

Role of Electronic Vaccine Intelligence Network (eVIN) in Improving Routine Immunization Services: A Cross-Sectional Assessment in Unnao District, Uttar Pradesh, India

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Abstract Vaccination remains one of the most cost-effective public health interventions for reducing childhood morbidity and mortality globally. The Universal Immunization Programme (UIP) in India, initiated in 1985, has expanded significantly with technological innovations like the Electronic Vaccine Intelligence Network (eVIN) implemented since 2014 to strengthen vaccine logistics and supply chain management. This cross-sectional study assessed the effectiveness of eVIN implementation in Unnao District from November 2024 to October 2025, evaluating 21 Cold Chain Points (CCPs) across the district. The study examined cold chain infrastructure, vaccine storage practices, logistics management, health worker knowledge, and system performance. Results revealed 100% functional large ice-lined refrigerators and cold boxes, universal compliance with temperature monitoring protocols, and perfect adherence to vaccine storage standards. All healthcare personnel (n = 21) demonstrated competency in freeze-sensitive vaccine enumeration and shake test procedures. However, supervisory oversight gaps emerged with only 33.3% of sites receiving District Immunization Officer reviews in the preceding three months. Critical infrastructure deficits included complete absence of functional vaccine transport vans and dedicated drivers at 95.2% of facilities. eVIN integration demonstrated 95.2% operational efficiency with minimal system issues. The study demonstrates that while technological interventions like eVIN significantly improve vaccine logistics, supply chain transparency, and health worker competencies, sustained performance requires complementary investments in supervision infrastructure, transport logistics, and periodic competency-based training. Digital health solutions integrated with existing immunization approaches present promising opportunities for achieving universal immunization coverage goals and improving service delivery quality at the district level.

Keywords Cold Chain Management, Digital Health, Electronic Vaccine Intelligence Network, Health System Strengthening, Health Worker Practices, Immunization Coverage, Supply Chain Management, Vaccine Logistics.

Introduction

Vaccination continues to be among the most affordable methods of public health intervention in curbing morbidity and mortality of childhood in the world [1]. Universal Immunization Programme (UIP) in India was initiated in 1985 with the objective of providing life-saving vaccines to all the eligible children and pregnant mothers in the country to prevent them against vaccine-preventable infections [2]. Although there has been a tremendous advancement in the immunization coverage, vaccine and supply-chain business, and cold-chain business challenges have historically dented the efficiency of routine immunization services, especially in rural and underserved regions [3-5]. In order to resolve these systemic gaps, in 2014 the Government of India launched the Electronic Vaccine Intelligence Network eVIN, a new digital health initiative that aims to transform the management of vaccine logistics and enhance the immunization supply chain via this innovation [6].

eVIN system is an indigenously developed smartphone and cloud based platform that digitalises the data on the stocks of the vaccine, real-time monitoring of cold-chain temperature and offering evidence-based information to support the decision-making at every level of the vaccine supply chain [2]. As part of the Health System Strengthening initiative, eVIN was first implemented in 12 states in 2014-2017 with assistance of the United Nations Development Programme (UNDP) and the support of Gavi, the Vaccine Alliance, and has since been expanded to cover all 733 districts of 36 states and union territories of India [4]. The platform connects more than 29,000 cold-chain locations, giving real-time tracking of availability of vaccines, temperature deviations and the movement of stocks between state stores to final mile of service delivery [7]. EVIN has recorded fantastic amounts of success in substituting the

traditional paper based systems with electronic vaccine logistics management which has seen 99 + percent availability of vaccines at cold-chain locations, reduction of stock-out cases by 80 percent and enhanced management of wastage of vaccines [1].

