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Implementation of an electronic health information system using DHIS2 tracker to manage and evaluate the National cervical screening programme in Bangladesh



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Abstract

Background The cervical screening programme in Bangladesh upgraded its electronic health information system (e-HIS) in 2019 using DHIS2 tracker application. The upgraded e-HIS collects individual level data and has useful functionalities like sending SMS reminders. Also, the system facilitates data linkage between community clinics, VIA (visual inspection with acetic acid) screening centers, and colposcopy clinics using a unique national identifier. Our present mixed-method study aimed to perform an in-depth assessment of functioning of the new s-HIS and recommend measures to overcome the implementation challenges identified.

Methods In 2024, the Ministry of Health, Bangladesh and the International Agency for Research on Cancer, France, jointly formed a study team, which conducted desk review of documents, visited different health facilities to physically verify functioning of the e-HIS, engaged with health professionals and other stakeholders involved with the programme, and conducted in-depth interviews with e-HIS users and officials managing the system. Key performance indicators (KPIs) like VIA-positivity, colposcopy compliance, detection rate segregated by districts were derived from the e-HIS data for the years 2022 and 2023 for a selected division (Rajshahi).

Results Till April 2024, 14,213 community clinics (out of total 15,564 in the country) were using the e-HIS to register women and motivate them to attend any of the screening centers to undergo VIA. Due to establishment of a functioning linkage between the screening and the colposcopy centers it was possible to track the screen-positive

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women and remind them to undergo colposcopy. KPIs could be successfully estimated based on data collected in Rajshahi division. Unstable internet connection, inability to register women without national identifier, errors in manual entry of the identifier, not being able to capture histopathology diagnosis were some of the challenges identified.

Conclusions A recommendation was made to prepare a quality improvement protocol specifying a set of KPIs for the programme and their benchmarks for the programme.

Keywords Cervical screening programme, Bangladesh, Health information system, DHIS2, Tracker

Background

The International Agency for Research on Cancer (IARC/ WHO), France convened a global expert consultation in 2021 to identify the 'essential' elements of an organized cancer screening programme [1]. 'Having a system to identify the target population and inviting them' and 'having a system to notify the results and sending recall notice to noncompliant individuals' were identified by the experts as two essential requirements for an organized programme. A functioning electronic health information system (e-HIS) with appropriate linkages between different services is key to successfully implementing these two essential elements. An e-HIS collecting individual level data across the screening process is critical to invite the eligible individuals, recall the screen-positives, monitor progress, and evaluate the programme using key performance indicators (KPIs). However, global surveys indicate that cancer screening programmes in most resource-limited countries lack an e-HIS that complies with the above criteria [2].

Bangladesh is a low middle-income country (LMIC) in Southeast Asia with a total population of 168 million (census 2021) spread across eight divisions split into total 64 districts [3]. Cervical cancer is a major public health problem in the country with 9640 new cases (age-standardized incidence rate 11.3/100,000) and 5826 deaths reported in the year 2022 [4].

The cervical screening programme in Bangladesh was officially launched by the Ministry of Health (MoH) in 2005 after the implementation and evaluation of a pilot in 16 districts [5]. Women between 30 and 60 years of age are offered screening every 5 years with visual inspection after acetic acid (VIA) test performed by trained nurses [6]. VIA-positive women are referred to a colposcopy center where the procedure is performed by gynecologists. Women suspected to have high-grade lesions at colposcopy and those with low-grade colposcopy suspected not to come back for further follow-up investigations are offered either thermal ablation or LLETZ (large loop excision of transformation zone) during the same visit. Cervical tissue is sent for histopathology and results are reviewed later.

The programme is coordinated by the National Center for Cervical and Breast Cancer Screening and Training (NCCBCST) at Bangabandhu Seikh Mujib Medical University (BSMMU), Dhaka. The NCCBCST is responsible for protocol development, conducting regular training of nurses and clinicians, monitoring performance of different health facilities, and coordinating with the MoH, Directorate General of Health Services (DGHS) and other stakeholders to ensure smooth operations and expansion of services.

The programme has been opportunistic since inception. Women attending health facilities for various reasons are motivated to undergo screening. Periodic media campaigns and promotional efforts by the MoH and different civil society organizations are arranged to improve participation. Individual medical records related to screening, colposcopy and treatment are maintained in paper-based registers at each facility.

