IMPROVING ACCESS TO REPRODUCTIVE HEALTH SERVICES THROUGH GIS MAPPING AND DATA-INFORMED COMMUNITY ENGAGEMENT

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Joseph Russo

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As members of the Dissertation Committee, we certify that we have read the dissertation prepared by: Joseph Russo
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and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

Velia Leybas Nuno — Date: Apr 26, 2023
Velia Leybas Nuno (Apr 26, 2023 17:49 PDT)
Velia Leybas Nuno

Leila Barraza — Date: Apr 27, 2023
Leila Barraza (Apr 27, 2023 13:21 PDT)
Leila Barraza

Christina Cuthaw — Date: Apr 27, 2023
Christina Cuthaw (Apr 27, 2023 11:38 PDT)
Christina Cuthaw

Heidi E Brown — Date: Apr 27, 2023
Heidi E Brown (Apr 27, 2023 07:40 PDT)
Heidi E Brown

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copies of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Velia Leybas Nuno — Date: Apr 26, 2023
Velia Leybas Nuno (Apr 26, 2023 17:49 PDT)
Velia Leybas Nuno
Department of Health Promotion Sciences

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We respectfully acknowledge the University of Arizona is on the land and territories of Indigenous peoples. Today, Arizona is home to 22 federally recognized tribes, with Tucson being home to the O'odham and the Yaqui. Committed to diversity and inclusion, the University strives to build sustainable relationships with sovereign Native Nations and Indigenous communities through education offerings, partnerships, and community service.

DEDICATION

To Natalie and Everett,

May this show the doors that are open to you, toward this or any path you choose.

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ABSTRACT

Background: Since 1983, Affirm — Sexual and Reproductive Health for All has been the primary grantee for Arizona's Title X Service Grant, the largest federal grant program specifically dedicated to providing affordable access to reproductive health services.[1,2] Individuals attempting to access reproductive health services report a wide array of barriers, including cost, insurance coverage, and distance.[3–6] Through the lens of implementation science, an emerging discipline focused on bridging the gap between health research and practice, we examine the existing reproductive health resources available within Arizona and areas of potential elevated need.[7] **Methods:** A multi-part framework was utilized to assess current community needs and service area coverage. Geographic Information System (GIS) tools were developed for the community partner and integrated with the organization's existing dashboard system. GIS tools were then used to map publicly-supported reproductive health service providers and associated drive time distances for each location. Using American Community Survey (ACS) data, multivariate overlay analysis was used to identify census tracts and Public Use Microdata Areas (PUMAs) where unmet Title X need may be present. Separate analyses were run for rural and urban census tracts. **Results:** Profile scoring identified 335 unique areas of potential need (APNs) based on the percent of the population ages 15-44 years, percent of the population without insurance coverage, percent of the population below 200% FPL, and percent of the population without access to a personal vehicle. Of Arizona's overall population, 21.9% was estimated to live in an APN, including 52.7% of the population in Apache County. 30 APNs were located entirely outside of the current Title X service area. **Discussion:** 20 of the 22 identified rural APNs overlap with American Indian Areas. Unmet needs for reproductive health services in American Indian Areas may contribute to disparities in rates of maternal mortality and severe maternal morbidity for Native American and Alaskan Native women in Arizona. Recommendations for Affirm were developed to guide utilization of new GIS tools in strategic planning, stakeholder communication, and community needs assessment activities moving forward.

PROJECT NARRATIVE

1. Introduction

Researchers in the natural sciences often repeat a classic joke to illustrate the fraught relationship between research and practice.[8] As it is told, a dairy farmer approaches a theoretical physicist for help to improve the milk production of their herd. The researcher accepts the job, and after some time returns to the farmer triumphant and confident in their results, which they eagerly share: "First, assuming spherical cows…"

Perhaps due to the pervasive nature of this issue across so many disciplines, "spherical cows" has become shorthand in the natural sciences for a fundamental failure to bridge the gap between research and practice.[9] The researcher fails to understand or appreciate the nuance and complexities of a real-world issue, and presents an oversimplified model that humorously abstracts beyond the point of usefulness. The response of the practitioner is one we can assume from the imagined fallout after the punchline is delivered – the farmer sighs and tosses out the final report, perhaps missing whatever valuable insight they could have otherwise gained. Both professionals have failed to effectively communicate between their respective dialects of practice, and the divide persists. Ultimately, the conditions of the farm remain the same as they always were.

Implementation science is an emerging discipline within the health sciences, focused on bridging the gap between research and practice.[10] Implementation scientists focus on research questions regarding how evidence-based practices are adopted by practitioners, policymakers, and the public.[7] A relatively young field, this scientific movement draws from related disciplines such as process improvement and translation research, applying them to the unique structural, organizational, and political challenges to utilizing best practices in public health and healthcare.

One particular phase in the implementation process that is vulnerable to poor translation is community engagement. The history of public health has at times been largely top-down, with outside experts determining community need without the involvement of the community.[11–13] At the same time, interventions used to address community needs may be shaped not by evidence-based practices, but by practical considerations such as policy, politics, cost, or geography. On the tail end of these efforts, evaluation plans often prioritize performance indicators based on their ease of measurement rather than their actual relationship to project outcomes. In such cases, practitioners wander into unfamiliar territory, fail to ask relevant questions, and apply theory without context; in short, we *assume spherical cows*.

This project seeks to bridge the gap between research and practice in the community engagement efforts for Arizona's Title X Reproductive Health provider network, which provides high-quality and affordable reproductive health services to underserved communities across Arizona. Working with this community partner, we explore how available quantitative data can be combined with an understanding of social determinants of health and health-seeking behavior, community engagement activities, and best practice case studies from multiple fields of practice to inform the practice of public health at an organizational level. How can the products of research and data analysis be incorporated and considered alongside the traditional fiscal, structural, and political factors which often steer organizational decision making?

2. Background and Need

2.1. Importance of Reproductive Health Services

An individual's access to reproductive health services can directly impact several maternal and child health outcomes. Contraceptive services and reproductive counseling reduce rates of unintended pregnancy. Unintended pregnancy is associated with delayed prenatal care,

low birth weight, and higher rates of premature birth.[14] Screening and treatment for sexually transmitted infections reduces rates of complications such as pelvic inflammatory disease, infertility, and ectopic pregnancy.[15] On a broader scale, an individual's agency to establish and follow a reproductive life plan of their choosing is a cornerstone of reproductive justice, and directly impacts economic and social outcomes as well as larger cycles of generational poverty.[16]

Individuals of all ages may benefit from reproductive health services, regardless of whether they are sexually active or biologically capable of becoming pregnant or causing a pregnancy. However, within the field of reproductive health, one priority population of interest is typically individuals of reproductive age. This range is commonly defined as ages 15-44, or 15-49, depending on which range best suits available demographic and indicator data.[17–21] The population within reproductive age is considered when estimating total need for reproductive health services, or when calculating common fertility statistics for a population such as the Total Fertility Rate.[21,22] Based on U.S. Census 2021 data, 39.6% of Arizona's total population was between the ages of 15-44 (38.4% of women, 40.8% of men).[23] This means over a third of the state's population is in the age range generally considered at highest need of reproductive health services.

2.2. Barriers to Access

Individuals attempting to access reproductive health services report a wide array of barriers.[3–6] While some of these barriers are medical in nature, many of them fall under the social determinants of health. Social determinants of health are defined by the Centers for Disease Control and Prevention as "nonmedical factors that influence health outcomes."[24] This definition is deliberately broad, and is meant to encompass any factor in an individual's physical, cultural, social, or political environment which may influence their health in positive or negative ways.

There are several social determinants of health which may impact an individual's reproductive health outcomes. Systemic barriers to healthcare access in the U.S. such as insurance coverage, cost, and physical distance to a provider are further complicated by additional social and cultural barriers surrounding reproductive health, such as stigma or increased concerns around confidentiality and patient privacy.[3,5] In the United States, poverty and insurance coverage are particularly egregious obstructions to access. Access can be influenced directly through affordability of services, and indirectly through social and economic barriers such as access to transportation and childcare needed to physically seek out care.

Socioeconomic status has been singled out as one of the most influential factors impacting health outcomes.[25] In 2019, 31.9% of Arizona's population was living below 200% of the Federal Poverty Level (FPL), and 13.4% fell under 100% FPL.[26] Poverty does not impact all populations in Arizona equally, with significant disparities for Native American (29%), Hispanic (18.2%), and Black (17.5%) Arizonans below the 100% FPL.[27] An estimated 11.1% of all Arizonans are also uninsured, rising to 19.2% for individuals below 200% FPL.[28,29] Twenty-one percent of Arizonans were covered by Medicaid or Children's Health Insurance Programs (CHIP).[28]

Following the 2022 overturn of *Roe v. Wade* by the United States Supreme Court, a large share of the public discourse has focused on geographic accessibility of reproductive health services.[30–33] While much of this discussion has been specific to abortion services, the same issues of geographic disparities and transportation barriers impact access to other types of reproductive health services as well.[6] According to the most recent Census data released for 2021, an estimated 5.6% of Arizona households did not have access to a personal vehicle.[34] For individuals without vehicle access, accessibility of reproductive health services may be further

complicated by other financial or logistical barriers.

Issues of stigma can also complicate access in terms of physical proximity to services, as patients in smaller communities may have reduced options for reproductive care providers. In the event a patient experiences internal or external stigma or social pressure surrounding reproductive healthcare, this reduced choice may further complicate their ability or willingness to access services.[5] With this in mind, the availability of services becomes more complex than funding a single-source network of care providers covering an entire geographic area. Further assessment of community needs and patient perceptions is needed to understand and address barriers.

