PROGRAM EVALUATION DASHBOARD DESIGN AND DEVELOPMENT FOR MISSOURI TELEHEALTH NETWORK SHOW-ME ECHO PROGRAM

A Thesis

presented to

the Faculty of the Graduate School

at the University of Missouri-Columbia

In Partial Fulfillment

of the Requirements for the Degree

Master of Health Informatics

---

by

PAULA ARINZE

Dr. Sue Boren, Thesis Supervisor

MAY 2022

The undersigned, appointed by the Associate Vice Chancellor of the Office of Research and Graduate Studies, have examined the thesis entitled

PROGRAM EVALUATION DASHBOARD DESIGN AND DEVELOPMENT FOR MISSOURI TELEHEALTH NETWORK SHOW-ME ECHO PROGRAM

presented by **Paula Arinze**,

a candidate for the degree of Master of Health Informatics,

and hereby certify that, in their opinion, it is worthy of acceptance.

X_____

Professor Sue Boren

X_____

Professor David Moxley

X_____

Professor Mirna Becevic

ACKNOWLEDGEMENTS

Foremost, I would like to express my sincere gratitude to my advisor Prof. Sue Boren for the continuous support of my master's thesis work and for her invaluable advice and patience during my master's study. Her guidance and recommendations were very helpful during the course of writing this thesis..

Besides my advisor, I would like to thank the rest of my thesis committee: Prof. Mirna Becevic, my supervisor, who not only provided me the opportunity to be part of the great work being done on Show-Me ECHO project but also lent her immense knowledge, support, and plentiful experience during my thesis study. Also Prof. David Moxley, who provided great encouragement, insightful comments, inquiries, and perspectives.

My sincere thanks further goes to Missouri Telehealth Network Organization, the Data Request Team, Evaluation Team, Outreach Team, and host of employees for their generous attitude, welcoming behavior during my time with the organization and their unlimited cooperation with my thesis study. Finally, I wish to extend my heartfelt regard to the whole Health Management and Informatics Department for a wonderful learning experience, I will never forget.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CME – Continuing Medical Education

ECHO – Extension of Community Healthcare Outcome - program

MU – University of Missouri

NCRR – National Center for Research Resources

NIH – National Institutes of Health

PCP - primary care providers

REDCap – Research Electronic Data Capture

UNM – University of New Mexico

ABSTRACT

Background: The Show-Me ECHO Program is a state funded telehealth project, established in 2014, that connects interdisciplinary teams of experts with rural and isolated primary care providers (PCPs) and other professionals using videoconferencing and interactive case-based learning in an effort to develop advanced skills, best practices and ultimately improve patient care access, quality, and efficiency. Since inception, the Show-Me ECHO program has experienced rapid growth and expansion to over 40 ECHO topics, impacting all 114 Missouri Counties and over 2,300 health/community organizations. The exponential growth experienced by the ECHO model highlights a crucial need for adept program evaluation, reporting tools and resources which will facilitate the process of systematically examining the implementation, quality, impact, and value of the program.

Objective: The objective of this project is to design and build data dashboards that support a macro-evaluation and management of Missouri Telehealth Network's Show-Me ECHO program and contributes to program improvement activities.

Methods: A stakeholder identification and needs analysis was completed to ensure comprehensive measurement of program performance metrics. Show-Me ECHO program administrative data, clinic information, attendance records for participants and facilitators, case presentation metrics, didactic presentations, and more were extracted from MTN data repositories for the 2014-2021 period and analyzed for dashboard development. Data cleaning and preprocessing was conducted in a combination of Excel, Python and Tableau. The dashboards and other data visualization metrics were created in Tableau.

Results: Data extraction generated a total of 70,910 observations across three reports ('Clinic Data', 'Didactic Presentation Data' and 'Patient Presentation Data'). Three preliminary dashboards – "Show-Me ECHO Project Reach and Attendance" "Show-Me ECHO Project Overview" and "ECHO Clinic Performance Report" were established to provide Missouri Telehealth Network (MTN) teams and stakeholders detailed insight into growth and performance of the Show-Me ECHO project and support development and management of action plans.

Conclusions: The constructed MTN Dashboards support organization efforts to establish a single unified approach to monitor program progress, identify and prioritize efforts and resource allocation, identify specific Missouri counties that may benefit from interventions and ECHO clinic expansions, and provide appropriate performance metrics that can be shared with both decision makers and relevant stakeholders. Future considerations for dashboard expansion include incorporating PCP self-efficacy and knowledge surveys and Claims data analysis to enable further tracking of Provider and Patient outcomes. A feasibility assessment of the implementation of dashboards at other superhubs for benchmarking and program outcome comparison studies should also be considered.

CHAPTER ONE

INTRODUCTION

Show-Me ECHO

Show-Me ECHO (Extension for Community Healthcare Outcomes) is a state and grant funded telehealth project operated by the University of Missouri's (MU) Missouri Telehealth Network (MTN) [1]. Based on the Project ECHO Model, established by Dr. Sanjeev Arora - a Hepatologist and Gastroenterologist at the University of New Mexico, the collaborative medical education and care management model strives to 'Move Knowledge, Not Patients' as it combats access to care disparities for chronic, costly, and complex health issues across Missouri [1,7,30].

The Project ECHO Model began in 2003 to address the high rates of untreated Hepatitis C patients in underserved areas of New Mexico [4,7]. The knowledge network is designed to connect interdisciplinary teams of experts with rural and isolated primary care providers (PCPs) and other professionals using videoconferencing and interactive case-based learning in an effort to develop advanced skills, best practices and ultimately improve patient care access, quality, and efficiency [27,28]. The objective of the ECHO model is to ensure the "right knowledge exists at the right place at the right time" and by utilizing tele-mentoring and education in best practices, it builds primary care clinicians' capacity to provide quality care for patients with complex and chronic conditions, resolving some of the access barriers patients might otherwise face [1,5,30]. Leveraging technology, community and rural based PCPs (physicians, nurses, physician assistants and other health care professionals) or "spokes" gain access to interdisciplinary specialist teams ("hubs") who deliver knowledge, decision support, and specialty consultation services through facilitated case discussions and didactic presentations [4,33].

In a typical ECHO session, a 10 - 30 minute didactic is delivered by a member of the hub team specialists, afterwards participants present one or more active deidentified patient

case which sparks interactive discussions where “all-teach-all-learn” and a learning loop is created through a hub and spoke knowledge sharing model resulting in improved knowledge, skills, and self-efficacy [4,27,29]. ECHO sessions occur weekly, semi-monthly, or monthly, depending on the ECHO topic, and count towards Continuing Medical Education credits [1].

Although originally created to increase access to Hepatitis C treatment, The Project ECHO model has rapidly grown and been adapted across a range of diseases and specialties in both clinical and non-clinical areas all around the world [30]. Currently there are 1,724 ECHO Programs from 523 Hubs operating in 71 Countries [18]. Particularly, the Missouri Telehealth Network’s Show-Me ECHO which launched in 2014 with Pain Management ECHO Clinic has grown to encompass over 40 ECHO topics, impacting all 114 Missouri Counties and over 2,300 health/community organizations [1,26]. MU’s Show-Me ECHO program was also designated as one of 14 global Superhubs, by New Mexico’s founding ECHO program, for training other organizations to create ECHOs [1,26].

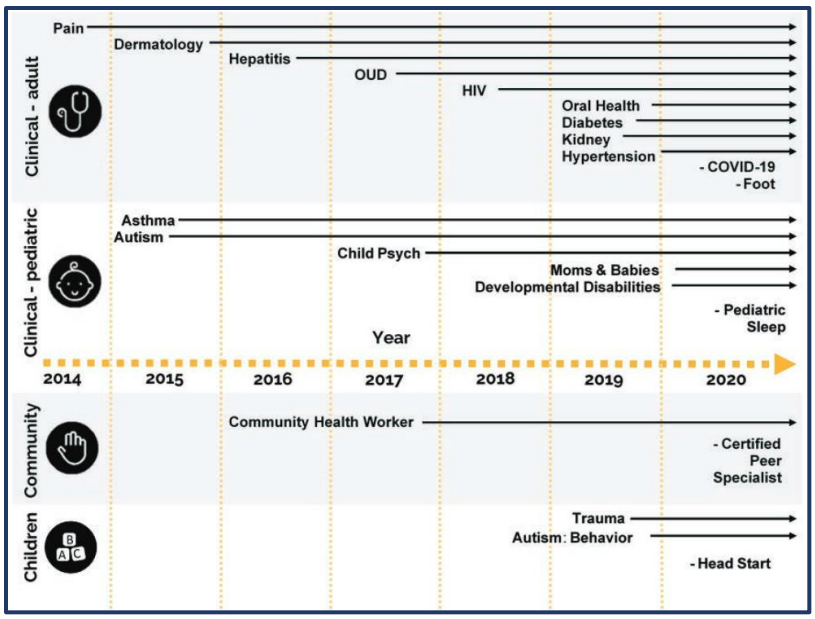


Figure 1. Timeline of Show-Me ECHOs (2020) [25]

Show-Me ECHO's expansion also boasts pioneer ECHO topics/areas such as COVID-19, opioid use, rural veterans' behavioral health, developmental disabilities, and kidney disease [1]. The exponential growth in the ECHO model across multiple applications highlights a crucial need for adept program evaluation, reporting tools and resources which will facilitate the process of systematically examining the implementation, quality, impact, and value of a program [31].

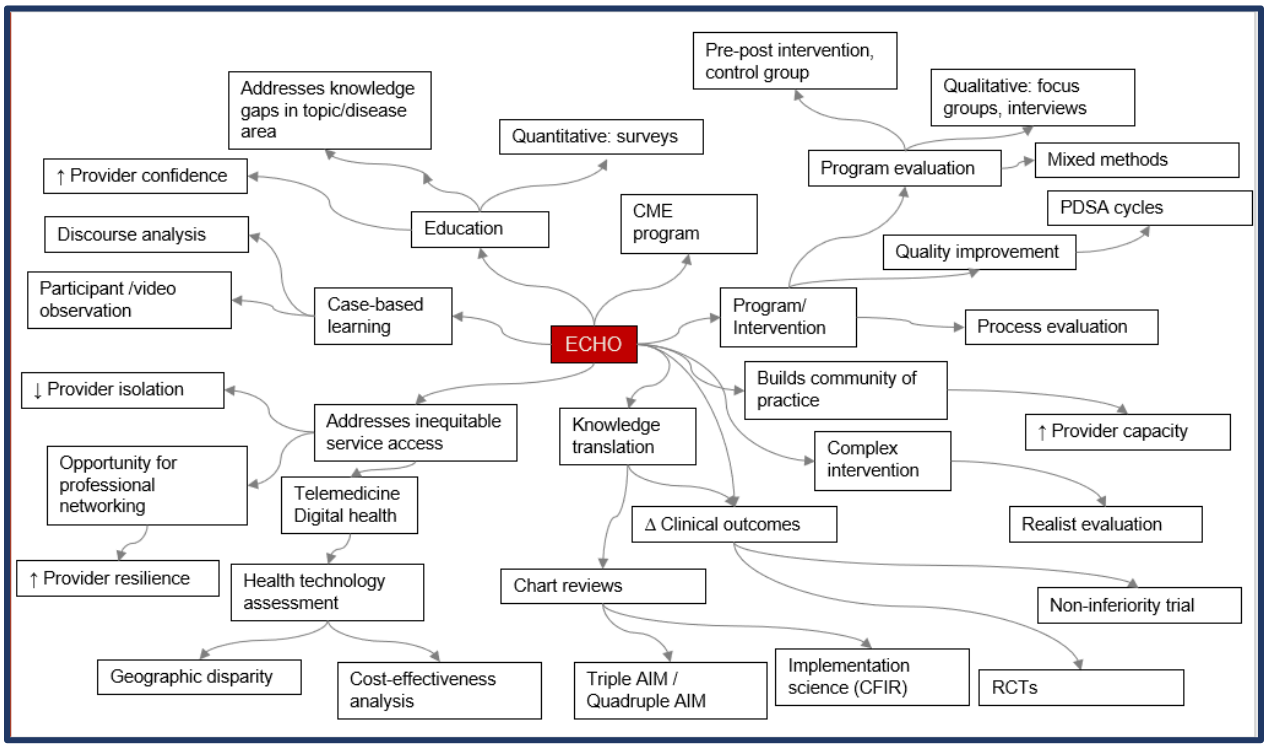


Figure 2. Graphical depiction of the ECHO Model components and outcomes [8]

Program Evaluation

As defined by the CDC, program evaluation is the systematic collection, analysis, and utilization of data to examine the "effectiveness and efficiency of programs and, as importantly, to contribute to continuous program improvement" [10]. Overall, program evaluation activities serve either formative or summative purposes, however specific objectives of program evaluation include supporting decisions regarding program

implementation, continuation, expansion, and modifications, as well as obtaining evidence to rally support or opposition for a program [41]. Program improvement, Funding and sustainability, and Stakeholder engagement are cited benefits of Project ECHO program evaluation [31]. In 2019, the Robert Wood Johnson Foundation sponsored an analysis of The Project ECHO Model. The study "Project ECHO: Review and Research Agenda," worked to assess the state of the evidence about Project ECHO and provide directions for improving its performance in the field [12]. In the published report, researchers call for increased ECHO data collection and improved program evaluative activities to advance research priorities on Project ECHO [12]. The study was conducted by third party, Diffusion Associates, a consulting firm that works to spread, implement, scale up, and assess social innovations, and a copy of key evaluation areas, research priority and recommendations identified is provided in Appendix B.

Challenges to program evaluation arise, especially in programs with vast components, application areas and various stakeholders. In a 2005 qualitative study that investigated challenges and facilitators to building program evaluation capacity among community-based organizations, 'difficulties developing or using evaluation tool' and 'difficulties collecting or analyzing data' were ranked second and third among evaluation challenges [20].

Data Dashboards

The use of dashboards and other business intelligence tools to monitor performance of projects, programs, teams, and organizations are a common trend in the for-profit sector that has increasingly spilled over into the social sector/nonprofit [11,34]. A widely accepted definition of Data Dashboards was posited by Stephen Few in 2004; "A data

dashboard is a visual display of the most important information needed to achieve one or more objectives, with the data consolidated and arranged on a single screen so the information can be monitored at a glance" [11,34]. Dashboards are utilized for a range of purposes such as Strategic (provide 360° overview of a program/organization status and performance), Analytical (support exploration and examination, typically interactive and used by data analysts, policy makers, evaluators, and researchers), and Operational activities (primarily for formative, quality assurance, or safety activities) [34]. Dashboards may be designed and developed using a variety of free or paid software. Software such as Microsoft Power BI, Tableau and Yellowfin are current popular options [11]. However, Microsoft Excel and other open-source resources can likewise be employed in dashboard creation [11].

Implementation of dashboards in program management and evaluation activities can contribute greatly to effective and engaging performance tracking and support timely interventions. Dashboards serve as a central hub of information about a program and all its components, allowing managers, leaders and stakeholders assess program health, drill down to assess the performance of individual areas, and decide on next steps.

Project Objective: The objective of this project is to design and build data dashboards that support a macro-evaluation and management of Missouri Telehealth Network's Show-Me ECHO program and contributes to program improvement activities.

.

CHAPTER TWO

RELATED LITERATURE

A comprehensive literature review was conducted to explore and understand the use of data visualization tools in managing and evaluating projects/programs, particularly in the health and public field, as well as the contributions of such tools in program improvement strategies and activities. To achieve this, studies were systematically selected and reviewed to evaluate established use and impact of dashboards in improving program success and outcomes.

Methods

Data Sources

The reviewed papers were selected by searching relevant publications on the use of dashboards and visualization tools in Medline database. A combination of the following search terms was used: (("Evaluation"[All Fields] OR "Program Evaluation"[All Fields]) OR (“Quality Improvement” [All Fields] OR “Total Quality Management” [All Fields]” OR “Process Improvement” [All Fields]”)) AND ("Data Visualization "[All Fields] OR "Data Dashboard"[All Fields] OR "Dashboard"[All Fields]). The reference lists of relevant and selected studies were also reviewed to identify additional studies.

Study Selection and Data Extraction

The search was limited to articles with abstracts published in English language. The titles and abstracts of resulting articles were then reviewed, and articles that included a study of any type, i.e., systematic review, cohort study, evaluation study, editorials, case series etc., on framework design, development, implementation, evaluation, and related topics of dashboards as a program management and/or quality improvement tools were selected.

Articles were not excluded based on publication year or the country where dashboards were implemented/utilized as the Project ECHO framework has grown and is being implemented across the world. Articles were also not excluded based on if dashboards utilized in the study were quality dashboards or clinical dashboards. Information on the description of the study type/design, location, health program scope, system or software used, dashboard purpose, development strategies and outcomes were extracted from eligible articles.

Table 1: Medline (Ovid) search strategy/terms

S. No	Search Terms	Results
1	Program Evaluation/ or Evaluation.mp.	1630239
2	Quality Improvement/ or Total Quality Management/ or process improvement.mp.	44048
3	Data Visualization/	475
4	Data Dashboard.mp.	25
5	Dashboard.mp.	1194
6	1 or 2	1666499
7	3 or 4 or 5	1640
8	6 and 7	365
9	limit 8 to (abstracts and English language)	343

Results

The comprehensive database search identified 365 articles. From this set of articles, 22 articles excluded based on language, and absence of an abstract. The remaining 343 articles were assessed for eligibility by reviewing the title, abstract and in some cases the full text. This resulted in 328 more articles being excluded for failing to meet the eligibility criteria.

The remaining 15 articles were included in the review. The process of the selection of the papers is presented in Figure 3.