In 2010, Bangladesh introduced an e-HIS using the District Health Information System version 2 (DHIS2), an open-source platform developed by the University of Oslo to collect data from various health programs [7]. The e-HIS caters to more than 14,000 health clinics spread across primary and secondary levels. With 98% of public health facilities covered by the e-HIS, Bangladesh has become the largest deployer of DHIS2 globally [8]. Each facility involved in cervical screening programme contributed aggregate performance data to the system periodically.

Since 2019, the e-HIS started collecting individual level data by registering each participant of the cervical screening programme using the DHIS2 Tracker application. This added a whole new dimension to the screening programme by creating opportunities for sending individualized invitation and reminders, tracking the screenpositive women and measure KPIs for programme evaluation.

The objective of our present study were as follows:

- 1. Report functioning of the new e-HIS application that would help other LMICs to manage and monitor their own screening programmes using the DHIS2 tracker.
- 2. Assess capabilities of the e-HIS to register eligible women, collect individual level data across screening

and colposcopy facilities and analyse the same to estimate the KPIs.

- 3. Identify implementation challenges of the new system and explore opportunities for improvement.
- 4. Recommend measures to enhance its effectiveness.

Methods

The health services research study involving both quantitative and qualitative components (mixed methodology) was implemented as part of a programme evaluation exercise initiated by BSMMU, the coordinating organization for the programme. The study focused on assessment of functioning and implementation of the new e-HIS was conducted between April 2024 and July 2024. No ethics approval was required as the study was part of quality improvement of routine health services and was based only on information and aggregate data collected from the e-HIS and various health facilities. Appropriate approval was obtained from the MoH to conduct the study and use aggregate data generated from the e-HIS. Only one DGHS authorized representative in the team had access to the password protected e-HIS that contained individual data.

The evaluation of e-HIS was conducted by a team comprising of national coordinator of the programme (AN), a colposcopist (RA) and an information system specialist (PN) from BSMMU, an Upazila Health and Family Planning Officer responsible for all type of DHIS2 data monitoring and access, an information system specialist from DGHS (SNU) and an IARC expert (PB). The assessment consisted of following activities:

- a) Desk review of documents that described organization and performance of the screening programme till date and documented implementation of the e-HIS.
- b) Visits to different health facilities for physical verification of functioning of the e-HIS.
- c) Meeting the health professionals and other stakeholders from multiple districts in groups to obtain their feedback on the e-HIS and their opinion on scopes for improvement.
- d) In-depth interviews with e-HIS users and officials managing the system at DGHS to obtain their feedback on the e-HIS and their opinion on scopes for improvement and understand their vision for the future.
- e) Analysis of data obtained from one division for the years 2022 and 2023 to estimate the KPIs.

As the DHIS2 Tracker -based application is still being rolled out across the country, for facility visits and data collection we selected Rajshahi administrative division, which is among the few divisions that completed rolling Page 3 of 10

out of the e-HIS across all the districts by 2023. Rajshahi is the third most populous among the eight divisions in Bangladesh. With a mix of eight rural and urban population, it is generally representative of other divisions in the country. As all the divisions are going to use the same software application, evaluation of data from a single division gave us a good understanding of functionality of the software to estimate various KPIs.

Details of various activities are described in the following sections.

Desk review of documents

The team did a review of documents published over the past five years, including national protocols, policies on cancer screening, quality assurance guidelines, operational guidelines, and training resources for e-HIS management. Most of the documents were made available by NCCBCST and the MoH. A scoping review of literature was done to identify relevant publications in peerreviewed journals. The team was supported by SP and MR from IARC to conduct the review.

Facility visits

The study team visited a community clinic (the last mile health facility in Bangladesh), an Upazilla Health Complex (UHC; equivalent to a primary health center), a district hospital, and a medical college hospital in Rajshahi district. The district and the health facilities were selected as convenient samples among the centers that handled high volume of screening participants and their use of the updated e-HIS for at least 3 years. The colposcopy clinic at BSMMU, the largest colposcopy clinic in the country, was also visited. Date and time of the visits were preplanned based on discussions with the facility in-charges. At each facility, the team checked availability and functionality of the computers dedicated to screening data entry, availability of trained staff for data entry and whether data entry from the register to the e-HIS was up to date. They also checked a few randomly selected case records for completeness of documentation and completeness of transfer of data to the online system. In-depth interviews were conducted at the facilities with service providers and data managers to gather their opinions and feedback on the system's user-friendliness, its value in managing clinical services, the additional impact on their workload, challenges encountered, and the opportunities created by the new system. In-depth interviews were conducted by AN and PB using an interview guide. Verbal consent was obtained from each interviewee prior to the interviews.