2.3. Unmet Need for Reproductive Health Services in Arizona

While some work has been done to more specifically estimate Arizona's unmet need for reproductive health care, these efforts have lacked depth and rigor. A 2014 study by the Guttmacher Institute estimated that only 15% of Arizona's need for publicly funded reproductive health services was being met.[35] This assessment was made using population statistics from national data sets, comparing poverty rates and population estimates to the theoretical capacity of existing funding. However, the study did not incorporate actual data from care providers, such as the actual number of patients being served by publicly funded services or other types of providers. The study also lacked any component of community needs assessment, which could have provided helpful context into how community members experienced these unmet needs, and whether reproductive healthcare needs were being met elsewhere.

2.4. Applications of Geographic Information Systems (GIS)

Geographic Information Systems are a category of tools with broad applicability in a variety of fields. At its most basic, a GIS is a system used to create, organize, analyze, and

display data with a geographic component.[36] As a class of tools capable of both data handling and visualization, GIS have a variety of potential applications based on the type of data, the needs of the user, and the intended audience for the final map products.

This section is not meant to be an exhaustive analysis of every potential application of GIS across all circumstances, but a review of the most relevant GIS applications in regard to this project. Example case studies have been selected not only from public health and social sciences, but from other sectors as well. The following applications and case studies have been used to inform the recommendations given to Affirm on how GIS maps can be used to enhance organizational decision making and community engagement efforts moving forward.

2.4.1. Identification and Analysis of Spatial Patterns

As the name implies, the primary factor distinguishing GIS from other data tools is the geographic component. One of the most basic and fundamental uses for GIS is the visualization of geographic data for the purposes of identifying and analyzing spatial patterns. This application of GIS is analogous to the function of a scatter plot. While a table of data points may not appear to have any significant correlation or trend, the use of a visual medium reveals patterns of distribution within the dataset.[37] While early mapping of disease outbreaks relied on visual pattern recognition, modern tools are able to conduct more advanced statistical tests based on geographic proximity or distribution.[38]

One of the most well-known stories in public health history is that of John Snow, often credited as the father of modern epidemiology, and his work to investigate a cholera outbreak in 1854.[39] As part of this work, Snow created a now famous map of cholera cases in the Soho district, demonstrating how cases clustered around a particular water pump on Broad Street. Although science historians have debated the exact role Snow's map and intervention truly

played in ending the outbreak, the story has gone on to become an important chapter in public health history.

More recently, GIS played a major role in tracking the spread of COVID-19 and its major variants throughout the pandemic. Spatial epidemiology using GIS was key in the identification of the disease's origin in Wuhan Province, China, a discovery which allowed researchers to better understand the origin of the variant and its early spread.[40] Later studies conducted when the pandemic had officially reached a global state helped definitively identify the symptom presentation of the disease and later variants, and track outbreaks not only through geographic areas but through specific demographic populations.[41]

2.4.2. Community Needs Assessment and Public Participatory GIS (PPGIS)

GIS can also be utilized in data collection from a variety of sources, including community needs assessment results. PPGIS is still an emerging field, bringing together traditional GIS applications from several professional sectors with qualitative research methods, community-based participatory research, and grassroots organizing.[42] A 2021 review summarizing the latest work in this area grouped most PPGIS activities into three phases: Explore, Explain, and Predict/Model.[43]

Between 2015-2016, the Los Angeles County Department of Parks and Recreation conducted a comprehensive needs assessment on all parks within their jurisdiction.[44] One issue facing the needs assessment team was that, due to gaps in historical record keeping, there was no comprehensive record of all parks in the county. As the largest county in the country by population, and one of the largest geographically, the inventory process alone was a daunting effort. As a solution, the team turned to a PPGIS approach to collect quantitative and qualitative data to complete their assessment.

Having assembled this comprehensive inventory of parks and amenities within the county, the needs assessment team was then able to conduct a number of qualitative analyses on space usage, park distribution, and equity of access.[45] PPGIS provided a pathway for both the organization of the needs assessment activities and data collection by area, and also allowed the needs assessment team to incorporate the community's voice directly into the GIS tools and analyses conducted later in the process.

2.4.3. Network Assessment and Site Selection

Within organizations, GIS also has applications relevant to strategic planning. One such application derives from the ability to analyze a physical network of geographic locations, and make data-informed decisions about network growth opportunities. Placement of new locations may be informed by a variety of factors, including: proximity to other locations in the network, proximity to locations in competing networks, travel times between locations, population density, and zoning restrictions.[46] This application of GIS has a long history in sectors such as retail, urban planning, and manufacturing. As public health and social service organizations explore similar uses for GIS, much can be gained by considering case studies from these fields as well.

In 2021, the Kentucky Office of Energy Policy (KOEP) utilized this aspect of GIS as part of a project to establish new solar farms across the state on lands formerly used for mining.[47] Solar farm placement in this region was difficult, due to conflicting priorities of geography and stakeholder priorities regarding this repurposed land. On one hand, there existed a finite number of sites objectively suited to the needs of solar farms: namely unobstructed space and adequate sun exposure. At the same time, local stakeholders had competing priorities for land use, including applications such as agriculture with stronger community support. The team found few

best practices from other states, but sought to create a more comprehensive and data-informed method than what was currently in place.

Ultimately, KOEP was able to develop the Solar Siting Potential in Kentucky platform.[48] Taking a variety of factors into account, this tool does not supply definitive conclusions on where solar farms should be located, but instead guides more in-depth decision-making to the sites most likely to be successful based on a variety of selected criteria. The tool provides a jumping-off point for discussion, allowing resources to be dedicated to finalizing decisions rather than assembling options from scratch.

2.4.4. Stakeholder Messaging Tools

In their capacity as a visual tool, maps can be an evocative aid in communicating to a diverse set of audiences. This is in part due to the familiarity of surrounding map landmarks, which presents information that is immediately relatable and understandable to the viewer. Visual communication also presents information in a more accessible way that facts and figures presented through text or speech alone.

This application of GIS is evident in the above KOEP case study. Like reproductive health clinics, the placement of solar farms in Kentucky is subject to a variety of social and political factors in addition to the standard questions of logistics and cost.[47] Local leaders were resistant to solar farms being placed on otherwise viable farmland, and public perception was that this trend was an active detriment to local agriculture. Through GIS, the KOEP was able not only to identify ideal locations for new solar farms, but to also demonstrate to leaders and advocates from the agricultural center that these sites were specifically chosen to avoid competition with other industries. This layer of transparency in the planning process invited the most vocal critics of solar farms into the conversation, and demonstrated the specific decision-

making process behind site selection.

In Los Angeles County, the Department of Parks and Recreation incorporated their newly created PPGIS tool into community forums and focus groups during later stages of the project. Having assembled the data and built these tools, these maps were formally integrated into the facilitator handbooks for community engagement teams working directly with stakeholders throughout the county. Feedback generated based on map examples was then used to generate data for additional maps for later analysis. In the words of then California Director of Government Affairs for The Trust for Public Land, “The map really did drive the conversation of how to make sure everyone in the county has access to parks and open space, because people could see what access looks like."[44]

2.5. Theoretical Basis

One element of disconnect between public health research and practice could be the lack of theoretical basis for interventions or program design. In many public health agencies and community-based organizations, the details of program activities or interventions are often dictated first and foremost by fiscal or policy factors rather than evidence-based best practice, a reality in the field that many theoretical models fail to note.[49] Rather than building intervention models around public health theory and evidence-based practice, many programs are beholden to the sometimes arbitrary metrics established by their stakeholders and funders – often raw counts of numbers served or dollars spent.

In addition to the financial and political pressures on public health organizations, another contributing factor may also be the composition of the public health workforce itself, which has a higher proportion of professionals whose formal training is in a separate discipline than their current field, compared to other segments of the workforce.[50,51] Public health leaders often have

little formal academic training in public health theory *or* practice, and instead often have backgrounds in clinical healthcare, public policy, business, or administration.[52] This leads to strategic plans and outcome metrics drawing from the norms of those other fields of practice.

For this project, a deliberate and thoughtfully considered theoretical basis was an important step in aligning the proposed project methods and deliverables with both established theory and the real-world needs of the partner. With this in mind, the major model and theory forming the foundation for this project are the Health Belief Model[53] and Complexity Leadership Theory.[54]

2.5.1. Health Belief Model

The Health Belief Model is a specific model built on the foundation of Social Cognitive Theory, which conceptualizes how various factors influence the likelihood of an individual to engage in a given health behavior.[53,55] Individuals begin with a set of underlying attitudes and knowledge based on their background, which the model defines using demographic factors such as age, race/ethnicity, education, etc. However, health beliefs driving behaviors only originate with these underlying attitudes, and are shaped by other perceptions before manifesting as behaviors. These modifying factors largely revolve around an individual's perceptions about the activity or health issue being addressed – the tension between perceived seriousness and susceptibility, the perception of benefits versus barriers, and other internal and external factors such as self-efficacy and calls to action the individual may be receiving. At its core, the model posits that these factors operate in concert to influence the likelihood of an individual choosing to engage in the health behavior or not. While objective factors of risk or benefit certainly play a role in this decision making, they only become relevant to the degree that their relevance is perceived by the subject.

The Health Belief Model provides important insight into the factors which may affect the decision-making of the population which Affirm serves. Within the model, systemic factors such as cost of services or geographic distance represent only one category of barrier which may impact accessibility of services.[55] Rather than focus solely on external factors which shape health-seeking behavior, the model presents these considerations alongside an individual's perceptions of risk, accessibility, and self-efficacy.[53] A community which does not perceive reproductive healthcare as necessary or accessible will not utilize those resources, regardless of how many clinics exist or how inexpensive their services.[56] For this reason, the deliverables of this project do not exclusively include top-down data analysis of structural barriers, but also connect work products to deeper community engagement and qualitative needs assessment strategies.