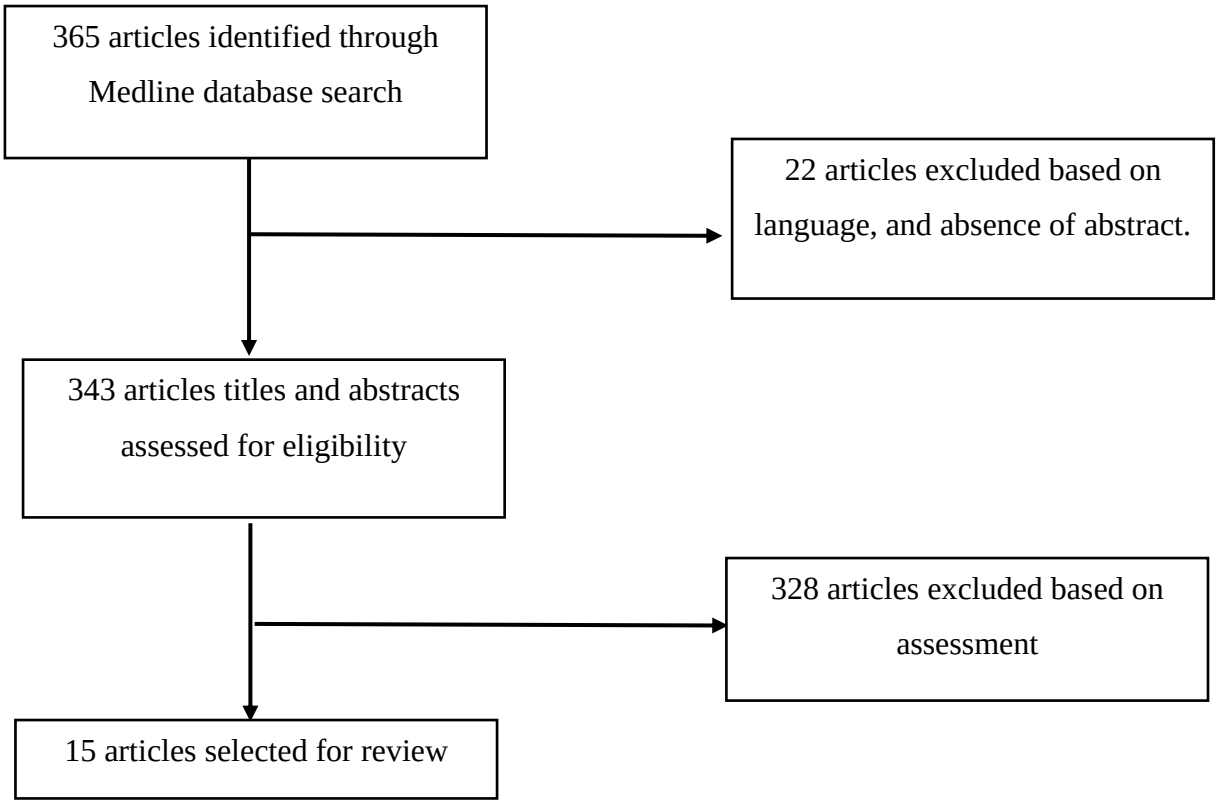


Figure 3. Overview of data extraction for selecting relevant papers

Study Demographics

The studies in the final reviewed papers, fifteen, involved dashboards implemented in various continents North America, Europe, Africa, Asia etc. Most of the studies were conducted in the USA [2,15,20,23,24,31,35], one in Canada [28], one in Indonesia [17], one in Mali [38], one in Netherlands [14], one in Nigeria [23], one in South Africa [9] and one in Uganda [22]. One paper reviewed involved multi-countries studies: England, Scotland, Wales, Ireland, and Northern Ireland [3]. Most of the studies employed a web-

based/open-source software in building and sharing the dashboard, however commercial software such as Microsoft PowerBI was also utilized.

Table 2. Description of the included articles and studies

Author/Year	Study Type/Design	Program Type / Scope	Location	Dashboard System/Software
Almasi et al	Systematic Review	Emergency Departments	USA	Various
Alvarado et al	Realist Evaluation	Myocardial Ischemia National Audit Project (MINAP) and Pediatric Intensive Care Audit Network (PICANet)	England, Scotland, Wales, Ireland, and Northern Ireland	QualDash (Web-based)
Bhardwaj et al	Case Reports and Series	Mother to Child HIV Transmission Program	South Africa	-
Gude et al	Protocol study	Pain management Program	Netherlands	Web-based
Harrison	Case Reports and Series	Health and Social Services Department	USA	-
Helmyati et al	Implementation Study	Maternal and Child Health Services	Indonesia	Excel, R (Online)
Lau et al	Case Reports and Series	Educational Outreach Intervention (Academic Detailing)	USA	SQL, SQL Server Reporting Services (SSRS)

Lee et al	Quality Improvement Initiative / Interrupted Time Series Study	Sepsis Care (Antibiotic Administration)	Uganda	Web-based
Lenglet et al	Pilot Study, Prospective Multicenter Quality Improvement Study	Health care Associated Infections (Hand Hygiene Adherence Rates)	Nigeria	PowerBI
Mayfield et al	Formative Evaluation Study	Health and Economic Improvement Initiative (Building Uplifted Families (BUF); cross-sector community initiative)	USA	RStudio package, RShiny, and web-hosted in the Shiny Server
McHugh et al	Exploratory, cross-sectional analysis	Percutaneous Intervention for Acute Myocardial Infarction	USA	-
Mulhall et al	Implementation Study	Long Term Care	Canada	-
Rattray et al	Observational Qualitative Evaluation	Transient Ischemic Attack	USA	Web-based
Taber et al	Qualitative Analysis	Antimicrobial stewardship (AS) programs	USA	Web-based
Whidden et al	Randomized Controlled Trial	Community Health Worker (CHW) program	Mali	-

Table 3. Dashboard purpose, development strategies and outcomes.

Author/Year	Dashboard Purpose	Dashboard Development Strategies	Dashboard Outcomes
Almasi et al	Improve the control and management of ED processes	Various	Quality dashboards facilitated processes, communication, and situation awareness in the ED, and can improve care provision in this department. To enhance the effectiveness and efficiency of ED dashboards, performance indicators should be set and the conformity of dashboard functionalities with user needs considered. Dashboards should also be integrated with other relevant systems at the departmental and hospital levels.
Alvarado et al	Support the use of national audit data for quality improvement in NHS acute health care organizations	Conducted within 5 NHS acute health care organizations and included interviews with 54 staff members, a workshop with audit suppliers, and 2 co-design workshops with clinicians and managers from one organization. Focus groups were held within each organization to identify strategies to support the uptake and adoption of QualDash.	Variable impact across sites within the evaluation period. Lack of metrics configuration led to QualDash not being perceived as a tool that could facilitate data use as part of professionalism in some sites. Lack of accurate and timely data constrained the use of QualDash in care quality monitoring
Bhardwaj et al	Track key indicators representing critical points in the prevention of mother-to-child transmission (PMTCT) cascade	Color-coded dashboards comprising key indicators representing critical points in the PMTCT cascade were agreed on for tracking using the 'traffic light/ robot' approach. Quarterly data for action reports, including dashboards, were completed at district, provincial and national levels.	Regular review of the dashboards and data for action reports. Improved understanding of bottlenecks and prioritizing actions at local levels. Supported improvement in program performance across the PMTCT cascade.

Gude et al	Provide detailed insight into clinical performance on quality indicators; and support development and management of action plans	Careful review of the empirical and theoretical evidence in A&F literature and continuous involvement by ICU clinicians: Derived indicator set using a modified RAND method. The method combines literature and guideline review with knowledge from ICU experts in an extensive rating and consensus procedure. To address a potential lack of knowledge on how to improve on quality indicators, which was identified as an important barrier in the previous A&F study, a particular focus was placed on ensuring the actionability of the indicators during their development.	N/A
Harrison et al	Provide easily accessible data on critical program areas to facilitate assessment of changes that may prove to be harmful to clients or the agency as a whole. Address the need for more transparency of data across departments, especially to highlight areas that reflected improvement as well as areas that needed improvement.	The Research, Evaluation and Planning division spearheaded the Dashboard featuring the seven program areas (Employment & Eligibility, Child Welfare Services, Mental Health, Public Health, Older Disabled Adult Services, Substance Abuse, and the Special Investigations Bureau), and three administrative units. Deputy Directors specified several key areas that their divisions were mandated to report or viewed as important for monitoring.	The Dashboard enabled Directors to communicate internally and externally about program results, strengths, and growth areas, as well as track progress in relationship to strategic plan initiatives and intervene in areas needing improvement. Executive team members identified critical areas for improvement and the Assistant Director for Research and Evaluation implemented corrective action through the Quality Assurance Committee.

Helmyati et al	Analysis and Reporting: improve the managerial capabilities of district offices staff; situation and policy analysis using routine data; and mapping the impact of the pandemic and possible mitigation strategies.	Gathered information and inputs from the health ministry and assessing which indicators to include. The selected indicators were routine data collected by district offices and stored in the health ministry database. Information about the impact of the pandemic, and strategies and challenges to deal with it, was gathered from the district offices and quality checked by the lead university before being transferred to the online dashboard. All activities were documented in open-access websites	Enabled rapid situation assessments of the impact of the pandemic on mother and child and nutrition programs in individual districts and nationwide and supported situation analysis for further recommendations to relevant stakeholders. Overall, proved effective and time-efficient – factors which are important in settings such as Indonesia with a large population and diverse geographical conditions, and during external shocks such as a pandemic
Lau et al	Benchmark and monitor academic detailing activities and performance and to identify opportunities for redistributing resources. Support several VA national campaigns including the Opioid Safety Initiative and Opioid Overdose Education and Naloxone Distribution Program.	After identifying the patients for surveillance, the VA ADS worked with stakeholders to determine the proper metrics to measure in regard to academic detailing OSI and OEND campaigns. (These metrics were used to benchmark and monitor academic detailing activity and redeploy resources to address areas of low activity.) Development has several challenges that include data validation, missing data analysis, standardization, user engagement, and technical limitations.	Provided end-users with information on outcome trends, leading to the development of quick and accurate reports, identification of high-risk patients for immediate intervention, and data visualization. End users of these VA ADS clinical dashboards could generate priority panel reports and data visualization of key performance indicators to identify areas for improvement or action

Lee et al	Provide real-time patient information for optimized resource allocation and patient prioritization.	Danger sign indicators, selected in collaboration with local clinical experts. After triage, patient details, which included the patient's age, presenting complaint, triage time, and triage category, were sent to an accompanying dashboard that allowed clinicians to appropriately prioritize patients. The web-based dashboard was accessible on the local network through desktop computers and Android tablets located in the consultation and treatment rooms for healthcare workers to view and record patient location (e.g., waiting room, consultation room) and treatments (e.g., intravenous fluids, antibiotics). A warning appeared if the elapsed time for priority or emergency triage exceeded an hour	Reduced antibiotic administration time, especially in the highest risk children, and increased proportion of children who received antibiotics under one hour, demonstrating the potential for data-driven electronic triage and technology in quality improvement. Clinical dashboard contributes to serving as a platform for continuous cycles of quality improvement through its data collection and feedback mechanisms, contributing to the culture of providing high quality care.
Lenglet et al	Improve the evaluation and feedback for hand hygiene adherence	Using the KoboCollect application programming interface, a set of clearly defined methods for allowing the communication of data among different applications and platforms, connected data from the Kobo Toolbox server to Power BI (Microsoft Corp), a partially proprietary online platform for automated data analysis with an interactive visualization display (dashboard). The application programming interface was used	Overall hand hygiene adherence increased from 32.4% to 57.4%. Inclusion of real-time monitoring and data visualization in a standard multimodal hand hygiene improvement strategy was associated with successful implementation and increased hand hygiene adherence in these low-resource settings.

		to populate Power BI, and the dashboard was refreshed daily.	
Mayfield et al	Part of a multistage data governance system for data collection, analysis, and dissemination of results. Aim to resolve absence of up-to-date preliminary results which create barriers for timely decision-making and program adaptation.	User-centered design process was anchored in the project goal of optimizing the application of current REDCap Cloud technology to reduce the 3-month time lapse. Conducted a detailed assessment of system requirements and current infrastructure limitations using key informant interviews and regular meetings with the Life Navigators. Key project stakeholders from each sector are engaged through a Partnership Advisory Board (PAB) that aligns resources, brainstorms solutions for barriers, and makes programmatic decisions.	Having up-to-date preliminary results led to improved BUF implementation, enhanced stakeholder engagement, and greater responsiveness and alignment of program resources to specific participant needs. Dashboard specifically used at 5 PAB meetings and 4 operational working team meetings to review progress and stimulate project implementation discussions (proportion of uninsured program participants was reduced by over 50% by the end of the beta test period, and nurses from the healthcare system partners developed a tailored healthcare utilization education program for participants based on identified problem areas)
McHugh et al	Manage ED flow and resources, providing staff with easy access to real-time information from laboratory, radiology, and admitting databases	-	Improved safety and reduced ED crowding. Findings indicate that Dashboard and consequent quality improvement interventions were linked to improvement of specific quality measures, such as PCI scores - hospital performance on receipt of percutaneous intervention (PCI)

Mulhall et al	“Audit and Feedback" Function: help clinicians enhance the care they provide to long-term care (LTC) home residents	Topics and indicators for the MyPractice selected by means of a modified Delphi process based on the RAND method. Once indicators were selected, a team of epidemiologists, biostatisticians, and clinicians conducted analyses to determine the most appropriate definition of the indicator and the contextual data to include in the report. The report is designed using a user-centered approach to minimize cognitive burden: physicians first see a summary of their prescribing indicators on a dashboard and find additional detailed data and information to guide practice improvement presented in subsequent pages.	Initial evaluation of dashboard shows statistically significant impact on reducing the prescription of antipsychotic medications in LTC homes (almost 2% reduction in antipsychotic prescribing equivalent to about 900 residents no longer receiving antipsychotic medications in Ontario LTC homes)

Rattray et al	Support Quality Improvement activities among newly formed multidisciplinary teams to improve TIA care quality	Best practices from A&F literature were considered during the design phase. The intervention team collaborated with the VA Office of Healthcare Transformation staff to design the user interface and develop the backend database containing performance data and text-based content. A senior data scientist (LJM) extracted data from the CDW using algorithms to calculate facility-level pass rates on validated performance measures	The PREVENT Hub, unlike many static dashboards, allowed team members at facilities not only to examine monthly performance data that had been previously inaccessible but also to interact with that data to evaluate change over time, to share resources as facilities engaged in QI, and to foster a sense of inter-facility community. Findings suggest that the Hub actively supported facilities in forming local teams around TIA care with the capacity for learning and adaptive behavior. Site team members utilized the Hub for staff and patient education, benchmarking, and ongoing QI activities; external facilitators used the Hub to help local implementation teams leverage data to target improvement areas in their nascent TIA protocols. Providers cited access to previously unavailable benchmarking data as a key source of motivation to continue improving TIA care. The Hub addressed three common informatics challenges: access to data, data integration, and common infrastructure for facility teams and communities of practice.
Taber et al	Improve AS decision-making by providing data that could be queried by location, drug, and in relation to the "Three C's" of antibiotic prescribing: choice, change, and	Antimicrobial use data from VA facilities was integrated into the VA Corporate Data Warehouse as well as the Centers for Disease Control and Prevention (CDC) National Health Safety Network (NHSN), and then extracted and made available to participating facilities via a web-based tool. In addition to	AS dashboard encouraged connections with local QI culture. Performance feedback from dashboard motivated and persuaded social goals. Shared problem awareness and group decision-making was aided by authoritative data.

	completion. In addition, provide antibiotic stewards with the capability of describing intra-facility antibiotic use and of making user-selected comparisons to other facilities in the VA system (Department of Veterans Affairs).	generating standardized reports, users could customize queries by selecting locations (e.g., wards or intensive care units), drug or key decision points in the antibiotic prescribing process	
Whidden et al	Performance feedback tool graphically displays a CHW's monthly performance in terms of quantity, timeliness, and quality of care provided alongside those of the highest performing CHW	-	Use of the Dashboard during monthly supervision significantly increased the mean number of home visits by 39.94 visits per month (95% CI = 3.56-76.3; P = 0.031). Estimated effects on secondary outcomes of timeliness and quality were positive but not statistically significant. Across both study arms, CHW quantity, timeliness, and quality of care significantly improved over the study period, during which time all CHWs received dedicated monthly supervision.

Summary

This review aimed to investigate the use and effect of dashboards in health and wellness program management and improvement processes. The literature analyzed demonstrates visualization tools (i.e., dashboards) are employed in a variety of health programs and for diverse purposes, with predominantly positive and significant program, organization, and user outcomes.

CHAPTER THREE

METHODOLOGY

Study Design

The primary goal of the dashboard is to provide a holistic view of the Show-Me ECHO program/project - historical trends, current state, impact, performance, and anomalies. In addition, the dashboard will contribute to evaluating how well data collected answers priority questions about Project ECHO, identify program improvement steps and support future planning efforts. After a thorough literature review and exploration of existing evaluation processes, a stakeholder identification and needs analysis was completed to ensure comprehensive measurement of program performance metrics. Major stakeholders were identified as Missouri Telehealth Network's (MTN) Data Request Team, Evaluation Team, and Outreach Team, and the Show Me ECHO Hub Teams. Stakeholder groups engaged for this study were contacted directly through in-person or phone interviews to solicit and establish their priorities in defining program effectiveness during this phase. Data resources and tools were sourced subsequently based on identified needs.

Data Source and Extraction

Data was sourced from the Missouri Telehealth Network (MTN) Show Me-ECHO data repository, which is housed across iECHO, REDCap and SharePoint sites. Identified program administrative data, ECHO clinic information, attendance records for participants and facilitators, case presentation metrics, didactic presentations, and more were extracted from Show Me-ECHO inception (09/20/2014) to data extraction date (11/29/2021). Inclusion criteria was all ECHO clinic and participant data within the date range except for ECHO clinics initiated within six months of data extraction to ensure sufficient data availability. Adult Psych (inception September 2021), Pediatric Weight Management (inception September 2021), Social Emotional Learning - Middle School (inception

October 2021) and Cultivating Positive Classroom Climate - High School (February 2022) ECHOs were excluded as a result. Data cleaning and preprocessing was conducted in a combination of Excel, Python and Tableau to resolve issues such as duplicates and missing values, fix structural errors, and create new variables as needed for metrics. Data extraction procedures available in Appendix B.

Dashboard Design

We based the dashboard prototypes on the University of New Mexico Project ECHO "ECHO Movement Overview" & "ECHO Hubs Dashboard" Dashboards in conjunction with Missouri Telehealth Network Semiannual individual ECHO reports [18] (see Appendix). Information and evaluation priorities obtained during stakeholder meetings further influenced the metrics investigated and tracking views created for the dashboards. The dashboards and other data visualization metrics were created in Tableau.