Meeting the stakeholders

Three stakeholder meetings were organized between 28th April and 2nd May 2024 jointly by the DGHS and

NCCBCST, which was attended by gynecologists, nurses and medical officers performing screening and colposcopy in different districts, pathologists from different laboratories, health administrators from the districts (in charge of UHCs, head of the district hospitals, civil surgeon of districts, principal/director of the Medical Colleges), MoH representatives (director of nursing, chief of health information unit, director general of health services) and representatives from WHO and UNFPA national office. The first meeting was held at Medical College, Rajshahi and other two at BSMMU, Dhaka. Focus of the meetings was to review performance of the programme, discuss various strategies to strengthen the ongoing screening, colposcopy and treatment services, and brainstorming ways to optimize the use of the e-HIS to improve compliance and streamline patient care workflows. Key comments, feedback and suggestions were noted down at the meeting by RA and PB who exchanged notes after the meeting. In-depth interviews were held with some of the health administrators by PB outside the meeting hours. Questions were mostly related to the issues raised by the participants of the meetings. No interview guide was used. Verbal consent was obtained.

Analysis of data from the e-HIS

Aggregate data was obtained from the e-HIS for the years 2022 and 2023 for 30 to 60 year old women registered for screening in Rajshahi. A software programme was

 Table 1
 Distribution of key performance indicators of cancer

 screening programme for the Rajshahi division, Bangladesh for
 2022 and 2023

Key performance indicators	2022	2023	<i>p</i> -value
Participation rate (%)	64.2	28.6	< 0.001
VIA positivity (%)	3.2	2.6	< 0.001
Further assessment participation rate (%)	57.9	52.7	< 0.001
Detection rate of colposcopic high-grade (per 1000 screened) *	2.0	1,3	< 0.001
Treatment initiation rate among the col- poscopic low/high-grade (%) *	7.6	7.2	0.846

* based on colposcopy diagnosis only

Footnotes: Key performance indicators (KPI) formulas

Participation rate (%) = $\frac{Number of individuals screened out}{\frac{of the registered (using VIA)}{\text{Number of individuals registered and invited}} \times 100$
$\text{VIA positivity (\%)} = \frac{Number \ of \ individuals \ with \ positive \ VIA}{\frac{requiring \ further \ assessment \ (colposcopy)}{\text{Number screened with VIA}} \times 100$
$\label{eq:sessment} \mbox{Further assessment participation rate} (\%) \; = \; \frac{Number \; of \; individuals \; undergone}{ \int urther \; assessment \; (colposcopy)} \times \; 100 \\ - \frac{Number \; of \; individuals \; unit hoositive VIA}{requiring \; further \; assessment \; (colposcopy)} \times \; 100 \\ \end{array}$
$\text{Detection rate (per 1000)} = \frac{\frac{Number \ of \ individuals \ with \ precancer}{\frac{/cancer \ detected \ (CIN \ 2/3/High \ grade/ca)}{\text{Number of individuals screened}} \times 1000$
$\label{eq:transformation} \text{Treatment initiation rate (\%)} = \frac{\begin{matrix} Number \ of \ individuals \ with \ a \ treatment \ initiated \\ for \ precancer \ (CIN 2/3/High \ grade \\ \hline Number \ of \ individuals \ with \ confirmed \\ precancer \ case \ (CIN 2/3/High \ grade) \end{matrix}} \times 100$

developed to analyse data from the e-HIS and estimate KPIs identified by the CanScreen5 project of IARC [6].

The dashboard of the e-HIS updates on real-time the total number of women registered with the system, total number of women undergoing screening and number of women tested positive across the country. Data of women registered in the system from 1 January 2022 till 31 December 2023 in Rajshahi division was analysed year wise, stratified by eight districts in the division to estimate the numbers of women registered, women screened, tested positive on VIA, number of VIA-positive women undergoing colposcopy, number of women suspected to have high-grade lesions or cancers on colposcopy and number of women with high-grade lesions treated. Aggregate data from e-HIS was provided by the DGHS authorized representative (SNU) to the IARC statistician (RM) for analysis. Variables were selected to estimate some of the KPIs. Calculation of the KPIs (numerator and denominator) is described in Table 1. These KPIs were defined by a group of global experts in cancer screening for the IARC project 'Cancer Screening in 5 Continents' [2, 6]. These KPIs were presented as percentages or per 1000 women screened with VIA (for CIN detection rates). Comparisons of the KPIs between the studied years was done using p-values estimated from the test of equality of proportions using large-sample statistics. Statistical differences were inferred at a 5% level of significance.