The achievement of immunization programmes is not only determined by technological advances but knowledge, practices, and performance of front line health workers who handle storage, transportation, and administration of vaccines [8]. Cold-chain handlers and vaccinators represent some of the most essential human resources as their skills in preserving optimum temperatures of storage, standard operating procedures, and delivery of vaccines on time directly affect the immunization coverage and vaccine strength [9]. Empirical research suggests that sufficient training, supportive supervision, and access to digital tools are excellent in improving health-worker practices and cold-chain management performance. However, knowledge gaps and poor implementation of best practices are still common especially in resource-starved environments where both infrastructure and human-resource constraints exist [10].

Unnao district in Uttar Pradesh is an exemplary setting where routine immunization services are faced with issues of vaccine logistics, health-system capacity and gaps in coverage [4]. As one of the most populated states in India, Uttar Pradesh was one of the first 12 states where eVIN was initiated and has also reported significant cost savings and better vaccine use after the system was introduced [5]. District level effects of the use of eVIN on health-worker practices and routine outcomes of immunization are critical towards establishing strengths, operational bottlenecks, and the scaling up of effective interventions in similar settings [6, 11, 12]. Digital health solutions, combined with existing immunization approaches, can bring about some promising opportunities to improve monitoring, accountability, and the

quality of service-delivery, which also leads to achieving universal immunization coverage goals [13, 14].

The proposed study will determine the effectiveness of eVIN in the Unnao district, estimate the health-worker knowledge and practices associated with vaccine management and cold-chain management, and determine the effects on the routine immunization outcomes, such as the vaccine availability, reduction in stock-out, and immunization coverage. The investigation of the interaction between technological interventions and human-resource capacity will enable this research to present evidence-based advice to enhance the supply chain of the immunization programme and enhance its performance at the district level [15, 16]. The results will help in the general comprehension of how digital health innovations, with the provision of good training and supervision of the health workers, can makeover routine immunization services and guarantee that all children receive timely and effective vaccines.

Materials and Methods

Study Design

This was a cross-sectional study conducted over a period of one year, from 1 November 2024 to 30 October 2025, to assess the role of

the Electronic Vaccine Intelligence Network (eVIN) in improving routine immunization services in Unnao District. The study focused on evaluating the eVIN process, examining the awareness, perceptions, and practices related to eVIN among health care personnel, and studying the immunization supply chain (ISC) mechanism. Additionally, it assessed infrastructure, vaccine utilization, distribution, documentation practices, and bottlenecks in the operationalization of eVIN in Unnao District.

Study Setting

The study was conducted across all Cold Chain Points (CCPs) in Unnao District. The district's eVIN system is operational through 21 CCPs.

Study Duration

The study was conducted over one year, from 1 November 2024 to 30 October 2025.

Sample Size and Study Subjects

The study included all key stakeholders and service providers involved in the eVIN system in Unnao District. These stakeholders were from 21 Cold Chain Points (CCPs). The total sample size and key health staff involved were as follows:

Table 1. Sample Size Distribution of Health Staff involved in eVIN

S.No	Key Health Staff Involved in eVIN	Sample Size
1	Chief Medical Officer (CMO)	1
2	District Immunization Officer (DIO)	1
3	Vaccine Logistics and Cold Chain Manager (VCCM)	1
4	Cold Chain Technician (CCT)	1
5	District Vaccine Store Manager (DVSM)	1
6	Routine Immunization Data Manager (RIDM)	1
7	Medical Officer (MO) at each health facility	21
8	Cold Chain Handler (CCH) at each CCP	21

Data Collection

1. **Primary Data:** Collected through interpersonal interviews of stakeholders involved in the eVIN mechanism.
2. **Secondary Data:** Retrieved from the UNDP-eVIN system database and the DIO-HMIS system.

Study Tools

1. **Semi-structured Questionnaire:** A pre-designed semi-structured questionnaire was used for conducting interviews with all the stakeholders involved in eVIN.
2. **Observation Checklist:** A checklist was developed to observe infrastructure, on-site vaccine utilization, distribution, documentation practices, and quality checks, including temperature monitoring. The checklist was based on the UNDP eVIN tools, which standardized the process.
3. **Secondary Data Checklist:** A checklist based on records from the UNDP-eVIN system database and the DIO-HMIS system was used to gather relevant secondary data.