Resources/Software

iECHO: iECHO is a wed-based program management software and database developed by University of New Mexico (UNM) in 2010 as a resource for collaborators/partners to track Project ECHO's programmatic activities around the world [19]. iECHO is designed to track and store vital ECHO data such as program administrative data, attendance records for participants and facilitators, case presentation metrics, didactic presentations, program documents, and awarded CME/CEU/CE credits, however Protected Heath Information (PHI) is not recorded in iECHO [19].

REDCap: Research Electronic Data Capture (REDCap), released in 2004 by a Vanderbilt University informatics team, is a secure web-based metadata driven electronic data capture

software utilized in designing and processing surveys, storing, and mining confidential multi-dimensional data [15,40]. Originally developed to address the lack of effective IT integration protocols in multidisciplinary independent research environments, the NCRR and NIH grant funded workflow management system can now be used to collect virtually any type of data in any environment (including compliance with 21 CFR Part 11, FISMA, HIPAA, and GDPR) [15,35,40]. REDCap features include easy and customizable survey design options, intuitive interface for validated data entry, versatile survey taking options, audit trails for tracking data manipulation and export procedures, automated export procedures to common statistical packages (excel, R, SAS, SPSS) and data import capabilities [15,35].

Tableau: Tableau software is a leading data visualization and business intelligence tool established in 2003 by Stanford University Department of Computer Science Researchers to improve the flow of analysis and make data more accessible [37,39]. Tableau supports powerful data discovery and exploration enabling fast queries that facilitate business decision making [37]. Some of its popular capabilities include integration with several data source types such as relational databases (Teradata, SAP, My SQL, Amazon AWS, Hadoop), online analytical processing cubes, cloud databases, and spreadsheets to generate reports and graph-type data visualizations and provision of centralized locations (server) to access and manage all published data sources within an organization [37].

*Table 4. Steps to building program dashboards**

Step	Action	Description
1	Determine the goals of the dashboards	Before developing the program dashboard, determine the goals: What will the dashboard be mainly used for? What capabilities should it possess? Who are the end-users?
2	Identify areas of interest	Work with stakeholders to identify areas of interests for monitoring and reporting. What are their goals?
3	Develop metrics	Work with stakeholders to identify metrics that reflect the program's performance.
4	ETL process	After the metrics are identified, the corresponding data needs to be extracted, transformed, and loaded onto a workspace where the dashboard will quickly retrieve the data. The ETL process can be stored and automated.
5	Dashboard development	Views, features, actionability, usability, and performance
6	Implementation	User acceptability testing (iterative process), education (demos), training
7	Sustainability	Feedback, updates, expansion, quality assessment, quality improvement

* Adapted from [20]

CHAPTER FOUR

RESULTS

The iECHO data extraction generated a total of 70,910 observations across three reports ('Clinic Data', 'Didactic Presentation Data' and 'Patient Presentation Data'). Variables pulled included data points such as information on ECHO sessions completed, facilitators, participating organizations and individuals, didactics presentation and instructors, case presentation, presenting PCPs and more from inception in 2014 to data collection end date in 2021. Information on the full variable list for each report can be found in Appendix B, in addition the Python Code used for initial exploratory analysis is provided.

Based on the inclusion criteria for the study, data on 41 ECHO clinics were extracted, preprocessed, and combined to establish a 'single source of truth' for the dashboard development. Table 5 summarizes descriptive information on the ECHO clinics included in this study.

Table 5. Show Me ECHO Clinic Information

ECHO Name	Category	Scheduled duration (hours)	Start date	End date	Number of Sessions *
Asthma 1 – Essentials: Impact Asthma	Clinical	1	9/8/2015	ongoing	152
Asthma 2 – QI/MOC: Asthma Care Accelerator	Clinical	1	3/6/2018	ongoing	32
Asthma 3 – Community: Asthma Care & Education	Clinical	1	3/13/2018	ongoing	42
Autism	Clinical	1.5	¾/2015	ongoing	156
Autism: Behavior Solutions	Community	1	1/6/2020	ongoing	36

Certified Peer Specialist	Community	1	2/5/2020	ongoing	43
Child Psych	Clinical	1	5/12/2017	ongoing	76
Community Health Worker	Community	1	½/2018	ongoing	75
COVID-19	Covid	1	3/23/2020	ongoing	80
COVID-19 & Kids	Covid	1	9/17/2020	ongoing	41
CROWN – High Risk OB (Rural)	Clinical	1	2/28/2019	12/12/19	17
Dermatology	Clinical	1	12/4/2015	ongoing	166
Developmental Disabilities	Clinical	1	8/8/2019	ongoing	43
Diabetes	Clinical	1	11/3/2020	ongoing	21
Endocrinology	Clinical	1	9/10/2015	8/15/17	40
Foot Preservation	Clinical	1	10/7/2020	ongoing	13
Genetics/Genomics	Clinical	1	2/14/2019	5/23/19	2
Head Start	Community	1	1/15/2020	ongoing	16
Healthcare Ethics	Community	1	7/13/2017	6/18/19	23
Hepatitis C	Clinical	1.5	1/20/2016	July 2020	82
HIV	Clinical	1	11/8/2018	ongoing	29
HOPE – High Risk OB (Urban)	Clinical	1	2/5/2019	12/17/19	19
Hypertension	Clinical	1	10/28/2019	ongoing	29
Kidney Disease	Clinical	1	6/20/2019	ongoing	42
Managing Hospital & Patients in a Pandemic	Covid	1	12/8/2020	6/1/21	16
Missouri Moms & Babies	Clinical	1	7/22/2020	ongoing	27

Mothers, Infants & NAS	Clinical	1	11/5/2020	ongoing	26
MTSS (Multi-Tier System of Supports)	Community	1	4/17/2018	2/27/20	18
NAS	Clinical	1	2/7/2019	10/17/19	17
Opioid Use Disorder	Clinical	1.25	9/8/2017	ongoing	80
Oral Health	Clinical	1	2/13/2019	ongoing	32
PAC/LTC: Post-Acute & Long-Term Care	Covid	1.5	3/17/2021	ongoing	34
Pain Management	Clinical	1	11/6/2014	ongoing	124
Pediatric Sleep	Clinical	1	8/10/2020	ongoing	33
SEMO Diabetes	Clinical	1.25	9/3/2019	5/19/20	17
Suicide Prevention in Health Care	Clinical	1	2/19/2021	ongoing	18
Telemedicine	Community	1	4/14/2020	ongoing	27
Trauma Informed Schools	Community	1	12/3/2019	ongoing	20
Urban Dermatology	Clinical	1	2/12/20	5/31/20	4
Veterinary Education & Training	Clinical	1	3/9/2021	ongoing	9
Viral Hepatitis and Fatty Liver	Clinical	1	9/18/2020	5/7/21	14

** As of data extraction date*

Missing Data

Missing and incorrectly entered Data was identified during Python exploratory analysis and addressed where needed in Excel. Using functions such as 'VLOOKUP' two new variables were created for Patient Presentation Dataset to provide data points for identified

metrics. To aid ease of dashboard maintenance majority of data manipulation was conducted in Tableau where rules and process can be stored and automated.

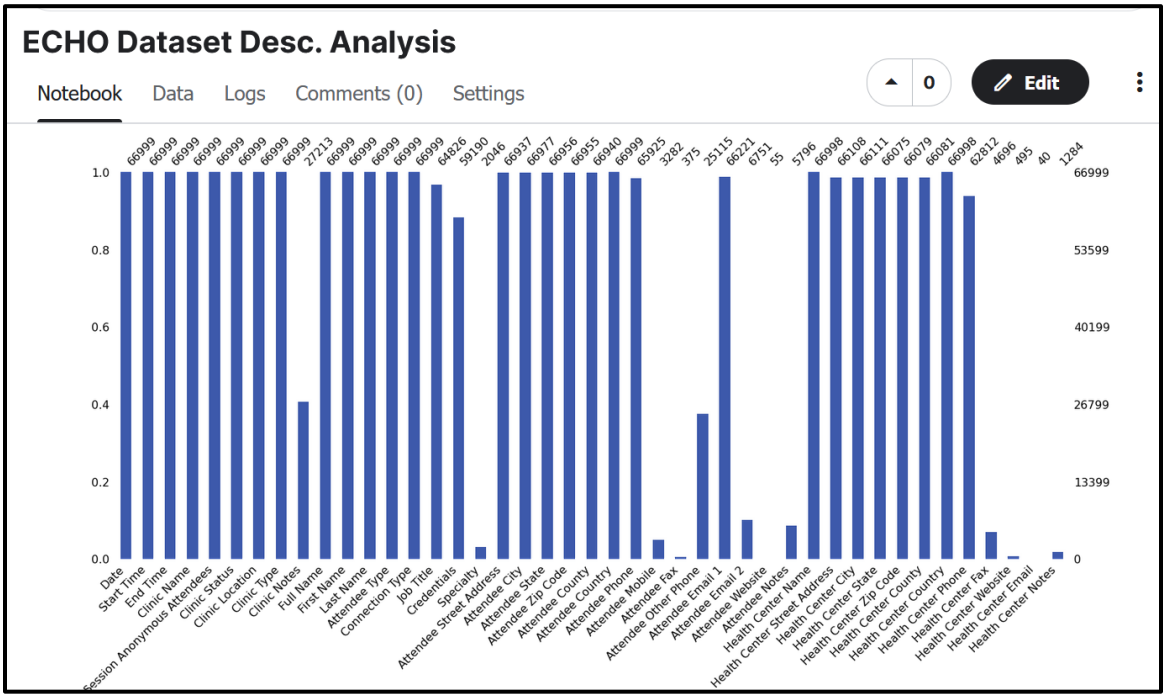


Figure 4. Graphical representation of missing variables for Clinic Data Dataset

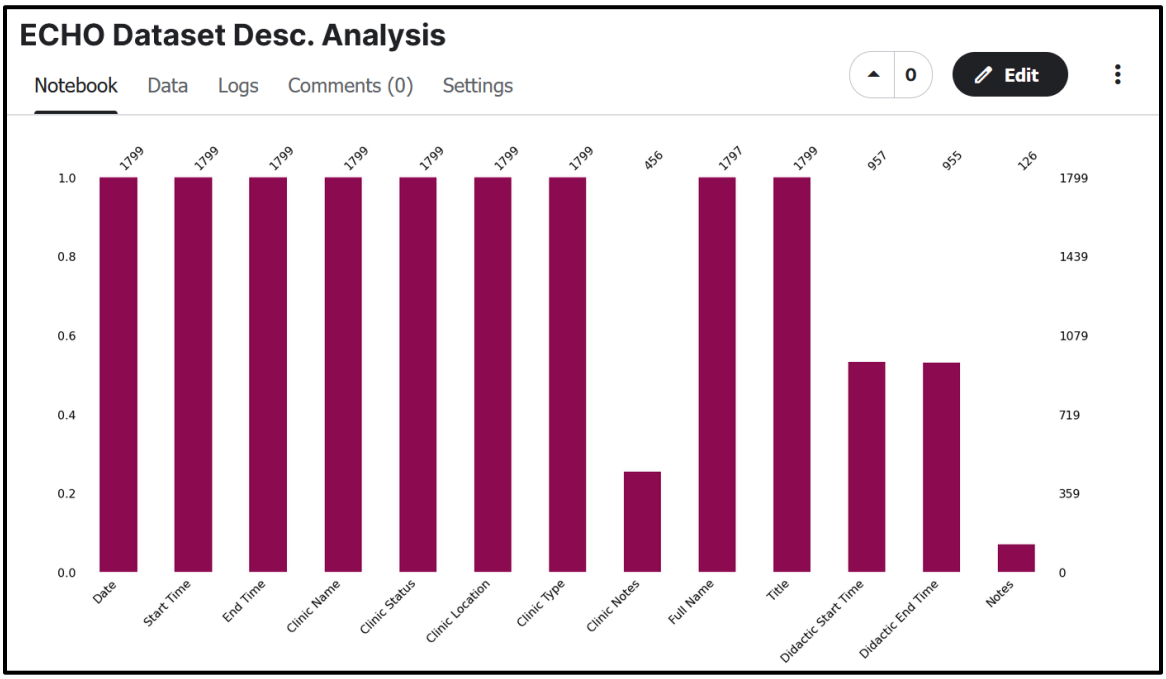


Figure 5. Graphical representation of missing variables for Didactic Presentation Dataset

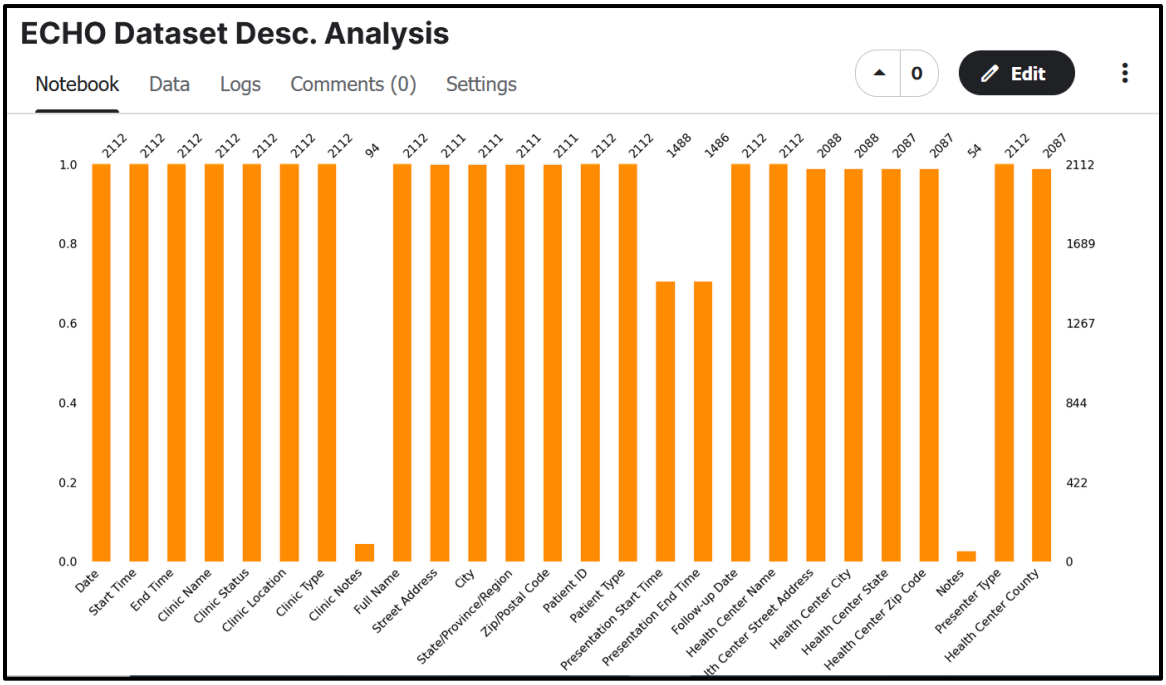


Figure 6. Graphical representation of missing variables for Patient Presentation Dataset

Metrics and Dashboard Development

Development work provided insight into how ECHO data collected were used (user tasks) and by whom across Missouri Telehealth Network teams, additionally what interrogative, and reporting functions a quality dashboard should retain to facilitate user acceptance. After identifying areas of interest for monitoring and reporting, we worked with stakeholders to determine the proper program performance metrics to measure, allowing end users to benchmark and monitor program progress. Table 6 lists some of the identified areas of interest/metrics and the corresponding Tableau views developed. Not all views developed were included the dashboards, however dashboard report features include ‘drill

down' capabilities that allow users explore all published views. Users will have access to non-dashboard views to facilitate customized report generation

Table 6. Metric Areas and Tableau Views Developed

Metric Area	Description/Scope	Views Created (Visual Type)	Worksheet Capabilities
Program Reach	Combination of metrics that express Show Me ECHO reach and impact across Missouri counties and the United States	Total Organizations Impacted (Text)	Customizable and Linked
		Health/Community Organizations Impacted (Table)	
		Number of Counties (Text)	
		Show-Me ECHO Reach (U.S level map)	
		ECHO County Activity (Missouri County level map)	
		Direct Patients Impacted (Missouri County level map)	
Total Attendance	Sum across all sessions of the number of attendees present (an attendee present for two sessions would be counted twice, for three sessions, thrice, etc.)	Total Attendance (Text)	Customizable (filters such as Clinic Name, ECHO Category, Attendee Type, Dates, etc.), Linked (e.g., 'Total Attendance drills down into 'Total Attendance by Year' View)
		Total Attendance by Year (Bar graph)	
		Total Attendance by ECHO (Bar graph)	
		Average Monthly Attendance Trend (2014 - 2021) (Line graph)	
Unique Attendance	Count of individual attendees participating in any session during the reporting year (counted once regardless of how many sessions attended)	Unique Attendees by Year (Line graph)	Customizable
		Unique Attendees by ECHO (Bar graph)	
Unique Learners	Count of individual learners (attendees and facilitators) participating in any session during the reporting year (counted once regardless of how many sessions attended)	Unique Learners by Year (Line graph)	Customizable
Total Sessions	Sum of ECHO virtual discussion/meetings held. Show-Me ECHO sessions	Total Sessions (Text)	Customizable and Linked
		Total Sessions by ECHO (Bar graph and Table)	

	occur weekly, bi-monthly, or monthly depending on the ECHO topic	Total Sessions by Year (Bar graph)	
		Average Monthly ECHO Sessions (2014 - 2021) (Line graph)	
		2020 vs 2021 Average ECHO Sessions (Side by Side bar)	
Hours of Instructions	(Total learners) × length of session (usually 1 hour)	Hours of Instructions by Year (Bar graph)	Customizable and Linked
		Hours of Instructions by ECHO Category (Bar graph)	
		Hours of Instructions by ECHO (Bar graph)	
Cases Presented	Presentation and discussion of a challenge encountered by an ECHO learner in the course of their interaction with patients/clients.	Total Cases (Text)	Customizable and Linked
		Total Cases by ECHO (Bar graph)	
		Case Presenter Type (Stacked Bars)	
		Case Presenter by ECHO (Stacked Bars)	

Dashboard Outputs

Three preliminary dashboards – "Show-Me ECHO Project Reach and Attendance" "Show-Me ECHO Project Overview" and "ECHO Clinic Performance Report" were established to provide Missouri Telehealth Network (MTN) teams and stakeholders detailed insight into growth and performance of the Show-Me ECHO project and support development and management of action plans.