To bridge the gaps between theory, research, and practice, this project will utilize the Health Belief Model when developing tools and best practice recommendations for the community partner. Recommendations will cite relevant case studies regarding how GIS tools and data-informed approaches have been integrated into community and stakeholder engagement, strategic planning, and goal setting by organizational leaders. Case studies will not be restricted to public health, but will also draw from other disciplines with more developed foundations in the utilization of GIS in organizational decision-making and needs assessment.

2.5.2. Complexity Leadership Theory

At the organizational and systems levels, effective implementation of interventions and evidence-based practices relies on effective leadership strategies. While much of the literature around leadership theory has traditionally focused on private sector business settings, many of these existing theoretical models can be effectively applied to leadership roles in the health and

human services sector.[57]

Many of the oldest established leadership theories focused on describing inherent abilities or talents of effective leaders.[58,59] However, more recent theoretical models have moved toward a lens which presents leadership as a set of skills, attitudes, or behaviors.[57,60] One such theory initially established in the early 2000s is Complexity Leadership Theory, a theory of organizational leadership arising from the broader field of Complexity Theory.[54] Complexity Theory describes organizational systems in terms of the complex interactions between their moving parts. Under Complexity Theory, systems are seen as dynamic, adaptive, and fundamentally unpredictable. These complex systems require broad and adaptive definitions, which allow room for uncertainty and change.

Emerging from this perspective of systems, Complexity Leadership Theory adds an additional layer of interpretation for leaders in complex settings. If we understand systems to be ever-changing interactions between individual stakeholders, an effective leader must understand these components and the various ways in which they may work together as the system grows and evolves.[61] The fundamentals of Complexity Leadership Theory emphasize integrated and adaptive leadership practices rather than top-down approaches. The functions of decision-making should not be tied to inflexible bureaucratic functions or omnidirectional chains of command. Instead, decision-making should make active use of stakeholder feedback, meaningful performance indicators, and iterative cycles of process improvement.[54,61,62]

This project aligns with Complexity Leadership Theory in two major ways. First, the design of the project establishes a living relationship between Affirm's utilization of geographic data and community needs assessment activities. Rather than treat these as two separate processes or data sources, the project emphasizes and even strengthens the interaction between

the two through an active iterative loop. These connections will allow quantitative geographic data and qualitative community stakeholder feedback to not only impact leadership decisions, but to build on and inform one another to create a more comprehensive understanding of community need.

Second, the design of the data tools and GIS maps themselves are grounded in a Complexity Leadership Theory mindset. Variables included in the tool include structural and environmental factors of geography and physical access, as well as demographic variables and social determinants of health. The development of an interactive tool will allow Affirm's leadership to utilize maps in an active fashion. Map tools will be used to assess need in regard to different combinations of risk and protective factors, community needs assessment results, or stakeholder priorities.

3. Project Description

3.1. Specific Aims

The overarching objective of this project is to explore novel uses of GIS data to guide state-level decision-making in expansion of Arizona's Title X service provider network and community engagement. This is accomplished through the following three specific aims:

1. With Affirm, develop an interactive data map using ArcGIS to visualize reproductive health providers and coverage areas against population density, poverty status, insurance coverage, race/ethnicity, age, and access to transportation by census tract and PUMA.
2. Develop a user-friendly data organization tool in Microsoft Excel for analysis of ACS data, to facilitate Affirm's creation of future data maps and to direct the ongoing utilization of these maps as a tool to inform future expansion of the Title X provider

network, community engagement efforts, and future assessment of service utilization and accessibility.

3. With Affirm, develop a community needs assessment implementation plan which integrates the use of Geographic Information System (GIS) maps alongside an evidence-based qualitative research tool, to prioritize high-need communities for engagement, and to verify trends in map data based on the lived experience of patients.

3.2. Community Partner

The largest federal funding program specifically dedicated to reproductive health services is the Title X Service Grant. Established in 1970, Title X provides a variety of reproductive health services on a sliding fee scale, with an emphasis on serving individuals ages 15-44 years that meet the criteria for below 250% of the FPL.[2,63]

Arizona's primary Title X grantee since 1983 has been Arizona Family Health Partnership (AFHP).[1] As of November 2022, AFHP has rebranded as Affirm — Sexual and Reproductive Health for All.[64] Affirm engages in three main activities: legislative advocacy, community education about reproductive health, and clinical services through sub-awards. The author formerly collaborated closely with Affirm during his employment at the Arizona Department of Health Services (ADHS) while managing the Title V Reproductive Health program. During this time, Title V and Title X programs were run concurrently, with a high degree of overlap in provider training, program policies, and data reporting. This required close collaboration between the author and Affirm leadership providing the relevant professional relationships and familiarity to support this project.

In October 2021, a new Final Rule was issued, formally revising Trump-era changes to

Title X and emphasizing the need for accessibility, equity, client-centered focus, and quality in Title X services.[65] This mandate presented an opportunity to assess potential areas of elevated need and facilitate more intentional community engagement. The goal of this work was to not only conduct a one-time analysis, but to provide Affirm with resources and training to build capacity and guide future efforts. In September 2021, the author began meeting weekly with Affirm to discuss the proposed goals and products of the project, and to incorporate those plans into the 2022-2027 Title X application submitted to the Office of Population Affairs (OPA) in January 2022.[66] This group met 15 times in 2021, and obtained three data share agreements with Affirm partners for geographic data on additional reproductive health provider networks outside of Title X.

Affirm has identified a need for capacity building in two areas: developing a sustainable process to use GIS maps for data-informed decision-making, and recommendations on how to incorporate public health models and concepts such as the Health Belief Model and social determinants of health into their strategies.

3.3. Project Deliverables

In order to address the stated specific aims, this project utilized GIS data mapping to visualize geographic data pertaining to reproductive health services and community needs in Arizona. The following deliverables supported this objective, while also contributing to capacity building, establishing best practices for how the community partner could update these map products over time and also use them to inform organizational decision-making and community engagement. The following work products were developed as components of this project. A more detailed overview of the design process and challenges is included in the Methods.

GIS Data Map. An interactive GIS data map was created in ArcGIS and integrated with

Affirm's current Tableau dashboard platform. This includes data layers for clinic locations, drive time coverage areas, and potential areas of need. Identified areas of potential need are color-coded by both census tract and PUMA, enabling analysis at either geographic level.

Data Management Tool. A data management tool was built in Excel, for future analysis of ACS data or the preparation of additional GIS maps. Excel was selected based on discussions with Affirm about their current software access and staff familiarity. The structure of the tool mirrors the format of ACS data reports, and includes step-by-step guides on how data can be added, analyzed, and exported. A summary of the data management tool's format and content can be found in **Appendix A.**

Arizona Reproductive Health Provider List. A comprehensive list of all publicly-supported Reproductive Health Providers within Arizona was assembled by combining existing databases provided by Affirm, OPA, the Guttmacher Institute[67], and the Bedsider Birth Control Support Network[68].

User Manual. A user-friendly manual with step-by-step instructions was prepared and included within the format of the data management tool. The manual details how and where ACS data can be accessed, how the data management tool can be used to organize future data, and how to export this into future map layers. As the identified staff member responsible for utilizing the prepared GIS tools, Affirm's Director of Grants and Evaluation was also given in-depth training, using the user manual as a guideline. A summary of the user manual's format and content can be found in **Appendix A.**

Implementation Plan Recommendations. The utility of the data management tool, outlining the use of GIS maps with future community engagement and needs assessment activities, was described. This component was integrated into the methodology and

implementation plan for Affirm's community needs assessment already underway.

Summary and Recommendations. A high-level overview summary of the project and recommendations for how this data-informed approach could be incorporated into future strategic planning and organizational decision-making was developed, citing relevant literature from the background section and public health theory.

4. Methods

4.1. Data Sources and Preparation

Data was accessed from the following eight sources for use in the creation of GIS map products for Affirm. With the exception of data provided by Affirm about their grantee network in Arizona, all other data are from national sources and provided by government agencies and private organizations. Data types and sources included:

- **Base Map Data – ESRI ArcGIS Data and Maps**[69]

  A base map represents the underlying features that a data map is built upon. This can include physical geography (e.g., oceans, rivers) and human geography (e.g., roads, borders, labels). Base map layers provide important context for the topical data being presented. Underlying labels and landmarks provide context to viewers, and assist with their ability to understand and interpret data the map is presenting. Basic map layers for this project were sourced from the Esri ArcGIS Data and Maps group. These data layers included streets, place name labels, and underlying topography.

- **Legal Boundary Shapefiles – U.S. Census Bureau**[70]

  The U.S. Census Bureau maintains a database of shapefiles, a type of GIS file containing polygons for different geographic area boundaries used in other Census data products. These shapefiles are used to display the visual borders defining geographic areas, but also

contain the numerical identifiers (IDs) used to join all other Census data to their corresponding area. These joins are then used to tell the mapping platform how to visually represent each data point by filling in the corresponding area for each geographic ID.

- **American Community Survey Data – U.S. Census Bureau**[71]

  ACS is a demographics survey running parallel to the U.S. Census, gathering data on a variety of social and economic factors such as: insurance coverage, poverty, age, and race/ethnicity. ACS data samples a smaller portion of the total population each year, compared to the more comprehensive Population and Housing Census completed every 10 years.[72] This survey data is then extrapolated to the total population to provide projected demographic and descriptive characteristics for the entire country. Data is available as annual and 5-year estimates, broken down for geographic units down to a block group. This project primarily used 2019 5-year estimates at the census tract and PUMA levels.

