails, and the internet are unequally distributed in the society, and, therefore, are designed and used to create an unjust and inhumane social order, reinforcing what Anthony Wilhelm (2010) argues the production of 'asymmetrical power relations in the society. Wilhelm calls the asymmetric possession of technology in society the 'Red Queen effect,' -the constant pressure to compete and adapt faster for survival. The real dilemma is that the citizens who fail to compete and adapt to new technologies are left out of availing public services.

Some would argue that the fascination with technology has led to the uncritical and unrestrained adoption of ICTs in the public sector. This is because there is an 'exotic value' and 'a wow factor' attached to technology. The fascination to do something different and more 'exotic' puts the political bosses, such as the Ministers in Pakistan under constant pressure to do things that are more visible to the people, such as the purchase of software, hardware, tablets, computers, creation of electronic dashboards, and other ICT generated services. The blind acceptance of newer technologies and the constant quest to augment and upgrade technologies are further driven by the government narrative that technology can bring efficiency, transparency, and inclusivity in service delivery. There is a lack of critical approaches behind technological interventions among the political and bureaucratic circles. Technological practices that are more successful in the West have been imitated without concern for their local contexts as well as their objectives. This results in non or underutilisation of different ICT-induced initiatives. For example, the installation of smart boards in 60% of the Khyber Pakhtunkhwa schools is unmatched by the survey results, where most students had no exposure to these smart board teaching methods. It is, therefore, highly essential that there needs to be an in-depth pre-launch analysis of what is actually needed to improve education and its accessibility. A critical approach to determine what ICT intervention is really needed, who can access it, how people will understand it, in what manner the data received will be arranged, analyzed, or dealt with, how the data will be secured, and how to identify and resolve the problems in soft wares, and lastly, how the remote areas, in the absence of internet and power shortages will benefit from technology. Therefore, any attempt at digitisation without proper forethought will lead to under-utilisation of such ICTs and wastage of resources as demonstrated by our survey results.

The findings of our surveys and interviews suggest that a managerial model of e-service delivery prevails in Khyber Pakhtunkhwa, where the citizens are seen as passive customers and are primarily at the receiving end. Though the ICTs have brought quantitative improvement in previous technologies, however, online citizen participation to avail of these services is largely in the form of a one-sided flow of information to the citizens as their input on the quality of services provided is almost non-existent. Citizens' connectivity with the government is one-sided with information displayed on government websites. Only a few online feedback portals are available, which are almost rarely used. This practice runs against the real aim of digitisation, which is to increase citizen participation, and to make policy making and formulation with citizen's input; however, the findings suggest that there is no input of citizens in policy formulation. It means that the digitisation era is a continuation of the New Public Management Model (NPM), in which the government adopts and applies a business model to deliver services. Service delivery is made synonymous with business relationships; citizens are customers, whom the government must satisfy. Here, the service providers assume the character of businessmen who are trying to gain profit, not necessarily in terms of money but in the form of public support or public trust.

The Participatory model given by Chadwick and May is not yet fully incorporated neither in highly technologically advanced Western countries nor in developing countries like Pakistan. The bureaucracy in Pakistan, which is not yet familiar with the NPM model is exposed to the transformations brought by the ICTs in governance, making them change-weary. There are separate units in government departments to advise on performance management and help with ICTs re-structuring (such as the PMRU, HMIS, EMIS), which was previously the job of the high government civil servants; as Pollitt (2012) points out that in the 2000s in England, the NPM reforms led to the creation of 'arm's length' executive agencies and hiring of consultants advising on performance management and restructuring issues, which was once the task of higher civil servants. This led to confusion, change-weariness and loss of institutional memory among civil servants (Pollitt, 2012). Osborne and Gaebler (1992) argue that the instrument (government), which is used by society to solve its problem has become outdated and it is time to remake it. In Pakistan, especially in Khyber Pakhtunkhwa, this remaking is taking the shape of digitisation to supposedly improve the accessibility, efficiency, and transparency of service delivery.

Our findings suggest that bureaucratic norms and practices are quite firmly entrenched and are difficult to change. In the Third World, the introduction of ICTs was never intended to make bureaucracy accessible to the people; ICTs were introduced to make service delivery more efficient. Technology has not impacted bureaucratic norms and practices in a significant manner, nor was it able to ensure citizens' meaningful participation in government. The lack of information on government websites is one manifestation of the bureaucracy's reluctance to share information with the public; openness is seen as a fearful thing. Although the bureaucrats argued that digitisation of the various government departments was often personality-driven, conditional to the tech-savviness of the secretaries, however, it was to deal with bureaucratic resistance that the provincial government established the Performance and Management Reforms Unit (PMRU)[3] in January 2016 under the office of the chief secretary to push reform efforts, including digitisation. The PMRU spearheaded several key reform initiatives, which were implemented across all departments and the district administration. For example, the e-filing system was made mandatory by the PMRU by an order issued from the office of the chief Secretary, Khyber Pakhtunkhwa. Some other initiatives include HRMIS, file tracking system, efficiency tracking system, and district performance monitoring systems. We can, however, argue that the PMRU enjoys autonomy to develop apps, feedback systems, e-filing systems etc., but since it has been placed under the office of the chief secretary, which again displays centralisation tendencies. This is what Langdon Winner (1980) points out that technology by its very nature is political. To quote him, it *'unavoidably brings with it conditions for human relationships that have a distinctive political cast-for example, centralised or decentralised, egalitarian or inegalitarian, repressive or liberating'* (Winner, 1980, p128).

It is not without saying that technology is bringing transformation in the way people access and bureaucracy administers services. For example, college admissions in Khyber Pakhtunkhwa have gone online in the last few years. It has been accepted as mandatory and, therefore, is more prevalent and positively rated, as the survey data suggests a positive review of this app. For other apps and e-services, which are not mandatory, there is less penetration and selective usage by the end-users. Technology's use, therefore, could not become as common as was envisaged in the government policies. We can also argue that connectivity is indispensable for democracy as

[3] The PMRU works directly under the Chief Secretary and the Chief Minister as an independent unit.

information and communication technologies are considered to be an essential requisite for freedom- the freedom to participate. As Anthony Wilhelm explains that the ends for which IT is used and people's access to it will determine the influence of technologies in democracy and politics in the real sense (Wilhelm, 2000, p 149). In line with what William Dutton, argues, *"Digital government can erode or enhance democratic processes ... (but) the outcome will be determined by the interaction of policy choices, management strategies and cultural responses – not by advanced technology alone..."* (Dutton, 1999, p 193), we can also conclude that digitisation's impact on service delivery is more a function of critical policy choices, change management strategies and public access to ICT tools.

The digital interventions in Khyber Pakhtunkhwa demonstrate a unilinear flow of information and services from the government to the citizens. The government's emphasis is on service delivery and policy presentation. Care is taken that there is fast and efficient delivery of information and that is also sugar-coated to make it desirable or acceptable to the people. Each department has its own slogan, such as *'Badal raha hey Khyber Pakhtunkhwa'*, 'from pen to pixel', 'policing by technology', and 'technology is our new ideology' to mention some. This brings the provincial government's digital initiatives under the domain of the managerial model of e-governance. Second, bureaucratic change in conduct is not significant. ICT-induced transformations in bureaucracy's organisational culture have led to resistance and scepticism of the ICT-introduced reforms. Third, digitisation has led to the expansion of government departments, which is an old phenomenon. Several adjacent structures have sprung up alongside the already existing sections. Expansion in the size of the public sector is seen in the establishment of new departments, sections, units, etc., such as the PMRU, EMA, HMA, EMIS, HMIS and others. It is expanding the power of the government, although the digital transformation is projected as empowering the common man. We may say that it has led to the diversification of the old homogeneous bureaucracy – a new class of bureaucracy with new patterns of conduct, real-time data calculations, new rules and modus operandi. Fourth, as far as public trust is concerned, there have been improvements in the trust levels of the government, more so in the health sector, rather than the education one. To sum up, the provincial government's digitisation scheme is still at its take-off stage, and it will require proper investment, a commitment of the policymakers and the adaptability of the service providers and the end users for making the journey worthwhile.

6. CONCLUSION

The primary object of this research project was to explore how the use of information and communication tools (ICT) is affecting efficiency, transparency, and inclusiveness in service delivery by the provincial bureaucracy in Khyber Pakhtunkhwa and making it undergo organisational and cultural changes. Further, how digitisation affects citizens' trust in the government's service delivery in the province. The case study of the project was two government departments of Education and Health. The Khyber Pakhtunkhwa Education and Health Departments spearheaded many policy initiatives focused on promoting e-government in schools/ colleges and hospitals to provide quality education and improved healthcare to the residents of Khyber Pakhtunkhwa. The research team of the project collected data through quantitative surveys, interviews, focus group discussions and analysis of government documents, reports and other secondary sources of data. The introduction of Information and Communication Technology (ICT) tools in the governance of Khyber Pakhtunkhwa province has been a unique experience with policy making in this otherwise economically and socially underdeveloped province. The findings of the study suggest that significant digital interventions were made by the provincial government in both the education and health sectors. Pushed further by the Covid 19 emergency, these interventions stemmed from an understanding of generating evidence-based policies derived from data to enhance the efficiency and transparency aspects of service generation. These interventions are driven by first, the desire to generate policies based on evidence-based data and second, to optimize efficiency, bring transparency and ensure accessibility of public services. The ICT-induced impacts on service delivery gravitated towards increased efficiency, time and resource-saving as well as greater transparency and improved accessibility of both the education and health sectors. However, some major issues impaired the sustainability of digital interventions; change management in bureaucracy being one of them, which led to bureaucratic resistance and scepticism of the ICT-introduced reforms. There is underutilisation of the e-initiatives by the end-users in education and health as identified in the survey outcomes. The reasons can be the lack of awareness among citizens about these initiatives, insufficient digital skills to utilize these services and the context of the digital divide as around half of the respondents have no access to digital tools to access services. Hence, the desire for providing efficient, transparent, and inclusive services through ICTs is hampered by many challenges.

7. POLICY RECOMMENDATIONS

Pakistan is relatively slow in the adoption of e-governance practices as its position on the UN 2018 e-Government Index ranked 148 out of a total of 193 countries (The World Bank, March 18, 2019, 75-78). Whereas the Global Information Technology Report 2016 in its Networked Readiness Index cited Pakistan's position at 110 with a 3.4 score (Maximum is 6) among a total of 139 countries in terms of adoption of factors, policies and institutions for ICT adoption and usage in increasing economic competitiveness and well-being. It was up from last year by two positions (World Economic Forum, 6 July 2016; Bellar, Dutta and Lanvin, 2016, p. 16).

The following policy implications and recommendations are suggested:

- In Khyber Pakhtunkhwa, much needs to be done to involve citizens in the participatory practices of e-governance, where the citizens are not just involved in utilising digital governance steps for citizen complaints and redressal, but also play their roles in policy formulation and direction. For this to be practical, it is important that the IT wings (HEMIS, EMIS and HIS) of both education and health departments must engage citizens in the process of online consultations before an app or digital service is launched. It is important to mention here that such online consultations may be popularised through social media projection. The only recent attempt at engaging citizens is on the KPESED website, which opens a window inviting citizens to pen their suggestions on school syllabus changes. Such steps are noteworthy because citizen participation will further boost their trust in the government's service delivery undertaking through the ICTs.