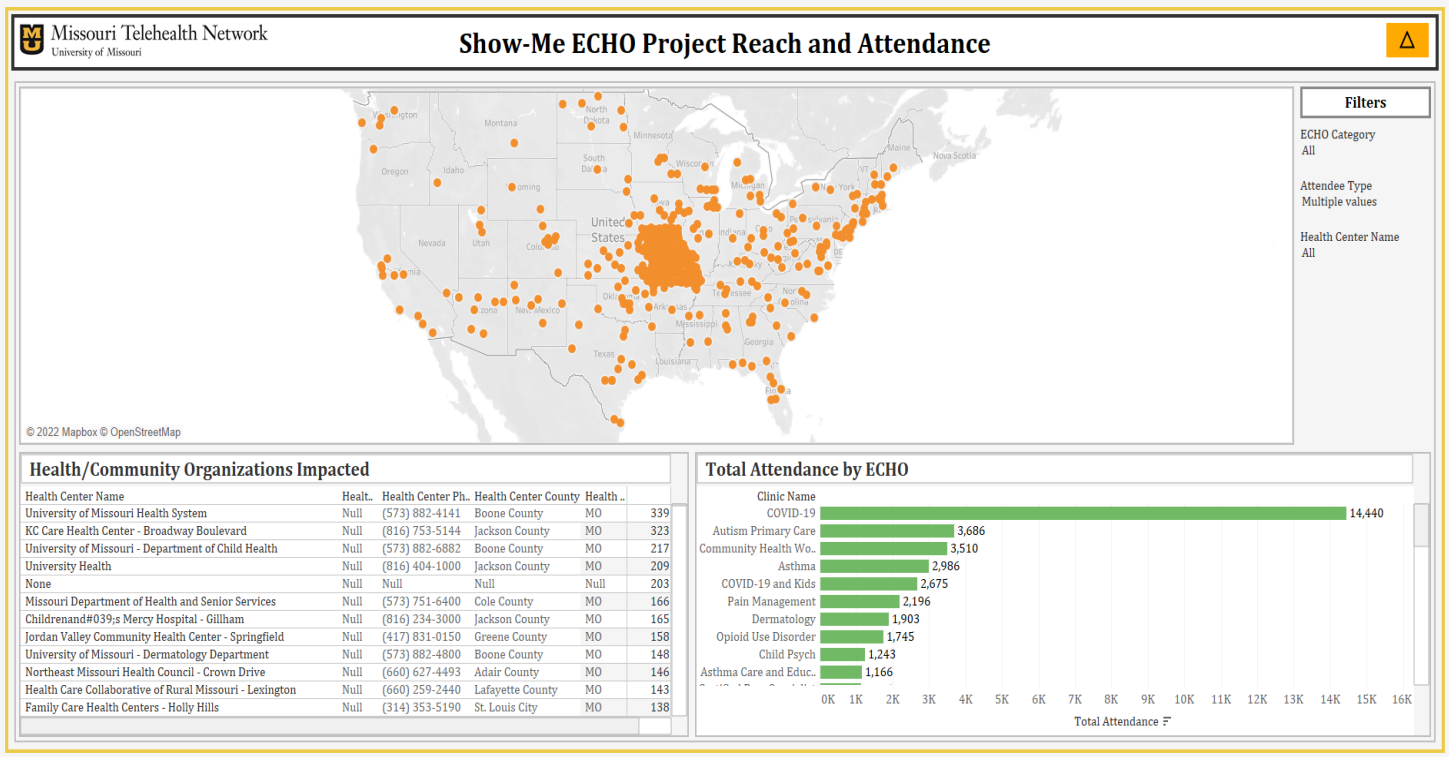


Figure 7. MTN Dashboard 1 "Show-Me ECHO Project Reach and Attendance" – Highlights the breadth of the Show-Me ECHO Project presenting the states and counties ECHO attendees reside, which organizations attendees are affiliated with {and therefore influence} and corresponding ECHO attendance information. Active filters (3) are present in dashboard; however, worksheets also have filter capabilities activated, allowing users use map or table data points as filters to investigate specific queries.

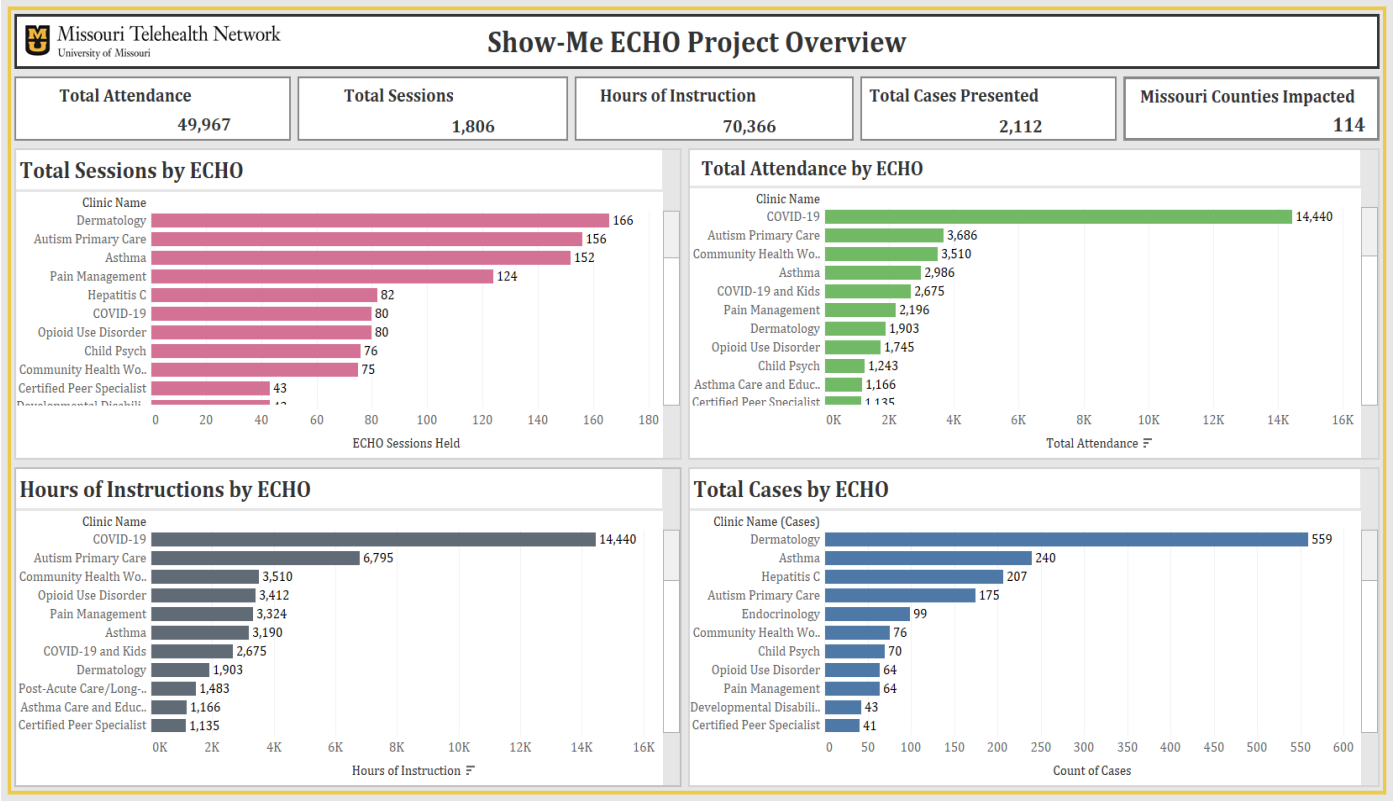


Figure 8. MTN Dashboard 2 "Show-Me ECHO Project Overview" – Presents a synoptic view of Show-Me ECHO Project providing summary on program metrics such as Total Attendance, Total Sessions, Hours of Instruction, Total Cases Presented and Missouri Counties Impacted. The initial four metrics are further broken down by ECHO Clinic, allowing end users view specific ECHO Clinics metrics.

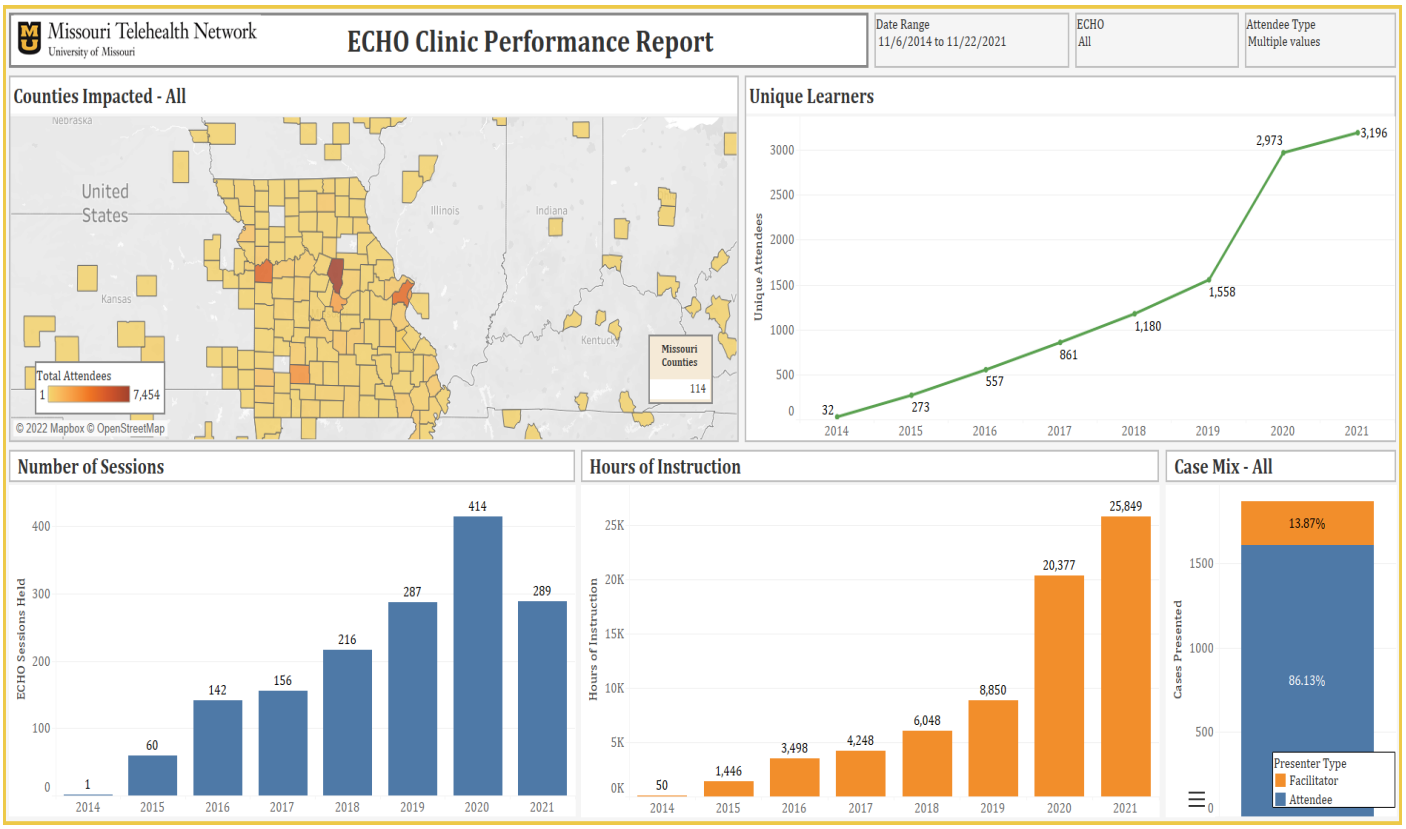


Figure 9. MTN Dashboard 3 "ECHO Clinic Performance Report" An interactive report that enables users investigate ECHO Clinic performance metrics across multiple time periods. Users can filter down to specific ECHOs or ECHO Categories. This dashboard is modeled after MTN Semi -Annual ECHO Reports to Hub Team Members.

CHAPTER FIVE

CONCLUSION

The main purpose of this study was to design a dashboard that provides essential information highlighting the Show Me ECHO overview, growth, and performance in a range of designated quality areas. Reviewed literature established dashboards to aid in continuous tracking and evaluation of quality management metrics, issues, trends, and risks, hence the visualization tool was proposed to serve a similar function at Missouri Telehealth Network.

Stakeholder analysis and interviews provided pertinent information on user needs and dashboard requirements. Stakeholders' diverse needs necessitated dashboards to be actionable, intuitive, agile and to allow customization for the needs of the end user. The analytic strategy for the Show-Me ECHO dashboards was descriptive and displayed data as aggregated counts, proportions, and changes in proportions over time. These metrics provide comprehensive understanding of the program reach and participation informing targeted intervention adjustments; facilitating alignment between resource needs, availability, and allocation; and monitoring changes in program areas over time. After initial dashboard construction, feedback was solicited from future end users. Automation is a key component of reports and dashboards, Tableau possesses data manipulation features that store and automate the process, hence moving forward, the data extraction and loading is the only major manual activity. Implementation is a crucial step in dashboard development, this study focused on the design and development of the dashboard; however, its strategies encompassed a multidisciplinary collaboration with end users, subject matter experts, and key stakeholders at Missouri Telehealth Network. Identifying their needs and tailoring the end products according will contribute to user acceptance. In addition, after initial dashboards and views were built, demos were provided to various stakeholders for

feedback and suggestions, future plans include publishing to accessible servers for pilot testing to a wider group of end users to solicit additional comments and feedback. Even after organization wide deployment, feedback will still be welcomed for continued improvements and sustainability.

Challenges encountered during Dashboard development revolved around the ETL process, limitations to iECHO report generator require data extraction in batches to avoid pulling empty datasets, missing and incorrect data issues were also present sometimes requiring data validation via cross-referencing. Some recommendations from this experience include acquiring better integrated repositories and investment in relational database resources, especially should dashboard scope expand. Dashboard effectiveness may be limited by lag in data updates; hence it is recommended that a fixed data update schedule is set.

The constructed MTN Dashboards support organization efforts to establish a single unified approach to monitor program progress, identify and prioritize efforts and resource allocation, identify specific Missouri counties that may benefit from interventions and ECHO clinic expansions, and provide appropriate performance metrics that can be shared with both decision makers and relevant stakeholders. Future considerations for dashboard expansion include incorporating PCP self-efficacy and knowledge surveys and Claims data analysis to enable further tracking of Provider and Patient outcomes. A feasibility assessment of the implementation of dashboards at other superhubs for benchmarking and program outcome comparison studies should also be considered.

REFERENCES

1. *About us - show-me echo*. Show-Me ECHO. (2021). Retrieved February 23, 2022, from https://showmeecho.org/about/
2. Almasi, Sohrab & Rabiei, Reza & Moghaddasi, Hamid & Vahidi-Asl, Mojtaba. (2021). Emergency Department Quality Dashboard; a Systematic Review of Performance Indicators, Functionalities, and Challenges. 9. 10.22037/aaem.v9i1.1230.
3. Alvarado, N., McVey, L., Elshehaly, M., Greenhalgh, J., Dowding, D., Ruddle, R., Gale, C. P., Mamas, M., Doherty, P., West, R., Feltbower, R., Randell, R. (2021). Analysis of a web-based dashboard to support the use of national audit data in quality improvement: realist evaluation. Journal of Medical Internet Research, 23, e28854.
4. Arora, S., Geppert, C. M., Kalishman, S., Dion, D., Pullara, F., Bjeletich, B., Simpson, G., Alverson, D. C., Moore, L. B., Kuhl, D., & Scaletti, J. V. (2007). Academic health center management of chronic diseases through knowledge networks: Project ECHO. *Academic medicine: journal of the Association of American Medical Colleges*, *82*(2), 154–160. https://doi.org/10.1097/ACM.0b013e31802d8f68
5. Arora, S., Thornton, K., Jenkusky, S. M., Parish, B., & Scaletti, J. V. (2007). Project ECHO: linking university specialists with rural and prison-based clinicians to improve care for people with chronic hepatitis C in New Mexico. *Public health reports (Washington, D.C.: 1974)*, *122 Suppl 2*(Suppl 2), 74–77. https://doi.org/10.1177/00333549071220S214

6. Arora, S., Thornton, K., Murata, G., Deming, P., Kalishman, S., Dion, D., Parish, B., Burke, T., Pak, W., Dunkelberg, J., Kistin, M., Brown, J., Jenkusky, S., Komaromy, M., & Qualls, C. (2011). Outcomes of treatment for hepatitis C virus infection by primary care providers. The New England Journal of Medicine, 364(23), 2199–2207. https://doi.org/10.1056/NEJMoa1009370
7. Arora, Sanjeev, et al. (2010). "Expanding Access to Hepatitis C Virus Treatment—Extension for Community Healthcare Outcomes (ECHO) Project: Disruptive Innovation in Specialty Care," Hepatology 52, no. 3
8. Becevic, M. (2022). Thinking critically about research and program evaluation ECHO Summit [PowerPoint slides]. School of Medicine, University of Missouri.
9. Bhardwaj, S., Barron, P., Pillay, Y., Treger-Slavin, L., Robinson, P., Goga, A., Sherman, G. (2014). Elimination of mother-to-child transmission of HIV in south Africa: rapid scale-up using quality improvement. South African Medical Journal. Suid-Afrikaanse Tydskrif Vir Geneeskunde, 104, 239-43. care: protocol for a laboratory experiment and cluster randomised trial. Implementation Science, 12, 68.
10. Centers for Disease Control and Prevention. (2021, November 16). *Program evaluation home - CDC*. Centers for Disease Control and Prevention. Retrieved January 23, 2022, from https://www.cdc.gov/evaluation/index.htm
11. *Data Dashboard*. Better Evaluation. (2020, August 26). Retrieved January 23, 2022, from https://www.betterevaluation.org/en/evaluation-options/data_dashboard