- **Arizona Title X Provider Locations – Arizona Family Health Partnership**[73]

  Site data was provided by Affirm for all contracted Title X service providers, as well as clinic information such as provider type and delegate agency. Some mobile and community-based providers operate in a physical location (different from their registered address) in Affirm's internal provider list. For these providers, specific latitude and longitude coordinates were provided to manually set the accurate service location on the final map.

- **Outside-Arizona Title X Provider Locations – Office of Population Affairs**[74]

  The final GIS map also included data for the locations of all Title X service providers outside of Arizona, but within 100 miles of the Arizona border. Provider site data was accessed from the OPA Title X provider listing. All clinic locations for neighboring states

were initially geocoded and mapped. A geographic select operation was then used to narrow to only those points within 100 miles of the Arizona border.

- **Title X Like-Service Provider Locations – Guttmacher Institute**[67] **and Bedsider Birth Control Support Network**[68]

  Two databases of Title X look-alike service providers in Arizona and within 100 miles outside of the Arizona border were provided for internal use only, one by the Guttmacher Institute and one by the Bedsider Birth Control Support Network. Both of these organizations have ongoing data collection projects to track publicly-supported reproductive health providers across the U.S. These two databases were combined into a single comprehensive list of locations, and duplicates discarded. Data share agreements have been established for both of these confidential data sets.

- **School-Based Health Center Provider Locations – School-Based Health Alliance**[75]

  A list of all school-based health centers and school-linked mobile providers in Arizona was provided for internal use only by the School-Based Health Alliance. This data was also used to verify the clinic type status (traditional, school-based, or mobile) for provider locations included in other data layers. A data share agreement was established for this confidential data set.

- **Rural-Urban Commuting Area (RUCA) Codes – U.S. Department of Agriculture**[76]

  RUCA codes are a system developed by the U.S. Department of Agriculture (USDA) to more accurately classify census tracts and zip codes by rurality. Rather than simply relying on population density to determine the rurality of an area, the RUCA code classification system also considers urbanization and daily commuting patterns to assign a code on a 10-point scale. RUCA code designations include Urban Center, Suburban, Large Rural, Small

Town, and Rural, with sub-ratings within each category to identify sub-groups based on surrounding geography. A set of secondary codes exist to further differentiate geographic areas based on more specific commuting patterns. However, for this project only primary RUCA codes 1-10 were utilized.

Address data for all point location layers was geocoded using the ArcGIS World Geocoding Service. Failed joins included 3 sites, primarily tribal health providers located within Navajo Nation. Due to the atypical address system used in these areas, and the small number of locations effected, location markers were able to be manually placed and verified with the delegate agency for accuracy.

4.2. Development of Data Management Tool

This project was originally conceptualized with a focus on the GIS map products. However, the larger share of work load and time by far was spent on the development of a data management tool for handling selected ACS data. This development process included elements of data preparation, programming, and user interface design. This component of the project was done in Microsoft Excel, a decision made based on two important criteria: the needs of the project and the needs of the end user.

First, the data utilized is readily available in .xlsx or .csv formats, and data sets were relatively small in nature. The methods of data preparation and analyses conducted prior to mapping range from simple to intermediate complexity, but fall well within the capabilities of the standard Excel package. This makes Excel the simplest tool readily available for completing the required tasks.

Second, there is the consideration that any tools developed should be usable not only by

the original developer, but also by Affirm. Advanced statistical analysis platforms (e.g., STATA[77], SAS[78], SPSS[79]) include much more powerful capabilities but are less user-friendly, cost more, and are less accessible. Basic literacy in these software packages is less common among the standard computer user base than Microsoft Office[80] platforms. Additionally, while all of these software packages require paid subscriptions, all Affirm staff already had access to an Enterprise subscription for Microsoft Office products.

The overarching structure for the tool is simple, making use of the existing ACS data format to simplify the process of future data updates. ACS data exports follow a standard format, with columns for: geographic identification code (also referred to as GEO ID, the alphanumeric code identifying a specific geographic area), common area name, and variable-specific columns for the selected criteria in a given table. **Table 1** below is an example of this format. Analyzing the existing data or pulling new data reports from the US Census website for further analysis is a simple and direct task, especially for more specialized statistical software packages. However, in order to build a reliable and user-friendly tool in Excel that could be updated and used by Affirm staff in the future, several design challenges had to be considered.

Table 1: Geographic ID, Name, and selected variable data columns in data management tool

GEO_ID	NAME	AREA	TOTAL_ POP	POP_ DENS	POP_ SCORE	RURAL ITY	RUR_ SCORE
Geographic Area ID	Geographic Area Name	Area in Square Miles	Total Population	Population Density	Population Score	RUCA Code	Rurality Score
1400000US04001942600	Census Tract 9426, Apache County, Arizona	588.96	1742	2.96	0	2	0
1400000US04001942700	Census Tract 9427, Apache County, Arizona	1155.35	5345	4.63	0	8	0
1400000US04001944000	Census Tract 9440, Apache County, Arizona	305.81	6547	21.41	0	5	0
1400000US04001944100	Census Tract 9441, Apache County, Arizona	708.25	5987	8.45	0	10	0
1400000US04001944201	Census Tract 9442.01, Apache County, Arizona	193.93	4473	23.07	0	2	0
1400000US04001944202	Census Tract 9442.02, Apache County, Arizona	165.83	4009	24.18	0	8	0

4.2.1. Join Validation

Joining data sets natively in ArcGIS Pro or in a dedicated statistical analysis software has the distinct advantage of built-in validation – a step which ensures the two data sets to be joined are aligned based on an identified common value. Validation minimizes errors, and identifies issues in data sets to be joined before source data is altered in any way. In the case of public GIS data, GEO IDs are standardized and provide a simple and effective marker for joins. This has the added advantage of allowing geographic data from several government entities to be easily and efficiently used together, as these identifiers are widely used across US governmental data sources.

For future data updates to be made directly in the Excel tool, some method of validation is needed. This way, new data is pulled into the appropriate rows matching the source GEO IDs.

To address this design challenge, a dedicated landing area for new data is added to the end of the primary sheet containing raw data values. Headings indicate where new data should be copied into the tool, including the column for GEO IDs alongside the new variable headings and values. A simple tool then compares the new GEO ID column to entries in the main data set, verifying which rows align and which do not, and providing a total number of errors.

Line-by-line test cells are also color-coded to aid in visual identification of specific rows returning errors. In the event of a single-line error, such as a change in GEO ID for a specific geographic region which was missed in the accompanying metadata, the specific row of values can be quickly and easily identified and addressed. In cases of an insertion or deletion error, the specific issue can be quickly identified at the exact point of divergence. An example of the join validation tool in use to identify an insertion error can be seen in

Table *2*. In this example, an entry has been deliberately inserted in the sixth row of the data set, causing this line and all below it to return match errors. The indicator at the top left of the tool counts a total of 1521 errors (affecting all lines except for the 5 preceding the insertion).

Table 2: Join validation tool showing an example insertion error at the sixth entry

# of Errors	JOIN VALIDATION		DATA COLUMNS		
1521	Validation Check 1 = Matched 0 = Error	Geographic Area ID	Percent of Population under 200% FPL		
	1	1400000US04001942600	0.72158439		
	1	1400000US04001942700	0.64901777		
	1	1400000US04001944000	0.62318619		
	1	1400000US04001944100	0.71354602		
	1	1400000US04001944201	0.72143975		
	0	1400000US04001945001	0.45106589		
	0	1400000US04001945002	0.62541549		
	0	1400000US04001945100	0.69286754		
	0	1400000US04001970200	0.37258348		
	0	1400000US04001970300	0.41427502		

After developing this tool, the functionality is used to insert data on Rural-Urban Commuting Area (RUCA) codes, a late addition to the project based on a request from Affirm. RUCA data is provided by the U.S. Department of Agriculture but uses the same GEO ID system employed by the U.S. Census Bureau. In carrying out this manual join validation, six errors were successfully identified and addressed. Five of these errors were the result of official GEO ID updates which occurred between the preparation dates of the USDA and U.S. Census datasets used. However, the remaining error was the result of an error in the USDA data, resulting in an incomplete GEO ID. All six errors were identified and corrected using the newly developed join validation tool.

4.2.2. Profile Scoring

A major component of this mapping project is implementing an analytical method to

visualize “hotspots” of potential service need, using data available from the ACS survey. The initial plan for this hotspot mapping was to utilize overlay analysis, a method in which maps of different variables are displayed on top of one another to visualize the areas with high values for more than one variable of interest. The most common method of overlay analysis utilizes bivariate maps, displaying two individual variables each with separate visual metrics, in such a way that areas scoring high on both axes at once are clearly visually distinguishable. While methods to introduce additional variables into this type of visualization do exist, they are not widely used, as the exponential increase in information contained in the map quickly diminishes its utility as a visual tool for communicating data.

However, there are a variety of demographic factors which inform both Title X’s official eligibility criteria and Affirm’s population within Arizona, requiring the use of multivariate mapping. A multivariate mapping approach allowed for a more specific visualization of where in Arizona this specific population may be found. To begin, a profile of factors is identified from available ACS variables. In discussion with the community partner, a short list of patient characteristics quickly emerged as the factors by which Title X and Affirm define their intended population. These factors were: age, poverty, and insurance coverage. Additional factors were also identified based on Title X populations of special interest: access to a personal vehicle and race/ethnicity. In order to create a tool with lasting value to Affirm and their delegates, it was essential to develop a way any mix of these key factors could be looked at to better understand the ways different types of barriers were distributed across different types of patient populations in Arizona.

