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# Design and implementation of a novel electronic health records (EHR) system for knowledge sharing at an international medical outreach program field clinic

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## Abstract

*A prominent medical school in the Southeast United States conducts an active International Medical Outreach Program (IMOP) at multiple international locations. These medical outreach trips provide medical services to those who do not have access to or limited access to health care. Medical students who volunteer to participate in these trips welcome the experiential education experiences. This developmental research study focuses on three IMOP trips to San Cristóbal, Galápagos Islands (Ecuador). Traditional approaches in the dissemination of clinical knowledge, skills, and confidence building for medical students rely on classroom training. In the IMOP experiential trips, knowledge sharing was supported by oral communication with senior clinicians and patients, as well as the transition from a paper-based to a novel custom-built Electronic Health Record (EHR) system. Paper-based record systems are cluttered with issues; some include illegible handwriting and missing or incomplete data. A team of health informatics professionals from the university transitioned the paper-based forms to a novel digitalized EHR system. The new novel digitalized EHR system resolved many of the paper-based issues and significantly improved knowledge dissemination among medical students, patients, and clinicians, furthering skills enhancement as well as efficiencies in resource coordination, however, some adjustments in clinical documentation procedures were needed to reduce the volume of missing data entries during the implementation, where a total of 848 adult and pediatric patients were treated over the three IMOP trips documented in this research. This digitalized EHR system enabled a more efficient transfer of knowledge to medical students.*

**Keywords**: Medical field clinic, International Medical Outreach Program (IMOP), knowledge sharing, skills transfer, experiential learning in medical schools, Electronic Health Records (EHR) system, EHR design and implementation.

## Introduction

While traditional medical school curricula, particularly in the first year, tend to prioritize theoretical knowledge, hands-on clinical experience is an essential stepping stone for nurturing skills and competency among medical students. Experiential learning approaches aim to emphasize experience-based learning and be a more successful strategy in acquiring clinical skills and problem-solving competency (Jain & Dewey, 2021; Kusurkar et al., 2012). In this context, medical students_become active participants in solving complex problems with tacit knowledge, intuition, judgment, and past experiences (Sanford et al., 2020; Wu, 2021). Emphasizing tacit knowledge underscores the importance of personal, experiential communication between medical students and physician trainers, which is frequently neglected in efforts to apply evidence-based practices.

Osteopathic medical education is governed by the accreditation standards as set forth by the American Osteopathic Association (AOA) Commission on Osteopathic College Accreditation (COCA), most recently updated in October 2024. One of the core standards relates to teaching and education, ensuring the development of the seven core osteopathic competencies, which are patient care, medical knowledge, communication, practice-based learning, professionalism, systems-based practice, and osteopathic principles and practice/osteopathic manipulative treatment (American Medical Association, 2022). Medical outreach trips provide ample opportunity to create growth opportunities in all the core competencies, allowing medical students to practice skills until proficient, gain confidence in patient interactions, and integrate new concepts into the healthcare experience.

This paper is articulated as follows: In the Knowledge Sharing in Healthcare, we discuss the evolution of knowledge sharing in healthcare, highlighting the role of technology—especially EHR and data analytics—in improving clinical workflows, medical education, and decision-making, while also acknowledging the challenges of implementing these advancements in underdeveloped regions and economically disadvantaged settings. In the International Medical Outreach Program (IMOP) section, we outline the key component of osteopathic medical education that provides medical students with immersive field experiences in underserved, rural communities, fostering the development of clinical, leadership, teamwork, and communication skills through interdisciplinary collaboration and exposure to international medical practices and public health challenges. In the Methodology section, we describe the design, building, and implementation of the data acquisition of the digitalized data acquisition system. Details about the trips and the participants will be discussed. In addition to showcasing the immediate benefits of student learning, in the Results section, we report changes in the accuracy of data collection based on the volume of missing data entries as well as the advantages and limitations of the transition from traditional paper-based methods to a digital system. In the Discussion section, we discuss the results, highlighting the advantages and limitations of the current system. Lastly, we present future research directions in Conclusions.

## Knowledge Sharing in Healthcare

Numerous frameworks and theories have been developed to explain the knowledge cycle from creation to sharing, dissemination, and integration across various contexts and processes. In their seminal work, Abidi (2007) conceptualized knowledge sharing in healthcare as the process that drives decision-making, patients' education, translation of knowledge into practice, and dissemination. At that period, however, the implementation of knowledge sharing was underutilized and faced several barriers, limiting its effectiveness. Following the enactment of the