12. Dearing J.W., Cruz S.M., Kee K.F., Larson R.S., & Rahm A.k. (2019). Project ECHO Review and Research Agenda. Diffusion Associates,
13. Elshehaly, M., Randell, R., Brehmer, M., McVey, L., Alvarado, N., Gale, C. P., & Ruddle, R. A. (2021). QualDash: Adaptable Generation of Visualisation Dashboards for Healthcare Quality Improvement. *IEEE transactions on visualization and computer graphics*, *27*(2), 689–699. https://doi.org/10.1109/TVCG.2020.3030424
14. Gude, W. T., Roos-Blom, M. J., van der Veer, S. N., de Jonge, E., Peek, N., Dongelmans, D. A., de Keizer, N. F. (2017). Electronic audit and feedback intervention with action implementation toolbox to improve pain management in intensive care: protocol for a laboratory experiment and cluster randomised trial. Implementation Science, 12, 68.
15. Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research Electronic Data Capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. Journal of Biomedical Informatics, 42(2), 377–381. https://doi.org/10.1016/j.jbi.2008.08.010
16. Harrison, L. (2012). Using agency-wide dashboards for data monitoring and data mining: the solano county health and social services department. Journal of Evidence-Based Social Work, 9, 160-73.
17. Helmyati, S., Dipo, D. P., Adiwibowo, I. R., Wigati, M., Safika, E. L., Hariawan, M. H., Destiwi, M., Prajanta, Y., Penggalih, M. H., Sudargo, T., Herawati, D. M., Marthias, T., Masrul, M., & Trisnantoro, L. (2022). Monitoring continuity of

maternal and child health services, Indonesia. Bulletin of the World Health Organization, 100(2), 144–154A. https://doi.org/10.2471/BLT.21.286636

18. Hubs & Programs. (2022). Retrieved Jan 22, 2022, from https://hsc.unm.edu/echo/data marketplace/interactive-dashboards/
19. IECHO. (n.d.). Retrieved May 21, 2021, from https://iecho.unm.edu/
20. Kegeles, S. M., & Rebchook, G. M. (2005). Challenges and facilitators to building program evaluation capacity among community-based organizations. *AIDS education and prevention: official publication of the International Society for AIDS Education*, *17*(4), 284–299. https://doi.org/10.1521/aeap.2005.17.4.284
21. Lau, M. K., Bounthavong, M., Kay, C. L., Harvey, M. A., Christopher, M. L. D. (2019). Clinical dashboard development and use for academic detailing in the u.s. department of veterans' affairs. Journal of the American Pharmacists Association:
22. Lee, V., Dunsmuir, D., Businge, S., Tumusiime, R., Karugaba, J., Wiens, M. O., Gorges, M., Kissoon, N., Orach, S., Kasyaba, R., Ansermino, J. M. (2020). Evaluation of a digital triage platform in Uganda: a quality improvement initiative to reduce the time to antibiotic administration. PLoS ONE [Electronic Resource], 15, e0240092.
23. Lenglet, A., van Deursen, B., Viana, R., Abubakar, N., Hoare, S., Murtala, A., Okanlawon, M., Osatogbe, J., Emeh, V., Gray, N., Keller, S., Masters, P., Roolvink, D., Davies, J., Hickox, K., Fotso, A., Bil, K., Ikenna Nwankwo, C., Ahmad, B., Caluwaerts, A., Lessard, I., Dimeglio, S., Malou, N., Kanapathipillai, R., McRae, M., Wong, S., Hopman, J. (2019). Inclusion of real-time hand hygiene observation and feedback in a multimodal hand hygiene improvement strategy in low-resource

settings. JAMA Network Open, 2, e199118. JAPhA, 59, S96-S103.e3. Journal of Emergency Medicine, 48, 744-50.

24. Mayfield, C. A., Gigler, M. E., Snapper, L., Jose, J., Tynan, J., Scott, V. C., Dulin, M. (2020). Using cloud-based, open-source technology to evaluate, improve, and rapidly disseminate community-based intervention data. Journal of the American Medical Informatics Association, 27, 1741-1746.
25. McHugh, M., Kang, R., Cohen, A. B., Restuccia, J. D., Periyanayagam, U., Hasnain-Wynia, R. (2015). Use of quality improvement interventions and the link to performance on percutaneous intervention for acute myocardial infarction.
26. Missouri Telehealth Network. (2021, April). *Show-Me ECHO 2020 Annual Report*. Show Me ECHO News. Retrieved March 20, 2022, from https://showmeecho.org/wp-content/uploads/2021/04/Annual-Report-published-April16.pdf
27. Miriam Komaromy, Dan Duhigg, Adam Metcalf, Cristina Carlson, Summers Kalishman, Leslie Hayes, Tom Burke, Karla Thornton & Sanjeev Arora (2016) Project ECHO (Extension for Community Healthcare Outcomes): A new model for educating primary care providers about treatment of substance use disorders, Substance Abuse, 37:1, 20-24, DOI: 10.1080/08897077.2015.1129388
28. Mitruka, K., Thornton, K., Cusick, S., Orme, C., Moore, A., Manch, R. A., Box, T., Carroll, C., Holtzman, D., Ward, J. W., & Centers for Disease Control and Prevention (CDC) (2014). Expanding primary care capacity to treat hepatitis C virus infection through an evidence-based care model--Arizona and Utah, 2012-2014. *MMWR. Morbidity and mortality weekly report*, *63*(18), 393–398.
29. Mulhall, C. L., Lam, J. M. C., Rich, P. S., Dobell, L. G., Greenberg, A. (2020). Enhancing quality care in Ontario long-term care homes through audit and feedback

for physicians. Journal of the American Medical Directors Association, 21, 420-425.

30. Project ECHO. (n.d.). Retrieved Jan 22, 2022, from https://hsc.unm.edu/echo/
31. *Project ECHO® Evaluation 101: A practical guide for evaluating your program*. New York State Health Foundation. (2018, January 23). Retrieved January 23, 2022, from https://nyshealthfoundation.org/resource/project-echo-evaluation-101/
32. Rattray, N. A., Damush, T. M., Miech, E. J., Homoya, B., Myers, L. J., Penney, L. S., Ferguson, J., Giacherio, B., Kumar, M., & Bravata, D. M. (2020). Empowering Implementation Teams with a Learning Health System Approach: Leveraging Data to Improve Quality of Care for Transient Ischemic Attack. *Journal of general internal medicine, 35*(Suppl 2), 823–831. https://doi.org/10.1007/s11606-020-06160-y
33. Salinsky, E. (2015, June 23). *Project Echo*. Grantmakers In Health. Retrieved January 23, 2022, from http://www.gih.org/Publications/Strategicdetail.cfm?ItemNumber=7447
34. Smith, V. S. (2013). Data dashboard as evaluation and research communication tool. In T. Azzam & S. Evergreen (Eds.), Data visualization, part 2. New Directions for Evaluation, 140, 21–45.
35. Software – REDCap. (n.d.). Retrieved May 21, 2021, from https://projectredcap.org/software/
36. Taber, P., Weir, C., Butler, J. M., Graber, C. J., Jones, M. M., Madaras-Kelly, K., Zhang, Y., Chou, A. F., Samore, M. H., Goetz, M. B., & Glassman, P. A. (2021). Social dynamics of a population-level dashboard for antimicrobial stewardship: A

qualitative analysis. *American journal of infection control*, *49*(7), 862–867. https://doi.org/10.1016/j.ajic.2021.01.015

37. *What is tableau?* Tableau. (n.d.). Retrieved January 23, 2022, from https://www.tableau.com/why-tableau/what-is-tableau
38. Whidden, C., Kayentao, K., Liu, J. X., Lee, S., Keita, Y., Diakité, D., Keita, A., Diarra, S., Edwards, J., Yembrick, A., Holeman, I., Samaké, S., Plea, B., Coumaré, M., & Johnson, A. D. (2018). Improving Community Health Worker performance by using a personalised feedback dashboard for supervision: a randomised controlled trial. *Journal of global health*, *8*(2), 020418. https://doi.org/10.7189/jogh.08.020418
39. Wikimedia Foundation. (2022, March 12). *Tableau Software*. Wikipedia. Retrieved January 23, 2022, from https://en.wikipedia.org/wiki/Tableau_Software
40. Wikimedia Foundation. (2022, March 8). *Redcap*. Wikipedia. Retrieved March 23, 2022, from https://en.wikipedia.org/wiki/REDCap
41. Worthen, B. (1990). Program evaluation. H. Walberg & G. Haertel (Eds.), The international encyclopedia of educational evaluation (pp. 42-47). Toronto, ON: Pergammon Press.

APPENDICES

APPENDIX A

Glossary of Terms

Anonymous attendee = Unidentified individual attending ECHO – such individuals are not included in the attendance report.

Attendee (also spoke) = Individual attending ECHO to learn and be mentored in a condition.

Case = Presentation and discussion of a challenge encountered by an ECHO learner in the course of their interaction with patients/clients, all identifying information having been removed.

Clinical ECHO (past and current) = An ECHO focusing on a medical condition. These ECHOs are designed to allow Primary Care Providers to treat their patients without specialist referrals.

Community ECHO (past and current) = An ECHO focusing on non-medical community concerns. They represent an extension of the ECHO model to non-medical conditions.

Coordinator = An MTN staff member whose role is to help the hub team run the ECHO by handling all administrative matters.

COVID ECHO = An ECHO focusing on COVID-related medical and/or community concerns.

Didactic = Short (15-minute) lecture on a topic relevant to the ECHO. **ECHO** = Extension for Community Healthcare Outcomes

ECHO model = Through innovative telementoring, the ECHO model uses a hub-and-spoke knowledge-sharing approach where expert teams lead virtual clinics, amplifying the

capacity for providers to deliver best-in-practice care to the underserved in their own communities. (https://hsc.unm.edu/echo/)

Facilitator (also hub team member) = Member of a hub team

Hours of instruction or instructional hours = (Total learners) × length of session (usually 1 hour)

Hub team = Carefully selected team of content and mentoring experts who devise didactic lectures and facilitate an ECHO

Kirkpatrick model = A typology of evaluation used to evaluate the effectiveness of educational programs. Often visualized as a triangle, higher levels of evidence are more difficult to collect but provide more robust information about the impact of a program.

Learners = Combination of attendees (spokes) and facilitators (hub team members)

MTN = Missouri Telehealth Network

Organization = The place of employment of an ECHO learner. Note that different clinic locations count as different organizations.

Primary Care Provider (PCP) = A health care practitioner who sees people that have common medical problems (https://medlineplus.gov/medlineplus.html). At MTN, PCPs are defined as Physicians, Nurse Practitioners, Physician Assistants, who practice in Family and Community Medicine, Pediatrics, Geriatrics, Internal Medicine, Obstetrics and Gynecology.

Session = One instance (between an hour and an hour and a half) of a virtual discussion around the ECHO topic. Show-Me ECHO sessions occur weekly, bi-monthly, or monthly depending on the ECHO topic

Session attendance = Number of individuals present during an ECHO sessions

Show-Me ECHO = The ECHO programs administered by MTN in the state of Missouri

Spoke (also attendee) = Individual attending ECHO to learn and be mentored by facilitators

Total attendees = Sum across all sessions of the number of attendees present (an attendee present for two sessions would be counted twice, for three sessions, thrice, etc.)

Total facilitators = Sum across all sessions of the number of facilitators present (a facilitator present for two sessions would be counted twice, for three sessions, thrice, etc.)

Total learners = Total facilitators + Total attendees = Sum across sessions of the session attendance

Unique attendees = Count of individual attendees participating in any session during the reporting year (counted once regardless of how many sessions attended)

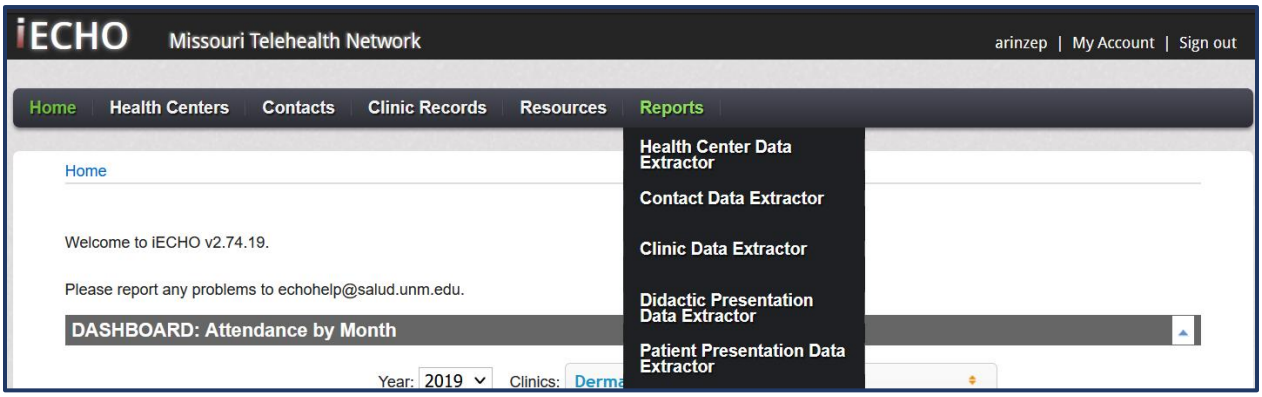
Unique facilitators = Count of individual facilitators participating in any session during the reporting year (counted once regardless of how many sessions attended)

Unique learners = Count of individual learners participating in any session during the reporting year (counted once regardless of how many sessions attended)