The solution to this issue was not to abandon the overlay analysis method, but to instead find a way to simplify the variables included. This allows any number of factors to be included in

a single “score”, leaving only a single variable to be visually displayed on the map itself. Univariate maps are the most visibly legible and make it clear to distinguish points of interest. For each variable, a scoring system was implemented to assign a binary value to the geographic area, based on whether the variable of interest fell above or below a set cutoff point. These binary scores can then be easily added together to form a “profile” score, the maximum value for which will always be the number of scoring variables included. For an analysis examining geographic areas with high values for five overlay variables, the map displays color-coded profile scores of 0-5, where areas scoring a 5 are above the set cutoff value for all 5 variables overlaid. This approach allowed for a multivariate assessment of need, while visually representing data in a simpler and more legible univariate presentation.

Within the data management tool, a dashboard page was built to allow users to select which variables should be included in the profile, and the unique cutoff values for each variable, seen below in **Table 3**. **Table 4** shows the table of summary statistics included to display common values (median, mean, etc.) for each individual variable, assisting in the setting of these cutoff points. Summary counts show how many tracts fall above and below the cutoff entered.

Table 3: Variable selection and cutoff entry cells.

1. Determine Exclusion Variables and Cutoffs					
Exclusion Variables - Set cutoffs below to exclude certain areas from scoring at all. Areas below the cutoff value will NOT show up in the final Profile.					
				Counts	
	Include?	**Cutoff**		**-999**	**0**
Population Density	x	1		11	1515
Rurality (range, inclusive)	x	1	10	0	1526

2. Determine Scoring Variables and Cutoffs				
Scoring Variables - Set cutoffs below to determine your cutoffs for scoring. Areas above the cutoff will receive a score of 1, areas below will receive a score of 0.				
			Counts	
	Include?	**Cutoff**	**1**	**0**
Drive Time Distance		0	0	1526
% in Target Age	x	0.4002	763	763
% Female in Target Age		0.1959	763	763
% Insurance Coverage	x	0.0860	761	765
% Poverty (Overall)		0.1250	762	764
% Poverty (200% FPL)	x	0.3142	763	763
% no Vehicle Access	x	0.0157	763	763
% BIPOC		0.3850	764	762
% Non-English Language		0.1990	766	760

Table 4: Summary statistics preview in the data management tool. This information appears alongside variable and cutoff entry fields shown in Table 3**.**

Summary Statistics for Selected Rurality					
Rurality for Summary Stats (range, inclusive)	1	10			
	Median	**Mean**	**Min**	**Max**	**90%**
Population Density	3110.75	3726.29	0.00	26444.73	7918.84
Rurality (range, inclusive)	n/a	n/a	1	10	n/a
	Median	**Mean**	**Min**	**Max**	**90%**
Drive Time Distance	n/a	n/a	n/a	n/a	n/a
% in Target Age	0.4002	0.3850	0.0000	0.9953	0.5021
% Female in Target Age	0.1959	0.1865	0.0000	0.7755	0.2525
% Insurance Coverage	0.0860	0.1033	0.0000	0.4550	0.2050
% Poverty (Overall)	0.1250	0.1575	0.0000	0.8460	0.3330
% Poverty (200% FPL)	0.3142	0.3431	0.0000	1.0000	0.6300
% no Vehicle Access	0.0157	0.0289	0.0000	0.4178	0.0740
% BIPOC	0.3850	0.4487	0.0090	1.0000	0.8760
% Non-English Language	0.1990	0.2703	0.0000	0.9910	0.6050

4.2.3. Accounting for Rurality

Having developed the profile scoring method to simplify overlay analysis and visualize hotspots, a final obstacle was identified by Affirm: how to account for rurality. Arizona has a high degree of variation in population distribution. Rural communities tend to have unique public health challenges and barriers to access compared to urban communities, both in regard to physical environment as well as population makeup.[81] However, an approach which looks at population averages statewide can easily overlook nuances of need or disparity in rural areas, as

areas with larger populations will disproportionately impact pooled statistical analysis. Interventions prioritizing areas with the highest *counts* of target population or unfavorable outcomes will also overlook rural areas, simply because urban centers have more people and therefore higher numbers. Instead, a more nuanced look which allows us to consider rural and urban communities separately would allow for more targeted analysis.

RUCA scores provide a simple and nuanced method to account for the rurality of areas for census tract-level analysis. RUCA scores are assigned in a range of 1-10, also allowing a high degree of control in selecting how areas are divided within a sub-group analysis.[76] RUCA scores are provided by the USDA data division by census tract, but not PUMAs, meaning this added capability could only be integrated into analysis at the tract level. The custom-built data validation tool was used when adding this new data to the ACS data management tool, and allowed six join errors to be quickly identified and corrected.

Rurality introduced a new challenge in the profile scoring method developed for this project – how to incorporate variables not as scoring criteria, but as exclusion criteria. In order for a profile to be run for specific RUCA scores or population densities, a method had to be developed to allow a user to select for and apply exclusion criteria alongside the profile scoring step.

Selection of exclusion variables for and definition of cutoff values for each was added using the same format as implemented for scoring variables. With this addition, users have one additional step when setting up a profile to run overlay analysis. Before going through the process of selecting their scoring variables, a user has the option to select population density and/or rurality as exclusion variables. Population density has a single cutoff, similar to scoring variables. For rurality, there are two cells to enter an inclusive RUCA score range. This allows

users to run any continuous range of RUCA scores, down to just a single value. Geographic areas meeting the established criteria for exclusion variables will receive a neutral score of zero. Areas *not* meeting the identified criteria will receive a penalty score of -99, effectively removing them from the profile scoring system, regardless of values for any selected scoring variables. The entry fields for this new exclusion variable can be seen in **Table 3**.

This rurality metric was also integrated into the summary statistic tool. The existing summary statistics table was updated using conditional array formulas, and a new section added to the dashboard area where users may enter an inclusive RUCA range to see summary statistics for only geographic areas within that identified range. This allows users running sub-analysis of selected RUCA ranges to more easily set cutoffs based on the summary statistics of the selected subgroup of areas. For example, if a user is conducting an overlay analysis using median value cutoffs but wishes to include only areas with a RUCA score of 5, the tool now allows each variable cutoff to be set as the median value of all areas where the RUCA score is equal to 5.

This added capability allows regional pockets of need to be assessed relative to their rurality, rather than relying on state-level cutoff values which may “drown out” rural hotspots. To demonstrate this, a sample profile was run assessing overlay scores of age, poverty level, insurance statues, and access to a vehicle. Scoring variables used median values for all areas state-wide, with the only exclusion criteria set for areas with a population density less than 1 person per square mile. This profile included 1515 areas, with 325 areas scoring 4 out of 4 above the established cutoffs. When the analysis was run again, with separate group-specific scoring and cutoffs for areas of RUCA score 1-6 and areas of RUCA score 7-10, the distribution of scores included 10 additional areas with 4 out of 4. The exact change in distributions for these two profiles is outlined in **Table 5** below.

Table 5: Score distribution with and without RUCA sub-groups

Score	Census Tracts Receiving Each Score Through One-Step Analysis (State-Level Cutoffs)	Census Tracts Receiving Each Score Through Two-Step Analysis (Regional Cutoffs)	Change in Score Distribution
4	325	335	10
3	283	273	-10
2	287	284	-3
1	317	308	-9
0	303	315	12
<0 (Excluded)	11	11	0

This method of scoring areas in sub-groups based on rurality had the effect of redistributing some middle scores to higher or lower values. In the combined analysis, an additional 10 areas received a score of 4 out of 4 as compared to the single-group scoring method, indicating 10 areas of potential elevated need for services when using rurality-based scoring that would have received lower scores under state median cutoffs. Additionally, 12 areas that would have received a score of 1-3 when using state medians now receive a score of 0 when compared only to areas of like rurality. There was no change in areas excluded based on population density, as the cutoff value for this metric was the same for both approaches.

4.2.4. Sample Profile

Sample analysis provided to Affirm utilized median values for each variable as scoring cutoffs, meaning areas with a value above the group median for a selected variable would receive a score of 1 for that variable category. The sample profile provided to Affirm included the following four scoring variables: percent of the population between ages 15-44 years, percent of the population without insurance coverage, percent of the population below 200% FPL, and percent of the population without access to a personal vehicle.

Following the sample sub-group analysis method outlined previously, RUCA scores were used to divide geographic areas into two sub-groups. Each sub-group was scored independently based on its own group-specific set of median cutoff values. This approach allowed more urban and more rural areas to each be scored based on the median values of their like areas, rather than relying on a single state-wide cutoff value to score all areas regardless of rurality. Sub-groups were defined based on like ranges of RUCA scores, with groups divided between 1-6 (Urban Core, Suburban and Large Urban) in Group 1, and 7-10 (Small Town and Rural) in Group 2.[82] Median values used as scoring cutoffs for each of these sub-groups and selected variables can be found in **Table 6**.

Table 6: Scoring variable median cutoff values for RUCA code sub-groups

Variable	RUCA Group 1 (Urban) Cutoff Values	RUCA Group 2 (Rural) Cutoff Values
Population Density Cutoff	1 person/mi^2	1 person/mi^2
RUCA Range	1-6	7-10
% Population 15-44	0.4034	0.3670
% Population Uninsured	0.0840	0.1150
% Population <200% FPL	0.3072	0.4396
% Population without vehicle access	0.0157	0.0175

Table 7: Final score distribution of RUCA code sub-groups

Score	RUCA Group 1 (1-6)	RUCA Group 2 (7-10)	Final Combined Profile
4	313	22	335
3	254	19	273
2	263	21	284
1	288	20	308
0	297	18	315
Total Included	1415	100	1515
Total Excluded	111	1426	11

Table 7 shows the final scoring distribution for this sub-group analysis, along with the final combined scores for the sample profile. The final profile included 335 areas which scored 4 out of 4 for the selected variables, indicating areas of potential increased need for publicly-funded reproductive health services and candidates for targeted follow-up and community engagement.