Health Information Technology for Economic and Clinical Health (HITECH) Act, there has been a significant transformation in this domain. Rapid technological advancements coupled with the capacity to transmit large volumes of data have facilitated knowledge sharing and improved clinical workflow within healthcare facilities (Manca, 2015). As Russ (2021) sustained in his foundational work, the current cycle of knowledge management exhibits *"the merger of man and machine"* (p. 4) in knowledge creation, which is the latest major technological paradigm shift. This shift highlights an increasingly more difficult challenge: humans are currently experiencing multiple technological paradigms shifts with little time to adjust and implement new organizational and interpersonal knowledge management and learning processes. The transition of knowledge sharing towards technology represents a great opportunity and an immense endeavor in medical education, which needs to constantly adapt to the dynamic needs of the medical field. Currently, the increasing role of Electronic Health Records (EHR) and the integration of data analytics into healthcare are playing a central role in medical training. Nonetheless, the integration of technology is predicted to be constantly evolving (Bhatia, 2021; Lottonen et al., 2024). The technological transition is not just about adapting to specific tools. Rather, it boosts knowledge sharing among healthcare professionals and improves skills, competencies, and workflows. As such, numerous medical educational institutions across the United States are responding by incorporating a new set of skills into their educational programs (Ng et al., 2023; Yogesh & Karthikeyan, 2022). Consequently, they are facilitating a more connected and informed medical community. This adaptation reflects the changing landscape of healthcare, where proficiency in technology and data analysis is becoming as crucial as traditional medical knowledge. While technology has brought significant advancements in facilitating knowledge sharing, there is still a large gap between the success witnessed in large medical centers, predominantly in Western countries, and the challenges faced by economically challenged communities, which are especially prevalent in underdeveloped countries. The predominance of paper-based documentation and reliance on oral transmission leads to knowledge dispersion. Physician-patient interactions become difficult to track in time and hard to be considered for future medical treatments. Opegu et al. (2024) and Stoehr et al. (2021) focused on telemedicine and tele-education initiatives for medical students and health professionals spanning both Western and underdeveloped countries. Bälter et al. (2022) explored the utilization of health technology in devising an educational program for nutrition pediatric patients in Ethiopia and Rwanda. In Noack et al. (2021), information technology was used to develop an application that facilitates clinical communications between healthcare providers and immigrant patients through commonly used phrases. Fraser and Blaya (2010) offered an extensive list of guidelines and identified challenges in adopting digital health technologies in global health contexts, emphasizing factors such as local leadership, effective data collection, and the necessity of gathering patient-specific information alongside network and connectivity issues. Schreiber et al., (2022) addressed the clinical need to implement EHR systems for emergency medical teams, with the study evaluating their system across nine clinics. Moreover, Jafar et al. (2015) highlighted the significance of digital systems in improving patient outcomes, continuity of care, and future medical responses while also acknowledging the major challenges, such as the lack of standard documentation. They also identified other major barriers, including costs, limited computer literacy at the place of care, and limited access to necessary infrastructure (Schreiber et al., 2022). Despite the lack of systematic analyses about how digitalization impacts knowledge transfer in underserved settings, the possibility of sharing digital information can facilitate learning and streamline clinical operations.

## The International Medical Outreach Program (IMOP)

The IMOP is a critical part of medical education at the osteopathic medical school. Its focus is to organize international medical outreach trips focused on underserved, rural communities. Teams are comprised of medical school faculty, medical students, and support staff, as well as external healthcare providers and volunteers. Through interdisciplinary and interprofessional collaboration, medical students engage in acquiring clinical skills, knowledge, and confidence building before advancing to the clinical workforce. Skills transfer is taught using frameworks, observation, and feedback to medical students. Through repetition and practice, medical students improve and gain competency. Additionally, during field clinic experiences, medical students can tap into opportunities to improve their leadership, management skills, teamwork, and communication (Ahmed et al., 2023). It is estimated that around 100 medical students participate in IMOP each academic year. While participation in IMOP is not a required educational experience, it is promoted among medical students as a uniquely immersive experience. During IMOP, medical students are introduced to underserved communities facing unique healthcare needs and barriers to healthcare services. Medical students are immersed in interacting with patients, physicians, and other healthcare providers while uncovering the limitations of public health and medical interventions. This unique training experience exposes medical students to international medical practices, cultural norms, collaboration within healthcare, public health needs assessments, and pharmaceutical resource management. Moreover, such a learning experience combines medical and community health knowledge, clinical and soft skills, and workforce preparation. Most medical simulations are used to teach and assess knowledge and clinical skills by utilizing Advanced Class Standardized Patients (ACSPs), including high-fidelity manikins and paid actors who are trained to simulate a patient with symptoms (Willson et al., 2021). Other supporting technologies include extended reality, remote patient monitoring such as wearable and implantable devices, and more recently generative artificial intelligence (Choi-Lundberg, 2023).