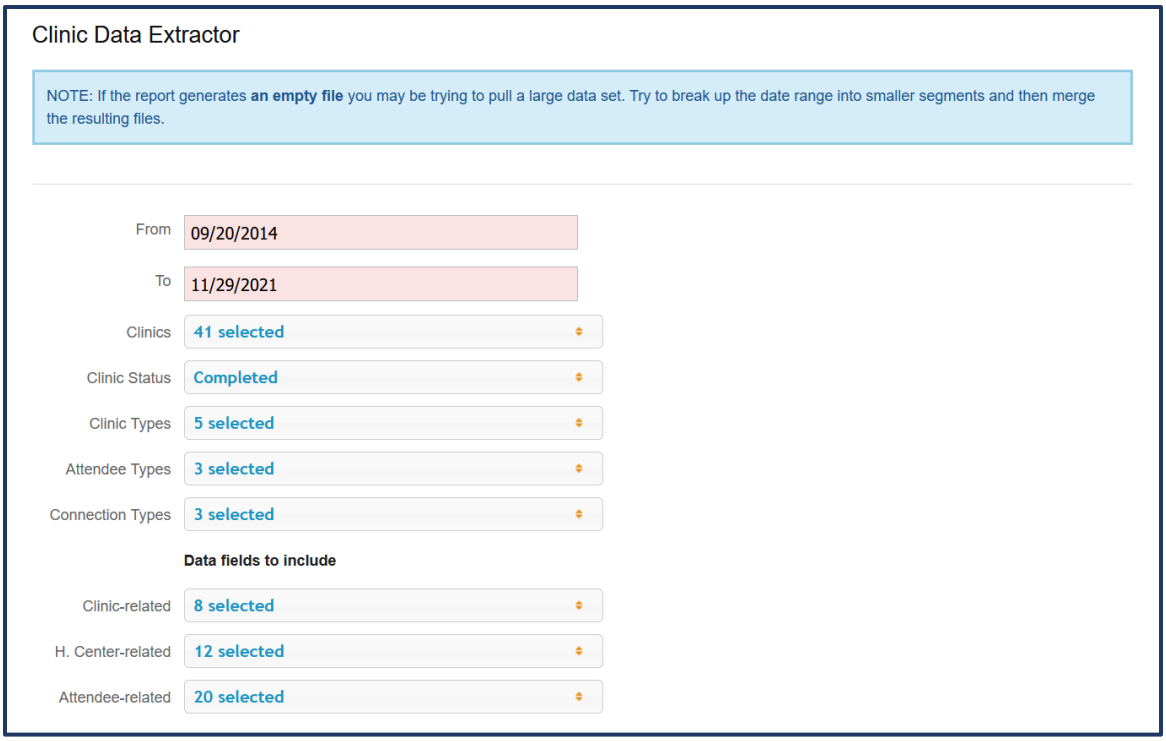
APPENDIX B

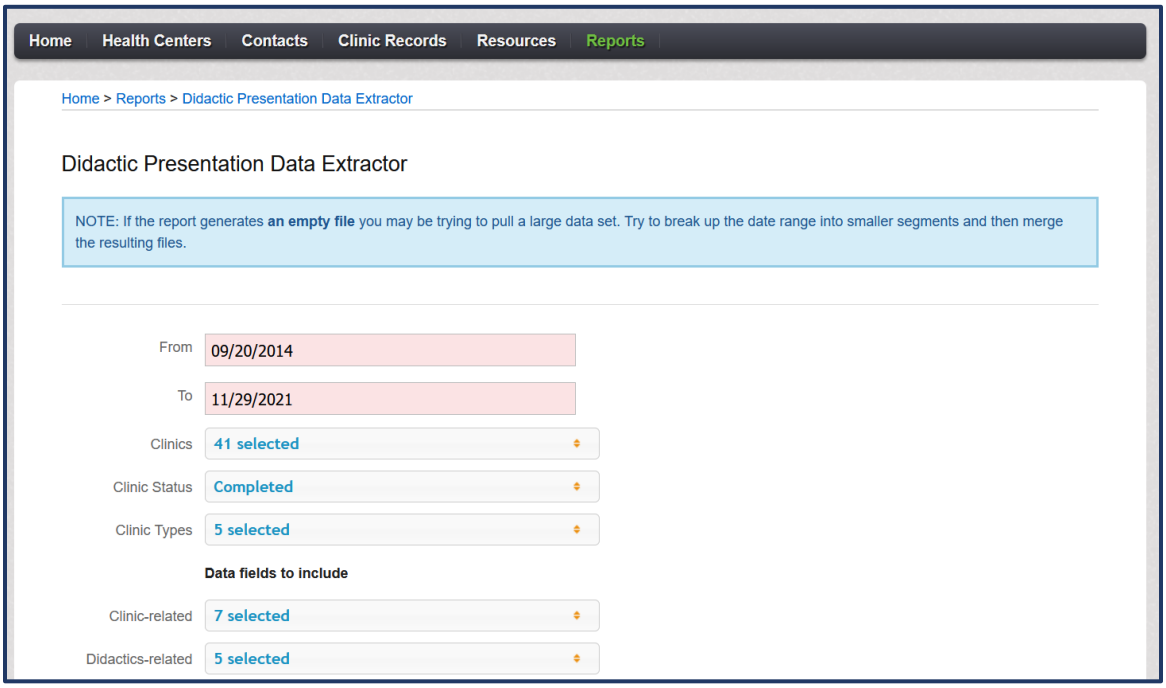
Data Extraction Procedure

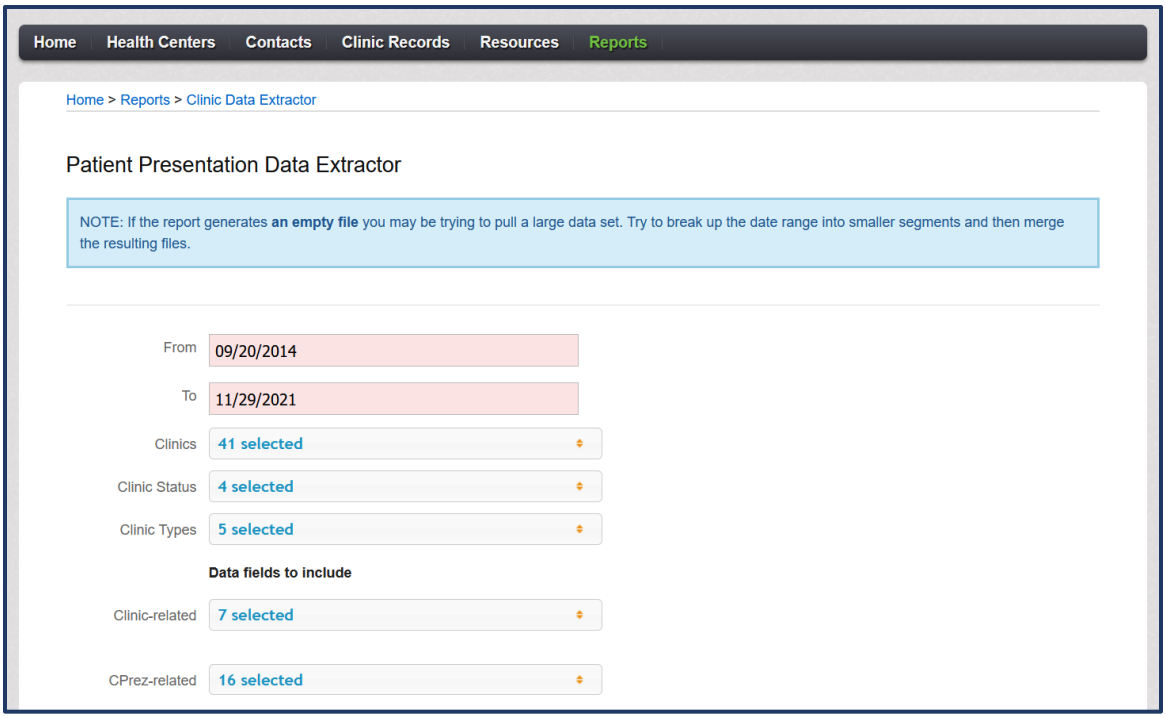
Missouri Telehealth Network iECHO Report Extractor



Three reports pulled from iECHO using the extractor function: 'Clinic Data Extractor,' 'Didactic Presentation Data Extractor' and 'Patient Presentation Data Extractor.' Total Date range extracted was 9/20/2014 to 11/29/2022 but during data collection, data was extracted in batches due to iECHO limitations and datasets were merged afterwards. A total of 41 ECHO Clinics was selected for study. For data field selections only 'Clinic Status' was limited to 'Completed,' all other fields options were fully selected to enable ease and consistency.


Clinic Data Extractor
NOTE: If the report generates an empty file you may be trying to pull a large data set. Try to break up the date range into smaller segments and then merge the resulting files.
From
09/20/2014
To
11/29/2021
Clinics
41 selected
Clinic Status
Completed
Clinic Types
5 selected
Attendee Types
3 selected
Connection Types
3 selected
Data fields to include
Clinic-related
8 selected
H. Center-related
12 selected
Attendee-related
20 selected


Home
Health Centers
Contacts
Clinic Records
Resources
Reports
Home > Reports > Didactic Presentation Data Extractor
Didactic Presentation Data Extractor
NOTE: If the report generates an empty file you may be trying to pull a large data set. Try to break up the date range into smaller segments and then merge the resulting files.
From
09/20/2014
To
11/29/2021
Clinics
41 selected
Clinic Status
Completed
Clinic Types
5 selected
Data fields to include
Clinic-related
7 selected
Didactics-related
5 selected



Python Code

```
# Import the necessary packages
import numpy as np
import pandas as pd

# Data visualization
import matplotlib.pyplot as plt
import seaborn as sns
import missingno as msno

# Algorithms
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import StratifiedKFold
from sklearn import preprocessing
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from sklearn.pipeline import Pipeline
from sklearn import linear_model
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
from sklearn.svm import LinearSVC
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.metrics import mean_squared_error
from sklearn.model_selection import learning_curve
from sklearn.model_selection import cross_val_score
```

```
from sklearn.metrics import precision_score, recall_score,
confusion_matrix, classification_report, accuracy_score, f1_score
from sklearn import metrics
from sklearn.metrics import roc_curve, auc, roc_auc_score
np.random.seed(0)

from subprocess import check_output
print(check_output(["ls", "../input"]).decode("utf8"))

import warnings
warnings.simplefilter(action ="ignore")

from collections import Counter
import warnings
warnings.filterwarnings('ignore')

# Load Dataset
data = pd.read_csv("../input/echo-dataset/Combined ECHO from iECHO
November 29 2021_Learners.csv")

# Print the first 5 rows of the dataframe.
data.head()

data.info()

# Count the missing and null values for Clinic Data Dataset.
miss_values = data.columns[data.isnull().any()]
print(f"Missing values:\n{data[miss_values].isnull().sum()}")

null_values = data.columns[data.isna().any()]
print(f"Null values:\n{data[null_values].isna().sum()}")

# Null count analysis
null_plot = msno.bar(data, color = "#3D59AB")
# Load Dataset
data = pd.read_csv("../input/echo-dataset/Combined ECHO from iECHO
November 29 2021_Cases.csv")

# Print the first 5 rows of the dataframe.
data.head()

data.info()

# Count the missing and null values for Patient Presentation Data
Dataset.
miss_values = data.columns[data.isnull().any()]
print(f"Missing values:\n{data[miss_values].isnull().sum()}")

null_values = data.columns[data.isna().any()]
print(f"Null values:\n{data[null_values].isna().sum()}")

# Null count analysis
null_plot = msno.bar(data, color = "#FF8C00")

# Load Dataset
data = pd.read_csv("../input/echo-dataset/Combined ECHO from iECHO
November 29 2021_Didactics.csv")
```

```
# Print the first 5 rows of the dataframe.
data.head()

data.info()

# Count the missing and null values for Didactic Presentation Data
Dataset.
miss_values = data.columns[data.isnull().any()]
print(f"Missing values:\n{data[miss_values].isnull().sum()}")

null_values = data.columns[data.isna().any()]
print(f"Null values:\n{data[null_values].isna().sum()}")

# Null count analysis
null_plot = msno.bar(data, color = "#8B0A50")
```

Python Outputs

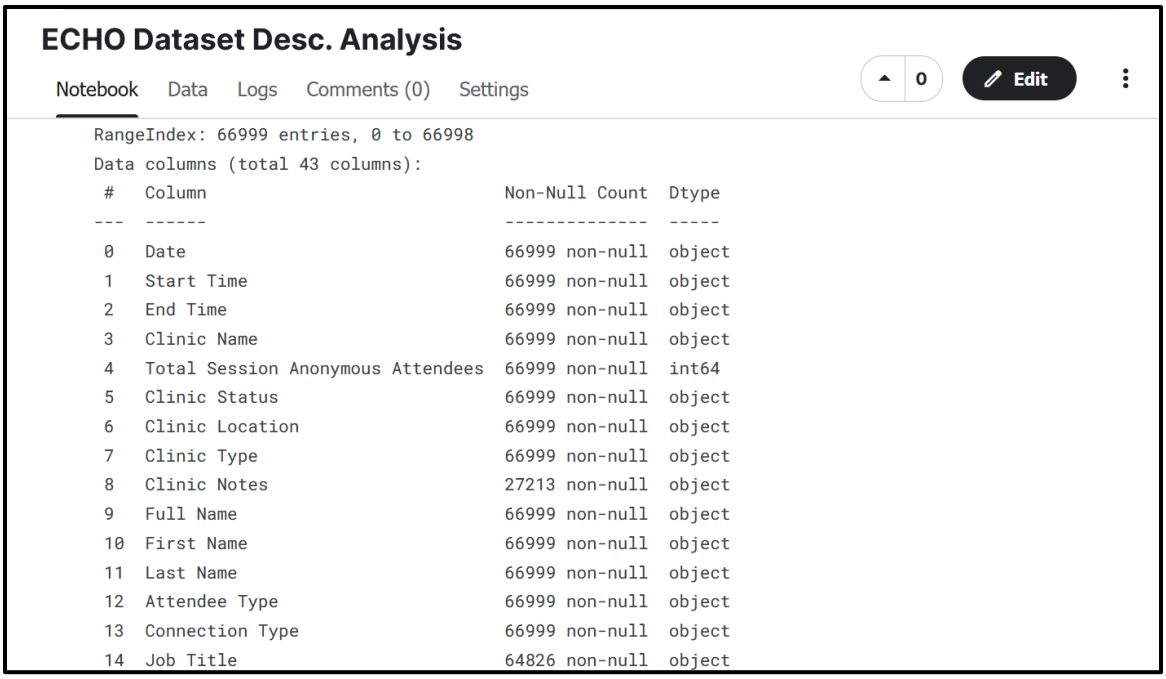
Clinic Data Dataset

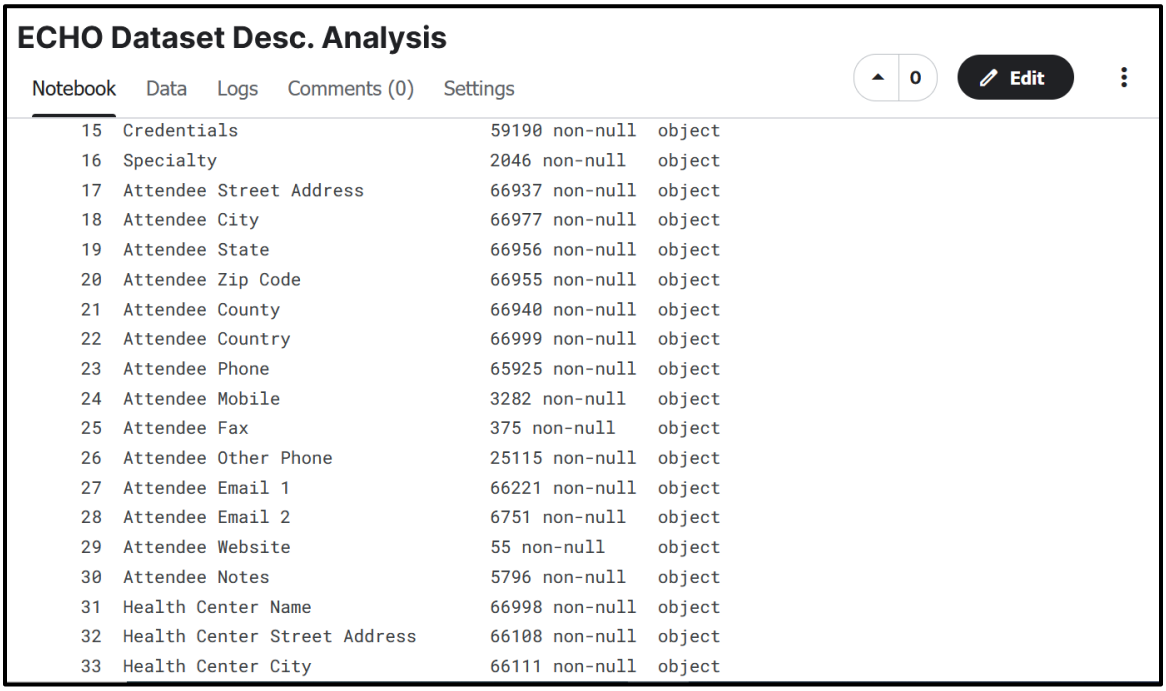
ECHO Dataset Desc. Analysis

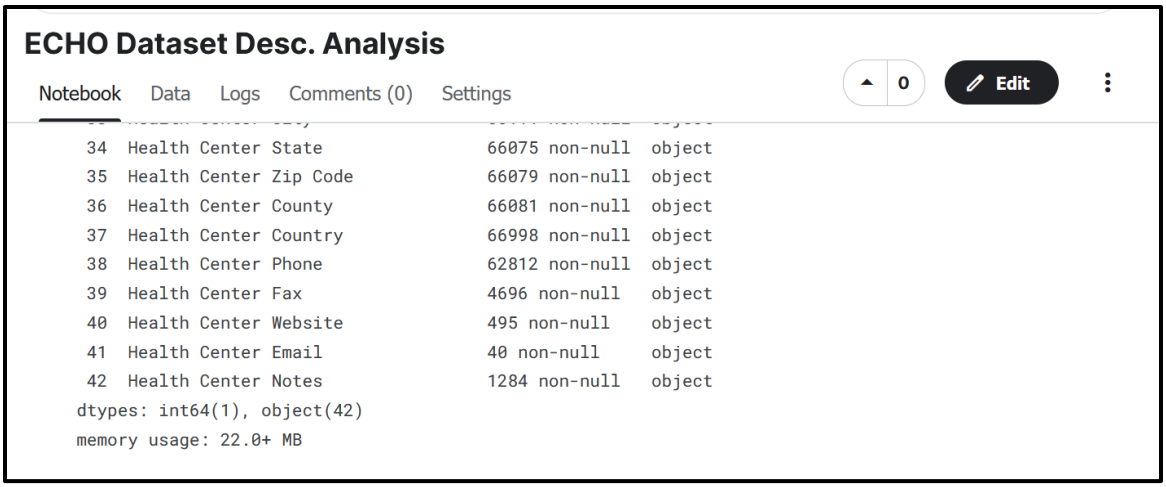
Notebook Data Logs Comments (0) Settings 0 Edit

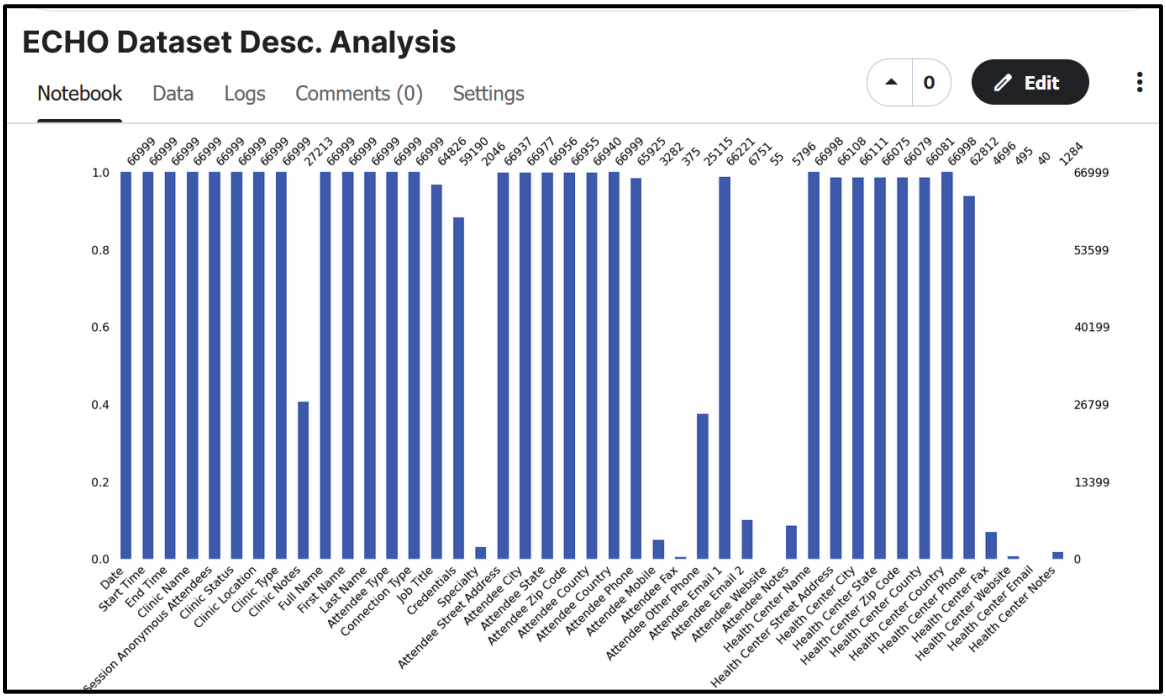
	Date	Start Time	End Time	Clinic Name	Total Session Anonymous Attendees	Clinic Status	Clinic Location	Clinic Type	Clinic Notes	Full Name	...	Health Center City	He Ce Sta
0	11/6/2014	12:00 PM	01:00 PM	Pain Management	2	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	...	Jefferson City	MC
1	11/6/2014	12:00 PM	01:00 PM	Pain Management	2	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	...	Jefferson City	MC
2	11/6/2014	12:00 PM	01:00 PM	Pain Management	2	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	...	Jefferson City	MC
3	11/6/2014	12:00 PM	01:00 PM	Pain Management	2	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	...	Jefferson City	MC
4	11/6/2014	12:00 PM	01:00 PM	Pain Management	2	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	...	St. Louis	MC