Results

Information obtained through desk review of documents, facility visits, stakeholder interactions and in-depth interviews were triangulated to prepare a report to be submitted to the MoH for their internal use. Key components of the report are described below.

Governance of e-HIS to organize screening & colposcopy services

The cloud-based e-HIS software (National Cervical Cancer & Breast Cancer Surveillance System; NCCBCST) is accessible through the DGHS, MoH portal [http://dghs .portal.gov.bd/site/page/492255ac-64e8-4a48-ac34-173 ebe6a4290] at each facility involved with cervical screen ing and management of screen-positive women (Fig. 1). In addition, civil surgeon of the districts, programme coordinator at BSMMU, e-HIS programme officer at the DGHS office have access. Same dashboard incorporates other DHIS2-based data management systems, such as the one for maternal health and child immunization. Each facility has been issued with a unique code and a password by the concerned department of MoH for authorized persons to access the system. Extent of individual data accessible to the users depends on type of service provided by the facility; e.g., the screening centers



Fig. 1 Screenshots from the dashboard of the e-HIS used to manage cervical screening programme in Bangladesh

have access to a woman's personal details and screening test results only, the colposcopy centers have access to these information as well as information related to colposcopy, histopathology and treatment, the programme coordinator at BSMMU or the e-HIS programme officer have access to all data.

Till April 2024, a total of 4,602,835 women were registered with the NCCBSS e-HIS, of whom 2,644,850 (57.5%) were enrolled at the community clinics. Rest of the women were enrolled at the screening centers directly. Total 14,213 community clinics (out of total 15,564 in the country) are registering women for cervical screening.

Registration of eligible women to the e-HIS

Community clinics are the last mile health facilities where the Community Health Care Providers (CHCPs) assisted by the multipurpose healthcare volunteers

conduct antenatal checkup, immunization and other basic outpatient examinations. Each clinic maintains list 600 to 800 eligible women beneficiaries for screening (with age and address). The list is periodically updated by the Health Assistants (HA) and Family Welfare Assistants (FWA) during home visits. When a beneficiary visits the community clinic due to any reason, her name, age/ date of birth, husband's and mother's name, and contact details are entered in the e-HIS by a CHCP. The national identification (NID) number serves as the unique ID as a woman is registered with the system. Following registration, a registration slip containing an autogenerated unique electronic code is issues to the woman and she is counselled to visit the nearest screening center. The HA and FWA during home visits and at the community meetings (Uthan Baithak) counsel unregistered screening eligible women to visit the nearest community clinic and get registered. Registration is also initiated during home visit by the HA/FWA in hard copy and then transferred to e-registration at the community clinic by the CHCP.

Women not yet registered with any community clinic may get themselves registered directly at any of the cervical screening centers. They will also be shown as registered under the community clinic nearest to their place of residence.

Managing screening workflow on the e-HIS

VIA screening is performed at dedicated clinics at primary (UHCs), secondary (district hospitals and mother and child welfare centers), and tertiary (medical college hospitals and specialized hospitals) levels of health care. Few clinics/hospitals in the private (profit and nonprofit) sector offering VIA service free of cost have also registered with the e-HIS. Total 601 centers are providing VIA services across the country, of which 424 are UHCs.

When a registered woman attends any screening facility, the unique code generated at the time of her registration or her national identifier (ID) is used to retrieve her information from the e-HIS. At the end of examination, the nurse performing screening enters VIA results in the online system. If the test is negative, the system automatically generates a message indicating that the woman will not require any further screenings for the next five years. Any access to update the system is blocked for that duration. This prevents the woman being screened too frequently.