- It is not without saying that transparency's starting point is the availability of open sources of information, easily accessible to the public on their websites. Open sources of information generated by the government also increase the trust of people. Therefore, there is an urgent need to update the websites of both the health as well as education departments. This is essential because the websites of both departments contain mostly outdated information or some very basic set of information. Within the health department, the Directorate General of Public Health (DGPH), which is a very critical policy implementation as well as monitoring and evaluation institution has a website that only contains some very fundamental and rudimentary information. Similarly, several affiliate institutions of both the KPESED and HED do not even possess their websites. A click on several subsites on their website takes us to messages about URLs not functioning. That needs a thorough revamping. Here, the responsibility of updating can be tasked to the department's respective IT wings. For this purpose, data administrators specifically tasked with uploading the current set of information on government websites can be hired and tasked with uploading new information every fortnight.

- The World Bank's report, 'Pakistan@100: Shaping the Future' recommends within the governance domain essential transparency and accountability reforms, which comprise the provision of 'transparent and accessible information' on reforms and service delivery to citizens, including budget documentation transparency. Pakistan had by 2016 declared its intention to join the Open Government Initiative and undertake fiscal transparency, however, no major plan has been initiated so far (The World Bank, March 18, 2019, 79). Therefore, another policy recommendation is that the government, including the Khyber Pakhtunkhwa, must ensure online access to the public about the government's financial statements relating to various expenditures and on various projects. This is imperative in achieving the goal of transparent service delivery.

- The interviews and the survey questionnaire and informal chats with the public also raised the important issue of the public's non-awareness of the different services providing digital apps. This led to the under-utilisation of service generation apps. At times, the public was even unaware of what ICT service generation constituted and how to access the same. Therefore, it is recommended that the government should seriously project its new as well as old ICT initiatives on social and print media platforms and educate the public on how such apps may be optimally utilised. This implies that all such digital programs for learning should be exposed to proper media coverage campaigns so that people have awareness of these initiatives. The task is attainable through engaging the already available

departmental PR and media officials or spokesperson, entrusted with the responsibility of proper projection of digital tools in service delivery. It is also recommended that the concerned departments can hold small seminars and workshops in educational institutions, especially higher secondary schools and colleges to train and educate the students and teachers about the potential usage and benefits of such apps. Awareness campaigns can also be generated through primary school teachers who are in a better position to motivate and educate their communities on specific benefits to gain from accessing service generation through such apps.

- This brings us to our next policy recommendation of how to bridge the digital divide. The quantitative survey analysis brings home the point that a large majority of public schools are populated by children who come from very low-income groups (with family income less than PKR 25000); similarly, mostly very poor patients access public hospitals. To make it harder, Cell phones have become 30% costlier under the mini-budget passed in January 2022. There is therefore a serious problem of affordability of digital tools on account of differences in socio-economic backgrounds. To bridge the digital divide in education, it is essential that students be provided with very subsidised microcredits for the purchase of computers and tablets. The banks can take up the initiative, with a focus on emulating the Grameen bank (Bangladesh) example in micro-financing. Pakistani companies can assemble or make basic tablets at low prices for consumption by low-income households. For this, the government of Pakistan may provide such companies with different tax concessions for inducing them to produce cheap tablets in bulk for consumption and use in public schools, or its cheap affordability for the general public.

- Another form of the digital divide is emerging within the public sector schools, between those schools that are exposed to IT and computer labs (60 %) and those that are not (around 40%). Unless proper infrastructure is not provided, other related changes in syllabus, etc., will not help the cause of ICTs. For this, the government besides raising its funding of infrastructure provision can also approach donor agencies and NGOs for assistance in bridging the lack of essential IT infrastructure as well as training teachers in IT skills.

- Public sector school children are exposed to computer education from secondary and higher secondary levels, which given the importance of IT learning at an early age is a very late exposure. The computer must be introduced in public sector primary and middle schools as a compulsory subject. Only by introducing children at a very early age to computer programming and coding, we can expect to produce a generation of IT experts. There is another side to the story. Even at the secondary and higher secondary level, the computer is an optional subject, which in turn is directly related to the lack of essential infrastructure in all schools. Here, mandatory intervention in making the computer subject compulsory and provision of essential infrastructure at all levels of schools is imperative.

- Agreements with cell phone companies for student packages or teaching packages for school and college teachers is also a desirable step; this has been attempted by the Government of Pakistan in the case of successfully running the online admissions system for colleges; the service was generated with the help of a renowned cell phone company.

- One suggestion is for the Khyber Pakhtunkhwa government to combine the efforts of its various IT-focused departments under one IT ministry and task the same with developing, implementing and assessing the ICT tools. In its current form, the Khyber Pakhtunkhwa Information Technology Board (KPITB), the Science and Technology & Information Technology department (ST&IT); the Directorate of Science and Technology (DoST); and the Directorate of Information Technology (DoIT) all perform some overlapping set of functions. Although recently the DoIT was merged into KPITB, there still is a need to streamline the technology-focused departments under a single ministry, so that duplicity of work and friction could be avoided.

- The overall performance monitoring of government departments on ICT tools can be managed solely by the Performance Management and Reforms Unit (PMRU). Though the PMRU is a cell established in 2016 in the Office of the Chief Secretary, Khyber Pakhtunkhwa to monitor, analyze and improve the

performance of all tiers of the provincial government through the innovative use of ICTs. However, this institution has been established as a unit, whose term of office is renewed every three years. There is a need to establish this unit as a department permanently with legal status defined so that it can perform its function of evaluation of service generation through the ICTs regularly. This regular evaluation will help understand the shortcomings and underperformance through ICTs by different provincial government departments.

- An essential aspect to overcome resistance to ICT usage among the officials is regular on-job IT training. The fact of the matter is that the e-filling system failed to take off in many government departments because of clerical staff and officers' unfamiliarity with it. ICTs are a technical domain and need to be continuously reinforced through regular in-service training. Such training can be managed by those specialised cells, which either are taking care of HMIS and EMIS systems within the health and education departments or by affiliate institutes that have specific mandates on training, for example, the Directorate of Professional Development in the Education Department. In big MTI hospitals, there are already IT sections functioning and they have reported on providing regular IT training to hospital staff.

- In the field of education, remoteness and accessibility issues hinder student's access to tele-education apps; it is suggested that since the PTV has wider access across all regions of Khyber Pakhtunkhwa, therefore, its services could be utilised by the KPESED as well as the HED for coordinated efforts at televising quality course contents teaching for school and college students to follow. This is essential especially in pandemic times, as the Corona emergency and resultant school and college closures wasted precious educational time of the majority of students, who had little access to the online education system. The PTV has its limited tele-education programme, but it is not connected with the education departments of Khyber Pakhtunkhwa and their efforts at tele-education.

- There is underutilisation of primary and secondary level healthcare systems because of the poor referral system, placing a burden on the tertiary level hospitals. According to rough estimates, around 5000 patients visit the OPDs of each one of the tertiary hospitals daily which becomes a great burden on the hospitals, which are essentially meant to provide highly specialised medical care by medical specialists. In the realm of digital health, one important aspect missing is e-referrals in hospitals. If the MTI hospitals in major cities want patients to access their local BHUs and district hospitals first, especially for common illnesses, the patients and doctors must be connected digitally with specialists in big hospitals. Since the government has already provided technicians in BHUs with tablets, and there was also planning underway for installing fixed tablets for disease monitoring, the same can also be utilised to connect district hospitals and BHU patients electronically with the consultants and doctors in a tertiary hospital. This will lessen the burden on major hospitals and encourage people to access basic health services in their hometowns. An introduction of the e-referral system will necessitate training courses on the e-referral system to healthcare professionals; a mechanism for feedback; educating people about life-threatening diseases and non-critical diseases; and the development of people's trust towards primary healthcare facilities (BHUs, RHCs etc.) in their respective areas.

- There is a need to provide information through "Citizen Charters" at all healthcare facilities, ranging from tertiary hospitals to primary healthcare centres. This will help the patients and their attendants understand available health care services, including drugs, service providers, user fees or cost of service, etc. The charter should also include information about the patient medical data protection rights. In countries like Bangladesh, for example, the Ministry of Health and Family Welfare (MOH &FW) has introduced Citizen Charter at all its healthcare facilities. An additional component of this initiative could be that information corners can be established to help patients and attendants register their complaints. The health department should make it mandatory to publicly display it for the patients to read and understand their right to equitable and quality healthcare. Independent Monitoring Units (IMU) of the Health Department (already in service) could be assigned the task of assessing the outcome of the citizen charter initiative.

- Another policy recommendation is that there must be inter-provincial sharing of best practices in ICTs

and service delivery. During our fieldwork, it came to light that there was no coordination between the IT departments of different provinces; resultantly all were working in silos, duplicating resources and infrastructure. The coordination between these IT departments will also help them learn from shared experiences and avoid failures from any new experimentations in ICT-induced service generation initiatives.

- In Pakistan, there is a lack of mechanisms that could assess the effects of the new technology interventions in the different sectors. There is a need to introduce 'technology assessment' to aid policymakers by providing them with information about the possible impact of new technology and assessing the short and long-term consequences of old technology. Technology assessment is a form of policy research which will provide policymakers with information on policy alternatives. Political action is required in the form of laws that would mandate or restrain the government (or the private sector) to pay or not pay for certain technologies in the presence of available data or absence of evidence, for example, the evaluation of the effective use of technologies in education and health sector at various levels of schools and colleges and various levels of healthcare facilities to know if they are working.

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APPENDIX A

INTERVIEW QUESTIONS - EDUCATION DEPARTMENTS

Khyber Pakhtunkhwa Elementary and Secondary Education Department (KPESED)
The Department of Higher Education, Archives and Library Khyber Pakhtunkhwa (HED)

- **ICT in Education: Programmes**
- **Impact on Service Delivery**
  - Digital Education Programmes: Efficiency and Effectivity
  - Education for All: Accessibility and Inclusivity
  - Accountability/ Transparency and Digital Assessments
- **ICT in Education: Issues and Problems**
  - Change Management Issues/ Organisational culture
  - ICTs in Education: Teachers Appointments and Training
  - Technological Infrastructure Shortages, Technical Glitches, Financial Issues
- **ICT in Education: Future Prospects**

Interview Questions

- Please introduce yourself (name, designation, years of service, responsibilities) and your department's responsibility.
- For how long have you been serving in this department?

ICT in Education: Programmes

- What is Digital-education and why investment in it is important for the Khyber Pakhtunkhwa government?
- Does the current educational policy 'Education Blueprint 2018-2023' of the Khyber Pakhtunkhwa government support ICTs in education?
- Which digital-education programs have been introduced by the Khyber Pakhtunkhwa government at primary, elementary and higher secondary level/ or college level?
- Which of these ICT programs in education are functioning most effectively and why?
- Which programs have not been very effective and why?
- Are officials in-charge of formulation of policies for school education and literacy and developmental projects in the Secretariat of Elementary and Secondary Education conversant with the concept and importance of ICTs in education? How enthusiastic are they about innovating education through ICTs in Khyber Pakhtunkhwa?[4]

Impact on Service Delivery

- *Digital Education Programmes: Efficiency and Effectivity*

  - At what level of education are children exposed to ICTs in public schools?
  - Do you agree that the introduction of ICTs enhanced the quality of teaching/ education in government schools? How?
  - Do you think ICTs have enhanced and facilitated student learning? If yes, How?
  - What technological facilities are provided to public school children, for example, smart boards, computers, internet access etc? What is your source of information?
  - What is the student-to-computer ratio in government schools? What is your source of information?