5 rows × 43 columns


ECHO Dataset Desc. Analysis
Notebook
Data
Logs
Comments (0)
Settings
0
Edit
RangeIndex: 66999 entries, 0 to 66998
Data columns (total 43 columns):
Column Non-Null Count Dtype
--- ------ -------------- -----
0 Date 66999 non-null object
1 Start Time 66999 non-null object
2 End Time 66999 non-null object
3 Clinic Name 66999 non-null object
4 Total Session Anonymous Attendees 66999 non-null int64
5 Clinic Status 66999 non-null object
6 Clinic Location 66999 non-null object
7 Clinic Type 66999 non-null object
8 Clinic Notes 27213 non-null object
9 Full Name 66999 non-null object
10 First Name 66999 non-null object
11 Last Name 66999 non-null object
12 Attendee Type 66999 non-null object
13 Connection Type 66999 non-null object
14 Job Title 64826 non-null object


ECHO Dataset Desc. Analysis
Notebook
Data
Logs
Comments (0)
Settings
0
Edit
15 Credentials 59190 non-null object
16 Specialty 2046 non-null object
17 Attendee Street Address 66937 non-null object
18 Attendee City 66977 non-null object
19 Attendee State 66956 non-null object
20 Attendee Zip Code 66955 non-null object
21 Attendee County 66940 non-null object
22 Attendee Country 66999 non-null object
23 Attendee Phone 65925 non-null object
24 Attendee Mobile 3282 non-null object
25 Attendee Fax 375 non-null object
26 Attendee Other Phone 25115 non-null object
27 Attendee Email 1 66221 non-null object
28 Attendee Email 2 6751 non-null object
29 Attendee Website 55 non-null object
30 Attendee Notes 5796 non-null object
31 Health Center Name 66998 non-null object
32 Health Center Street Address 66108 non-null object
33 Health Center City 66111 non-null object





Didactic Presentation Data Dataset

ECHO Dataset Desc. Analysis

Notebook Data Logs Comments (0) Settings

0 Edit

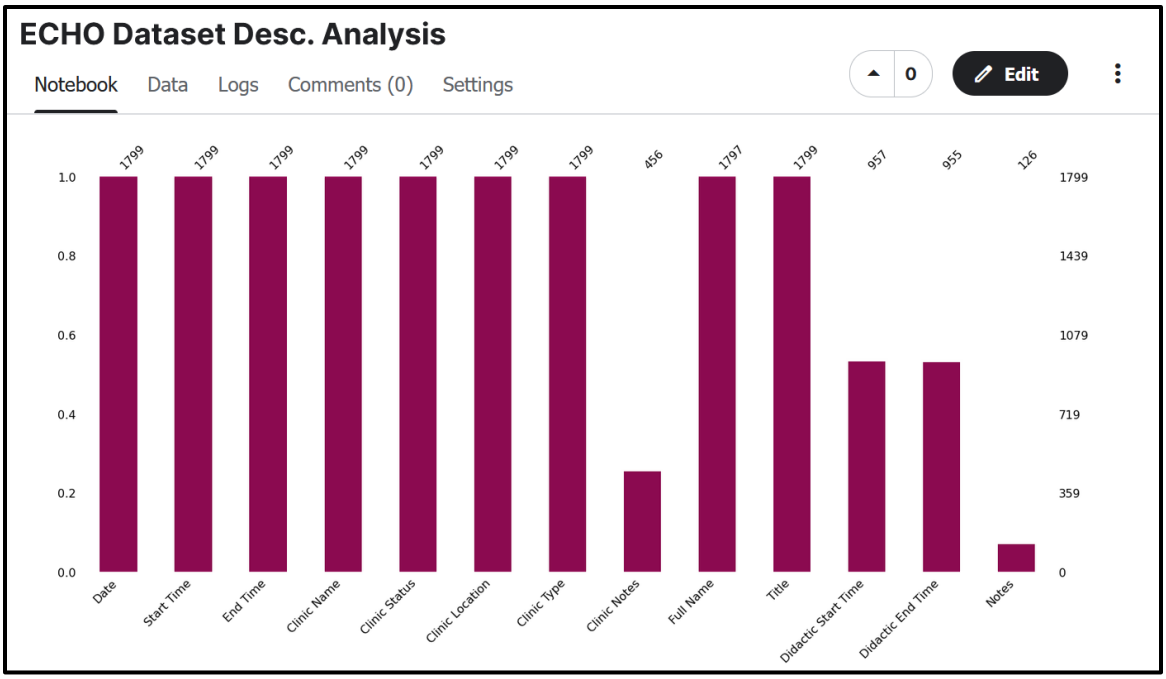
	Date	Start Time	End Time	Clinic Name	Clinic Status	Clinic Location	Clinic Type	Clinic Notes	Full Name	Title	Didact Start Time
0	11/6/2014	12:00 PM	01:00 PM	Pain Management	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	Opioid-Induced Hyperalgesia	12:30 PM
1	11/20/2014	12:00 PM	01:00 PM	Pain Management	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	Chronic Pain and PTSD: The Need for an Integr...	NaN
2	12/4/2014	12:00 PM	01:00 PM	Pain Management	Completed	Missouri Primary Care Association	ECHO Clinic	No recommendation form was completed, since th...	[redacted]	A Review of Tramadol: Facts and Use	12:35 PM
3	2/5/2015	12:00 PM	01:00 PM	Pain Management	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	The Pharmacist's Changing Role	12:00 PM
4	2/19/2015	12:00 PM	01:00 PM	Pain Management	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	Role of Behavioral Health in Integrated Pain M...	12:20 PM

ECHO Dataset Desc. Analysis

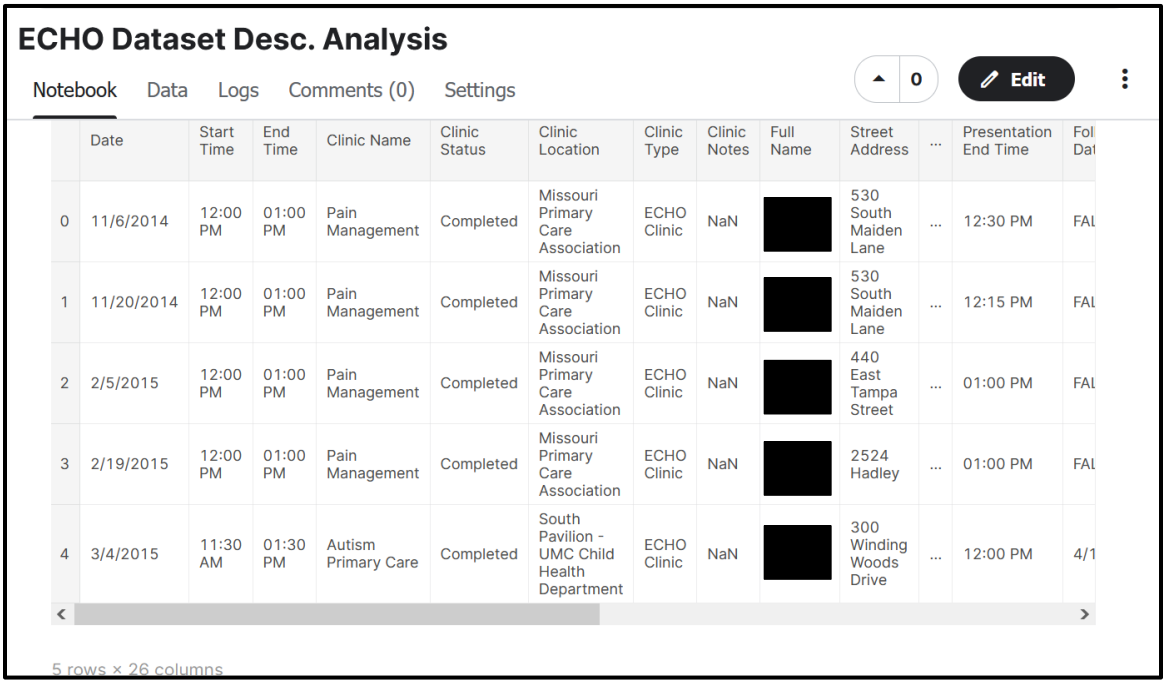
Notebook Data Logs Comments (0) Settings

0 Edit

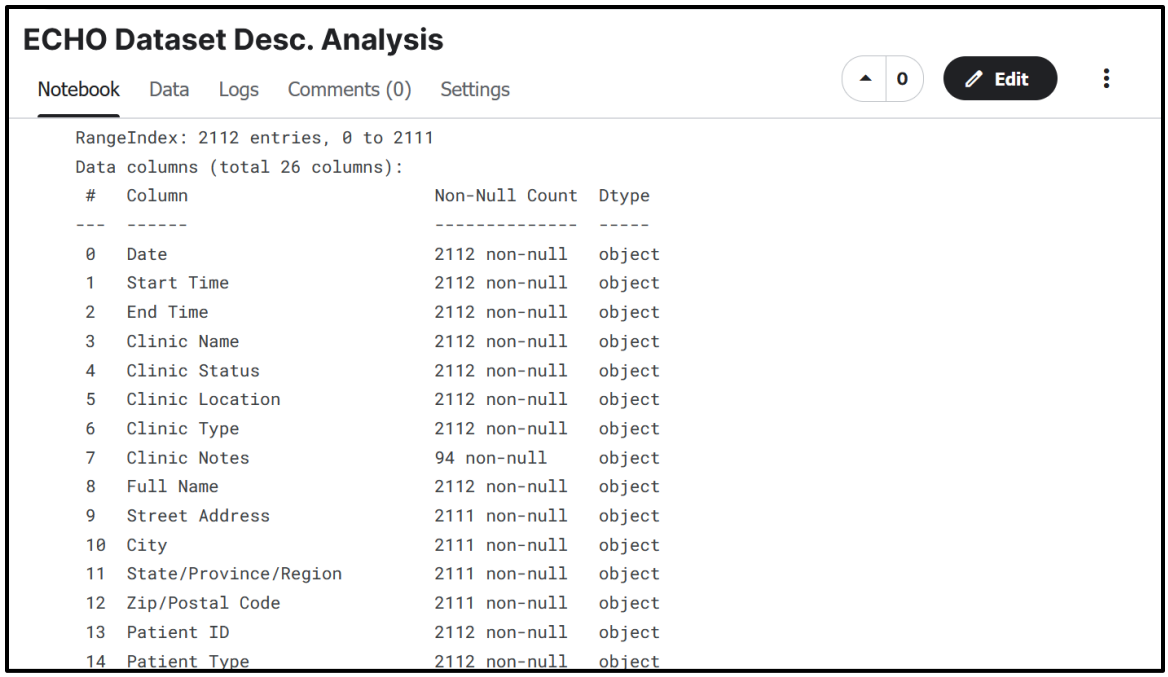
```
Data columns (total 13 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   Date                1799 non-null   object
 1   Start Time          1799 non-null   object
 2   End Time            1799 non-null   object
 3   Clinic Name         1799 non-null   object
 4   Clinic Status       1799 non-null   object
 5   Clinic Location     1799 non-null   object
 6   Clinic Type         1799 non-null   object
 7   Clinic Notes        456 non-null    object
 8   Full Name           1797 non-null   object
 9   Title               1799 non-null   object
 10  Didactic Start Time 957 non-null    object
 11  Didactic End Time   955 non-null    object
 12  Notes               126 non-null    object
dtypes: object(13)
memory usage: 182.8+ KB
```

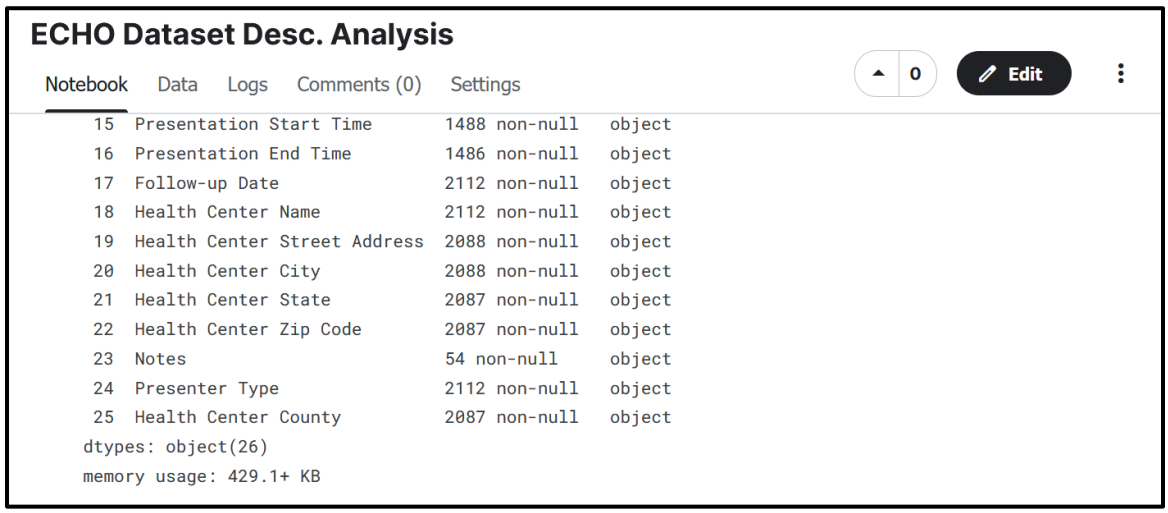


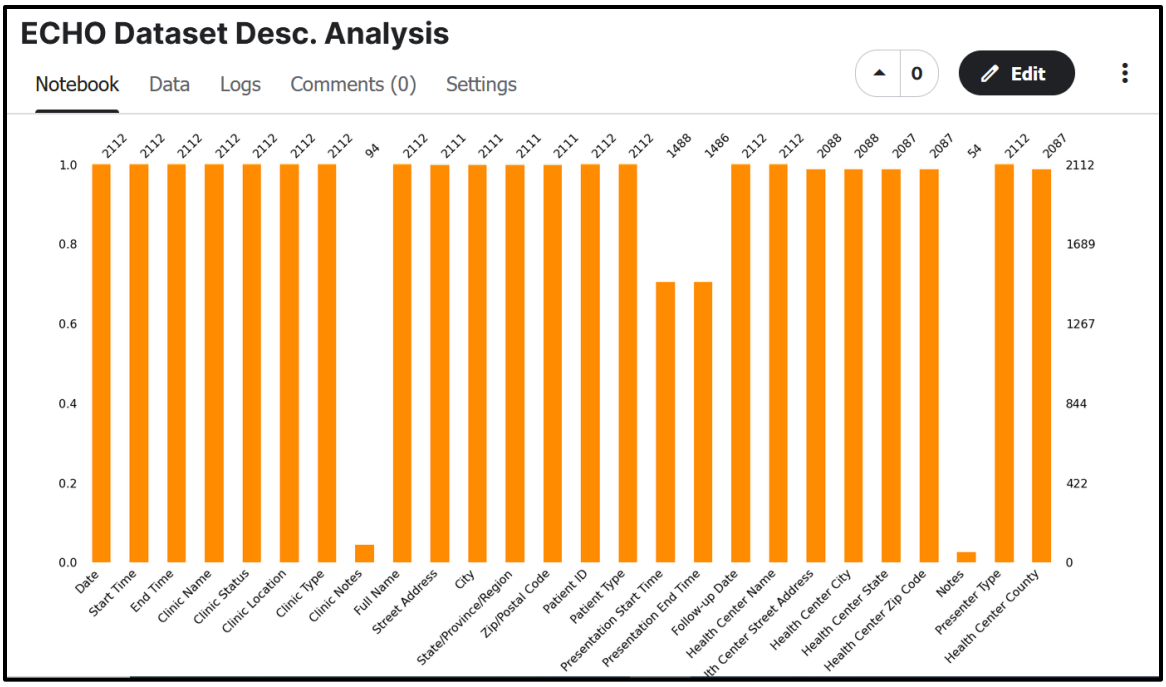
Patient Presentation Data Extractor



	Date	Start Time	End Time	Clinic Name	Clinic Status	Clinic Location	Clinic Type	Clinic Notes	Full Name	Street Address	...	Presentation End Time	Fol Dat
0	11/6/2014	12:00 PM	01:00 PM	Pain Management	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	530 South Maiden Lane	...	12:30 PM	FAL
1	11/20/2014	12:00 PM	01:00 PM	Pain Management	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	530 South Maiden Lane	...	12:15 PM	FAL
2	2/5/2015	12:00 PM	01:00 PM	Pain Management	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	440 East Tampa Street	...	01:00 PM	FAL
3	2/19/2015	12:00 PM	01:00 PM	Pain Management	Completed	Missouri Primary Care Association	ECHO Clinic	NaN	[redacted]	2524 Hadley	...	01:00 PM	FAL
4	3/4/2015	11:30 AM	01:30 PM	Autism Primary Care	Completed	South Pavilion - UMC Child Health Department	ECHO Clinic	NaN	[redacted]	300 Winding Woods Drive	...	12:00 PM	4/1