## Knowledge Sharing Transition: The Galapagos Islands IMOP

Given the adoption of satellite connection in the Galapagos Island since April 2023 through web services by StarLink©, the division of International Medicine and the Department of Health Informatics at the medical school initiated a collaboration aimed at digitalizing the paper-based medical record system used for the outreach trips. The primary goals were to create an efficient, secure, and user-friendly digitalized medical record system that would also save time for providers who were manually updating paper records and digitalize medication administration and inventory control. Moreover, the digital electronic record system would further enhance medical students' knowledge and clinical upskilling. In the following section, we describe the working teams for the IMOP trips during July 2023 (pre-transition), December 2023 (post-transition 1), and December 2024 (post-transition 2), where, respectively, paper-based and digitally based records were utilized. The July 2023 IMOP trip took place in Santa Cruz, Galapagos (Ecuador). A group of 21 Doctor of Osteopathy (DO) medical students, five doctoral medical students from couple and family therapy, one post-baccalaureate student, and seven clinical providers, composed of five faculty members and two community physicians, provided clinical care. The providers' specialties included couple and family therapy (2), pediatrics (1), internal medicine (1), primary care and sports medicine/osteopathic manipulative medicine (1), primary care and osteopathic manipulative medicine (1), and nutrition (1). Also, one staff member served as the manager and logistics director. The December 2023 IMOP trip took place in San Cristóbal, Galapagos (Ecuador) 23 DO medical students, one high school student, two public health faculty, one health informatics faculty, and seven providers, composed of two faculty, four alumni, and one community provider participated in clinical care. The providers' clinical specialty areas included primary care (2), osteopathic manipulative medicine and primary care (1), osteopathic manipulative medicine and sports medicine (1), neurology (1), and mental therapy/counseling (2). Additionally, one staff member served as a manager and logistician for this trip. The December 2024 IMOP trip took place in San Cristóbal, Galapagos (Ecuador) 32 DO medical students, three public health students, four couples and family therapy students, two faculty members, one health informatics faculty lead (Department Chair), and eight providers, composed of five faculty, two alumni and one community provider participated in clinical care. Before the implementation of the digitalized EHR system, the process was predominantly paper-based, supplemented by informal, oral communication. The process required each patient to be accountable for their paper form, which was assigned at triage. At each step of the visit, medical providers and medical students added further evaluations to the form. Medical students, under the supervision of a healthcare provider, dispensed pharmacological treatment at the end of the visit and collected each paper form from the patient before discharge. Overall, this workflow was highly inefficient. The illegibility of the forms was one of the major issues due to a variety of factors, including the inexperience of medical students inappropriately documenting details of the patient encounter, variability among experienced providers in their use of terminology and acronyms, poor penmanship across all participants, and the fact that in these humid environments, the hands of those manipulating the paper cause the papers to become moist as well, often smudging the ink, rendering some information unreadable. Paper loss and missing data were also a limitation of the paper-based data entry. The reliance on physical records and verbal communication limits the accessibility and continuity of information. This limitation poses challenges in fostering collaborative learning and limits the ability of medical students to fully contribute to the knowledge sharing process. Lastly, the tracking of available medications was impossible in real-time. A paper list of medications was provided to each provider on day one and required the head of the medical outreach trip to manually count and update the medication inventory daily, providing a new pill count to each provider again in writing. As part of typical medical outreach trips, medical students are assigned a topic to research in advance to further the group's understanding of the community served. Topics range from topics such as the availability of public transportation, religions in the region, and means of income to health-care-related issues such as the most common cardiovascular and neurologic complaints. To ensure that the medical students were up to date and engaged, they were assigned to present a five-minute oral report to the entire group, divided among the various days of the trip. Typically, these reports were based on online research and mostly interviews with locals, especially those involved in healthcare administration and direct patient care. However, this approach often proved to be rather fruitless, as there is little published information available. The paper's main contribution is to show the significant impact of implementing a digitalized data acquisition system on knowledge sharing, particularly for the remote and dynamic IMOP setting on the Galapagos Island.

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## Methodology

The research strategy for this research is a developmental study. Developmental research is a methodical approach to designing, building, and assessing systems, processes, and/or products, with a focus on assessing their quality and overall performance (Richey & Klein, 2005). According to Richey and Klein (2005), developmental research "is a way to establish new procedures, techniques, and tools based upon a methodical analysis of specific cases" (p. 24). This section outlines the design of the novel digitalized EHR system, building the digitalized system, training, and implementation of the digitalized system employed throughout the outreach medical trips to allow the exchange of knowledge across the entire healthcare team.

### Design of the Digitalized System

The design of the novel custom-built digitalized EHR system was based on the organization of previous IMOP trips, aiming to emulate the previous paper-based processes. This required gathering information captured in the clinical forms and understanding the workflow and distribution of resources at the field clinic, which was achieved by reviewing 25 randomized paper samples from three previous trips as well as conducting semi-structured interviews with the IMOP director and five clinical staff, medical specialty providers and healthcare professionals that were involved in prior IMOP trips. The data presented was aggregated from three medical outreach trips: one in July 2023 (pre-transition), the December 2023 trip (post-transition 1), and the December 2024 trip (post-transition 2). Given that adults and pediatric patients had different sets of vital signs collected, the data, specifically the missing data entries, were separated into analyses for the adult and pediatric patients. We utilized Microsoft Excel© for data analysis and visualization. The workflow included a patient triaging stage, where medical students recorded on paper basic demographic information (i.e., first and last name, age, town or village of residence), eight vital signs (i.e., blood pressure, respiratory rate, temperature, height, weight, blood glucose, heart rate, and oxygen saturation), and chief complaints for adults, whereas similar basic demographic information and chief complaints were captured for pediatric patients, however, only four vital signs (i.e. respiratory rate, temperature, height, and weight) were collected for pediatric patients. Triage information helped the clinical staff determine the most suitable healthcare provider for the patient and assign them accordingly and documented on the patient's form. Subsequently, the patient was referred to one or multiple visits among the available providers at the field clinic, depending on the patient's needs. The patient interacted with their provider, relying on English-Spanish interpreters when necessary. At the end of the visit, the patient was provided with a prescription as appropriate, fulfilled via an onsite pharmacy that provided locally purchased medication.

### Building the Novel Digitalized EHR System

The novel EHR system was built using REDCap©, which is a web application with enhanced security designed to build data acquisition projects. REDCap© allows the creation of customized projects and provides users with the right to access the project, capture data, and visualize existing data in real-time. Each team relied on the medical students to access the system to retrieve data such as patient information and medication inventory or add notes to develop their skills in using the system. The project included four data-capturing forms per patient, which are aimed at reproducing the clinical data records used in previous paper-based medical trips. The four forms used for data capturing are shown in Figure 1.