[4] Secretriat of E&SE Address: 2nd & 3rd Floor, Block A, Civil Secretariat, Peshawar.
Phone: 091-9223477
Web : https://www.kpese.gov.pk
Open : Monday – Friday 09:00 AM– 05:00 PM

- At what level of education are children exposed to ICTs in public schools?
- Do you agree that the introduction of ICTs enhanced the quality of teaching/ education in government schools? How?
- Do you think ICTs have enhanced and facilitated student learning? If yes, How?
- What technological facilities are provided to public school children, for example, smart boards, computers, internet access etc? What is your source of information?
- What is the student-to-computer ratio in government schools? What is your source of information?
- How many % of government schools have access to regular electricity? (Source of information?)
- How many % age of government schools have internet access? (Source of information?)
- How many % age of students use the internet in schools? (Source of information?)
- Tell us something about the digital schooling programme, 'KP Learning Portal.'[5] Is it being effectively utilised by students at public schools? How? What is the source of your information?
- Have you any measures to determine the number of students making use of this app? What is your source of information?
- Tell us about the video lectures in the 'KP E&SE YouTube Channel: Learn Today, Lead Tomorrow,' which seems to have been taken down by YouTube on account of probably violating the policy of content ownership.
- There is another digital schooling programme mentioned on KPESED website 'Virtual Teacher Question/Answer Forum' on Google Play Store. How effectively is the being utilised by the students and teachers for questions and answers? A visit to its website reveals very few questions asked and answered.[6]
- Tell us something about the Tele-education or 'Teletaleem'[7] project introduced in 14 districts of Khyber Pakhtunkhwa (2019), where thousands of children were supposed to be provided online lectures by teachers in Islamabad.[8] How far has it progressed?
- Kindly shed light on the 2020 pilot project of KPESED for integrating the provincial educational system with 'Google G Suite for Education' with help from Tech Valley Pakistan. This was to digitally train the teachers and digitally equip institutions for e-learning. What is the progress in this programme?
- Please tell us about the Khyber Pakhtunkhwa Information and Technology Board (KPITB), and the Khyber-Pakhtunkhwa Elementary and Secondary Education Department's (KPESED) 'Early age Programming and IT Essentials Initiative' training program (2020) for teaching children of public schools computer programming and coding, etc? How far has it progressed and what was the outcome?
- The students (Grade 1-8) have been given access to the digital contents of cable TV 'Taleem Ghar,' initially developed by the Schools Education Department of the Government of Punjab for providing digital lessons. How far is this made progress? How many numbers of children are accessing this particular Cable TV for learning and tuition? (Source of information?)

- Please tell us about the web portal 'Learn Smart Pakistan,' which is classified as Pakistan's biggest gamified cloud learning platform, where more than 2 lac students from Grade 6-10 are

[5] The around 287 animated videos dubbed in Urdu and 217 in Pashto for students of Grade 1-10 mostly cover topics related to Math, General Knowledge and Sciences (KPE&SE Department GoKP, n.d).

[6] An observation of the Q/A session on this site shows fewer interactions of around 59 questions posed with the first of the questions asked in August, 2020 and the last one in January 30, 2021.

[7] It is based on blended learning, which is an approach to education that combines online education materials and opportunities for interaction online with traditional place-based classrooms methods to educate millions of children around Pakistan.

[8] Tele-Education in Khyber Pakhtunkhwa was launched in 14 districts of Peshawar, Charsadda, Swabi, Nowshera, Mardan, Mansehra, Abbottabad, Swat, Dir, Chitral, Bannu, Dera Ismail Khan and Lakki Marwat. Under this program, grade 4 and 5 students are taught English, Mathematics and Science subjects online. For the purpose, 150 schools have been selected where 16,000 students would be imparted online education. The programme has been jointly launched by ESEF, DFID, Pakistan Poverty Alleviation Fund (PPAF) and Tele-education Organisation. Computer labs are to be established in the schools, where the online classes would be arranged with teachers sitting in Islamabad delivering online lectures (The News, January 2, 2019)

supposedly learning English, Sciences and Mathematics through animated video lessons, tests/ assessments and learning games. This has been partnered with Jazz, the website claims to provide high-speed internet bundles at affordable prices. What is the progress here and do you think the private sector can be engaged in similar programmes to help provide internet access to underprivileged schools and colleges for e-learning? How far such a partnership has been successful?

- The Directorate of Professional Development (DPDKP), working under the KPESED has been tasked with managing online homework for students in English, Math, Urdu and General Science and instructions to teachers to encourage students under this app for timely completion of homework and keeping in touch with parents. How far is this programme a success? And what issues are faced by the DPDKP in the smooth running of the programme?
- Do you think such measures can help e-learning while schools and regions may be lacking in technological infrastructures?
- How have ICTs enhanced the effectiveness and efficiency of administrative activities and processes?
- Is there any inter-provincial exchange of information on the effective use of different digital education programs and best practices?

■ *Education for All: Accessibility and Inclusivity*

- The KPESED logo, Ta'aleem- sab key leay meaning, 'Education for all' seems to represent the government's priorities for an inclusive approach to extend education to all groups and regions in the province. Do you think ICTs have the potential to extend not just education to all, but quality education to all? How?
- To what extent current ICT programmes in education have been able to gain the objectives of inclusivity across gender, class, ethnicity, region and religion?
- Do you think children coming from poor, uneducated and rural households can afford to gain access to digital venues of education?
- How can ICTs in education be made more accessible to all children irrespective of differences?
- Does the KP ICT policy meet the Education for All (EFA) and Millennium Development Goals (MDG), especially MDG 2 on universal primary education and MDG 3 on gender equality in education? AND the Sustainable Development Goal relating to education, especially SDG 4 is to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for
- all'?
  Do you think the current syllabus taught at schools and colleges requires modifications to

■ *Accountability/ Transparency and Digital Assessments*

- How a teacher and student absenteeism can be tackled through ICTs in education?
- Has the bio-metric system been introduced in schools to ensure the regularity and punctuality of the teachers? If yes, how far school absenteeism has been tackled?
- How can ICTs help in improving the examination systems in government schools and colleges?
- Are the District Education Offices working monitored through ICTs? How?
- Does the KPESED have any plans for online admission? When?
- How does the Khyber Pakhtunkhwa Education Monitoring Authority (KPEMA) assess the performance of government schools across the province?
- Does it also assess schools on ICT usage in education? Is there a process in place to hold accountable when a school is failing or performing below expectations?
- Has such regular assessment improved the performance of schools in terms of teacher and student attendance and improved results?
- Another issue is political interference in recruitment, transfers, and postings of teachers with scholars arguing that the whole system has become hostage to corrupt officials and their patrons leading to poor education service delivery. The Khyber Pakhtunkhwa government has recently introduced the E-Transfer system with the claim that it will 'revolutionize teachers' transfer and pave the way for quality learning.' How will this system bring transparency to teachers' transfers?

- The app also mentions a grievance redressal mechanism for teachers to submit their grievances online. How does this feature function in making the system transparent?

ICT in Education: Issues and Problems

- *Change Management Issues/ Organisational culture*
  - How many % age of teachers in primary and secondary schools are ICT qualified or trained to handle ICTs in education? (Source of information?)
  - Are teachers afraid to use technology in their classrooms? How far change management acts as a barrier to digital learning?
  - What is the function of the Education Sector Reforms Unit (ESRU), working under the KPESED? The website mentions it is mandated to 'plan, coordinate, monitor and evaluate' the ongoing reforms activities/programmes' and provision of stipends to students. Does it have any role in ICTs and education?
  - The KPESED website also shows 'School Management Information System (SMIS) directing to another login portal. What sort of data repository is it and is it accessible to the common public? Has it been developed with help from donor partners?
  - Since the SMIS or EMIS[10] is an effective planning and management tool which coordinates data collection from multiple organisations generally involved in the provision of education. So when EMIS was planned, do the needs of the different stakeholders (central ministry planners, officials of other ministries especially the finance department, regional/ district education officers, donors, NGOs) who rely on this data has been met?
  - What is the impact of EMIS on administration?

- *ICTs in Education: Teachers Appointments and Trainings*
  - Tell us about the government's experience of recruiting schoolteachers through MCQ-based NTS tests. How far are such tests transparent? And what about the allegation that teachers who were not appropriately trained under CT (certified teachers), PTC (primary teaching certificate) or B.Ed (Bachelor of Education) certifications were appointed under NTS tests?
  - The NTS and better pay packages for tests are credited with the appointment of qualified teachers, which led to the shift of around 34,000 former private school students to government schools (The Express Tribune, 2016). Do you think the trend is still there as most parents can hardly afford private education?
  - Does professional training of teachers also involve ICT-based training? Who undertakes the training? How regularly?
  - How effective is the 'Online Teachers Training Program'[11] in providing online Teacher training certification for government schoolteachers? How many have been trained under this online training programme? The website provides online registration for schoolteachers to get enrolled in this online training programme.
  - Is the Department of Professional Development Khyber Pakhtunkhwa (DPDKP) under KPESED also involved in teacher training? The website mentions an online LMS system in use for training schoolteachers via curating and sharing of subject-wise videos and its scheme of studies is developed by the DPDKP. How far are such initiatives progressing effectively in imparting teachers' training?
  - Was teacher training conducted online during Covid 19 emergency? Which ones and How effective were such online teacher training programmes? Do you think teachers can be effectively trained through online training programmes?

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[10] Governments across the globe are the biggest users of the EMIS to streamline the operations of all schools and gather live data from schools for decision making (Fedena, July 20, 2020). Experts believe that MIS can provide administrators and teachers with the information required for informed planning, decision making, staff workload management, human resource management, communication, staff performance, and student evaluation (Fedena, Feb 24, 2021).

[11] The website of KPESED mentions this programme undertaken with American Board Teaching Certification (American Board, 2019, www.americanboard.org).

- *Technological Infrastructure Shortages, Technical Glitches, Financial Issues*
    - How far do you think technological and infrastructural issues are hampering ICTs in education?
    - Do you think there has been a systematic generation of finances to support ICTs in education in Khyber Pakhtunkhwa? Has resource deficiency been an issue in the way of ICTs in education?

ICT in Education: Future Prospects

- Do you think the government has been able to undertake a robust, effective and target-oriented ICT policy in education?
- What policy changes or recommendations do you suggest for imparting quality digital education to children in government schools?
- Do you think the digital education measures have improved the Khyber Pakhtunkhwa government's service delivery and increased citizens' trust in the government?

APPENDIX B

Interview Questions - Health Department

Introductory Questions

- Please introduce yourself (name, designation, years of service, responsibilities).
- What are your department's responsibilities and role in service delivery?