Study Process

1. **Permission:** Permission was obtained from the Chief Medical Health Officer (CMHO) office for conducting the study.
2. **Evaluation of Immunization Supply Chain:** The ISC mechanism and the role of eVIN were evaluated from the initial vaccine point to the final session site.
3. **Stakeholder Interviews:** Interpersonal interviews were conducted with all key stakeholders (CMO, DIO, CCT, DVSM, MOs, RIDM, VCCM, and CCH) to gather information and identify bottlenecks in the eVIN process.
4. **Infrastructure and Vaccine Distribution:** The infrastructure, vaccine utilization, and distribution were studied by analyzing the real-time monitoring system, interviewing healthcare providers, and monitoring the on-site vaccine quality, including

temperature monitoring. Documentation practices were also observed and assessed.

Inclusion Criteria

All healthcare personnel working in eVIN in Unnao district who provided consent for participation.

Exclusion Criteria

- Healthcare personnel not involved in eVIN.
- Personnel involved in eVIN who did not provide consent.

Data Analysis

1. **Data Coding:** Data was collected and coded appropriately, and compiled in an MS Excel spreadsheet for analysis.
2. **Descriptive Statistics:** Continuous data was represented using mean and standard deviation. Descriptive statistics (frequencies and percentages) were calculated using MS Excel.
3. **Graphical Representation:** Data was represented visually using figures and tables.
4. **Statistical Analysis:** Z-score tests using SPSS 25 (trial version) software were applied where necessary to analyze associations.

Results

The study assessed 21 cold chain points (CCPs) across Unnao district, with a predominant rural distribution (76.2%) compared to urban areas (23.8%) (Table 2). Cold chain infrastructure revealed that the majority of sites had 2-3 ice-lined refrigerators (57.1% had 2 ILRs), with all sites reporting functional large ILRs, though 9.5% had non-functional units (Table 2). Deep freezer availability showed 61.9% of sites having 2-3 units, with 66.7% reporting at least one functional small deep freezer, while 9.5% had non-functional small deep freezers (Table 2). All sites maintained functional cold boxes with no non-functional small cold boxes

reported (Table 2). Power supply challenges were evident, with 76.2% of facilities experiencing 8-20 hours of daily electricity availability, necessitating power backup systems present in 95.2% of sites through generators, though only 5.0% had functional

auto-start features (Table 2). Regarding CFC-free equipment modernization, 47.6% of sites had 5-6 CFC-free CCEs, while 57.1% reported having no equipment older than 10 years (Table 2).

Table 2. Cold Chain Infrastructure and Equipment Status at Cold Chain Points in Unnao District

Infrastructure Component	Frequency (n = 21)	Percentage (%)
Location		
Urban	5	23.8
Rural	16	76.2
Ice-lined Refrigerators (ILR)		
Sites with 2 ILRs	12	57.1
Sites with 3 ILRs	8	38.1
Functional large ILRs (≥ 1)	21	100.0
Non-functional large ILRs	2	9.5
Deep Freezers		
Sites with 2–3 deep freezers	13	61.9
Functional small deep freezers (≥ 1)	14	66.7
Non-functional small deep freezers	2	9.5
Cold Boxes		
Sites with functional cold boxes	21	100.0
Non-functional small cold boxes	0	0
Power Supply		
Power availability 8–20 hours/day	16	76.2
Functional power backup (generator)	20	95.2
Auto-start feature functional	1	5.0
CFC-free Equipment		
Sites with 5–6 CFC-free CCEs	10	47.6
CCEs >10 years old (none)	12	57.1

Vaccine storage practices demonstrated excellent adherence to cold chain maintenance standards, with 100% of sites ensuring CCE placement on wooden/plastic blocks, maintaining functional thermometers in each equipment with correct placement, utilizing separate temperature log books, and recording temperatures twice daily (Table 3). All sites maintained recommended temperature ranges for ILRs (+2 to +8°C) and deep freezers (–15

to –25°C), stored only UIP vaccines appropriately, and ensured all vaccines were within expiry dates with usable VVM status (I & II) (Table 3). However, temperature recording on holidays was practiced at 90.5% of sites, and correct ice pack placement in deep freezers was observed in 76.2% of facilities (Table 3). An isolated incident of vaccine found in frozen condition was reported at one site (4.8%) (Table 3).

