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Improving Rural Healthcare in Mobile Clinics: Real-Time, Live Data-entry into the EMR Using a Satellite Internet Connection

Daniel Jackson Smith [1,2,*], Elizabeth Mizelle [2,3], Nina Ali [1], Valery Cepeda [2,4], Tonya Pearson [2,5], Kayla Crumbley [2,6,7], Dayana Pimentel [2,4], Simón Herrera Suarez [2], Kenneth Mueller [2,6], Quyen Phan [2,6], Erin P. Ferranti [2,6] and Lori A. Modly [2,6,*]

[1] School of Nursing, University at Buffalo, Buffalo, NY, USA
[2] Farmworker Family Health Program, Atlanta, GA, USA
[3] College of Nursing, East Carolina University, Greenville, NC, USA
[4] School of Pharmacy, University of Georgia, Athens, GA, USA
[5] College of Pharmacy, Mercer University, Atlanta, GA, USA
[6] Nell Hodgson Woodruff School of Nursing, Emory University, Atlanta, GA, USA
[7] Rollins School of Public Health, Emory University, Atlanta, GA, USA
* Correspondence: dsmith55@buffalo.edu (D.J.S.); lamodly@emory.edu (L.A.M.)

Abstract: The Farmworker Family Health Program (FWFHP) annually supports 600 farmworkers in connectivity-challenged rural areas. Traditional paper-based data collection posed validity concerns, prompting a pilot of direct data entry using tablets and satellite internet to enhance efficiency. The purpose of this article is to describe, using the TIDier checklist, a real-time, live data-entry EMR intervention made possible by satellite internet. Utilizing a customized REDCap database, direct data entry occurred through tablets and satellite internet. Patients received a unique medical record number (MRN) at the mobile health clinic, with an interprofessional team providing care. Medication data, captured in REDCap before the mobile pharmacy visit, exhibited minimal defects at 6.9% of 319 prescriptions. To enhance data collection efficiency, strategies such as limiting free text variables and pre-selecting options were employed. Adequate infrastructure, including tablets with keyboards and barcode scanners, ensured seamless data capture. Wi-Fi extenders improved connectivity in open areas, while backup paper forms were crucial during connectivity disruptions. These practices contributed to enhanced data accuracy. Real-time data entry in connectivity-limited settings is viable. Replacing paper-based methods streamlines healthcare provision, allowing timely collection of occupational and environmental health metrics. The initiative stands as a scalable model for healthcare accessibility, addressing unique challenges in vulnerable communities.

Keywords: farmworker health; real-time data entry; satellite internet; healthcare accessibility; mobile clinics

1. Introduction

Geographic isolation limiting healthcare access is just one of the many reasons rural Americans experience significant health disparities [1]. Mobile clinics have been used to increase healthcare access for isolated populations [2], however, geographic limitations, like internet availability, are a barrier to mobile clinic implementation [3]. The Farmworker Family Health Program (FWFHP), is a long-standing mobile collaboration that has been providing free healthcare to farmworkers, who live and work in rural areas, via a mobile clinic [4]. To overcome some of the complications of digital data collection, the FWFHP staff implemented a relational database in 2019 to collect electronic medical record (EMR) data for participants of the programs [5]. Due to the perceived limitations of field-based

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data collection, the program was completing dual data entry, once on a paper form, and then finally into the REDCap database. The intervention, described here, was developed to overcome these data collection challenges. The purpose of this article is to provide a methodology and recommendations for practitioners who may have historically not used real-time data entry due to the field-based nature of their work. We will also describe the equipment needed for direct data-entry and provide an example of data tracking for the pharmacy services of the FWFHP mobile health clinic.

2. Materials and Methods (TIDieR Checklist 1-11)

The intervention will be described using the TIDieR checklist, a 12-item Template for Intervention Description and Replication [6]. TIDieR is an extension of the Consolidated Standards of Reporting Trials [7] and Standard Protocol Items statements [8] and was developed to improve the quality of reporting on interventions [9].