E-Health programmes & Importance

- What is Health IT? Do you believe investment in Health ICTs is important? And why?
- Which particular programs have been introduced in Health ICTs by the government of Pakistan? And the government of Khyber Pakhtunkhwa?
- Which of these ICT programs is functioning most efficiently and productively? And why?
- Which programs in Health IT have not been very successful and why?
- Is there any disease early warning systems in this hospital which could detect and signal a public health emergency, such as detecting communicable disease through surveillance and response?
- Has the government provided any Electronic Health Records (HER) systems to the hospitals?
- Do Pakistan/ Khyber Pakhtunkhwa health systems have an e- referral system? "Referral is a process in which a health worker at one level of the health system, having insufficient resources (drugs, equipment, skills) to manage a clinical condition, seeks the help of a better or differently resourced facility at the same or higher level to assist in' (Gupta et al., 2017). [[Does any written policy for the referral system exist in KP, or in the absence of such a policy, anyone can go to any level of a hospital for treatment irrespective of the seriousness of the illness.]]
- Since health is a devolved subject, do you think such devolution has helped in achieving or improving the prospects for e-health in Khyber Pakhtunkhwa?

Impact on Service Delivery

- *Improvement in Health Service Delivery: Efficiency, reachability, accountability*
    - Do you have an estimate of how much percentage of patients visiting government hospitals make use of ICT tools for service generation?
    - Has ICTs in health led to better provision of health services to the people in Khyber Pakhtunkhwa and Pakistan? If yes, how can you measure such improvements?
    - Have this ICT in health helped reduce health expenditures by the government of Pakistan and Khyber Pakhtunkhwa on the health sector?
    - Have ICTs helped in providing quick, cheap, cost-effective and quality services to the people in Khyber Pakhtunkhwa? (efficiency)

- How effective are these ICTs in providing health services accessible to people in far-flung/ rural areas, to women and children? (Reachability or accessibility by the public)
- Do you think ICTs in health have made these services more transparent and accountable? (transparency and accountability)
- Do you think ICTs have impacted traditional practices of medicine?
- Is there any mechanism to evaluate the performance and quality of service of health care professionals under ICTs?
  Do healthcare providers encourage their patients to use web-based facilities? Which group is less
- likely to use these ICT-related health services? (such as women, any ethnic group, less-educated, poor etc). Can they learn and be comfortable with using Health IT or e-health facilities? How?

- *Productivity of Health Care Workers and Work Practices/ processes*

  - How far the working and management of public sector hospitals in Pakistan and Khyber Pakhtunkhwa have changed with ICT usage? Kindly elaborate.
  - Have ICT in health care led to improvements in productivity, work practices and ethics in hospitals? Or How has ICT in health changed the work practices of paramedical staff in hospitals?
  - Has the introduction of ICTs in the health sector improved communications and teamwork inside hospitals? How?
  - Is health ICT, such as the HIS (civil registration and vital statistics (CRVS) registration, nationally notifiable diseases, private sector data including insurance, confidentiality, and other official statistics) covered by the legal framework of the government? Usually, in the absence of legal coverage, officials, staff and other related personnel drag their feet in the implementation of the HIS system believing that they are not legally bound to carry out the task.
  - Do the HIS assessment system focus on the inputs of all stakeholders such as health care providers (doctors, physicians, nurses), clients (patients/citizens), donors, policymakers, etc? Does the health department develop a standard questionnaire to be filled by all the HIS stakeholders to help diagnose the gaps between inputs and outputs/ impact in e-health service provision?

Issues/ Problems of ICTs in Health Care Provision

- *Change Management Issues/ organisational culture*

  - Do you think bureaucracy resistance is an issue in the adoption of ICT? Do hospital doctors and paramedical staff readily adopt it?
  - Do you think the officials/ administrators feel threatened by the use of technology?
  - Are customers/ patients willing to embrace them happily? If yes, why?
  - How far organisational culture is responsible for the success or failures of ICT interventions in Health? Such as lack of communication and poor teamwork?

- *Capacity building/Training of staff to handle ICTs*

  - What problems are faced by health professionals in the use of ICT in hospitals? Do you think there is hesitancy to use ICT tools by health care professionals due to a lack of training and understanding?
  - Do you think hospitals have the required trained workforce for health informatics to successfully use the ICT tools in hospitals?
  - At the sub-national level (province, districts) are there designated full-time health information officer positions and they are duly filled?
  - Does the health department/ hospital provide any training to healthcare providers in ICTs? How many capacity-building activities have been conducted place over the past few years for HIS staff and health facility staff?
  - Do such training focus on management, analysis and use of data?
    Is the Health Informatics System user-friendly? Did the vendors give any training relating to the use of this system?

- Is the Health Informatics System user-friendly? Did the vendors give any training relating to the use of this system?
- Are there any written guidelines for the processes of HIS data collection, management and analysis?
- Do you plan on training them further and how?

- *Issues faced by patients in ICT usage*
  - What are the problems faced by the patients while accessing ICTs and Health services in the hospitals?
  - Are patients aware of such ICT tools in health services?
  - How are citizens informed/ made aware of the provision of specific e-health services by the government?
  - Are patients aware of their rights under Citizen's Charter or Health care information? These charters inform the citizens of their rights and the provision of specific services by a public agency.
  - Do hospitals have any Citizen's Charter which patients can read and understand their rights?

- *Technical Glitches/ infrastructure problems*
  - What are the technical glitches (delays, interruptions) of IT?
  - Are Computers and other basic communications technology infrastructure (internet access, telephones, e-mail) available at the provincial and district levels for the rapid compilation of subnational data?

- *Health Information System Monitoring (HIS) and administration*
  - Is there any HIS administrative unit in the ministry of health to design, develop and support health information collection, management, analysis, dissemination and use for planning and management?
  - Is there a system to monitor the HIS and its various subsystems such as telemedicine? Or Is there a Health Metrics (system of measurement) to assess the Health Information system in Khyber Pakhtunkhwa, which could identify the strengths and weaknesses of the provincial health information system? Assessing the HIS will help identify the issues and challenges faced by the system or/and the usefulness/ strength and cost-effectiveness of the system and share this information with partners, the general public and potential donors and recipients.
  - Is there any official policy to conduct regular meetings at a facility, district and rural levels to review HIS information and take action based on that information?

- *The issue of health inequalities: accessibility and inclusiveness; Digital divide*
  - Do you think patients prefer the traditional way of treatment in hospitals?
  - Do you think ICTs in health accentuate health inequality in the country? Do you think the poor and uneducated can access e-health facilities in public sector hospitals?

- *Security of Patient Data*
  - How far is the health data secure? Do you think the privacy of data and especially its security is difficult in our hospitals and IT systems?
  - Do you think patient data should be freely exchanged between hospitals and health professionals?
  - How sensitive is this topic of privacy and consent of the user?
  - Should patients be given the right to obtain and use their own health data and collaborate with clinicians?

- *Performance Evaluation of ICTs*
  - Do the HIS system help districts and provinces compare their performance against objective standards of health care? Health Technology Assessment (HTA) is a systematic evaluation of

properties, effects and/or impacts of health technologies and interventions, which started in high-income countries in the 1980s and moved to middle-income countries since 2000; they have established specialist units, committees or programmes to evaluate health technology initiatives and provide recommendations to decision-makers.

- *Government Commitment to e-health; allocation of funds*
    - How do you see the government's commitment to providing e-initiatives/ ICT tools in the public health sector? Are you satisfied with the measures?
    - Have there been delays in the implementation of e-projects by the government and why?
    - Did resource issues or lack of finances create problems? How much resource commitment is required from the government for the adequate functioning of the HIS?

Future Prospects of ICTs in Health

- Do you think ICT in health has a future in Pakistan and Khyber Pakhtunkhwa?
- What are the policy prescriptions/ recommendations to improve e-health usage and practice in Khyber Pakhtunkhwa?

APPENDIX C

Interview Consent Form

Department of Political Science
University of Peshawar

Project/ Research Title

Transforming Public Service through Digital Governance Initiatives in Khyber Pakhtunkhwa: Bureaucratic Conduct, Transparency in Service Delivery and Citizen Centric E-Governance Project

I Ms Shagufta Aman, PhD., Research Scholar and faculty (visiting) at the Department of Political Science, University of Peshawar am conducting a research project on E-governance in Khyber Pakhtunkhwa. This project, which is funded by PIDE aims at exploring how the use of Information and Communication Tools (ICT) is affecting efficiency, transparency and inclusiveness in service delivery by the provincial bureaucracy in Khyber Pakhtunkhwa and how digitisation affects citizen's trust in the government's service delivery in the province. The case study is three government departments of Health, Education and Police. This is purely academic and policy-oriented research and the information collected through interviews shall be treated as confidential and used entirely for academic purposes.

- I ……..working as ……. in …….. volunteer to participate in this research project conducted by PI Ms Shagufta Aman from the University of Peshawar. I understand that the project is designed to gather information about e-government initiatives undertaken by the Khyber-Pakhtunkhwa government in service-providing departments.

- I confirm that my participation in this research project is voluntary.
- I understand that I will not receive any payments for participating in this research interview.
- I understand that I have the right to decline to answer any question or to end the interview at any time I deem fit.
- The interview will be recorded (audio-taped) and a transcript will be produced.
- I understand that I can communicate to the researcher for not mentioning my name in the research drafts if I want to.
- I understand that my confidentiality as a participant in this study will remain secure.
- I have read and understood the explanation provided to me by the interviewer.
- I know that If I wish to review the notes, transcript, or other data collected during my interview, I cannot be denied.
- I agree that the researcher may publish documents that contain quotations by me and If I don't wish to be named with these quotations, I will communicate to the interviewer during or soon after the interview.

By signing this form, I agree to the terms indicated above.

_____ _____

Signature of participant Signature of researcher

Dated: _____

APPENDIX D

Information on Different Apps Launched by KPE&SED

KPESED Apps on Google Play					
	Apps		Launched	Downloads	Rating, Reviews & Link
1	KPESED Books App	This app is developed to facilitate users by E Reading books in soft form.	February 5, 2022	1000+	Rating: 3.1 Reviews: very bad reviews with complaints about the non-availability of books and inability to open the books. Link: https://play.google.com/store/apps/details?id=com.sad.schoolbooks
2	KPESE – Virtual Teacher	A question-answer platform for students, parents and the general public to spark the spirit of conceptual knowledge. Experts answer any question at the elementary education level in the subjects of Physics, Chemistry, Biology and Mathematics With the hope to improve the knowledge of the students and the general public	August 17, 2020	10,000	Rating: 3.3 Reviews: with complaints of not working Link: https://play.google.com/store/apps/details?id=com.asif.virtualteacher
3	KPESE - (HRIS)	Human Resource Information System	Sep 3, 2021	100,000+	Rating: 3.2 Reviews: Complaints of it being time-consuming, non-user interface, not working. With complaints of it not working properly, lots of bugs, errors and showing incorrect information terming it a 'horrible app'; 'the worst app ever'; 'application and browser portal not working; 'no data could be uploaded'; 'poor interface, hard to use, 'app not working' etc. (https://play.google.com/store/apps/details?id=com.asif.kpese_hris&hl=en&gl=US&showAllReviews=true). Link: https://play.google.com/store/apps/details?id=com.asif.kpese_hris