Table 3. Vaccine Storage Practices and Cold Chain Maintenance Standards in Unnao District

Practice/Standard	Frequency (n = 21)	Percentage (%)
Equipment Placement		
CCE away from sunlight/moisture (All)	19	90.5
CCE on wooden/plastic blocks (All)	21	100.0
Minimum 10 cm gap maintained (All)	20	95.2
Temperature Monitoring		
Functional thermometer in each CCE	21	100.0
Thermometer placed correctly	21	100.0
Separate temperature log book	21	100.0
Temperature recorded twice daily	21	100.0
Temperature recorded on holidays	19	90.5
Temperature Ranges		
ILR temperature +2 to +8°C	21	100.0
DF temperature – 15 to –25°C	21	100.0
Vaccine Storage		
Only UIP vaccines in ILR	21	100.0
T-series/Hep-B at top of ILR	21	100.0
All vaccines within expiry dates	21	100.0
All vaccines with usable VVM (I & II)	21	100.0
Vaccines found in frozen condition	1	4.8
Ice Pack Management		
Correct ice pack placement in DF	16	76.2
Ice packs filled and capped properly	21	100.0
Dedicated space for conditioning	19	90.5
Clean cloth for wiping available	21	100.0

Vaccine logistics management and record-keeping practices revealed universal compliance, with 100% of sites maintaining stock registers, distribution registers, documenting expired/wasted vaccines, and conducting physical stock counting within the last three months that matched register entries (Table 4). All facilities implemented dual paper and web-based management systems reflecting eVIN integration (Table 4). However, supervisory gaps emerged with only 33.3% of sites reporting District Immunization Officer (DIO) review of temperature log books

in the preceding three months (Table 4). Infrastructure support was robust, with all sites having dedicated cold chain rooms, 95.2% possessing adequate repair/maintenance space, and all technicians equipped with tool kits, though 47.6% reported at least one CCE being non-functional for over one month at the time of visit (Table 4). Critical gaps included the complete absence of functional vaccine transport vans (100% sites) and dedicated drivers for vaccine delivery (95.2% sites), while 52.4% of sites had never disposed of condemned CCEs (Table 4).

Table 4. Vaccine Logistics Management and Record-Keeping Practices in Unnao District

Logistics Component	Status	Frequency (n = 21)	Percentage (%)
Stock Management			
Stock register in use (as per norm)	Yes	21	100.0
All parameters recorded	Yes	21	100.0
Distribution register in use	Yes	21	100.0
Expired/wasted vaccines documented	Yes	21	100.0
Physical stock counting (last 3 months)	Yes	21	100.0
Physical stock matches register	Yes	21	100.0
eVIN Implementation			
Management system type	Paper & Web	21	100.0
Supervision			
DIO review of log book (last 3 months)	Yes	7	33.3
DIO review of log book (last 3 months)	No	14	66.7
Infrastructure Support			
Dedicated cold chain room/space	Yes	21	100.0
Space for CCE repair/maintenance	Yes	20	95.2
Technician has tool kit	Yes	21	100.0
Technician has spare parts	Yes	20	95.2
Dedicated dry storage space	Yes	20	95.2
Equipment Status			
CCE down >1 month (at visit)	Yes	10	47.6
Functional vaccine van available	No	21	100.0
Condemned CCEs never disposed		11	52.4
Driver posted for vaccine delivery	No	20	95.2

The sociodemographic profile of cold chain handlers showed a predominantly male workforce (95.2%) with mean age of 39.86±11.80 years, most commonly Block Health Workers (42.8%) and Health Supervisors (28.6%), with 47.6% having graduation-level education (Table 5).