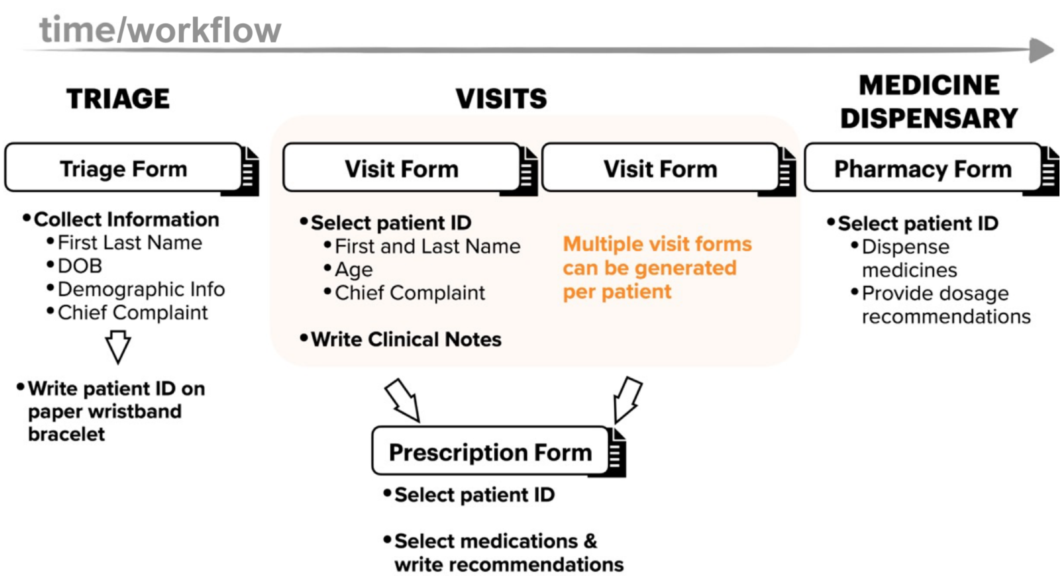


**Figure 1.** Overview of the Digitalized Data Collection Process

At the initial step, the patient underwent a triage assessment, where the *triage form* was used to collect information, including demographics such as first and last name, date of birth, residence, sex, and gender, as well as vital signs (eight for adults and four for pediatric patients). Additionally, for adult patients, the blood glucose was measured, and patients were asked if they were fasting to give context to the results. Lastly, the patients were questioned about their reason for coming to the facility (chief complaint). At this initial stage, each patient was assigned a unique identification number, which was used throughout the process to retrieve the patient's information. The next phase in the workflow was the *visit form,* where the providers enter information about the patient's encounter. Given the patient ID, each visit form imported the first and last name, age, vital signs, and chief complaint from the *triage form*. The information captured in the *visit form* includes assigned providers and medical students who are filling in the form, followed by the provider's initial assessment, review of the medical history, physical examination, as well as orders for diagnostic tests such as a urine test. Additionally, the team created a treatment plan, including medications, therapies, and other osteopathic interventions. Built to accommodate various providers' needs, the visit form has been designed to be flexible. For example, all the fields related to the patient's condition are entered in a free text form. Multiple *visit forms* can be created for each patient each instance, they are assessed by a specialty provider. Another phase of the workflow was the *prescription form* that was accessible to all the users at the various clinical stations rather than just at the time of discharge. This form was designed to automatically import data from the *triage form* once the patient's ID was entered. The *prescription form* included a dropdown menu with all the available medication names in the inventory system, dosage, frequency, duration, and refills allowed. Additional fields in the form include the prescriber's name, title, and signature. Since all the prescriptions were fulfilled by the field camp pharmacy, the form did not include pharmacy information. As part of the discharge process, the patients arrived at the pharmacy station and submitted their prescriptions for processing. Medications were dispensed without charge. Moreover, missing data entries across the three IMOP trips for both the pediatric and adult groups were evaluated due to system adjustments during the implementation (transition).

## Training on The EHR System

The novel digitalized EHR system was designed to be intuitive and user-friendly. To promote the system's adoption and skill-building, medical students were required to attend mandatory online training. Most of the medical students participating in the IMOP lacked clinical care experience and were unfamiliar with a digitalized EHR system commonly used at a hospital or clinic prior to the IMOP experiential learning trip. The pre-trip training included knowledge-based training about the data collection and management processes as well as hands-on practice, including documenting patient visits, diagnosis, treatment plans, and outcomes, ordering lab tests, such as urine tests, prescribing and managing patient medications, including dosages and refill instructions, and updating patient information. Moreover, medical students were trained to retrieve data to assess patient outcomes, treatment plans as well as medication inventory status. Subsequently, faculty members were able to assess the students' competencies and knowledge of clinical experiences. As noted, before each IMOP trip, all medical students participated in the training, while on average, only a bit over half of the providers attended and trained on the use of the digitalized medical record system. As a result, medical students served an important role by supporting their clinical team in the patient data entry and retrieval processes.

## Implementation of the Novel Digitalized EHR System

During the IMOP trip, medical students used tablets and laptops provided by the medical school to access the digitalized medical record system, which was safeguarded on a server with advanced security measures. The triage station was equipped with two laptops, whereas other stations had one laptop each, all of which were connected to the internet through a local satellite communication network. The initial digitalized data collection process extended over four days of service. The medical student team charged with data entry acquisition was assigned to various stations: four students assisted with triage, seven pairs of students supported treatment providers, and two students facilitated discharges. Additional students engaged in public health assessment and provided flexible support across the stations. Patients underwent triage in pairs, with two medical students simultaneously collecting data and aided by local interpreters. Once the initial stage of triage was complete, patients were provided with a wristband bracelet with their identification number generated by the system enumeration system. Patients were directed to a specific healthcare specialty for their initial consultation based on their primary reason for seeking care. Medical students entered patient data into the REDCap© system, capturing demographics, vital signs, and chief complaints. Additionally, they documented treatment information for each patient at their respective stations. At the discharge station, medical students facilitated prescription fulfillment, recorded discharge instructions, and oversaw the medication inventory management system. The implementation of the digitalized system enabled better distribution of resources in stations, efficient management of patients' data and workflow, as well as efficient management of discharge and medication inventory.