Managing colposcopy services workflow on the e-HIS

VIA-positive women are referred to a colposcopy center at the nearest Medical College Hospital or district hospital. However, a woman may attend any center of her choice, and her screening data can be accessed using the unique identifier. Total number of colposcopy units operational across the country is 51, of which 24 have thermal ablation and LLETZ facilities and the rest have thermal ablation facility only. Colposcopy centers at some of the district hospitals may not have supply of equipment for LLETZ and these centers have thermal ablation services only. Treatment is offered to all women with high-grade and low-grade lesions on colposcopy according to the national guideline. Before treatment with thermal ablation, punch biopsies are taken from women with colposcopy suspected high grade lesions. These biopsy samples are sent to the local Medical College Hospitals, and women are advised to return with the histology reports as soon as they receive them. Women suspected to have invasive cervical cancer on colposcopy undergo biopsy followed by clinical staging at the clinic.

A nurse or a clinician at the colposcopy clinic fills out the colposcopy form in the electronic system after completion of the procedure. Histopathology reports are entered at the colposcopy clinic as the woman returns with the report. There is provision in the e-HIS to enter follow-up information.

Sending reminders to unscreened women registered with the system

The system of sending reminders to the registered women who have not undergone screening is not yet activated, though it is feasible to generate a list of such women by the community clinics. It was decided at the stakeholders meeting that such a list (by community clinics) would be generated every month by office of the civil surgeon of each district. The civil surgeon's office will share the list with the health inspectors and health volunteers of the community clinics so that they can remind the women during home visits.

Use of e-HIS to track VIA-positive women

It is feasible to track a VIA-positive woman who has not attended any of the colposcopy clinics within one month of referral using the queries generated through e-HIS. The responsibility of ensuring compliance to colposcopy and treatment of the VIA-positive women residing in a particular district lies with the colposcopy center responsible for that district. A list of VIA-positive women from the district who have not undergone colposcopy within a month of referral is generated by the system every month and is reviewed by the clinic in-charge. The incharge instructs the clinic nurses to make a telephone call to each of the non-compliant women and remind them to undergo colposcopy. A list of women not reachable through mobile phone is sent to the referring UHCs to track them through the CHCPs, HA, FWAs. Same process is applied for women who underwent colposcopy but refused treatment on the same day. It was decided at the stakeholders meeting that the list of women

non-compliant to colposcopy or treatment would also be sent to the district civil surgeon for her/his office to follow-up.

The e-HIS department has negotiated a contract with a telecom service provider to send reminder messages to the non-compliant women using short messaging service (SMS). The SMS can be autogenerated from the online system. It was decided at the meeting that at least one reminder message will be sent to the women who have not undergone colposcopy or treatment. The MoH will be responsible to coordinate this activity.

Ensuring quality of data

NCCBCST at BSMMU organizes training for the providers of VIA and the colposcopy services. Until April 2024, a total of 2726 nurses and paramedics were trained to perform VIA, and 489 clinicians were trained in VIA, colposcopy and precancer treatment. The service providers are trained on managing e-HIS and data tracking over two days, either during their VIA/colposcopy training or as a stand-alone refresher course. The community clinic staffs receive one day training in e-registration, screening counselling and women's referral. A training manual has been prepared to be used for training and as an on-job aid.

There is a system of supervising data entry and checking data quality at each level of health facilities. Health inspectors perform data completeness and quality checking at the community clinics. The same is done by Upazilla Health & Family Planning Officers (chief of UHCs) at the UHCs and heads of the department of Obstetrics and Gynecology at the medical college hospitals or the district hospitals. The civil surgeons at the district level also monitor the data and discuss the performance data of all the upazilas in the regular monthly meeting with all the chief of UHCs. The system can autogenerate a list of incomplete entries for correction. The divisional programme coordinators employed by BSMMU also visit the VIA and colposcopy centers to check data quality from time to time. The e-HIS department at DGHS performs aggregate data analysis to check for data consistency and completeness. The e-HIS interactive dashboard allows generation of lists by month, year and facility.