2.1. Why

Historically, data collection in rural public health endeavors has been completed using spreadsheets; the use of relational databases is a relatively new method for smaller public health projects [5]. For occupational health clinicians, this poses an interesting conundrum for ensuring data validity when working with rural workers in settings that may lack broader internet connectivity [10]. Real-time, live data entry is critical for syncing patient and medication data across multiple devices and maintaining the functionality of healthcare systems in remote or outdoor environments.

2.2. What

We planned and implemented real-time, live data-entry using a satellite internet connection for a rural, mobile health clinic serving migrant farmworkers across southern Georgia, United States.

2.3. Materials

The technological infrastructure required for this project was a combination of both internet access technology and point-of-care data entry technology. The internet access technology consisted of Starlink© satellite internet [11]. Data entry technology consisted of laptop computers, tablets, Bluetooth keyboards, a portable document scanner, barcode scanners, and an EMR developed prior to the intervention year [5]. A 240Wh fully charged mobile battery was available to provide back-up power supply for satellite internet and data entry technology if needed. Additionally, mobile solar panels were used for onsite battery charging. A complete list of equipment, quantity, and location within the mobile clinic can be found in Table 1.

Table 1. List of technology infrastructure required, quantity, and approximate location to facilitate real-time, field-based data entry.

Internet Access Technology		
Equipment	**Quantity**	**Approximate Location**
Satellite	1	Unobstructed View of Sky
Mobile Base	1	Unobstructed View of Sky
Internet Modem	1	Unobstructed View of Sky
Starlink© Cable (50ft)	1	Connects modem and satellite
AC Power Cable (6ft)	1	AC power to Starlink
Extension Cords (50ft)	2	AC power to mesh routers
Wi-Fi Mesh Network Routers#	4	1 at Triage, Nurse Practitioner Treatment Area, Physical Therapy Treatment Area, and Pharmacy

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Battery Packs	5	1 power internet modem and 1 power each of the Wi-Fi mesh network routers. In areas without electricity
Point-of-Care Data Entry Technology		
Equipment	**Quantity**	**Approximate Location**
Laptop Computers	4	2 Pharmacy,2 Data managers: mobile
Tablet Computers with electronic pencil*	4	Check-in
	20	Triage, Screening stations
	2	Check-out
Tablet Computers with Bluetooth keyboards*	15	Nurse Practitioner Treatment Area
	10	Physical Therapy Treatment Area
	2	Mental Health Treatment Area
	5	Clinic preceptors
Portable Document Scanner	1	Pharmacy
Barcode Scanner	2	Pharmacy

*These numbers were increased in 2024 through the addition of 40 extra tablets that could be used for this intervention. #Wifi mesh routers were added when the intervention was modified in 2024. .

2.4. Procedures

During the evenings of the 2-week-long program, medical clinics are set up on farms where the migrant workers both live and work and provide episodic medical care (e.g., acute care visits, physical therapy visits, and prescriptions provided by the pharmacy). From 201-2023, all data was collected on paper and subsequently entered into the REDCap as the EMR. This process was error prone as there were often delays in data entry and a "mad dash" was done to ensure all data was entered before the conclusion of the 2 weeks, often on the last day of the program. To facilitate data collection and analysis all instances of patient encounters within our database were systematically assigned a medical record number (MRN). Patients were assigned an MRN in the format of YYFXXX, with YY representing the current year, F representing a predetermined code for each farm (that matched the code label for the farm identification variable in REDCap), and XXX being a unique identifying number. This unique identifying number was assigned as farmworkers checked into the clinic and went in order from "001" to a possible "999".

During mobile clinics for farmworkers, the first interaction with the patient occurs in triage, where vital signs and chief complaints are assessed and recorded by the nursing team. This data is used to triage patients as they move throughout the clinic to prioritize care level with: 1) a nurse practitioner, or physical therapist; 2) a mental health provider; or 3) a dental care provider. All stations are set up outdoors on the farm property and distance between each ranges from 10 feet to 200 feet. With our intervention, patient data was seamlessly accessible by multiple medical providers as the patients moved throughout the clinic.