# Results

This section presents the results of the transition to a digitalized EHR system supporting the following outcomes of improved efficiencies by way of fewer missing data incidents, the addition of data fields to forms during the implementation process, improved knowledge and skills enhancement to medical students who were tasks with the data acquisition, as well as efficiencies in the management of human and resource coordination resulting from the data acquisition. Overall, the implementation of the novel digitalized EHR system provided medical students with a unique experiential learning opportunity to practice a field clinic operation that is supported by an EHR system that most medical students are not usually exposed to in their medical education programs. Our results showcase comparative data from the July 2023 trip (pre-transition) (Total 366 patients), December 2023 trip (post-transition 1) (Total 289 patients), and December 2024 trip (post-transition 2) (Total 192 patients). In total, 848 patients were included in this research, of them 734 patients are adults (about 86.6%), and 114 pediatric patients (about 13.4%). Given that adults and pediatric patients had different sets of vital signs collected, the data, specifically the missing data entries, were separated into analyses for the adult and pediatric patients. Tables 1 and 2 showcase missing data entries during the triage phase. We compared the number of instances of missing patient data entries using paper records pre-transition and the digitalized system post-transition for both the December 2023 trip (post-transition 1), and the December 2024 trip (post-transition 2). We organized our data samples into adult groups, as shown in Table 1, and pediatric groups for patients under 16 years old, as shown in Table 2. Table 1 showcases initially mixed results with an initial decrease in missing data entries in the December 2023 (post-transition 1) trip for adult patients, with only one out of the eight vital signs (i.e. *Blood Pressure*) decreasing. However, five other vital *Respiratory Rate, Temperature, Height, Weight, and Heart Rate* showed an increase in missing data entries for adult patients in the December 2023 (post-transition 1) trip. Two adult vitals (i.e. *Blood Glucose* and *Oxygen Saturation*) were not initially measured during the paper-based system, while were captured later in the EHR system. For the pediatric groups, overall, higher missing data incidents were noted compared with the adult groups between July 2023 (pre-transition) and December 2023 (post-transition 1) trips. Higher pediatrics missing data entries were noted in the December 2023 (post-transition 1) trip for *Respiratory Rate, Temperature, and Height*, except for the anthropometric measurement of *Weight,* resulting in a 65% decrease between the two trips. Furthermore, additional adjustments to the training and clinical experiences were made prior to the December 2024 (post-transition 2) trip. Specifically, the health informatics team lead was added to the trip assisting the team to ensure that all vitals for both the adult and pediatric groups were fully captured with the aim to eliminate all the missing data entries for both groups. In our analysis, we overlooked the legibility of the data entries in the post-transition forms, focusing instead on the presence or absence of the recorded value. Upon comparison of the two tables, we observe a consistent increase of missing values during triage after the adoption of the digitalized system, while further emphasis on eliminating such instances was made in the additional post-transition trip (December 2024) resulting in the full elimination of all missing data entries for both groups (See Figures 2 and 3, and Tables 1 and 2)). This result is supported by the observation of workflow and patient flow at the various stations during the three IMPO trips. In the discussion of the limitations section, we further elaborate on these trends.