Performance of the programme in Rajshahi division

Analysis of the e-HIS data from Rajshahi Division by the districts is presented for the years 2022 and 2023 in Tables 2 and 3 respectively. Total 514,877 women were registered in the system over two years, of whom 190,201 (36.9%) were screened. We estimated several KPIs. The

	Bogura	Chapainawabganj	Joypurhat	Naogaon	Natore	Pabna	Rajshahi	Sirajganj	Total
Number registered in 2022	20,025	10,489	11,720	9,206	13,170	14,941	14,841	25,813	120,205
Screened with VIA (n,%)	16,876	9,085 (86.6)	6,158 (52.5)	6,951 (75.5)	5,395	10,246	10,686	11,818	77,215
	(84.3)				(41.0)	(68.6)	(72.0)	(45.8)	(64.2)
VIA positive (n,%)	678 (4.0)	139 (1.5)	92 (1.5)	312 (4.5)	105 (1.9)	403 (3.9)	354 (3.3)	386 (3.3)	2,469 (3.2)
Undergone colposcopy (n,%)	401 (59.1)	79 (56.8)	59 (64.1)	183 (58.7)	58 (55.2)	248 (61.5)	202 (57.1)	199 (51.6)	1,429 (57.9)
Colposcopy diagnosis									
Normal	137	32	23	104	30	104	116	103	649
Low grade	220	37	20	64	22	105	77	77	622
High grade	33	7	6	9	1	28	7	8	99
CA cervix	11	3	10	6	5	11	2	9	57
Inadequate	-	-	-	-	-	-	-	2	2
Type of precancer treatment									
Cone Biopsy	-	-	-	-	-	-	-	-	-
LEEP	3	2	1	3	1	4	3	2	19
Thermal ablation	4	3	4	4	2	6	5	6	34
Cryotherapy	1	-	-	-	-	-	-	-	1
Total treated for low/high grade	8	5 (11.4%)	5 (19.2%)	7 (9.6%)	3	10	8 (9.5%)	8 (9.4%)	54
(n,%)	(3.2%)				(13.0%)	(7.5%)			(75%)
Biopsy									
Biopsy taken among low/high- grade and cancer (n, %)	236 (89.4%)	36 (76.6%)	18 (50.0%)	50 (63.3%)	24 (85.7%)	129 (89.6%)	76 (88.4%)	45 (47.9%)	614 (78.9%)
Histopathology report available among low/high-grade and cancer with biopsies taken (n, %)	103 (43.6%)	34 (94.4%)	11 (61.1%)	42 (84.0%)	20 (83.3%)	72 (55.8%)	73 (96.1%)	25 (55.6%)	380 (61.9%)

Table 2 Distribution of screening, colposcopy and treatment status of individuals registered with the cervical screening HMIS in Rajshahi division by districts in the year 2022 (data extracted in June 2024)

Table 3	Distribution of screening,	colposcopy ar	nd treatment :	status of ind	dividuals registe	red with the	cervical scree	ening HMIS in
Rajshahi	division by districts in the	year 2023 (dat	a extracted in	June 2024)			

	Bogura	Chapainawabganj	Joypurhat	Naogaon	Natore	Pabna	Rajshahi	Sirajganj	Total
Number registered in 2023	27,092	8,320	25,148	72,373	125,879	18,206	55,288	62,366	394,672
Screened with VIA (n,%)	25,248 (93.2)	6,898 (82.9)	6,666 (26.5)	17,773 (24.6)	12,872 (10.2)	11,032 (60.6)	18,264 (33.0)	14,233 (22.8)	112,986 (28.6)
VIA positive (n,%)	512 (2.0)	120 (1.7)	125 (1.9)	467 (2.6)	278 (2.2)	509 (4.6)	481 (2.6)	406 (2.9)	2,898 (2.6)
Undergone colposcopy (n,%)	295 (57.6)	67 (55.8)	80 (64.0)	214 (45.8)	168 (60.4)	263 (51.7)	262 (54.5)	177 (43.6)	1,526 (52.7)
Colposcopy diagnosis									
Normal	140	39	41	122	92	94	132	97	757
Low grade	134	23	29	72	63	127	113	56	617
High grade	16	3	3	10	5	33	13	6	89
CA cervix	3	2	7	10	8	9	4	18	61
Inadequate	2	-	-	-	-	-	-	-	2
Type of precancer treatment									
Cone Biopsy	-	-	-	-	-	1	3	1	5
LEEP	3	2	1	3	3	5	3	4	24
Thermal ablation	2	1	2	3	2	7	-	5	22
Cryotherapy	-	-	-	-	-	-	-	-	-
Total treated for low/high grade (n,%)	5 (3.3)	3 (11.5)	3 (9.4)	6 (7.3)	5 (7.4)	13 (8.1)	6 (4.8)	10 (16.1)	51 (7.2)
Biopsy									
Biopsy taken among low/high- grade and cancer (n, %)	141 (92.2%)	25 (89.3%)	18 (46.2%)	45 (48.9%)	58 (76.3%)	163 (96.4%)	103 (79.2%)	62 (77.5%)	615 (80.2%)
Biopsy taken among low/high- grade and cancer (n, %)	88 (62.4%)	25 (100.0%)	8 (44.4%)	41 (91.1%)	51 (87.9%)	118 (72.4%)	99 (96.1%)	37 (59.7%)	467 (75.9%)