2.5. Who Provided

The interprofessional program provides health screenings with student nurses, medical visits with student nurse practitioners, musculoskeletal evaluations with student physical therapists, oral health visits with student dental hygienists, mental health support with student social workers, and medication counseling & dispensing through a student-led mobile pharmacy. Allied health students participating in the program include pre-licensure nursing (i.e., students becoming registered nurses), post-licensure nursing (i.e., students becoming nurse practitioners), physical therapy, psychology, dental hygiene, and pharmacy; volunteers make up the Spanish-English interpreters and data management team.

2.6. How

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The real-time data entry Starlink© satellite internet made it possible to conduct real-time data entry, by having live WiFI available on all iPad simultaneously. Starlink Roam is a satellite internet service offered by SpaceX [11], which uses low Earth orbit satellites to provide high-speed, low-latency internet access worldwide. The "roam" service specifically allows users to access the network while traveling, whether stationary or in motion.

2.7. Where

The FWFHP is based out of Colquitt County, GA, which is designated as rural by the Office of Management and Budgets [12]. This mobile clinical provides clinical care to approximately 600 migrant farmworkers and their families annually [4].

2.8. When & How Much

These intensive mobile clinics run for 2 weeks in June every year. This specific intervention with real-time data entry was first implemented in June of 2023 and has been maintained since.

2.9. Tailoring

In the mobile pharmacy, medications were organized by “fast movers” or “non-fast movers”. “Fast movers” were identified based on historical dispensing of commonly used over-the-counter medications such as ibuprofen, acetaminophen, menthol-based muscle rub creams, multivitamins, and lubricant eye drops. “Fast movers” were prelabeled with generic directions for dispensing efficiency, and dispensing were logged using paper records due to limited QR scanners. After the conclusion of the program, the paper records for the “fast movers” were converted electronically into the REDCap system for accuracy. “Non-fast movers” required filling and dispensing by the mobile pharmacy. Filling includeed typing a prescription label in Spanish using label printers, dispensing the medication, and having a student pharmacist under the supervision of a licensed pharmacist double check for validity. Each “non-fast mover” prescription was scanned into REDCap using our drug and dose specific QR codes for the patient. Barcode scanners ensured a closed-loop system for medication administration by corresponding with the patient’s EMR [13].

The original FWFHP database was developed and first implemented in 2019 [5]. This process led to the identification of common diagnoses made by clinicians in the fields and increased capturing of procedure and evaluation and management (E&M) codes by placing them in the field-based EMR. REDCap allows for complete customization of data collection procedures, including variable coding (i.e., 0=no and 1= yes), variable naming, variable type (i.e., select-all-that-apply, single options, and free text), pre-selection of variable values, and branching logic to only allow for the selection of variables under specified criteria [14,15]. To facilitate a live-field based data collection, we refined our original database from 2019 to prefill variable responses for values that were likely to not change. For example, Current Procedural Terminology codes for vital signs and health screenings were defaulted as affirmative. International Classification of Diseases-10 codes were defaulted as negative, which allowed for clinicians to only change the selection from “no” to “yes” for the diagnoses made. The database was also updated to reflect the NIH and Emory Nell Hodgson Woodruff School of Nursing’s common data elements [5,16], which had not been considered in the original design of the database.

2.10. Modifications

The intervention was further upgraded in 2024 by 1) adding 40 additional computer tablets so each clinician could connect to the internet and enter in data real time and 2) adding a mesh WiFi network to ensure adequate internet access across the mobile clinic.

2.11. How Well (Planned)

The fidelity of the intervention was assessed by data defects, defined as prescriptions that were not properly logged into REDCap, which led to missing prescriptions and uncertainty if a medication

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was dispensed to the patient. Data defects were calculated using the number of prescription discrepancies divided by the number of prescriptions written into the data system, where discrepancies are variances in the number of prescriptions compared to what was recorded in the system. For example, if an individual had 4 total prescriptions listed in their chart, but only 2 were recorded or scanned into REDCap, this would be counted as 2 defects due to 2 missed/unknown prescriptions.