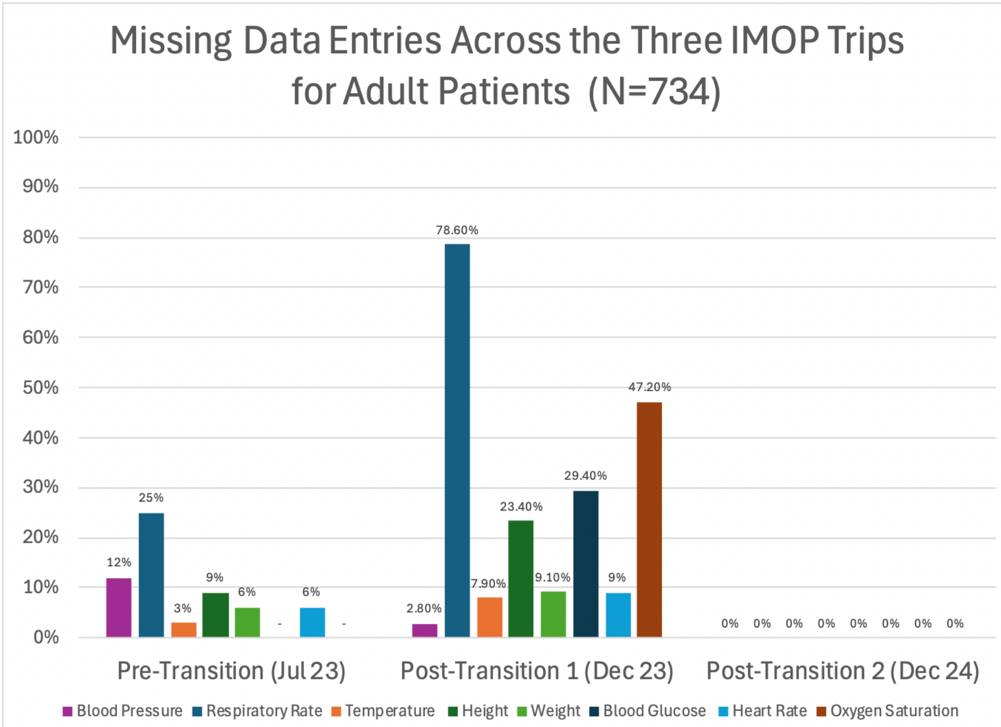


**Figure 2.** Missing Data Entries Across the Three IMOP Trips for Adult Patients

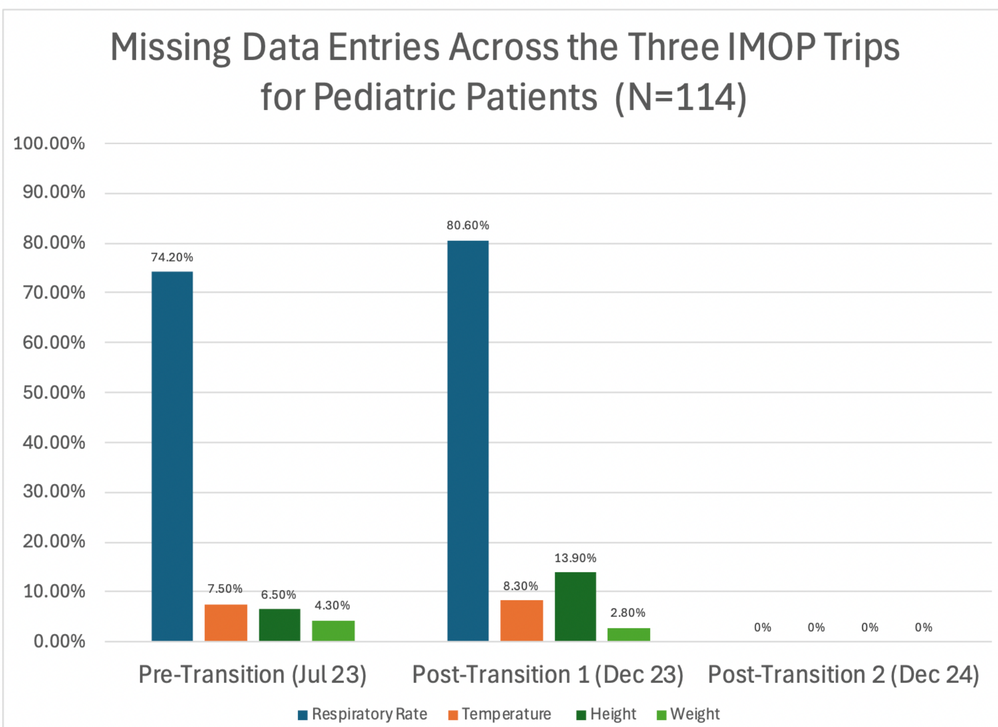


**Figure 3.** Missing Data Entries Across the Three IMOP Trips for Pediatric Patients

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**Table 1.** Missing Data Entries Across the Three IMOP Trips for the Adult Group ($N_a$=734)

| Vital Sign and Anthropometric Measurements for Adults | July 2023 ($N_{1a}$=302) | December 2023 ($N_{2a}$=253) | December 2024 ($N_{3a}$=179) |
|---|---|---|---|
| Blood Pressure | 12 % | 2.8 % | 0% |
| Respiratory Rate | 25 % | 78.6 % | 0% |
| Temperature | 3 % | 7.9 % | 0% |
| Height | 9 % | 23.4 % | 0% |
| Weight | 6 % | 9.1 % | 0% |
| Blood Glucose | - | 29.4 % | 0% |
| Heart Rate | 6 % | 9 % | 0% |
| Oxygen Saturation | - | 47.2 % | 0% |

**Table 2.** Missing Data Entries Across the Three IMOP Trips for the Pediatric Group ($N_p$=114)

| Vital Signs and Anthropometric Measurements for Pediatrics | July 2023 ($N_{1p}$=64) | December 2023 ($N_{2p}$=37) | December 2024 ($N_{3p}$=13) |
|---|---|---|---|
| Respiratory Rate | 74.2 % | 80.6 % | 0% |
| Temperature | 7.5 % | 8.3 % | 0% |
| Height | 6.5 % | 13.9 % | 0% |
| Weight | 4.3 % | 2.8 % | 0% |

## Prescription and Medication Inventory

The medication dispensation process became streamlined through the electronic system, allowing medical students and providers to select the medication name, dosage, frequency, and duration recommendations. This data was accessible to the medical students working at the pharmacy station, who were tasked to dispense the medication and provide additional special instructions for reinforcement compliance. Figure 4 demonstrates the efficacy of digitalized data acquisition in providing real-time updates on medication shortages. The figure is divided into two sections: the left side shows the medication inventory, while the right side displays the prescription form, with each row representing a different time frame. On Day 1, the inventory table records the initial quantity of available medications while prescriptions were not yet issued. The prescription form contains all the medications available. By Day 2, closer to the end of the shift, the pharmacy experienced shortages of several medications, such as acetaminophen. The medical students working at the pharmacy, utilizing the medication inventory system, identified these shortages. As a response, the prescription inventory on the right is manually updated to indicate that these medications are not available. At the end of Day 2, the IMOP director takes proactive steps by replenishing the medication inventory. On Day 3, the system is updated with the new stock levels of the medications. Consequently, the status of the 'NOT AVAILABLE' indicator is removed from the prescription form, reflecting the updated status.


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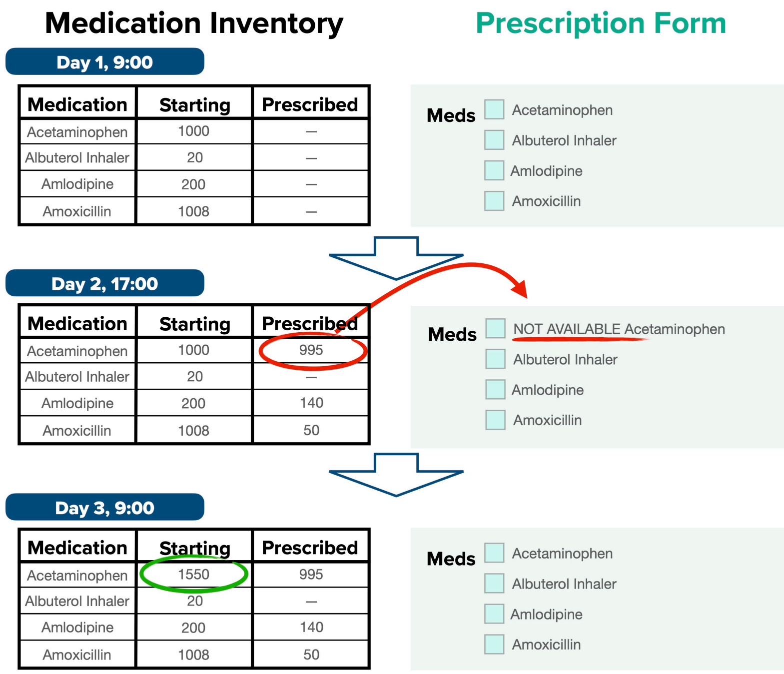