4.2.5. PUMA Data Management Tool

The above development process was initially conducted using ACS data at the census tract level. Having developed a functional tool for this data set, a duplicate tool with slight adaptations was then made for handling PUMA data. PUMA data differs from U.S. Census tract data in a small number of key details. First, because PUMAs are generally larger than census tracts, there is a smaller number of PUMAs than tracts in Arizona. This meant an overall smaller data set, and associated adjustments to formulae throughout the tool. In terms of variable inputs, all variables included in the census tract tool were included in the PUMA tool except for RUCA scores. RUCA scores are not available for PUMAs, so this column and the special functionality for adjusting by RUCA score was removed during creation of the PUMA tool.

4.3. GIS Data Mapping

Having developed the data management tool and protocol for its use, data was then able to be visualized in the maps themselves. Map products were developed in ArcGIS Pro, using vector tile basemap layers from the Esri Human Geography Map. This basemap was selected primarily for its uncluttered visual style, monochromatic color scheme, and inclusion of roads and neighborhoods. All map layers were standardized to the Global Coordinate System North American Datum of 1983 (GCS NAD83), the standard coordinate system adopted by the U.S. Census Bureau.[83]

4.3.1. Calculation of Drive Time Trade Areas

An important feature for the map project, as identified by Affirm, was related to their attempt to visualize the abstract concept of "reach". This was accomplished through the use of drive time trade areas. The Drive Time Trade Area tool is a feature included in the ArcGIS Pro Business Analytics package, and utilizes point data and road data to estimate all areas around a defined point within a set travel criteria.[84] This tool can be used to estimate areas using time or distance inputs, and simulates travel along established roads to determine the geographic area around a point accessible within the selected travel criteria. Drive time trade areas were calculated separately for each category of provider network, with travel times at 15 and 30 minutes. Analysis utilized a Rural Drive Time calculation, which includes travel on unpaved roads in rural areas.

4.3.2. Symbology and Visual Design

In utilizing maps as a tool for visual communication, design decisions play an important part in determining the usability of the map and whether it successfully and clearly communicates its message to the intended audience. This process includes decisions regarding

color, shapes, and selecting combinations of data to display together at one time.

Visual density refers to the amount of information being displayed at a given time. High visual density presents a large amount of information at once, but at the expense of clarity and legibility. The first area where this concept became relevant was in the data for provider locations. At its simplest, this information could have been visualized in a single data layer as uniform markers on the map. However, at Affirm's request, the map had to include locations of providers of several types (Title X providers, other types of publicly-supported reproductive health providers, and school-based providers not specializing in reproductive health) and multiple delivery settings (traditional brick-and-mortar locations, mobile clinics, and school-based health centers). Each provider type was also associated with two layers calculated drive-time areas as described above. Altogether, careful decisions regarding the visual design and organization of these layers were required to keep these layers clear and distinct.

The first decision concerned use of colors and shapes. Provider types were represented by color, which also allowed drive-time areas to be visually coded with the relevant point locations using matching hues. Variations by delivery setting were indicated by varying symbol shape, using a round point for traditional clinical settings, triangles for mobile clinics, and square for school-based health centers. For sites which were both mobile and school-based, their status as a mobile unit was prioritized in the iconography.

Another challenge that arose during the design phase was how to best design for visual accessibility. In visual design, it is considered best practice to avoid communicating information purely through color variation, as this can be illegible to individuals with colorblindness.[85,86] Instead, designers often pair color indicators with a secondary visual element (text, symbols, etc.). Unfortunately, the visual density included in the final map product made this impossible.

Variation of both symbol shape *and* color were required to represent provider type and delivery setting side-by-side. In order to maintain a high degree of visual accessibility, additional research was done on adapted color palettes to maximize accessibility for the most common forms of color blindness. While this compromise does not rule out all legibility barriers for colorblind users, it does seek to minimize those barriers as much as possible. The selected color palette was developed by the IBM Design Lab, and has been optimized for the three most common forms of colorblindness while also maximizing overall contrast for users with other types of visual impairment.[87]

Finally, layers were prioritized according to the relevance of each provider network to Affirm's mission. Each individual provider type may be viewed individually to provide an unobstructed view. However, if multiple layers are viewed at once, the layer order must be accounted for in the design of the map. Data layer order was chosen based on specificity and relevance to the target audience. First, layers representing more specific classifications take precedence over more general ones, so Affirm provider markers appear above markers for all publicly-supported reproductive health providers. Second, less relevant data layers such as the locations of school-based providers were placed lower in the layer order. This data may be useful in limited cases, but is not the central data the map was designed to emphasize. In the final map, overlapping data is shown in the following order, from top to bottom:

1. Affirm Title X providers
2. Non-Affirm Title X providers (outside Arizona but within 100 miles of the state border)
3. All publicly-supported reproductive health providers
4. School-based providers not specializing in reproductive health

   In this case, a school-based provider which also qualifies as a publicly-supported

reproductive health provider *and* receives Title X funding through Affirm will show up in the color scheme of the top layer (Affirm Title X providers). The provider qualifies as all three of these categories, but the most relevant to this user audience is its status as an Affirm grantee. Drive-time areas were layered in a similar order, meaning the drive-time areas for Affirm's network appears on top of all other types of drive-time area, and so on.

4.3.3. Exporting Maps for Community Partner Use

In order for GIS map products to be available and fully interactive for Affirm's ongoing use, final map products were integrated with their existing Tableau dashboard. While a simple output would provide a static image with fixed scope and visual data included, dashboard interaction preserves the capability to zoom where desired and turn layers on and off to view only what is needed. Long-term, this extends the useful lifespan of the resource and the partner's ability to use it flexibly for future projects.

An initial meeting was held with Affirm's Tableau designer to share the scope of the map project and explore the capabilities of the Tableau system. Bridging the gap between ArcGIS expertise and Tableau expertise allowed a more detailed follow-up correspondence regarding specific file types and data organization to facilitate layer import and design in the new platform. A data dictionary was also prepared to organize information on file names, formats, and design notes for each map layer.

Once assembled, all data tables and associated shapefiles were provided in zip format to the Tableau team. After construction of an initial map build in the dashboard system, another meeting was held to review the Tableau map tool's design and functionality. Future updates will be able to utilize this same workflow as needed.

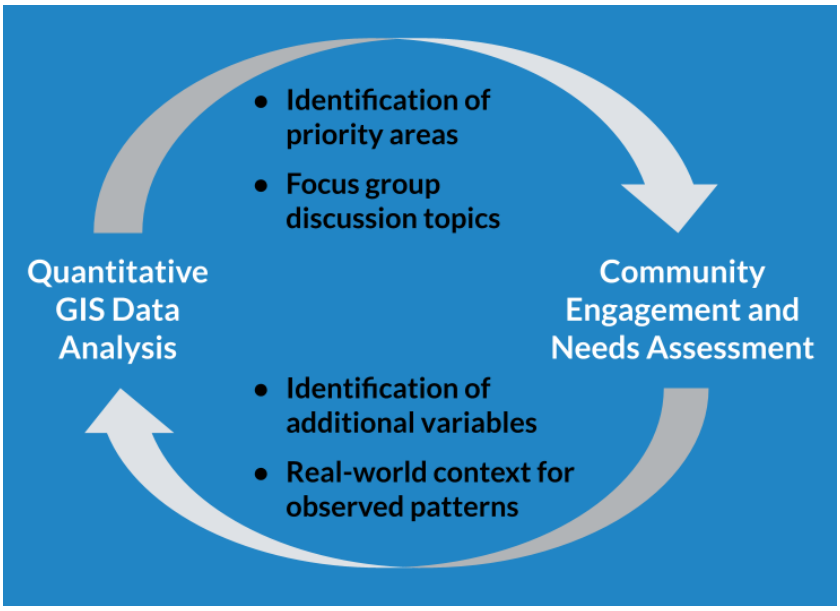
4.4. Integration with Community Needs Assessment

This project actively engages in current Affirm initiatives to explore and explain community needs, while also developing tools and organizational capacity to predict or model data trends in the future as this work continues. To address Specific Aim 3, deliverables were developed in close collaboration with the team responsible for Affirm's community needs assessment and engagement activities. During the initial project design, Affirm was conducting a search for a contract community engagement partner, specifically seeking out an organization with experience and existing connections in Arizona's black, Indigenous and people of color (BIPOC) communities. These initial decisions sketched out the potential ways the dissertation project could dovetail with community engagement efforts but left specific plans deliberately open for further discussion once a specific partner was identified and contracted for the work.

In March 2022, Affirm formally contracted with Collective Equity Partners (CEP) to conduct the community needs assessment and plan follow-up community engagement activities for the 2022-2027 Title X award period. A comprehensive overview of the project structure, methods, and specific aims was provided during an initial meeting with CEP. The intent of this meeting was to orient this new group to the existing work, and to collaboratively explore opportunities for this dissertation project to both be informed by the proposed community engagement project, and to produce specific deliverables which could support that work. **Figure 1** below was originally presented during the dissertation proposal defense and was used during this introductory meeting to guide discussion and brainstorm around additional ways these programs could be mutually supportive. This graphic illustrates the proposed feedback loop through which GIS map analysis and community engagement activities can reinforce one another moving forward. This discussion also included an overview of the ACS dataset to illustrate other

types of data that may be available.

Figure 1: Proposed model for synergy between dissertation project and community engagement activities



The introductory meeting ended with two specific action items. First, CEP was asked for feedback on the variables to be included in the final GIS map tool. Second, CEP was asked for any specific map visualizations or products which could benefit their project planning, community outreach, or focus group activities. These would be developed alongside the deliverable outlining suggested implementation and best practices for including GIS tools in their community engagement process.