Regarding eVIN implementation, all handlers (100%) received standardized 2-day district-level physical training, with 33.3% having 2 years of eVIN experience and varying CCH training exposure (52.4% trained once, 33.3% twice, and 14.3% thrice) (Table 5).

Table 5. Sociodemographic Profile and Training Status of Cold Chain Handlers in Unnao District

Characteristic	Category	Frequency (n = 21)	Percentage (%)
Location	Urban	5	23.8
	Rural	16	76.2
Gender	Male	20	95.2
	Female	1	4.8
Age Group (years)	<30	7	33.3
	31–40	3	14.3
	41–50	6	28.6
	51–60	5	23.8
	Mean±SD	39.86±11.80	

Position	Block Health Worker (BHW)	9	42.8
	Health Supervisor (HS)	6	28.6
	Health Visitor (HV)	2	9.5
	Pharmacist	2	9.5
	Others (NMA, Ward boy)	2	9.6
Education	8th class	1	4.8
	Intermediate	7	33.3
	Graduation	10	47.6
	Post-graduate	3	14.3
eVIN Experience (years)	1 year	5	23.8
	2 years	7	33.3
	3–10 years	9	42.9
eVIN Training	Trained	21	100.0
	Training venue (District)	21	100.0
	Training duration (2 days)	21	100.0
	Training type (Physical)	21	100.0
CCH Training	Number of trainings (1 time)	11	52.4
	Number of trainings (2 times)	7	33.3
	Number of trainings (3 times)	3	14.3
	Trained in last 3 years	21	100.0

Health worker knowledge and practices demonstrated universal competency, with all handlers able to enumerate freeze-sensitive vaccines and elaborate the shake test procedure (Table 6). System performance was satisfactory, with 95.2% reporting no issues in eVIN execution and only one site (4.8%) experiencing occasional system slowness (Table 6). Back-up cold chain handlers or link persons were available at 85.7% of facilities, and meticulous record maintenance was evident with 95.2% documenting power

failures and 100% maintaining defrosting/cleaning records (Table 6). Quality indicators showed perfect compliance, with all sites reporting properly labeled vaccine vials, vaccines within expiry, and usable VVM status (Table 6). Facility standards revealed that 52.4% of sites had separate stabilizers for all ILR and deep freezer units, 85.7% maintained 2–5 functional stabilizers, and 90.5% had no non-functional stabilizers (Table 6).

Table 6. Health Worker Knowledge, Practices, and System Performance Related to eVIN in Unnao District

Knowledge/Practice Component	Status	Frequency (n = 21)	Percentage (%)
Technical Knowledge			
Can enumerate freeze-sensitive vaccines	Yes	21	100.0
Can elaborate shake test	Yes	21	100.0
eVIN System Performance			
Facing issues in eVIN execution	None	20	95.2
Facing issues in eVIN execution	Sometimes slow	1	4.8
Human Resource Support			
Back-up CCH/link person available	Yes	18	85.7
Back-up CCH/link person available	No	3	14.3

Record Maintenance			
Power failure recorded in log book	Yes	20	95.2
Defrosting/cleaning records maintained	Yes	21	100.0
Quality Indicators			
All vaccine vials with readable labels	Yes	21	100.0
All vaccines within expiry	Yes	21	100.0
Usable VVM status (I & II)	Yes	21	100.0
Facility Standards			
Separate stabilizer for ILR+DF	All	11	52.4
Separate stabilizer for ILR+DF	Some	10	47.6
Functional stabilizers (2–5 units)		18	85.7
Non-functional stabilizers (none)		19	90.5