4	KPESE - SQMI (EMIS)	School Quality management initiative (SQMI) to revitalize the function of the ASDEOs and SDEOs to inspect the quality of teaching and learning processes in primary schools and to provide regular, timely feedback to the observed teachers and head teachers for remedial actions	Nov 13, 2020	500+	Rating: No rating Reviews: complaints of not working Link: https://play.google.com/store/apps/details?id=com.ese.sqmi
5	KPESED - Monthly Assessment Induction Program	KPESED introduced an induction program for newly recruited teachers. This application will be used to conduct the monthly assessment	Feb 9, 2020	10,000+	Rating: 4.5 Reviews: Complaints of the app not working properly Link: https://play.google.com/store/apps/details?id=com.induction.MA.kpk.api&hl=en&gl=US
6	Induction Program KP (ESED) PITE, Peshawar, KP	The first of its kind "Induction Program" (IP) for newly hired teachers to enhance their content knowledge and pedagogical skills in the subjects of English, Math, and Science. The program has been designed by the Directorate of Curriculum and Teacher Education (DCTE) and will be implemented by the Provincial Institute of Teacher Education (PITE). The program will be delivered to primary, middle and secondary	March 7, 2020	10,000+	Rating: 3.1 Reviews: problems with video uploading, time-consuming and disappointing Link: https://play.google.com/store/apps/details?id=com.induction.Sec.kpk

		school Beginning Teachers (BTs). A specialised learning management system has been developed for the delivery of content in the above-mentioned subject areas and to manage the learning process of these teachers over an extended period of more than six months. Note: This application is for government teachers of Khyber Pakhtunkhwa. the application needs an additional download of 16 -18 GB of content which is already copied to teachers' tablets. Other users who wish to download the application may need additional data to run the program			
7	e-Transfer KPE&SED	Transfer Process of Teachers simpler, efficient and Transparent E-Transfer Policy for transfer/posting of teaching staff in the province implemented through a mobile application. KPESE-e-Transfer is android based application available free of cost on the Google Play Store.	March 12, 2020	10,000+	Rating: No rating Review: Complaints about the web server not working properly. Link: https://play.google.com/store/apps/details?id=.com.asif.development.etransferappnew&hl=en&gl=US https://apkcombo.com/kpese-etransfer/com.asif.development.etransferappnew/

		KPESE-e-Transfer consists of the following options. 1. Search Posts: Search in a list of vacant posts added/announced by the concerned DEO. 2. Transfer Application: Applying for a transfer 3. My Applications: After successfully submitting your transfer application you can view/download your application. Also, you can check your Application status (Pending, verified, order issued) 4. Settings: Changing password and logout.			

APPENDIX E

Education Survey Questionnaire

PIDE- RASTA RESEARCH PROJECT - EDUCATION

DEMOGRAPHICS - SECTION A: Instruction: Please tick the relevant option or write the answer.
Govt. Higher Secondary Schools and Govt. Colleges in Abbottabad and Peshawar

---

Name of School / College:
Peshawar / Abbottabad

- ◯ Government College Peshawar for boys, Peshawar
- ◯ Government Frontier College for Women, Peshawar
- ◯ Government Post-Graduate College No. 1 for boys, Abbottabad
- ◯ Government Girls Degree College for Women, Abbottabad
- ◯ Government Shaheed Osama Zafar Centennial Model Higher Secondary School No. 2 Peshawar
- ◯ Government Lady Griffith Higher Secondary School, Peshawar
- ◯ Government Higher Secondary School No. 1 Abbottabad
- ◯ Government Comprehensive Girls High School, Abbottabad

Name

Grade :

- ◯ Grade 9
- ◯ Grade 10
- ◯ Grade 11
- ◯ Grade 12

APPENDIX F

Health Survey Questionnaire

Updated Version of PIDE- RASTA RESEARCH PROJECT - HEALTH

DEMOGRAPHICS - SECTION A: Instruction: Please tick the relevant option or write the answer.
Tertiary Hospitals in Abbottabad and Peshawar

Name of Tertiary Hospital:

- ◯ Lady Reading Hospital MTI, Peshawar
- ◯ Ayub Teaching Hospital MTI, Abbottabad

Name

Are you the patient or patient relative?

- ◯ Patient
- ◯ Patient relative

Age

- ◯ 14 - 25
- ◯ 25 - 35
- ◯ 35 and above

Gender

- ◯ Male
- ◯ Female
- ◯ Other

APPENDIX G

Health and Education Sector – Survey Sites in Peshawar and Abbottabad

Khyber Pakhtunkhwa Leading Public Colleges			
	Government College	Location	Number of respondents
	Boys		
1	Government College Peshawar	Adjacent to Shahi Bagh, Peshawar	25
2	Government Post-Graduate College No. 1 Abbottabad	Near FBR Regional Tax Office, College Rd, Abbottabad	25
	Women		
1	Government Frontier College for Women, Peshawar		26
2	Government Girls Degree College for Women, Abbottabad		25
		Grand Total	101

Health Sector: Survey Sites in Peshawar and Abbottabad

Khyber Pakhtunkhwa Leading Public Hospitals			
	Hospital Name	Location	Number of Respondents
1	Lady Reading Hospital MTI	Peshawar	52
2	Ayub Teaching Hospital MTI	Abbottabad	52
		Grand Total	104

Total Number of Survey Sites	10
Total Number of Survey Questionnaires administered	305
Number of Cities	2

APPENDIX H

Information about Government Colleges Surveyed

>Postgraduate College No 1 (GPGC), Abbottabad;
>Government Girls Degree College for Women (GGDC), Abbottabad;
>Government College for Boys (GC), Peshawar
>Government Frontier College for Girls (GFC), Peshawar

		GPGC Abbottabad	GGDC No.1 Abbottabad (Girls)	GC Peshawar	GFC Women Peshawar
1	Total number of students in grade 11 & 12	2263	1193	3189	1650
2	Total number of teachers	61	70	113	111
3	IT Labs	Yes	Yes	Yes	Yes
4	Who built the computer labs in your college? (Ownership)	KP Government	KP Government	KP Government	KP Government
5	How many computers are in the computer lab?	61	53	18	25
6	How many permanent IT staff?	4	5	7	7
7	Do teachers have access to a computer?	Yes	Yes	Yes	Yes
8	How many smart boards/ one screen in the college?	None	None	None	None
9	Is the internet facility available?	Yes	Yes	Yes	Yes
10	working website?	https://gpgc-atd.edu.pk/	No	https://gcp.kp.gov.pk/	No
11	Facebook page?	No official Facebook page	No official Facebook page	No official Facebook page	No official Facebook page

College Finances (per year)

Sr.No	College Name	2019-20	2020-21	2021-22
1	GPGC Abbottabad	182.3m	184.75m	195.39m
2	GGDC No.1 Abbottabad (Girls)	95.6m	99.5m	105.5m
3	GC Peshawar	166.2m	192.4m	190.5m
4	GFC Women Peshawar	151.1m	157.9m	173.9 m

Source: Mr XYZ, HEMIS CELL
Higher Education Archives & Libraries Department
Government of Khyber Pakhtunkhwa

APPENDIX I

Information about Government Schools Surveyed

> Government Higher Secondary School No. 1 Abbottabad
> Government Comprehensive Girls High School (GCGHSS), Abbottabad. Code: 36718
> Government Shaheed Osama Zafar Centennial Model Higher Secondary School No. 2 Peshawar (GHSS No. 2)
> Government Girls Lady Griffith Higher Secondary School (GGHSS), Peshawar. Code: 36729

		GHSS No. 1 for Boys Abbottabad	GCGHS, Abbottabad (Girls)	GHSS No. 2 for Boys, Peshawar	GGHSS Lady Griffith, Peshawar
1	Total number of students/ total enrolment	-	1171	-	800
2	Total number of teachers	-	73	-	46
3	Who built the computer labs in your college? (Ownership)	-	-	-	-
4	IT Lab	-	Yes	-	yes
5	How many computers are in the computer lab?	-	16		16
6	How many permanent IT staff?	-	2	-	2
7	Do teachers have access to a computer?	-	-	-	-
8	How many smart boards/ one screen in the college?	-	One available and fully operational	-	One available and fully operational
9	Is the internet facility available?	-	-	-	-
10	working website?	-	-	-	-
11	Facebook page?	-	No official Facebook page	-	No official Facebook page

Source: Mr XYZ, Reform and Initiative section, EMIS
Government of Khyber Pakhtunkhwa

Notes: No information was available with the computer operator about the above-mentioned 2 boys' schools and he asked for the code number for these schools. On telling him how would they know as these codes were assigned by his own department, he was clueless and couldn't find the names of these boy schools on the dashboard although he was in charge to maintain the latest data for KP schools.

About the school budget:
The Section Officer Budget (SO Budget) EMIS informed the research team that EMIS or Education Department does not allocate budget to any schools. He said, "we do not release budget to schools, there are two kinds of educational institutions namely; 1. Autonomous bodies such as Cadet Schools and Colleges (for which we do not provide any budget) 2. The ones that are being run under annual grants but these are a few schools, such as Fazl I Haq School and College Mardan, UPS (University Public School), and APS (Agricultural Public School). But these grants are provided through ETEA, not through Education Department."

Moreover, he said that currently, DEOs are given 449,000 conditional grants which they use on the direction of DC. Besides, 2.99 m rupees are given to the Directorate but the money is being issued on demand from the Directorate. The concerned Head/ principal of the school writes to the Directorate for funds. And in the year 2020-2021, 88,000,00 Rs were allocated to the DEO Offices to be utilised for IT-related purposes.

However, there is no such thing as a per-school budget or release of money from the Education Department! Everything is on-demand directed to the directorate and DEOs office. The section officer budget EMIS told the research team to contact the DEOs office in every district for more information

APPENDIX J

Web Presence of KP Schools/ Colleges

	School/ college	Website	Facebook page
1	Government College for boys, Peshawar	https://gcp.kp.gov.pk/	https://www.facebook.com/pages/category/Education/Government-College-Peshawar-HED-KPK-156866728316121/
2	Government Lady Griffith Higher Secondary School, Peshawar	http://schools.kpese.gov.pk/webportal/cms/content/186/36729)	https://www.facebook.com/pages/category/Education/G-G-H-S-S-Lady-Griffith-Peshawar-342590795764504/
3	Government Shaheed Osama Zafar Centennial Model Higher Secondary School No. 2	No Website Available	https://www.facebook.com/pages/category/Elementary-School/Government-Shaheed-Osama-Zafar-Centennial-Model-Higher-Secondary-School-157406384796042/
4	Government Higher Secondary School No. 1 Abbottabad	No Website Available	https://www.facebook.com/pages/category/School/Govt-High-School-NO-1-Abbottabad-695646837272121/
5	Government Comprehensive Girls High School, Abbottabad	No Website Available	No Facebook Page
6	Government Frontier College for Women, Peshawar	https://admission.hed.gkp.pk/college.php?college_id=4	https://www.facebook.com/pg/Govt-Frontier-College-For-Women-Peshawar-645781155791863/posts/)
7	Government Post-Graduate College No. 1 for boys and girls, Abbottabad	https://www.gpgc-atd.edu.pk)	https://www.facebook.com/gpgc1abbottabad).
8	Government Girls Degree College for Women, Abbottabad	http://www.admission.hed.gkp.pk/college.php?college_id=153	https://www.facebook.com/ggpgcno.1abbottabad/

APPENDIX K

Lady Reading Hospital MTI, Peshawar & Ayub Teaching Hospital MTI, Abbottabad

		Lady Reading Hospital , Medical Teaching Institute, Peshawar	Ayub Teaching Hospital, Medical Teaching Institute, Abbottabad
1	Established in	1924	1998
2	Number of Departments	33	-
3	Hospital Beds	1691	1460
4	Doctors	1350	500
5	Staff	4500	60 residents & fellows + 200 nurses

6	OPD Patients in 2021	1169497	-
7	Emergency Patients in 2021	852998	-
8	Admit Patients in 2021	105041	-

Source: Lady Reading Hospital, MTI, Peshawar website. Retrieved January 2, 2022, from LRH website https://www.lrh.edu.pk/
GoKP, Policy Board, Khyber Pakhtunkhwa. MTI's. Retrieved Feb 12, 2022, from https://policyboardkp.gov.pk/mtis/

Note: An attempt to read or download MTI's Governance Framework available on Policy Board KP website was futile. https://policyboardkp.gov.pk/downloads/

Note: The ATH, MTI, and Abbottabad website is down for many months showing errors.