3. Results (TIDieR Checklist 12)

3.1. How Well (Actual)

Out of the 319 prescriptions, only 6.9% (n=22) were reported as data defects. Factors that may have contributed to data defects include user training, the data collection process and the number of QR scanners. Pharmacy students rotated daily through numerous roles such as patient counseling, medication filling, label typing, or barcode scanning. Due to daily rotation, there was no consistency in roles, thus a potential for knowledge gap in appropriate bar code scanning. “Fast mover” data collection was handwritten and then manually converted into the REDCap system due to the high volume of “fast mover” dispensing. This two-step process may have resulted in human-error due to difficulty reading handwriting or missing prescription data (omitted name, MRN, medication). Another factor that may have contributed to data defects was that the QR scanner was only used inside the mobile pharmacy to fill “non-fast movers” prescriptions.

4. Discussion

The rural setting of the FWFHP highlights the importance of reliable internet connectivity to support field-based healthcare tools. Wi-Fi extenders were instrumental in expanding network coverage to open areas, ensuring uninterrupted access to EMRs and other digital tools [17]. In the event of connectivity interruptions from storms, paper forms were used. Incorporating robust infrastructure, including backup power sources and offline-capable software, can further enhance resilience during adverse weather conditions [18]. While satellite internet users currently report inconsistent throughput and experience time delays, the technology is rapidly improving as more satellite internet providers enter the market [19].

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Seamless tracking of changes over time in the EMR is a capability particularly beneficial in coordinating care for migrant populations. In rural areas, adult farmworkers often access care individually based on their work schedules and geographic proximity to the clinic [20,21]. The inclusion of a farm identification variable and the current year in adult MRNs linked patients to specific locations. This allowed for a streamlined care delivery for a geographically dispersed population when workers were referred to the brick-and-mortar migrant health clinic for further care.

In the pharmacy component of the FWFHP, technology further enabled a mobile clinic team to provide streamlined and accurate care. We were able to link patients, prescriptions, and diagnosis codes, facilitating data analysis for quality improvement. This was previously not possible using Excel tracking. The new data management process improved workflow and decreased entry time into the REDCap system. The use of QR barcodes and scanner technology streamlined real-time data entry into REDCap, with a 6.9% defect rate. A recent systematic review and meta-analysis showed that across pharmacy settings, there is a 1.6% defect rate in prescription filling [22]. The daily rotation

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of pharmacy students may have created variability that affected the consistency of data collection. Lack of continuity can increase the risk of errors, particularly in systems that rely on both electronic and paper-based documentation. Transitioning to a fully electronic system, supported by increased access to barcode scanners, can address these challenges by eliminating the need for paper in rural settings [13]. Furthermore, streamlining training programs and effective hand-off communication may also be critical for ensuring accuracy in medication related data collected in rural settings. Analyzing factors that would promote for a further reduction in this prescription defect rate in mobile settings could be an area of future research.

5. Conclusions

The implementation of real-time, live data entry using satellite internet and integrated digital tools represents a scalable and effective model for enhancing healthcare delivery in connectivity-challenged rural settings. By leveraging a customized REDCap database, barcode scanners, Wi-Fi extenders, and backup power sources, the initiative successfully addressed the limitations of traditional paper-based documentation, reducing errors and streamlining clinical workflows. For mobile clinics operating in rural areas with inconsistent or no internet access, this approach offers a transformative solution. By reducing reliance on paper records and improving the accuracy of patient data collection, mobile teams can ensure continuity of care, particularly for migrant populations who require seamless health record tracking across multiple visits and locations. Expanding this model to other mobile clinics could significantly enhance access to care in rural and underserved communities. As satellite internet technology advances and digital tools become more widely available, mobile clinics can achieve greater efficiency, improve patient outcomes, and strengthen healthcare equity by ensuring that even the most geographically isolated populations receive high-quality, data-driven care.

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Institutional Review Board Statement: This study did not involve human or animal subjects. The development and refinement of the EMR presented here have previously been determined to fall under the category of quality improvement by the Emory University Institutional Review Board (IRB) and were thus exempt from IRB oversight. As such, ethical review and approval were not required.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data is available upon reasonable request from the corresponding author.

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Abbreviations

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The following abbreviations are used in this manuscript:

FWFHP	Farmworker Family Health Program
EMR	Electronic Medical Record
MRN	Medical Record Number
TIDieR	Template for Intervention Description and Replication

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