Discussion

The present study findings demonstrate robust cold chain infrastructure and exemplary health worker practices following eVIN implementation in Unnao district, with outcomes that align favorably with national and international benchmarks. The predominant rural distribution of cold chain points (76.2%) in our study reflects the geographical reality of vaccine service delivery in Uttar Pradesh, similar to the pan-India eVIN implementation across 29,000 cold chain points spanning urban and rural areas. Our findings of universal availability of functional large ILRs (100%) and cold boxes (100%) surpass the infrastructure adequacy reported in earlier Indian studies, where Goel et al. [17] documented unsatisfactory maintenance of cold chain equipment in Chandigarh, and Aggarwal et al. [18] reported vaccine carrier shortages in 15% of vaccination clinics in New Delhi. The challenge of intermittent power supply observed in our study, with 76.2% of sites experiencing 8–20 hours daily electricity availability and only 5.0% having functional auto-start generators, mirrors findings from the national cold chain assessment that identified power infrastructure as a persistent bottleneck in India's immunization supply chain. However, the near-universal availability of backup generators (95.2%) in Unnao district

represents a substantial improvement over baseline conditions prior to eVIN rollout.

Temperature monitoring practices in our study demonstrated exemplary compliance, with 100% of sites maintaining functional thermometers, separate temperature log books, and twice-daily temperature recording, ensuring optimal vaccine storage within recommended ranges (+2 to +8°C for ILRs and -15 to -25°C for deep freezers). These findings contrast sharply with pre-eVIN assessments in India, where studies in Kolkata by Chatterjee et al. [19] reported temperature readings outside optimal ranges and scarcity of maximum-minimum thermometers at cold chain points. Similarly, a multi-state temperature monitoring study by the National Institute of Epidemiology identified frequent vaccine exposure to sub-optimal temperatures (<0°C or >8°C) at various cold chain levels, highlighting freezing as a critical concern [20]. Our study recorded only one isolated incident of vaccine found in frozen condition (4.8%), suggesting substantial improvement in temperature management following eVIN deployment and health worker training. International evaluations in the UK, Georgia, Canada, Australia, and Ethiopia also documented vaccines exposed to freezing temperatures and suboptimal storage conditions, underscoring cold chain management as a global challenge.

The universal compliance with stock management protocols observed in our study—100% of sites maintaining stock registers, distribution registers, and conducting physical stock counting that matched register entries—validates the effectiveness of eVIN's dual paper-and-web-based management system. These results align with national eVIN assessment reports demonstrating over 99% vaccine availability at cold chain points, 80% reduction in stock-out instances, and improved vaccine wastage control across India. A comparative study by Sharma et al. [6] on the impact of eVIN application in cold chain points similarly reported pivotal improvements in vaccine supply management and stock availability. However, our finding of inadequate supervisory oversight, with only 33.3% of sites reporting District Immunization Officer review of temperature log books in the preceding three months, identifies a critical gap requiring programmatic attention. This supervisory deficit, coupled with 47.6% of sites having at least one CCE non-functional for over one month, suggests that despite technological advances, human resource engagement and accountability mechanisms need strengthening.

Health worker training and knowledge demonstrated universally positive outcomes in our study, with 100% of cold chain handlers receiving standardized 2-day district-level eVIN training and all handlers capable of enumerating freeze-sensitive vaccines and elaborating the shake test procedure. These findings corroborate evidence from multiple studies emphasizing the critical role of on-the-job training in improving knowledge and practices related to vaccine cold chain management. Desta et al., [21] in a systematic review and meta-analysis of health professionals' knowledge on vaccine cold chain management in Ethiopia, found that professionals receiving on-job training were 6.64 times more likely to have good knowledge compared to untrained

counterparts. Similarly, Akwaowo et al. [22] reported that health workers trained in vaccine management within the last five years had significantly better knowledge compared to those trained six or more years prior ($p = 0.04735$). Our study's observation of varying CCH training exposure (52.4% trained once, 33.3% twice, 14.3% thrice) suggests opportunities for periodic refresher training to sustain competencies. Studies in Turkey, Yemen, and Malaysia have consistently proven the effectiveness of on-job training in improving health professionals' knowledge and practices, reinforcing evidence-based vaccine handling.