APPENDIX L

Additional Institutions Connected with KPE&SED

	KPE&SED Affiliated Institutions
1	**Khyber Pakhtunkhwa Education Monitoring Authority (KPEMA):** Education Monitoring Authority, Khyber Pakhtunkhwa (KPEMA). With a motto 'Better Education with Better Living Standards,' this monitoring authority made in 2014 aims at establishing performance monitoring mechanisms over schools and increasing public awareness and ensuring social accountability by giving access to information about school facilities, infrastructure and service delivery outcomes; information on key indicators is posted on the web for citizens to review. Data evaluation is also one of the tasks done to evaluate the performance of public schools across the province. The 'accurate and timely' data is further shared with all the education departments as well. KPEMA is also required to randomly select a sample of schools in various Districts for ensuring the accuracy of data and developing remedial measures for data inconsistencies etc. The website shows the % age of teachers' presence across the province and also information about the total number of schools and madrassas in KP province (EMA GoKP, 2014). Link: http://175.107.63.45/newimusite/
2	**The Elementary and Secondary Education Foundation (ESEF**): It is another affiliated institution, which is tasked with setting up informal community schools in those hilly areas of Khyber Pakhtunkhwa where there are few government schools available (GoKP ESEF, n.d.). Link: https://eef.org.pk/
3	**Education Management Information System (EMIS):** EMIS is "an Information System for Managers of the Education System". EMIS is a Tool for: 1. Data collection 2. Storage 3. Integration 4. Analysis 5. Dissemination This unit of KPE&SED, headed by a director, is responsible for all IT undertakings in primary and secondary education, including HR Information Systems, School Management Information Systems, E-Transfer Systems, Bio-metric Attendance Systems and other IT-related activities. The director of EMIS reported EMIS Cell functioning in each district of Khyber Pakhtunkhwa and manned by around 400 to 450 technical manpower (S. M. Khan, Personal interview, July 14, 2021)Link: https://ese.kp.gov.pk/page/education_management_information_system_emis

4	**Education Sector Reforms Unit (ESRU):** This body working under the KPE&SED is mandated to 'plan, coordinate, monitor and evaluate' the ongoing reforms activities/programs,' undertaken with the DPC (Departmental Promotion Committee) and future reforms activities (KPESED, 2021). The website provides a list of donors and the amount of money provided to the ESRU, which accounts for a total of PKR 55,338 million, spent on providing incentives to ***female teachers*** in disadvantaged districts of Kohistan, Shangla, Battagram, Tank, Dir Upper and Buner. Additionally, to promote girls' education, ***girl students*** (grades 6-10) in Khyber Pakhtunkhwa are also provided with stipends through the local Post Offices & Education District Offices. The website claims 309090 students benefited from this project in 2009-10 and around 90 poor intelligent students have been provided admission to the 7th class in the centres of excellence in the province (KPESED, 2021). **Link: https://ese.kp.gov.pk/page/education_sector_reforms_unit_esru#:~:text=The%20Main%20Purpose%20of%20the,and%20future%20reforms%20activities%2Fprograms.**
5	**Private School Regulatory Authority (KPPSRA):**

APPENDIX M

Additional Institutions connected with KPHED

	KPHED Affiliated Institutions
1	Directorate of Higher Education (https://hed.kp.gov.pk/)
2	Directorate of Archives and Libraries (http://kpdal.gov.pk/)
3	Higher Education Teachers Training Academy (HETTA) (no separate website; https://hed.kp.gov.pk/page/higher_education_teacher_training_academy_hetta)
4	Project Management Unit (https://hed.kp.gov.pk/page/project_management_unit)
5	Higher Education Regulatory Authority (HERA) (http://www.herakp.gov.pk/)
6	Testing and Evaluation Agency (https://hed.kp.gov.pk/page/educational_testing_and_evaluation_agency)
7	Frontier Education Foundation (FEF) (https://kpef.edu.pk/public/app)
8	Employee Education Foundation (EEF) (https://hed.kp.gov.pk/page/employeeseducationfoundationeef)

APPENDIX N

Total Number of Schools & Madrassahs in Khyber Pakhtunkhwa (KPEMA)

Website visited in May 2021

Schools Break Up

Levels	Boys	Girls	Total
Mosque	766	0	766
Primary	12596	8660	21256
Middle	1439	1199	2638
High	1435	830	2265
Higher Secondary	470	269	739
Total	**16706**	**10958**	**27664**

Source: KPEMA, GoKP. (n.d). Schools Break Up. Retrieved May 2, 2021, from the website: http://175.107.63.45/NewIMUSite/index.aspx#

Website visited in February 2022

Schools Break Up

Levels	Boys	Girls	Total
Mosque	326	0	326
Primary	8727	6812	15539
Middle	1098	991	2089
High	1060	633	1693
Higher Secondary	321	192	513
Total	**11532**	**8628**	**20160**

Source: KPEMA, GoKP (n.d). Schools Break Up. Retrieved February 2022 from the website: http://175.107.63.45/NewIMUSite/index.aspx#

APPENDIX O

Total Number of colleges in Khyber Pakhtunkhwa (KPEMA)

Website visited in May, 20221

Level	Total	Males	Females
Colleges	189	114	75
Students	164,886	106,198	58,775
Post-Graduate Colleges	20	15	5
Teaching staff	5531	-	-
Post-Graduate Colleges			

Source: HED, GoKP. (n.d). Welcome to the Higher Education Archives & Libraries Department Government of Khyber Pakhtunkhwa. Retrieved May 2, 2021, from the website: https://hed.kp.gov.pk/

Website visited in February 2022

Level	Total	Males	Females
Colleges	177	109	68
Students	150,691	95,014	55677
Post-Graduate Colleges	20	15	5
Teaching staff	5531	-	-

Source: HED, GoKP. (n.d). Welcome to the Higher Education Archives & Libraries Department Government of Khyber Pakhtunkhwa. Retrieved Feb 2, 2021, from the website: https://hed.kp.gov.pk/

Note: The number of colleges is, however, underreported on the website. According to a newspaper report, there are 303 fully functional colleges in Khyber Pakhtunkhwa, out of these 177 are male and 126 are female colleges. As reported in newspapers, around 67 new colleges are under construction, with 29 of these colleges for females. In the last financial year (2020-21), around 20 colleges were completed. Under the current 2021 Annual Development Program (ADP), 12 new colleges will be built in erstwhile FATA (The News, August 29, 2021). To quote the HED Minister, 'launching of a web portal for Higher Education Department Khyber Pakhtunkhwa is an important step towards merit and transparency,' (HED GoKP. b, n.d.).

APPENDIX P

Early Age Programming and IT Essentials Initiative' KPE&SED

Projects launched	Date	Districts covered	Number of schools	Number of beneficiaries (students)
Phase I	Jan 2017- Dec 2017	13 districts	57 schools	3000 students
Phase II	Jan 2018- June 2019	14 districts	300 schools	17000 students
Phase III	currently running	10 districts	225 schools	11000 students

This initiative falls under the Digital skills pillar of the 'Khyber Pakhtunkhwa Digital Strategy' and is praised by the KPITB website in these words 'The project has produced remarkable results and the computer literacy and digital skill level of the marginalised students at government schools have improved significantly.' However, a click on the 'list of schools' section shows that the URL is not available (GoKP, KPITB Early Age Programming, n.d.).

PART II

TECHNOLOGY & PUBLIC SERVICE DELIVERY

Policy Briefs

ELECTRONIC VOTING MACHINES FOR PAKISTAN: OPPORTUNITIES, CHALLENGES, AND THE WAY FORWARD

Hina Binte Haq, Syed Taha Ali and
Maryam Zafar Usmani

INTRODUCTION

Elections in Pakistan suffer from poor execution, persistent rigging and fraud, and a pronounced lack of transparency, which undermines citizens' confidence in elected leaders and negatively impacts civic participation and trust in democracy. In this context, the government's recent push for electoral reforms is a welcome step to restore citizens' confidence and trust in elections. Election technology, such as electronic voting machines (EVMs), result transmission system (RTS), and internet voting have documented benefits in curbing fraud. However, these technologies are prone to fail and may even result in disastrous election day outcomes if deployed without careful research and homework.

This policy viewpoint structures the ongoing debate around EVMs and election technology in Pakistan and is grounded in research, international best practices, and expert guidelines. The study on which this viewpoint is based is, to the best of our knowledge, the first technology-focused study that provides a systematic framework to evaluate and address the challenges faced in the transition to EVMs in Pakistan.

KEY FINDINGS

International Experience

- The international experience shows considerable benefits of using EVMs:
  - EVMs dramatically reduce the time and manual effort required for vote tabulation and result reporting and significantly mitigate certain types of electoral fraud.
  - EVMs provide accurate counts by eliminating spoiled ballots and human errors in counting.
  - The adoption of EVMs can improve voter turnout, empower marginalised communities to vote, reduce electoral expenses, and may even correlate with improved governance.
- The disadvantages are also considerable:
  - EVMs are closed systems, prone to malfunctioning, and can be easily hacked. While EVMs counter certain types of electoral fraud, they may open the door to new and more dangerous attacks.
  - Voters might find EVMs difficult to use.
  - EVMs can be very costly and can necessitate further significant costs on infrastructure and logistics.
- EVMs have been used in different countries since the 1960s and have proved highly controversial. Developed countries, including Ireland, the Netherlands, and Germany have phased out or terminated their EVM deployments over concerns about voter privacy and election integrity. At the same time, the deployment of EVMs in developing countries, such as India, Brazil, Venezuela, and the Philippines has yielded mixed results. There is, therefore, an urgent need to understand this trend such that we may maximise the gains of these technologies and avoid mistakes made by other countries.

New Election Technologies

- Revolutionary new technologies have emerged in recent years which enable citizens and observers to verify and audit election results to ensure trust in poll results:
    - **End-to-end verifiable (E2E-V)** voting systems are a promising new paradigm that provides voters with strong cryptographic guarantees that the vote was cast as intended, recorded as cast, and tallied as cast. These cryptographic guarantees make the entire election life cycle auditable by third parties, the voters, and the election administration alike. The voter does not have to blindly trust the voting system, polling officers, or election authorities regarding the integrity of the election. If there is any malfeasance or rigging, it will be exposed by the protocol itself.
    - **Risk-limiting audits (RLA)** are statistical tests that reduce the risk of an erroneous election outcome by identifying anomalies. RLAs are public ceremonies, to which invitation is extended to the public, civil society, and media. Such public ceremonies can also be live-streamed. They are a very effective measure to increase voter and stakeholder confidence in the outcome of elections and raise the perception of electoral integrity.
- E2E-V Voting Systems and RLA are being developed and piloted in developed countries. However, there is limited insight into how these technologies can be adapted to Pakistan's context.