participation rate (proportion of total women registered in the year who underwent screening) was 64.2% and 28.6% in 2022 and 2023 respectively (p-value < 0.001). VIA positivity was 3.2% in 2022 and 2.6% in the subsequent year (p-value < 0.001). Compliance to colposcopy was 57.9% in 2022 and 52.7% in 2023. Among those undergoing colposcopy, 10.9% (156/1429) in 2022 and 6.9% (150/1526) in 2023 were suspected to have high-grade lesions or cancer. Due to transfer of the trained colposcopists, two district colposcopy centers (Nababganj and Natore) were closed in 2023 and most of the VIA-positive women from these districts attended the colposcopy clinic at Rajshahi. This explains why the number of colposcopies was higher than the number of women having VIA test positive in the district. In 2002, 78.9% (614/778) women with colposcopy probable low- or high-grade or cancer had biopsies taken, of whom 61.9% (380/614) returned their histopathology reports to the colposcopy clinics. For 2023, the biopsy proportion was 80.2% (615/767; p-value = 0.539) and the proportion of histopathology reports returned improved to 75.9% (467/615; p-value < 0.001).

It was feasible to estimate the following performance indicators based on the e-HIS data for Rajshahi division: participation rate; screen positivity; compliance to colposcopy; detection rate of high-grade lesions and cancers on colposcopy; and treatment compliance (Table 1).

Challenges in implementation of the e-HIS

The internet connectivity is maintained by HMIS department, DGHS through broadband connections and dedicated internet modems to facilities from the level of UHCs and above. Unstable internet connection at the community clinics hampers real time data entry. A paper register is routinely maintained at the clinics as a backup. Information from the register is uploaded to e-HIS when internet connection is restored. Though it is mandatory to bring the ID card with unique number whenever someone visits a health facility, sometimes women forget to do so. These women cannot be registered unless they return with the card. Error in entering the long ID number was reported to be a problem. Transfer of trained staff may interrupt data entry. The e-HIS users also reported difficulty in accessing the system during software upgradation. Data on histopathology was very much incomplete as no linkage has been established with the pathology laboratories that are mostly outside the programme (in Medical Colleges and private sector).

Discussion

Establishing a system of invitation and call-recall through individual level data collection is a significant step to improve organization of cervical screening programme in Bangladesh. By collecting individual level data, the programme is further capable of analyzing screening performance disaggregated by the lowest levels of services, facilitating quality assurance and informed decision-making. Very few programmes in LMICs have been able to achieve this rare feat and are capable of reporting performance beyond screening coverage and test positivity as reported by CanScreen5 database of IARC [2, 6]. A survey conducted by IARC identified absence of an information system to collect individual data as one of the most important barriers to monitor and improve screening participation [9]. By successfully customizing the DHIS2 software and implementing the same to register and track every participant undergoing screening, Bangladesh has been able to overcome this barrier. Only LMIC that has reported KPIs for a VIA based national programme is Morocco [10]. However, the KPIs were based only on aggregate data regularly submitted by the screening and colposcopy facilities. They reported a screening coverage of 27.3% in 2019. VIA positivity and compliance to colposcopy were 3.6% and 73.9% respectively [6]. In absence of an e-HIS they could not track the screen-positive women or women requiring treatment.

DHIS2 is an open-source data collection system developed by the University of Oslo and is used by more than 129 countries worldwide (mostly LMICs) for collecting health data [7]. The 'tracker' application of DHIS2 platform allows the programmes to collect individual-level data and supports data analysis for the purpose of reporting and implementing quality assurance [11]. Tracker also includes tools to support SMS reminders and appointment scheduling.