**Figure 4.** Medication Inventory and Prescription Forms at Different Time Frames

## Workflow and Clinical Needs

A critical component of the data management process involves predicting medical resources needed for future IMOP trips based on historical data. Figure 5 displays two charts that illustrate the total number of medications prescribed during the four-day service period on a logarithmic scale of the first post-transition trip. For example, vitamins, pain relievers, and Type 2 Diabetes medications, like metformin, emerge as the most frequently prescribed medications. Through the digitalized data collection system, tracking the number of visits per specialty becomes straightforward. In the past, variations in handwriting or ink color were the only indicators to identify the use of a single paper form by multiple providers for the same patient. However, our current system efficiently categorizes patient visits by both provider and specialty. The second post-transition trip demonstrated a similar distribution across the total number of medications prescribed.

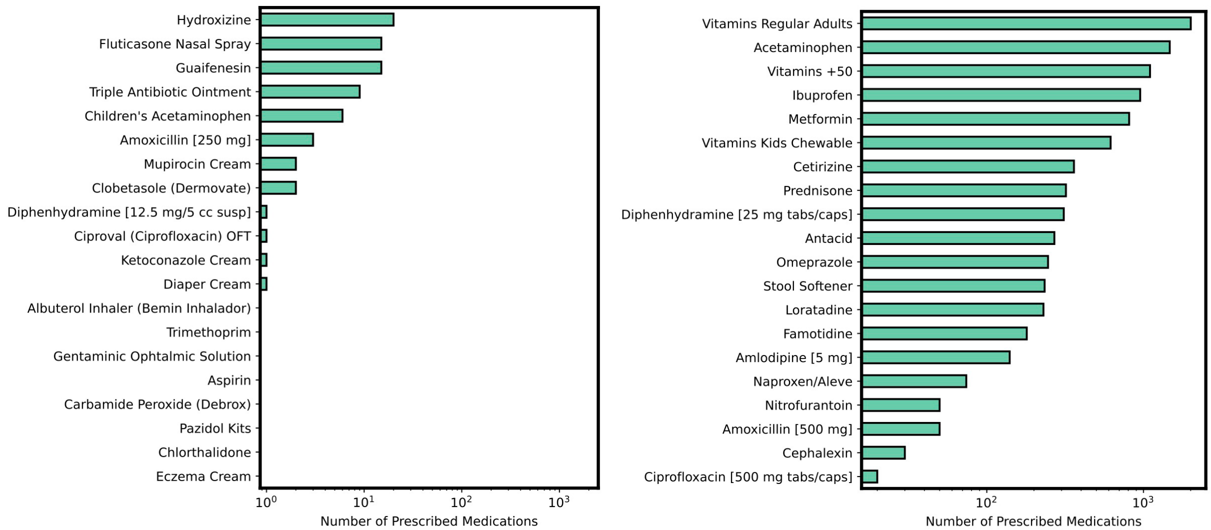


**Figure 5.** Number of Prescribed Medications at the End of the second IMOP Trip

In Figure 6, the number of visits per specialty is displayed for the first post-transition trip. Most patients were treated by primary care physicians. Neurology was the second most needed specialty, followed by sports medicine, osteopathic manipulative medicine, and mental health therapy. The second post-transition trip demonstrated a similar distribution across the specialty areas.

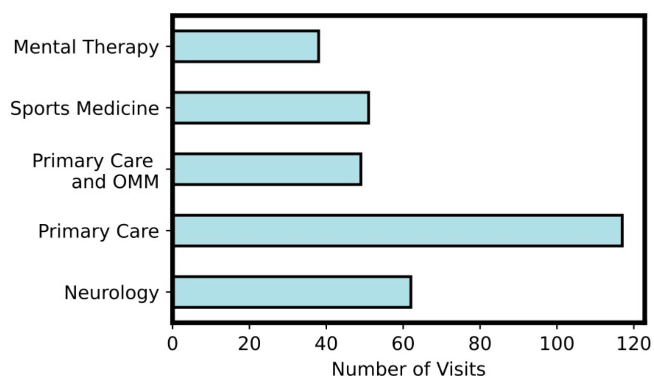


**Figure 6.** Number of Visits Per Specialty

## Daily Reports

Daily report meetings serve as a prime example of knowledge sharing in action. Daily reports were an activity conducted each morning and evening, where medical students prepared a concise presentation on a topic relevant to the community being served. This practice, already established on prior trips, has the potential to deepen the understanding of the social, cultural, and healthcare landscape at the hosting location, given the scarcity of online resources on such topics. Leveraging the REDCap© database, several medical students utilized this tool to prepare their presentations. This enabled them to report on the most prevalent cases encountered, including patients' demographics and other clinical information.

## Discussion

The previous section reveals that digitized data collection presents a multifaceted scenario, where some aspects demonstrate clear benefits from the novel custom-built EHR system and the knowledge transfer about medical clinic practices for medical students. However, other aspects of the transition show more subtle advantages during the implementation phase with challenges from missing data entries. The subsequent section delves into the benefits, drawbacks, and opportunities for growth, providing insights that will enhance the planning and execution of future IMOP trips, as well as future research initiatives.