Lack of fundamental expertise

- There is no global standard or formula for deploying EVMs, and each country must carefully adapt these machines to their unique ground realities and build a supporting ecosystem.
- Our prior experiences with election technology demonstrated our lack of fundamental expertise in this domain and highlighted critical knowledge gaps in our discourse and strategy. An expert audit commissioned by the Supreme Court of Pakistan identified critical vulnerabilities in every major component of a homegrown internet voting solution for overseas Pakistanis in 2018. Likewise, the mysterious failure of the result transmission system during the general elections of 2018 cast a cloud of suspicion on the election results.
- Adapting election technology to our unique ground realities in a secure, reliable, and cost-effective manner requires great care, effort, and deliberation on the part of stakeholders and considerable work on building a supportive ecosystem for the technology.

POLICY RECOMMENDATIONS

The following actionable recommendations based on our findings are accompanied by a summary of the roadmap that may serve as a guide in their implementation.

Foundational Principles

The ECP should ensure any election technology solution must expressly cater to the principles of secrecy of the ballot, electoral integrity, openness and transparency, accessibility and usability, and sustainability.

Groundwork to develop the requisite ecosystem

- The ECP should solicit stakeholder input from the onset to democratise the debate around EVMs and develop trust in the voting system. There is considerable polarisation in the current discourse around EVMs and we need to provide forums for stakeholders to engage constructively on this topic. Research suggests that consensus-building measures harmonise the conduct of the elections, reduce post-poll tensions and violence, and contribute to the overall credibility of the polls.
- The ECP may establish a research division to provide quality inputs for technological, legal and policy decisions.
- The ECP should undertake a gap analysis to identify the limitations in its capacity that may hinder the project from achieving its objectives. An action plan should be developed to bridge these gaps.

- The ECP should assess the readiness of the ecosystem, specifically from technological and infrastructural perspectives. Countries including Brazil, India, and Bangladesh have successfully innovated EVMs as per their own needs within their limited resources.
- The ECP can devise a digital transformation strategy to modernise the ECP and its systems to the point where they can successfully launch and manage large-scale EVM deployments.
- It should develop a cybersecurity strategy to counter attacks on IT infrastructure. Identify and work towards implementing international information security standards such as ISO/IEC 27001.
- The ECP must undertake measures to foster social support and trust. This includes targeted strategies for media, voter engagement and communication, public oversight and technologists' involvement, among other things.

Technical Specification and Pilots

- For the successful adaption of EVMs in Pakistan, the ECP should undertake a threat modelling study, to identify the security issues and vulnerabilities on the ground that we expect to address. It should also define baseline security requirements for EVMs accordingly.
- The Commission should conduct an analysis of the suitability of popular EVM types for use in Pakistan on a range of factors, including security, usability, costs, logistics, storage, and handling requirements.
- It should devise voter verification strategies, like multi-finger authentication, computer vision solutions, tokens, and smart cards.
- Moreover, it may undertake multiple large-scale pilots in a mix of urban and rural areas to ensure adequate representation of the electorate

Sustainability and Support

- Similarly, the ECP needs to develop a comprehensive strategy for the testing, piloting, and implementation of supporting technologies such as the result transmission system (RTS).
- The ECP needs to develop sustainability strategies for EVMs and supporting technologies. As a developing country, it is vital that we seek out cost-effective options and utilise our resources efficiently.

Transparency and Security

- The ECP must also focus on developing comprehensive standards and testing and certification protocols for EVMs to provide stakeholders with greater transparency into the state of the machines
- It may also organise hackathons and solicit feedback from the international and local election technology community to identify vulnerabilities and provide stakeholders with greater transparency.
- Furthermore, the ECP can engage third-party technical experts regularly to assess the security properties of EVMs.

Operations and Logistics

- The ECP also needs to develop comprehensive storage and transport facilities and protocols for accessing, handling, and maintenance of EVMs that can be rigorously monitored and policed.

Legal Framework

We recommend ECP introduce and update legislation to support EVMs through:

- conducting pilots for end-to-end verifiable voting systems and risk-limiting audits
- establishing institutions, standards and provisions for technology trials and certifications
- pre-auditing and post-auditing of EVMs and supporting equipment
- defining rules for access to source code, EVM, procedures for observers and political parties
- establishing efficient dispute resolution mechanisms under the new voting modality
- defining what constitutes admissible evidence in court

- updating procedural checks according to the updated voting mechanism
- specifying data protection law for voter data and what recourse is required in case of breach

Phased Implementation

Planning and implementation should not be rushed, and time should be provided in the pre-election phase for systems review, revisions, and retesting.

Roadmap: Ecosystem for EVMs in Pakistan

Key Steps	Document / Activity	Dependencies	Timeline
1	Establish Steering Committee	-	0-1 month
2	R&D Cell	-	1-2 months
3	Stakeholder Consultation and Outreach	[1-2]	3-4 months
4	Capacity Building	[1]	3 months onwards
5	E-Voting Readiness Strategy	[1-3]	3-4 months
6	A Digital Transformation Strategy for ECP	[1-3]	3-5 months
7	A Cybersecurity Strategy for ECP	[1-4] [6]	6-7 months
8	Public Engagement	[1-5]	4 months onwards

Roadmap: R&D Cell

1	Building Linkages & Knowledge Mobilink sation		2-4 months

Roadmap: Electronic Voting Machines for Pakistan

1	Threat Model for EVMs in Pakistan	-	2-4 months
2	Vulnerability Analysis of MoST EVM	[1]	5-6 months
3	Vulnerability Analysis of Smartmatic EVM	[1]	5-6 months
4	Comparative Analysis of Popular EVM Models	[1]	7-8 months
5	Deployment Study for E2EV Voting Systems	[1-4]	6-11 months
6	Deployment Study for Risk Limiting Audits	[1-4]	6-11 months
7	Voter Verification Mechanisms	[1-4]	6-8 months
8	Specifications and Requirements	[1-7]	12-13 months
9	Prototype EVM	[1-8]	14-16 months
10	Pilot Studies	[1-9]	16-18 months
11	Feedback and Improvement	[1-10]	18-19 months
12	Second Round of Pilots	[1-11]	20-21 months
13	Second Round of Feedback and Improvement	[1-12]	22-23 months
14	Hackathons. Source Code Review	[1-13]	16-17 months
15	Election System Certification	[1-14]	22-24 months
16	Procurement	[1-15]	24-42 months
17	System Integration	[1-15]	24-26 months
18	Infrastructure, Operations and Logistics	[1-15]	24-29 months
19	Updating Legal Framework	[1-4]	22 months onwards
20	Monitoring, Evaluation, and Innovation	[1-15]	30 months onwards

Source: Author's Illustration

TRANSFORMING PUBLIC SECTOR THROUGH E-GOVERNANCE: A CASE STUDY OF KHYBER PAKHTUNKHWA

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INTRODUCTION

The introduction of information and communication technology (ICT) tools for the governance of Khyber Pakhtunkhwa province has been a unique experience with policy making in this otherwise economically and socially underdeveloped province. These changes in governance, often known as e-governance, are aimed at providing cost-efficient, transparent and inclusive services. Since 2013, the province of Khyber Pakhtunkhwa is leading this race by introducing innovative e-governance reforms in various departments, such as health, revenue, education, and district administration. This research attempts to investigate the e-government reforms and impacts on service delivery in two of Khyber Pakhtunkhwa government's departments, namely education and health, where several e-policy initiatives are introduced, focused on the provision of quality education and improved healthcare to the residents of Khyber Pakhtunkhwa.

SCOPE

This policy brief is based on the study titled "Transforming the Public Sector Through Digital Governance Initiatives in Khyber Pakhtunkhwa: Bureaucratic Conduct, Transparency in Service Delivery, and Citizen-Centric E-Governance." The study explored the ICT initiatives and impacts on service delivery in the two provincial government departments of education and health. The aim was to critically analyse such impacts on efficiency, transparency, and inclusivity aspects of public service delivery and the improvement of citizens' trust in the government. It attempted to do so from the perspective of public service providers, i.e., the bureaucracy and end users (school and college students and hospital patients). It also evaluated the cultural and organisational changes in the provincial bureaucracy due to digital governance.

METHODOLOGY

The study was based on mixed methods, using data from both qualitative and quantitative sources. Qualitative data were collected from 25 in-depth semi-structured interviews and FGDs with officials of education, health and IT-focused departments of Khyber Pakhtunkhwa. Additionally, a structured survey questionnaire was used to collect data from 305 respondents based on 10 survey sites, which included students studying in 8 government secondary and higher secondary schools and colleges, and patients in 2 largest tertiary hospitals in Peshawar and Abbottabad districts of Khyber Pakhtunkhwa. Primary data sources were complemented with secondary data from books, journal papers, and online sources.

FINDINGS

The findings of the study suggest that significant digital interventions were made by the provincial government in both education and health sectors, and the Covid-19 emergency provided a big push for the digitisation of government services. These interventions are driven by, first, a desire to generate policies based on evidence-based data and, second, to optimise efficiency, transparency and accessibility of services. However, the ICT-induced impacts on service delivery varied depending on the nature and the context of digitisation interventions, which had differing results. In the context of the education

sector, for example, access to online tele-learning services was limited by a student's economic background and the paucity of funds inhibiting IT infrastructure in public schools. Most of the health and education e-initiatives focus on registering online complaints, applying for e-transfers, online admissions, or printing online forms, which made it a managerial type of government, as Chadwick and May (2003) suggest, measures that are steered toward greater government control and less public participation in policy-making.

Additionally, the propensity of significant groups being left out, either due to the non-availability of resources, such as computers, and the internet, or accessibility being limited to the ICT literate population only, made limited accessibility a greater possibility. The findings also suggest that ICT-induced transformations in bureaucracy's organisational culture in terms of its values, expectations, processes and practices have led at times to bureaucratic resistance and scepticism of the ICT-introduced reforms. Such limitations may prove a big stumble in the Khyber Pakhtunkhwa government's vision and attempts at providing speedy, efficient, accountable, and inclusive services to the public.

POLICY RECOMMENDATIONS

Pakistan is relatively slow in the adoption of e-governance practices as Pakistan was ranked 148 out of a total of 193 countries on the UN 2018 e-Government Index (The World Bank, March 18, 2019, 75-78). Similarly, the Global Information Technology Report 2016 in its Networked Readiness Index ranked Pakistan 110th with a 3.4 score (maximum was 6) among a total of 139 countries. The index evaluated countries in terms of adoption of factors, policies and institutions for ICT adoption and usage in increasing economic competitiveness and well-being. It was up from last year by two positions (World Economic Forum, July 2016; Bellar, Dutta and Lanvin, 2016, p. 16; Zeb, 2015).[1]

The following policy implications and recommendations are suggested:

- In Khyber Pakhtunkhwa, much needs to be done to involve citizens in the participatory practices of e-governance, where the citizens are not just involved in utilising digital governance steps for citizen complaints and redressal, but also play their roles in policy formulation and direction. For this to be practical, it is important that the IT wings (HEMIS, EMIS and HIS) of both education and health departments must engage citizens in the process of online consultations before an app or digital service is launched. It is important to mention here that such online consultations may be popularised through social media projection. The only recent attempt at engaging citizens is on the KPESED website, which opens a window inviting citizens to pen their
- suggestions on school syllabus changes. Such steps are noteworthy because citizen participation will further boost their trust in the government's service delivery undertaking through the ICTs.