Till date, DHIS2 Tracker application has been used to manage cervical screening only in project mode, such as the client tracking application used by *'The Scale Up Cervical Cancer Elimination with Secondary Prevention Strategy'* (SUCCESS) project to pilot HPV detectionbased screening in Burkina Faso and Côte d'Ivoire [12]. The application helped the project to notify women about their HPV test results through SMS, and remind them about scheduled appointments, thereby improving compliance to treatment and reducing loss to follow-up [12]. Bangladesh is possibly the only country to implement DHIS2 tracker in a national programme.

Initially, the cervical cancer screening programme in Bangladesh used the DHIS2-based electronic data collection system to collect only aggregate data on number of tests done and test positivity on monthly basis by the districts. Based on such aggregate data they reported that 3,358,441 VIA tests were performed cumulatively during 2014 to 2022, and overall VIA positivity was 2.5% with wide variability across the districts [13]. However, individual tracking of the women was not feasible till they introduced the new e-HIS. Investment made during COVID pandemic was an opportunity for the country to upgrade the e-HIS using DHIS2 Tracker [14].

Having a digital information system is not enough unless the programme has a strategy for effective implementation. Our evaluation study in Rajshahi Division demonstrated that the programme in Bangladesh has successfully done so. Nearly 20% of the targeted 2.7 million eligible women in the division have been registered in 2022 and 2023 [15]. About 40% of the registered and invited women have been screened during these two years. Colposcopy compliance improved from 57.9% in 2022 to 72.0% in 2023 essentially because of proactive recalling of the women. Effective implementation of the e-HIS is further strengthened through mandatory training of screening and colposcopy service providers on how to manage the e-HIS.

A few weaknesses in implementation of the information system were also identified. The e-HIS is supporting the facilities to send telephonic reminders and SMS to improve compliance to treatment. However, this activity needs to be better coordinated and strengthened. Histopathology diagnosis is not being captured in the system as the biopsies are performed outside the programme. Linking pathology laboratories performing histopathology with colposcopy clinics through the e-HIS may help to overcome this problem.

Based on the gaps identified through the evaluation exercise, the study team recommended following specific actions to ensure proper use of the e-HIS for regular programme quality improvement:

- 1. A documented policy is required to ensure uniform methodology and quality of implementation of the new e-HIS.
- Having access to the 10-digit national ID of all eligible women maintained by the election commission will make registration of women simpler and avoid errors due to wrong entry of ID numbers.
- The laboratories should be linked with the cervical screening e-HIS. The experience gained during the COVID pandemic to link the laboratories using a unique facility ID should be leveraged.
- 4. A quality improvement protocol needs to be prepared specifying a set of KPIs for the programme that are feasible to measure and are actionable. The 'acceptable' and 'desirable' standards (benchmark) for these KPIs should be identified. The same protocol should describe the process of regular checking of data quality and updating missing data.
- 5. The programme performance should be evaluated on a regular basis using the KPIs and the standards.
- 6. A dedicated team should be responsible for planning and implementing quality improvement initiatives and a budget must be allocated for these activities.

7. Dissemination of the evaluation report among stakeholders and regular training on quality improvement of all health professionals involved in the programme are essential.

Conclusions

The cervical screening programme in Bangladesh has demonstrated that the DHIS2 based e-HIS can be successfully implemented to collect individual level data. This capability will help the program achieve higher coverage of the target population, ensure appropriate downstream management of the screen positive individuals and conduct regular programme evaluation. However, there is still a scope for significant improvement.

Abbreviations

BSMMU	Bangabandhu Seikh Mujib Medical University
CHCrS	
DGHS	Directorate General of Health Services
e-HIS	electronic health information system
FWA	Family Welfare Assistants
HA	Health Assistants
IARC	International Agency for Research on Cancer
KPIs	key performance indicators
LLETZ	large loop excision of transformation zone
LMICs	low- and middle-income countries
MoH	Ministry of Health
NCCBCST	National Center for Cervical and Breast Cancer Screening and Training
NID	National identification
SMS	short messaging service
UHC	Upazilla Health Complex
VIA	visual inspection with acetic acid

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Author contributions

AN and PB conceived the study, collected the data, assisted in data analysis, drafted the manuscript and finalized it. AN, PB, SNU, PN and RA made facility visits and participated in the stakeholder meetings. SNU, EL, SP, MR, and RM were involved in data cleaning, data analysis and drafting the manuscript. Rest of the authors advised the study team, supervised the stakeholder meetings and in-depth interviews and reviewed the manuscript.

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Data availability

The datasets generated and/or analysed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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