### Advantages

Among the primary advantages of the digitalized approach are the ability to manage data efficiently and promote knowledge sharing across the team, fostering a more collaborative environment. First, the novel EHR system enabled real-time tracking of the resources, including patient demographics, type, and frequency of consults provided daily for adults and pediatric patients, particularly in the case of patients with complex, multifaceted diagnoses. This revolutionizes our process compared to the paper-based system. With paper records, multiple providers often handled a single document, making it challenging to determine individual responsibility for patient care and identify treatment needs and gaps during the trip. Also, handwriting and acronyms were ineligible or standardized, creating further challenges in the interpretation of notes. Moreover, the majority of the patients treated at the field clinic were familiar with their height and weight in metric units, such as centimeters and kilograms, rather than imperial units (i.e., feet, inches, and pounds). Paper records from the July 2023 IMOP lacked uniformity in measurements, while the digital electronic records were streamlined, consistent, and complete. The EHR system allows for easy data input in one unit with simultaneous conversion to another unit, eliminating the need for manual conversions and potential calculation errors. This standardization is particularly beneficial to accurately prescribe medications. For instance, in pediatric care, kilograms are the standard requirement in determining the appropriate medication dosage. Another key advantage of the introduction of the digitalized EHR system is time efficiency. Before December 2023, each evening, the IMOP director allocated one to two hours to review the medications prescribed during the day's clinical care. As part of this routine, the IMOP director evaluated the need to replenish medication supplies and developed instructions for colleagues to follow the next day. Additionally, following each trip before introducing the novel custom-built EHR system, the IMOP director spent approximately 30 hours organizing patient care information into a structured Microsoft Excel© capturing key data points like age, gender, visited specialties, and provided diagnoses. This was critical for predicting the resources needed in future IMOP trips. By introducing the digitalized EHR system, the IMOP director was able to eliminate the time spent on these tasks, freeing up resources for more strategic activities.

### Limitations

We observed several limitations related to the digitalization of the EHR system, data acquisition compliance, workflow, as well as knowledge and skills transfer to medical students. A significant challenge in the current data acquisition process is the large number of missing data entry incidents for vital signs recorded during triage in the pre-transition (July 2023) and the first post-transition

(December 2023), while strict adherence to missing data entry were made resulting in its elimination during the second post-transition IMOP trip (December 2024). It is noteworthy to point out the varying size and composition of the different teams made up of medical specialty providers, healthcare professionals, and medical students across the three trips, which influenced the degree of data acquisition compliance and human resource utilization. For example, the pre-transition team included a pediatrics physician, whereas the first and second post-transition team substituted a primary care family physician to treat pediatric patients, resulting in reduced data acquisition compliance. Additionally, the data acquisition requirements were relaxed during the pre-transition (July 2023) and first post-transition (December 2023) trips, resulting in a high percentage of missing data entries, where very strict data acquisition requirements were made during the second post-transition (December 2024) trip resulting in elimination of all missing data entries. Also, at the onset of the first post-transition trip, the health informatics expert noticed weak data acquisition compliance, thus, a mandatory training intervention was provided to all medical students. Subsequently, the results show the elimination of all missing data incidents and a higher degree of compliance in the second post-transition trip (December 2024). Another noteworthy point is the need to develop a standardized process should periods of lack of Internet connection service occur, and data acquisition is hampered. Indeed, such an incident occurred on the third day of the post-transition December 2023 trip. This provides another opportunity to teach medical students about real-world disruptions and ways to manage the workflow and data management processes.

Four medical clinic forms were digitalized during the custom-built EHR system, including triage, visit, prescription, and pharmacy. While these forms were collectively converted from paper forms, observation and feedback provided by medical students identified the need for structured input where appropriate. Moreover, additional consideration could be provided to redesign the pediatric forms so that they better align with the data acquisition and management needed, as well as patient treatment and outcome assessments. These adjustments could potentially enhance the consistency and accuracy of the data collected and data analysis.

The knowledge and skills transfer in the respective teams is essential in all stages of the IMOP experiential learning trips, beginning with the pre-trip training and extending throughout the time at the field clinic. The results indicate that the lack of a digitized system hampered such opportunities due to the lack of organized and consistent patient data. Providers were only able to discuss patient cases that they treated, whereas in the post-transition trips, providers and medical students were deeply immersed and engaged in more dialogues about patient cases that were reported in the system.

## Conclusions and Future Research

This study highlights the powerful synergy between humans and technology, demonstrating its potential to facilitate knowledge sharing, skill transfer, and competency development during experiential learning IMOP trips and the implementation of a novel custom-built EHR system. Humans remain indispensable in information and knowledge transfer, serving as recipients and disseminators of clinical insights. This technological advancement has not only enhanced the learning experience of medical students but also holds the potential to further enhance future healthcare delivery services to the same international community. Furthermore, this study demonstrates that a novel digitalized data-collection EHR system serves as a good fit for a field clinic that has a unique set of requirements. The implementation of a digitalized data collection tool in medical field clinics serving remote and underserved communities demonstrates a potential transformative shift toward optimized allocation of human and medical resources. Notably, hands-on experience in a field clinic setting demonstrates that this paradigm shift presents a valuable opportunity to enhance medical education, providing medical students with technology-augmented, real-world experience.

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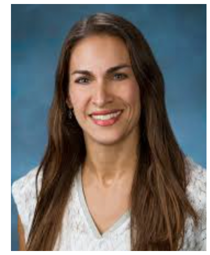

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