The initial variables selected were determined by the Title X target population, factors of interest to Affirm, and known barriers to access of reproductive health services as established in the literature (insurance coverage, access to a vehicle). After an initial review of the variable list, CEP requested the addition of two additional variables relevant to their community needs

assessment goals: the percent of the population that are black, indigenous, and people of color (BIPOC), and the percent of households speaking a language other than English.

The primary GIS map deliverable requested by CEP was an ability to see univariate maps for individual variables. The request was met by the author. While waiting for Affirm's Tableau team to build out the interactive map tool, CEP also requested specific map products which could guide their project planning. These included a state-wide map overlaying Affirm provider locations with the BIPOC population data, and county-specific visualizations overlaying high-need areas with current provider locations. The provision of these deliverables allowed GIS products to be integrated into the earliest stages of CEP's planning while the final, fully interactive tool was still under development.

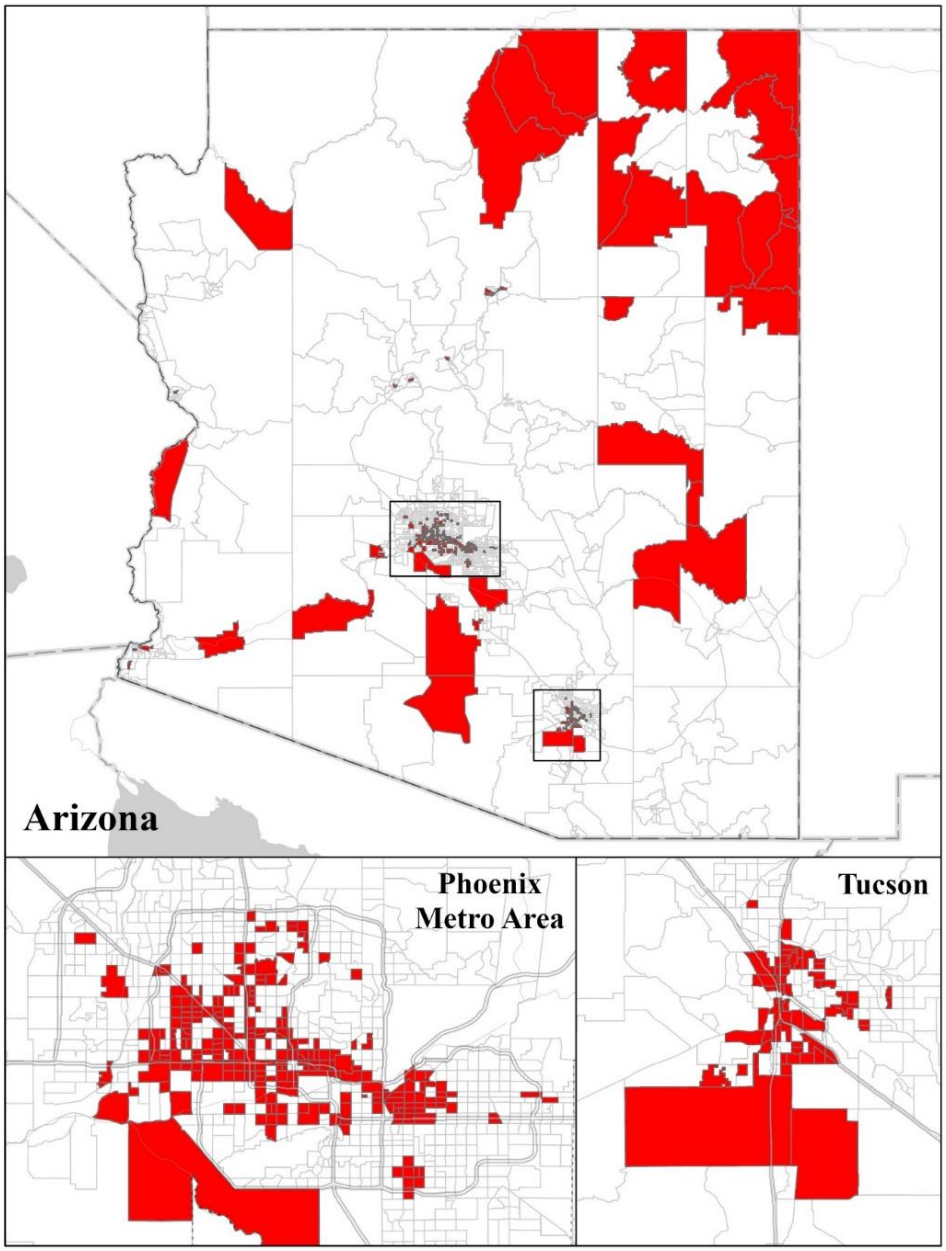
Having incorporated this feedback and incorporated additional variables into the data management tools and GIS map products, the final deliverable provided to CEP was a document outlining suggested additions to the proposed community needs assessment implementation plan, in order to integrate newly developed GIS tools into the needs assessment wherever appropriate. The GIS map deliverable illustrates areas where the need for publicly-funded reproductive health services *may* be the greatest, and also allows for comparison between these high-need areas and the service coverage of a reproductive health provider network (Title X, other publicly-supported providers, etc.). The intent of these products is not to mandate specific conclusions or next steps, but to provide data-informed guidance for Affirm's work in the community and with their delegates. Areas within the existing Title X footprint could guide additional outreach from current Affirm providers, while areas falling outside the current service range may be candidates for expansion of services or partnerships with other reproductive health service providers already present in the area. This document is included in **Appendix B**.

5. Results

5.1. Identified Areas of Potential Need

The example profile run using the ACS Data Mapping Tool and applied to the GIS map product identified 335 unique areas scoring above the established cutoff for all 4 selected risk factors, hereafter referred to as Areas of Potential Need (APNs). **Figure 2** below illustrates the geographic distribution of these areas throughout the state, and **Table 8** summarizes selected characteristics of all identified APNs, including their distribution across Arizona's 15 counties and the percentage of the population living in an APN.

Figure 2: Geographic areas of potential elevated need for reproductive health services



Based on the identified criteria, over half of Apache County residents live in an APN. This is over double the population share in the next two highest proportioned counties, Coconino (26.4%) and Maricopa (25.4%). There are some apparent trends in the tracts identified as APNs.

Comparing Arizona census tracts to American Indian Areas (a designation including both Federal American Indian Areas and off-reservation trust lands), 20 of the 22 rural APNs identified overlap with American Indian Areas in whole or part.

Table 8: Selected characteristics of identified Areas of Potential Need

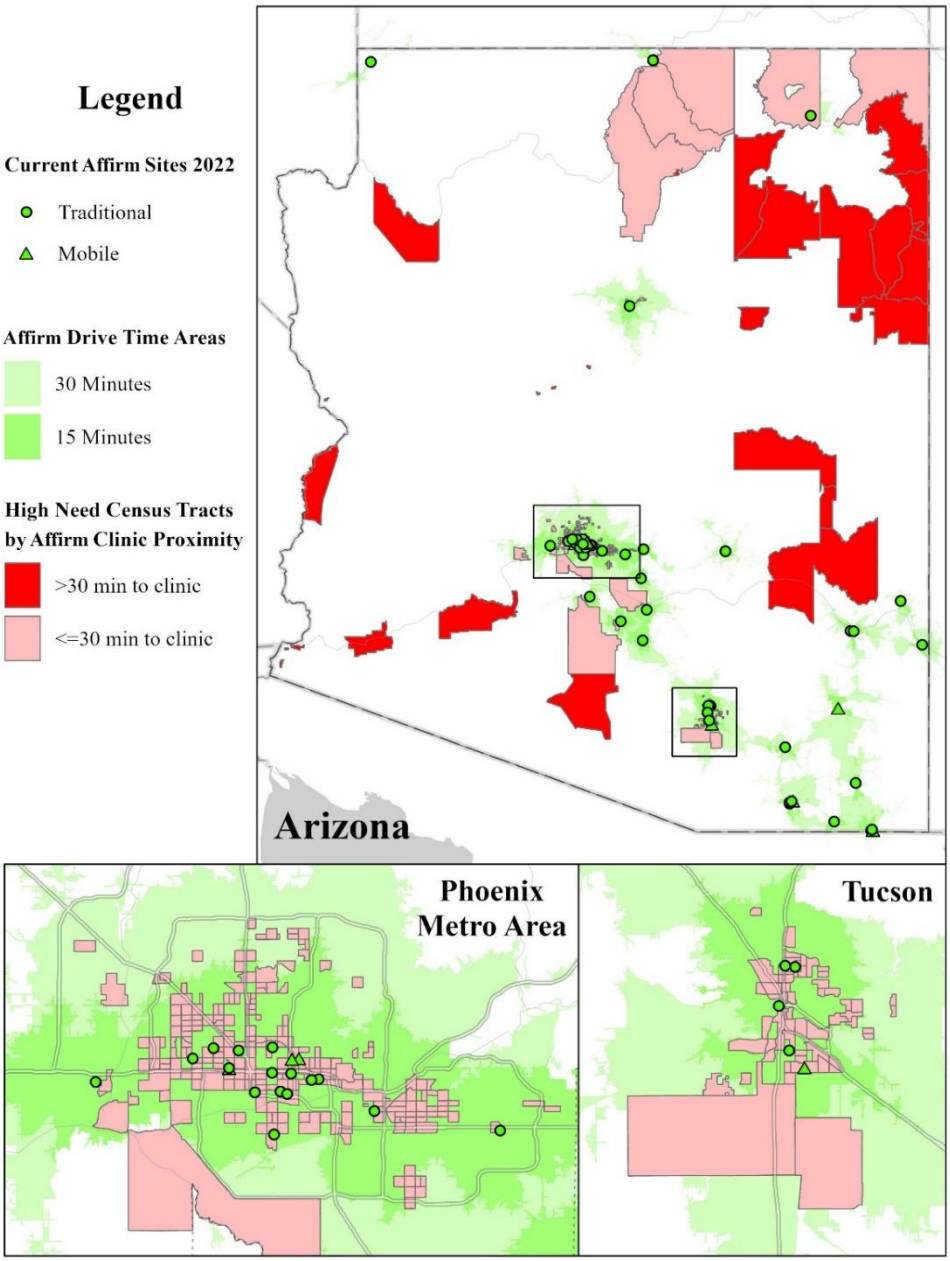
County	Total Areas of Potential Need Identified	Population Living in APNs	Total Population	% Population Living in APNs
Apache	8	37,651	71,511	52.7%
Cochise	1	2,083	125,867	1.7%
Coconino	8	37,344	141,274	26.4%
Gila	0	0	53,546	0.0%
Graham	1	4,805	37,996	12.6%
Greenlee	0	0	9,522	0.0%
La Paz	1	4,937	20,793	23.7%
Maricopa	233	1,098,823	4,328,810	25.4%
Mohave	2	7,600	207,695	3.7%
Navajo	6	22,442	109,270	20.5%
Pima	59	244,590	1,027,207	23.8%
Pinal	5	29,559	432,793	6.8%
Santa Cruz	0	0	46,480	0.0%
Yavapai	3	16,617	228,067	7.3%
Yuma	8	35,499	209,468	16.9%
AZ Totals	335	1,541,950	7,050,299	21.9%