- However, the starting point for transparency is the availability of open sources of information, easily accessible to the public on websites. Open sources of information also increase the trust of people in the government. Therefore, there is an urgent need to update the websites of both the health and education departments. This is essential because the websites of both departments contain mostly outdated information or some very basic information. Within the health department, the Directorate General of Public Health (DGPH), which is a very critical policy implementing, and monitoring and evaluation institution, has a website that only contains some very fundamental and rudimentary information. Similarly, several affiliate institutions of both the KPESED and HED do not even have websites. A click on several subsites on their website takes us to messages about URLs not functioning. That needs a thorough revamping. Here, the

[1] The UN assesses and releases every two years the E-Government Development Index (EGDI) to ascertain the level of e-government readiness across different countries. This is done through an in-depth analysis of survey data across different ministries and levels of government in three components: scope and quality of online public services (Online Service Index: OSI); the development of telecommunication Infrastructure (Telecommunication Infrastructure Index: TII); and that of the Human Capital (HCI). Pakistan ranks among the 66 middle E-Government Development Index countries (Middle EGDI group), which are ranked at a score of around 0.25 to 0.50 in terms of e-preparedness. The scores for the very high and high groups in e-preparedness range from more than 0.75 to more than 0.50 respectively (UN E-Government Survey 2018, 85-86). It mentions Pakistan among the 6 Asian countries to have improved its e-presence in terms of service provision (Online Service Index- OSI) online from 2016 rankings (UN E-Government Survey 2018, 94).

responsibility of updating can be tasked to the department's respective IT wings. For this purpose, data administrators specifically tasked with uploading the current set of information on government websites can be hired and tasked with uploading new information every fortnight.

- The World Bank's report, 'Pakistan@100: Shaping the Future' recommends within the governance domain essential transparency and accountability reforms, which comprise the provision of 'transparent and accessible information' on reforms and service delivery to citizens, including budget documentation transparency. Pakistan declared its intention to join the Open Government Initiative and undertake fiscal transparency in 2016 but no major plan has been initiated so far (The World Bank, March 18, 2019, 79).[2] Therefore, another policy recommendation is that the government, including the Khyber Pakhtunkhwa government, must ensure online access to the public to the government's financial statements relating to various expenditures and on various projects. This is imperative in achieving the goal of transparent service delivery.

- The interviews, the survey, and informal chats with the public also raised the important issue of the public's non-awareness of different services providing digital apps. This led to the under-utilisation of service generation apps. At times, the public was even unaware of what ICT service generation constituted and how to access the same. Therefore, it is recommended that the government should seriously project its new as well as old ICT initiatives on social and print media platforms and educate the public on how such apps may be optimally utilised. This implies that all such digital programmes for learning should be exposed to proper media coverage campaigns so that people become aware of these initiatives. This is not an unattainable task; since all departments already have PR and media officials or spokespersons, they can be engaged and tasked with the responsibility of proper projection of digital tools in service delivery. It is also recommended that the concerned departments hold small seminars and workshops in educational institutions, especially higher secondary schools and colleges to train and educate students and teachers about the potential usage and benefits of such apps. Awareness campaigns can also be run through primary school teachers who are in a better position to motivate and educate their communities on specific benefits to gain from accessing service generation through such apps.

- This brings us to our next policy recommendation for how to bridge the digital divide. The quantitative survey analysis revealed that a large majority of public schools are populated by children who come from very low-income groups (with family income less than PKR 25,000). Similarly, mostly very poor patients access public hospitals. There is, therefore, a serious problem of affordability of digital tools on account of differences in socio-economic backgrounds. To bridge the digital divide in education, students must be provided with subsidised microcredits for the purchase of computers and tablets. The banks can take up the initiative following the example of the Grameen bank (Bangladesh) micro-financing. Pakistani companies can assemble or make basic tablets at low prices for consumption by low-income households. For this, the government of Pakistan may provide such companies with different tax concessions to incentivise them to produce cheap tablets in bulk for consumption and use in public schools.

- Another form of the digital divide is emerging within the public sector schools, between those schools that are exposed to IT and computer labs (60 %) and those that are not (around 40%). Unless proper infrastructure is provided, other related changes in syllabus, etc., will not help the cause of ICTs. For this, the government, besides raising its funding for infrastructure provision, can also approach donor agencies and NGOs for assistance with essential IT infrastructure and training of teachers in IT skills. Some such attempts at IT training have already been attempted in the past.

[2] The report emphasises that there is a lack of access to centralised and digitised staff records creating inefficiencies, lack of transparency, and lack of coordination and collaboration within and across departments. Among its recommendations are increasing transparency in public financial management (Right to Information Act on financial information; timely disclosure of budget documentation and execution; publicising audited financial statements of SOEs; e-procurement for transparency, competition and reduced corruption), and strengthening citizen's voices in holding public officials accountable and expansion of monitoring efforts at the state level. For this, technology holds the key.

- The public sector school children are exposed to computer education from secondary and higher secondary levels, which, given the importance of IT learning at an early age, is very late exposure. It is important that computers are introduced in the public sector primary and middle schools as a compulsory subject. Only by introducing children at a very early age to computer programming and coding, we can expect to produce a generation of IT experts. There is another side to the story. Even at the secondary and higher secondary levels, computer is an optional subject, which, in turn, is directly related to the lack of essential infrastructure in all schools. Here, the mandatory intervention of making the computer subject compulsory and provision of essential infrastructure at all levels of schooling to see this decision implemented is imperative. We should not forget that specific schemes in which children of early age were introduced to computer programming and coding under specific interventions made by the KPITB, ended up winning international prizes. There is a need to bring out more of such computer programming and coding programmes by the specialised IT department of the Khyber Pakhtunkhwa government, i.e., KPITB and other IT-focused departments, such as the ST&IT.

- Agreements with cell phone companies for student packages or teaching packages for school and college teachers is also a desirable step. This has been attempted by the Government of Pakistan in the case of successfully running the online admissions system for colleges. The service was initiated with the help of a renowned cell phone company.

- One suggestion for the Khyber Pakhtunkhwa government is to combine the efforts of its various IT-focused departments under one IT ministry and task that ministry with developing, implementing, and assessing the ICT tools. In its current form, the Khyber Pakhtunkhwa Information Technology Board (KPITB), the Science and Technology & Information Technology department (ST&IT), the Directorate of Science and Technology (DoST), and the Directorate of Information Technology (DoIT) all perform some overlapping functions. Although recently the DoIT was merged into the KPITB, there still is a need to streamline the technology-focused departments under a single ministry so that duplication of work and friction could be avoided.

- The overall performance monitoring of government departments on ICT tools can be managed solely by the Performance Management and Reforms Unit (PMRU). The PMRU is a cell established in 2016 in the office of the chief secretary, Khyber Pakhtunkhwa to monitor, analyse, and improve the performance of all tiers of the provincial government through the innovative use of ICTs. However, this institution has been established as a unit, whose term of office is renewed every three years. There is a need to establish this unit as a permanent department with legal status defined so that it can perform its function of evaluation of service provision through the ICTs regularly. This regular evaluation will help understand the shortcomings and underperformance through ICTs by different provincial government departments.

- An essential aspect to overcome the resistance to ICT usage among the officials is regular on-the-job IT training. The fact of the matter is that the e-filling system failed to take off in many government departments because of clerical staff and officers' unfamiliarity with it. It must be realised that ICT is a technical domain and needs to be continuously updated through regular in-service training. Such training can be managed by those specialised cells that either are taking care of HMIS and EMIS systems within the health and education departments or by affiliate institutes that have specific mandates of training, for example, the Directorate of Professional Development in the Education Department. In big MIT hospitals, there are already IT sections functioning that provide regular IT training to hospital staff.

- In the field of education, remoteness and accessibility issues hinder students' access to tele-education apps. It is suggested that since PTV has wide reach across all regions of Khyber Pakhtunkhwa, its services could be utilised by the KPESED and the HED for coordinated efforts at televising quality teaching course content for school and college students to follow. This is essential, especially during emergencies as we know that the Corona emergency and resultant school and college closures wasted precious

educational time of students who had little access to online education. PTV has its limited tele-education programme but it is not connected with the education departments of Khyber Pakhtunkhwa and their efforts at tele-education.

- There must be inter-provincial sharing of best practices in ICT and service delivery. During our fieldwork, we found that there was no coordination between the IT departments of different provinces. The IT departments of all the provinces are working in silos, duplicating resources and infrastructure. The coordination between these IT departments will also help them learn from shared experiences and avoid failures from any new experimentations in ICT-induced service generation initiatives.

- There is underutilisation of primary and secondary levels of healthcare systems because of the poor referral system, placing a burden on the tertiary level hospitals. According to rough estimates, around 5,000 patients visit the OPDs of each tertiary hospital daily, which becomes a great burden on tertiary hospitals that are essentially meant to provide highly specialised medical care by medical specialists. In the realm of digital health, one important aspect missing is e-referrals in hospitals. If the MIT hospitals in major cities want patients to access their local BHUs and district hospitals first, especially for common illnesses, the patients and doctors must be connected digitally with specialists in big hospitals. Since the government has already provided technicians in BHUs with tablets, and there was also planning underway for installing fixed tablets for disease monitoring, the same can also be utilised to connect district hospitals and BHU patients electronically with consultants and doctors in tertiary hospitals. This will lessen the burden on major hospitals and encourage people to access basic health services in their hometowns. An introduction of the e-referral system will necessitate training courses on an e-referral system to healthcare professionals, a mechanism for feedback, educating people about life-threatening diseases and non-critical diseases, and developing people's trust in primary healthcare facilities (BHUs, RHCs, etc.) in their respective areas.

- There is a need to provide information through "citizen charters" at all healthcare facilities, ranging from tertiary hospitals to primary healthcare centres. This will help the patients and their attendants understand available health care services, including drugs, service providers, user fees or cost of service, etc. The charter should also include information about the patient medical data protection rights. In some countries, for example, Bangladesh, the Ministry of Health and Family Welfare (MOH &FW) has introduced a citizen charter at all its healthcare facilities. An additional component of this initiative could be that information corners can be established to help patients and attendants register their complaints. The health department should make it mandatory to publicly display it for the patients to read and understand their right to equitable and quality healthcare. Independent monitoring units (IMU) of the Health Department (already in service) could be assigned the task of assessing the outcome of the citizen charter initiative.

- In Pakistan, there is lack of mechanisms that could assess the effects of new technology interventions in different sectors. There is a need to introduce 'technology assessment' in order to aid policymakers by providing them with information about the possible impact of a new technology and assessing the short and long-term consequences of old technology. Technology assessment is a form of policy research that will provide policymakers with information on policy alternatives. Political action is required in the form of laws that mandate or restrain the government (or the private sector) to pay or not pay for certain technologies depending on the availability of evidence.

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