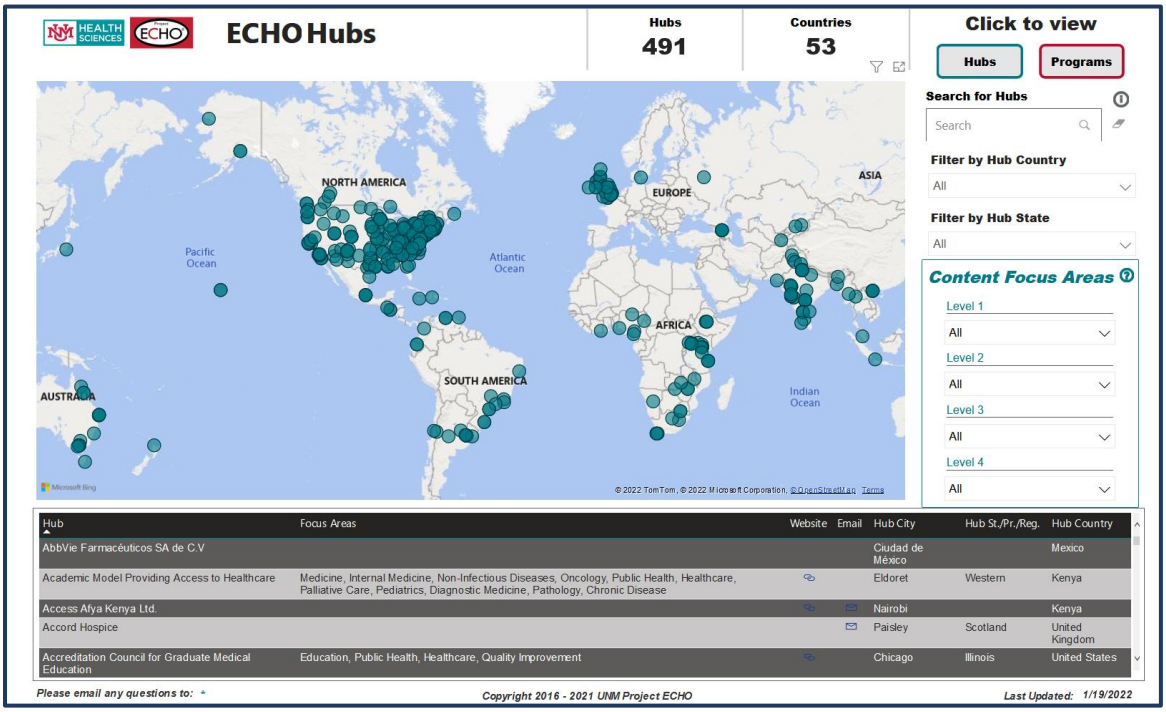

ECHO Dataset Desc. Analysis
Notebook
Data
Logs
Comments (0)
Settings
0
Edit
RangeIndex: 2112 entries, 0 to 2111
Data columns (total 26 columns):
Column Non-Null Count Dtype
--- ------ -------------- -----
0 Date 2112 non-null object
1 Start Time 2112 non-null object
2 End Time 2112 non-null object
3 Clinic Name 2112 non-null object
4 Clinic Status 2112 non-null object
5 Clinic Location 2112 non-null object
6 Clinic Type 2112 non-null object
7 Clinic Notes 94 non-null object
8 Full Name 2112 non-null object
9 Street Address 2111 non-null object
10 City 2111 non-null object
11 State/Province/Region 2111 non-null object
12 Zip/Postal Code 2111 non-null object
13 Patient ID 2112 non-null object
14 Patient Type 2112 non-null object


ECHO Dataset Desc. Analysis
Notebook
Data
Logs
Comments (0)
Settings
0
Edit
15 Presentation Start Time 1488 non-null object
16 Presentation End Time 1486 non-null object
17 Follow-up Date 2112 non-null object
18 Health Center Name 2112 non-null object
19 Health Center Street Address 2088 non-null object
20 Health Center City 2088 non-null object
21 Health Center State 2087 non-null object
22 Health Center Zip Code 2087 non-null object
23 Notes 54 non-null object
24 Presenter Type 2112 non-null object
25 Health Center County 2087 non-null object
dtypes: object(26)
memory usage: 429.1+ KB

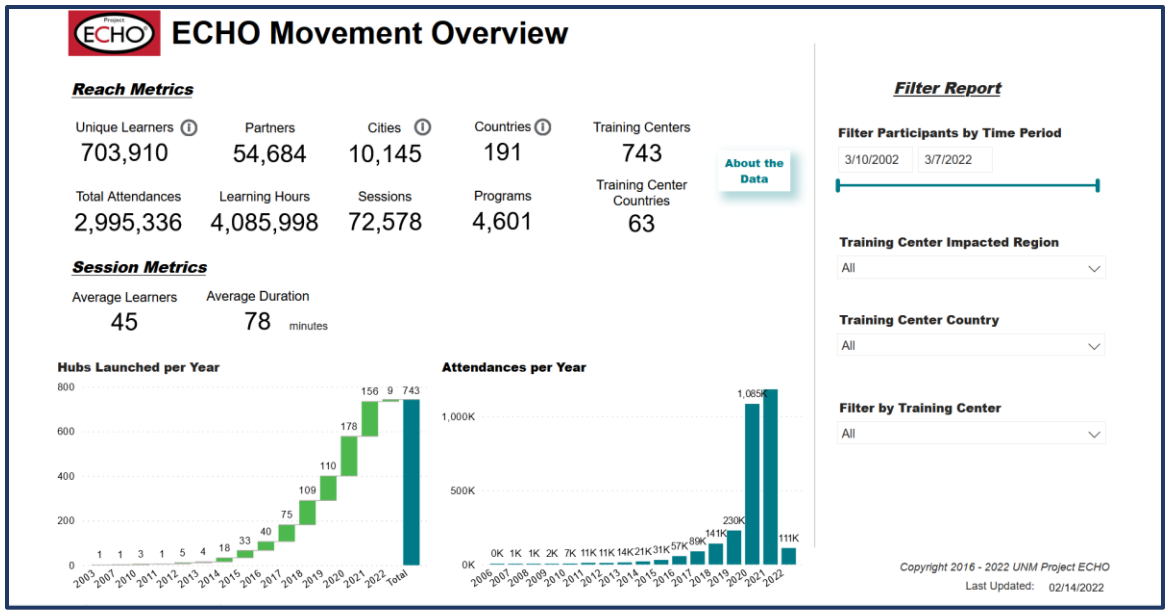


Dashboards Design

UNM Health Sciences Project ECHO – Hubs and Programs Dashboard

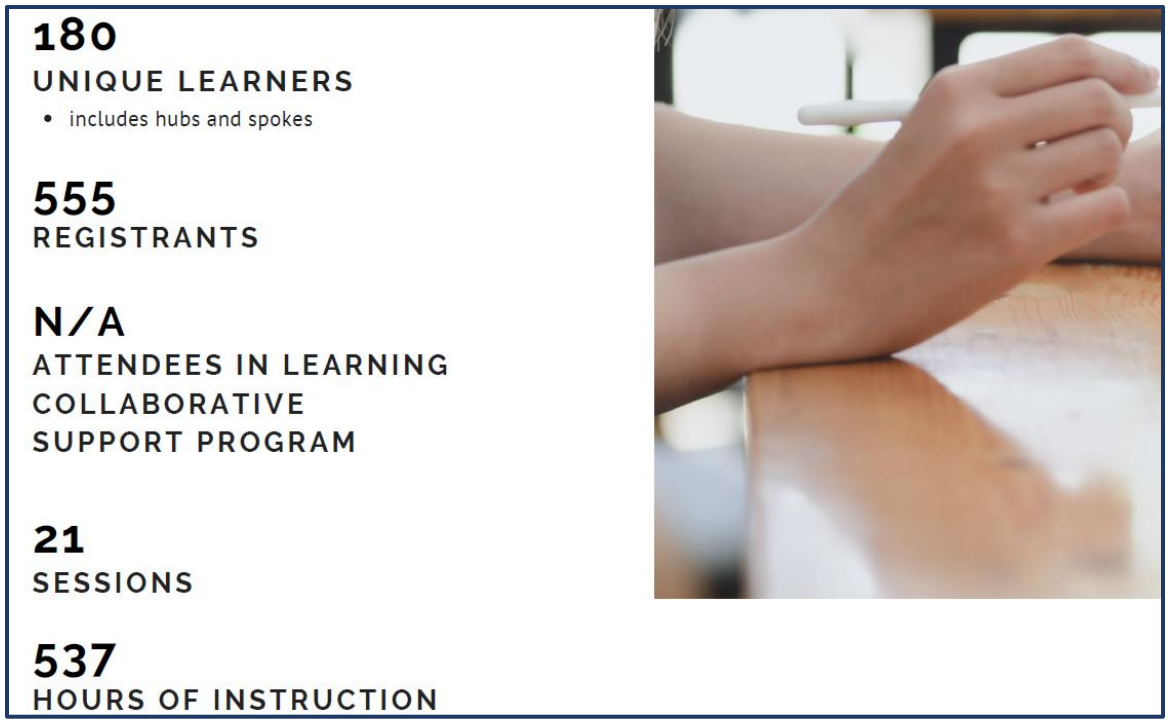


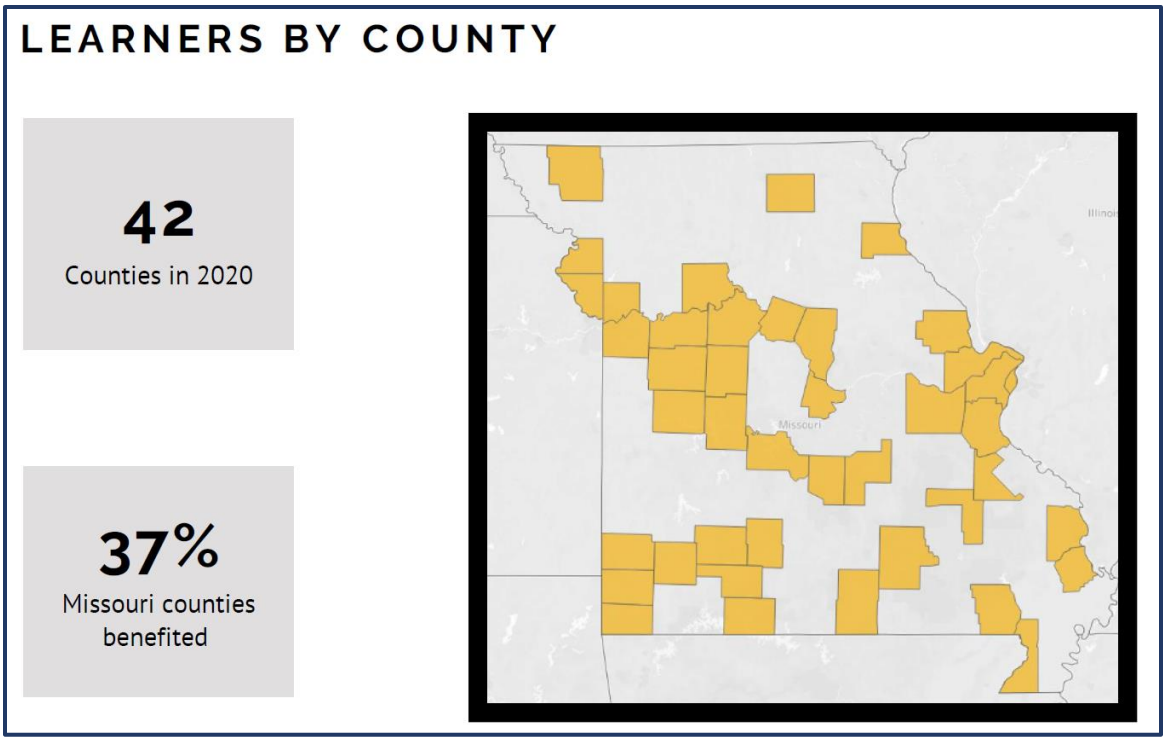
UNM Health Sciences Project ECHO – ECHO Movement Overview Dashboard

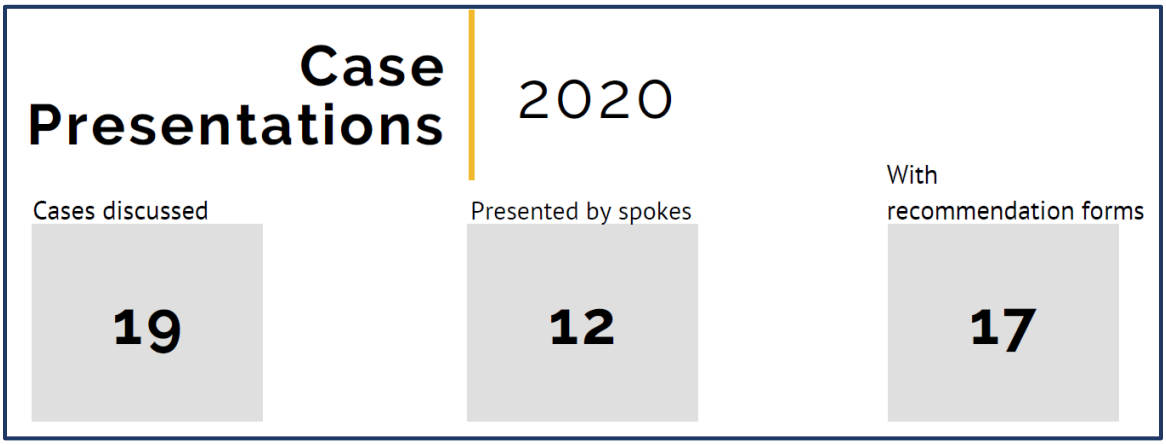


Missouri Telehealth Network Semiannual Individual ECHO Sample Reports

Extracts







"Project ECHO: Review and Research Agenda" key evaluation areas, research priority and recommendations

Evaluation Areas
Patient Access to Care and Patient Outcomes
Access to Care
Patient Outcomes
Patient Engagement
Patient Satisfaction

Provider Outcomes
Provider attendance
Provider knowledge and self-efficacy
Provider practice change
Provider communities of health care professionals
Research Priority
PRIORITY 1: EVALUATE ONGOING ECHO IMPLEMENTATIONS IN THE FIELD
What proportion of health care organizations invest resources in ECHO adoption (taking the time to learn about the program, attend trainings, train-the-trainer materials, become certified as coaches, etc.) but then never implement the program, and why?
What proportion of adopting organizations actually offer an ECHO program but then discontinue or pause it?
How many organizations stay in a holding pattern of adopting/not implementing/not discontinuing?
What is the yield rate of specialists recruiting PCPs in rural areas?
What proportion of ECHO implementers offer the program as its designers intended with the same content, same number of modules, same behavior stimuli, same support and checks on enrollee or client performance? Is ECHO ever offered exactly as taught? Is such precise fidelity even desirable?
What types of adaptations to the ECHO model do implementers make? Do they offer all the program's core components and with what regularity? Are they true to ECHO's theory of behavior change? Do they drop some components, customize others, and/or create their own to better suit their health care organization and their patients?
Does implementation of ECHO change in ways unanticipated by the ECHO Institute designers? Is collection of field-based process evaluation data assessed and used by ECHO Institute staff to monitor and consider improvements to ECHO as it is deployed?
Does learning the ECHO model serve as a trigger or precipitating event for hub-based health care organization decision-makers to adopt other, consonant, or complementary telehealth or telemedicine programs?
Do hub-based implementers think they are offering ECHO as the designers intended but, in practice, do something quite different?
To what extent do hub health care organizations and PCPs in rural areas continue in their participation, financial support, and FTE support for ECHO? Has ECHO become a part of routine health care service in these organizations?
In what proportions are each of the ECHO model components sustained in practice?
Which aspects of the model are least popular with providers and why is that the case?
Does enthusiasm among rural PCPs persist? What are the post-treatment opinions of patients in rural areas?
Is fidelity to the ECHO model, or adaptation to it, a better predictor of sustainability of offering the model and of its effects on providers and patients?

PRIORITY 2: ASSESS THE ROBUSTNESS OF THE ECHO MODEL
Are medical specialists of some types more favorable towards and more likely to participate in teleECHO clinics?
Do PCPs in rural areas more readily learn some medical specialties rather than other medical specialties?
Does type of local health care delivery organization matter in patient willingness to adhere to care recommendations?
Does ECHO improve patient access to care depending on country level health care infrastructure?
Is financing for ECHO better sustained in certain types of countries and certain types of health care delivery systems?
Compare ECHO effectiveness across locations
Compare ECHO effectiveness across health conditions
PRIORITY 3: CONDUCT FORMATIVE EVALUATION TO INFORM A DESIGNING FOR DIFFUSION STRATEGY
Does the ECHO Institute identify and target health care organizations that are not just motivated to adopt ECHO but also have the organizational capacity to implement it well?
Are health care organizations that adopt ECHO influential so that decision-makers in other health care organizations will take notice and in turn consider ECHO?
To what degree are adopting health care organizations serving high proportions of low-income or disadvantaged populations? Do they have existing relationships with providers in rural underserved areas?
Are criteria such as population need, organizational motivation, organizational capacity, and organizational social influence being used to prioritize who should be trained in the ECHO model first, or is training just first-come, first-served?
Has formative evaluation been conducted to understand which approaches to training work the best and for which types of providers?
Have demonstration projects at highly successful ECHO sites been used to invite potential adopters (including funders and government regulators) in so that well-informed decisions about ECHO can be made?
To what extent does the change agency strategically consider when to introduce the new program or do they just disseminate information as it becomes available?
What proportion of organizations targeted with dissemination messages about ECHO respond by contacting the ECHO Institute for more information?
How many specialists try the new program (which might qualify them as adopters) of all those targeted (a measure of reach)
Additional Recommendations
Use direct measures of patient outcomes
Randomly assign providers to condition
Randomize at the clinic level
Plan for over-time data collection

Compare presented cases with patients of ECHO providers not presented
Compare ECHO to other telehealth and telemedicine models
Test the incorporation of ECHO into graduate medical education

APPENDIX C

99 Missouri Rural Counties

Adair	Dunklin	Miller	Saline
Andrew	Franklin	Mississippi	Schuyler
Atchison	Gasconade	Moniteau	Scotland
Audrain	Gentry	Monroe	Scott
Barry	Grundy	Montgomery	Shannon
Barton	Harrison	Morgan	Shelby
Bates	Henry	New Madrid	Stoddard
Benton	Hickory	Nodaway	Stone
Bollinger	Holt	Oregon	Sullivan
Butler	Howard	Osage	Taney
Caldwell	Howell	Ozark	Texas
Callaway	Iron	Pemiscot	Vernon
Camden	Johnson	Perry	Warren
Carroll	Knox	Pettis	Washington
Carter	Laclede	Phelps	Wayne
Cedar	Lafayette	Pike	Webster
Chariton	Lawrence	Polk	Worth
Clark	Lewis	Pulaski	Wright
Clinton	Lincoln	Putnam	
Cooper	Linn	Ralls	
Crawford	Livingston	Randolph	
Dade	Macon	Ray	
Dallas	Madison	Reynolds	
Daviess	Maries	Ripley	
De Kalb	Marion	St. Clair	
Dent	McDonald	Ste. Genevieve	
Douglas	Mercer	St. Francois	

15 Missouri Urban Counties + The City of St. Louis

Boone	Christian	Jackson	Platte
Buchanan	Clay	Jasper	St. Charles
Cape Girardeau	Cole	Jefferson	St. Louis
Cass	Greene	Newton	St. Louis City