The near-perfect eVIN system performance reported in our study, with 95.2% of handlers experiencing no execution issues and only 4.8% citing occasional slowness, demonstrates successful technology adoption in a district setting. This stands in contrast to initial implementation challenges documented in early eVIN assessments, where infrastructure limitations and network connectivity posed barriers. The availability of backup cold chain handlers or link persons at 85.7% of facilities provides operational resilience, ensuring continuity of vaccine management even during staff absences. However, critical infrastructure gaps persist, notably the complete absence of functional vaccine transport vans (100% sites) and dedicated drivers (95.2% sites), potentially compromising last-mile vaccine delivery efficiency. This finding resonates with the effective vaccine management (EVM) assessment in Gujarat by recent studies, which identified vehicle infrastructure as scoring below WHO-recommended benchmarks despite overall high cold chain performance [23].

The integration of eVIN technology with traditional cold chain practices in Unnao district has yielded measurable improvements in vaccine logistics, temperature control, and health worker competencies, positioning the district favorably within India's Universal

Immunization Programme framework. Our findings of 100% compliance with vaccine labeling, expiry date management, and VVM status monitoring reflect the maturation of quality assurance systems enabled by digital health innovations. These results align with global evidence on digitized supply chains delivering vaccines to the last mile, as documented by eVIN's expansion across all 733 districts of India. The study underscores that while technological interventions such as eVIN are necessary catalysts for cold chain strengthening, sustained performance requires complementary investments in supervision, maintenance infrastructure, transport logistics, and periodic competency-based training for frontline health workers. Future research should evaluate the impact of eVIN implementation on actual immunization coverage rates, vaccine wastage reduction, and adverse events following immunization in Unnao district to establish comprehensive program effectiveness.

Conclusion

This comprehensive assessment of eVIN implementation in Unnao District demonstrates that digital health innovations, when properly integrated with existing immunization service delivery systems, significantly enhance vaccine logistics management, supply chain transparency, and health worker competency. The study documented exemplary cold chain infrastructure, universal compliance with vaccine storage and handling standards, and near-perfect system performance metrics.

However, the identified implementation gaps—including inadequate supervisory oversight, absence of dedicated vaccine transport infrastructure, and limited equipment maintenance facilities—highlight that technology implementation alone is insufficient for optimal program performance. Sustained success requires concurrent investments in strengthening human resource

management, enhancing supportive supervision systems, developing transport logistics capacity, and providing periodic competency-based training and refresher programs.

The findings provide evidence-based recommendations for health policy makers and program managers to leverage eVIN's technological capabilities while addressing systemic implementation challenges. As digital health solutions continue expanding globally, Unnao district's experience offers valuable lessons for other resource-constrained settings seeking to strengthen routine immunization services and achieve universal immunization coverage goals through integrated technological and human-resource interventions.

Conflict of Interest

The authors declare no conflicts of interest related to this research study or the institutions mentioned herein.

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Ethical Approval

The present study was approved by ethics committee of the institution, (Ethics Committee of Saraswati Medical College, Unnao). Written permission from CMO (Chief Medical Officer) was also obtained and informed consent was obtained from all study subjects before their participation. Confidentiality of responses was assured, and all measures were taken to protect the identity of the participants.

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Data Availability

The datasets generated and analyzed in the present study are not publicly accessible due to ethical considerations. However, they may be obtained from the corresponding author upon reasonable request and subject to approval from the Government of India.

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Author Contributions

Shwetanshu Saxena conceived and designed this study, done data collection and data analysis, and drafted the manuscript. While guide Mr CNV Bharath provided technical guidance on the study design and interpretation of findings. Authors reviewed and approved the final manuscript.

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