5.2. Drive-Time Area Coverage Comparison

Of the 335 APNs identified, 305 overlap at least partially with a 30-minute drive-time area from a current Affirm-funded provider (n=52). This leaves 30 APNs located in their entirety outside of Affirm's immediate service area, defined as all geographic areas within a 30-minute drive of a grantee provider location. **Figure 3** demonstrates the locations of these areas around the state, compared to those APNs which overlap in whole or part with the 30-minute drive-time area. The range of 15-minute drive-time areas is also included in the final map product. Affirm

has discussed whether they may use this metric in select circumstances when evaluating coverage within specific urban areas near Phoenix and Tucson, where transportation issues may present differently compared to other communities around the state.

Figure 3: Map of Affirm providers and drive-time areas, overlaid with Areas of Potential Need (APNs)



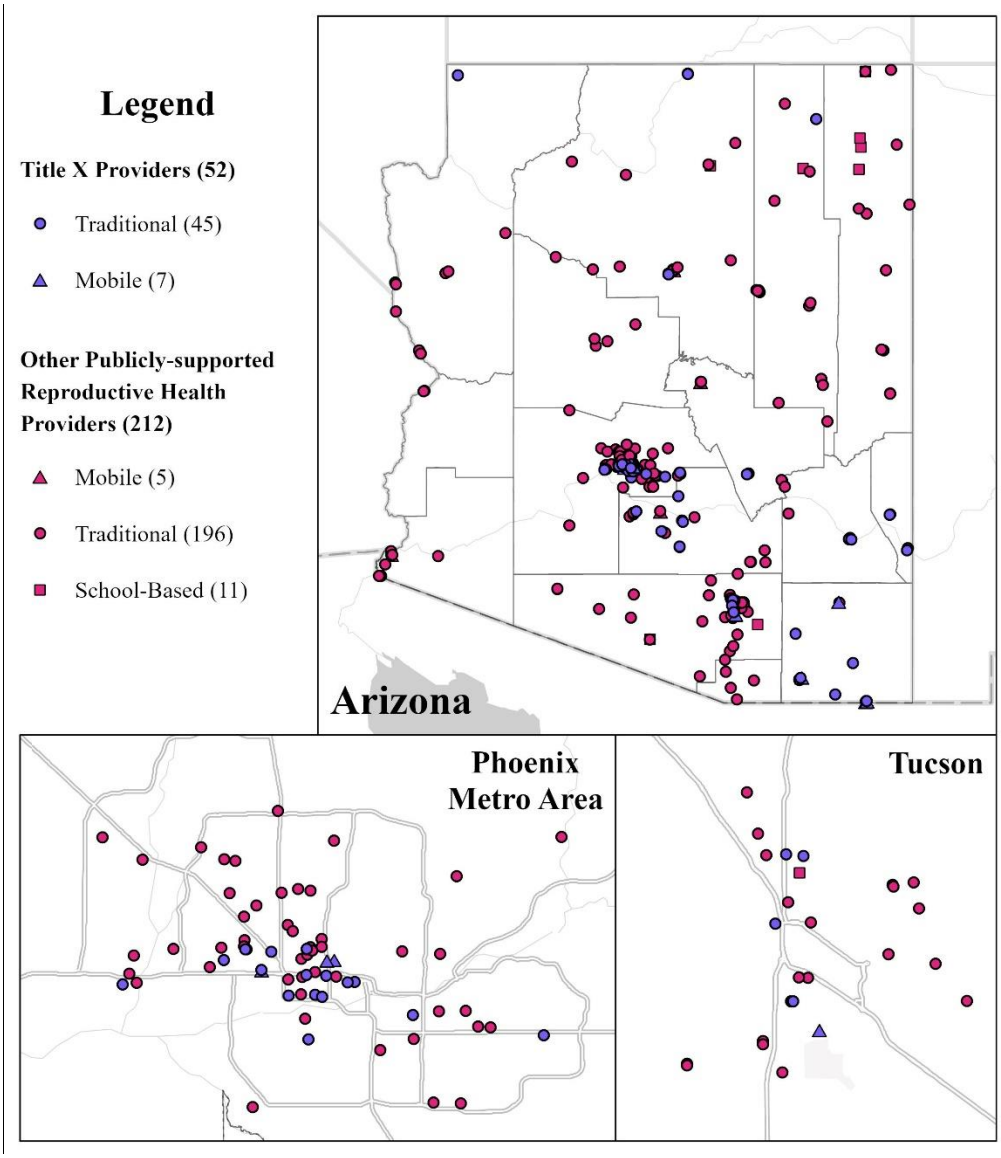
5.3. Map of Publicly-Supported Reproductive Health Providers

One accomplishment of this project initially considered a minor component was the mapping of all publicly-supported reproductive health providers and school-based health centers within Arizona or within 100 miles of the state border. While this deliverable was originally conceptualized as a stepping stone to addressing the stated specific aims, in hindsight this is an important accomplishment. Assembling this master list of Title X like-service providers required the review and combination of shared databases from the Guttmacher Institute and Bedsider Birth Control Support Network, two of the largest entities cataloguing these types of service providers across the US. This data was then further supplemented with internal delegate provider sites from Affirm, and with data on school-based health centers supplied by the School-Based Health Alliance. A breakdown of providers by county, type, and delivery setting can be found in **Table 9**. The full map of reproductive health provider locations within Arizona is shown below in **Figure 4**.

Table 9: Publicly-supported reproductive health providers within Arizona, by county, type, and delivery setting

County	Total Providers	Type		Delivery Setting		
		Title X	Other	Traditional	Mobile Clinics	School-Based
Apache	16	-	16	11	-	5
Cochise	15	12	3	11	4	-
Coconino	19	3	16	16	1	2
Gila	7	1	6	6	1	-
Graham	6	2	4	6	-	-
Greenlee	4	2	2	4	-	-
La Paz	2	-	2	2	-	-
Maricopa	74	19	55	71	3	-
Mohave	9	1	9	9	-	-
Navajo	16	1	16	15	-	1
Pima	44	5	39	40	1	3
Pinal	30	6	24	29	1	-
Santa Cruz	4	-	4	4	-	-
Yavapai	6	-	6	6	-	-
Yuma	10	-	10	9	1	-
AZ Totals	264	52	212	239	12	11

Figure 4: Map of publicly-supported reproductive health providers within Arizona, by type and delivery setting



Having aggregated the data from all of these sources, we feel confident that this is the most comprehensive and up to date database of publicly supported reproductive health providers and school-based health centers in Arizona and the surrounding region currently in existence. While the landscape of service providers and funding sources is constantly shifting, this database

provides the most current snapshot possible for Affirm and its delegates to visualize the landscape of service providers and coverage areas.

This network data could be used to assess the existence or absence of like services in an area Affirm or their delegates are considering expanding to, to engage important stakeholders already present in a specific service area for future collaboration, or to identify potential new delegates to bring into the Title X network.

DISCUSSION

1. Implications for Public Health Practice

The primary goal of this project was to develop a series of tools to benefit Affirm in their ongoing work to serve Arizona. However, the findings of this project also present novel results with potential relevance to current public health discourse regarding Arizona's Maternal and Child Health outcomes and access to services. Namely, results regarding identified APNs and reproductive health service area coverage have implications regarding Arizona's maternal and child health outcomes.

1.1. American Indian Areas and MCH Indicators

The finding that rural APNs overlap with American Indian Areas is consistent with other findings indicating disparities in health outcomes for Arizona's Native American population. Arizona's 2020 Title V Maternal Child Health Needs Assessment reported large disparities in both Severe Maternal Morbidity (SMM) and Maternal Mortality for American Indian and Alaska Native women.[88] SMM rates for this group were nearly 3.6x larger than that of White women (292.6 per 10,000 delivery hospitalizations, compared to 82.1 per 10,000), while Maternal Mortality was 4x higher (70.8 deaths per 100,000 live births, compared to 17.4 per 100,000 for White women).

Geographically, SMM was also highest in Apache County (273.8 per 10,000 hospitalizations) compared to the lowest county rate in Pinal County (98.6 per 10,000). This is consistent with county trends for the population living within an identified APN, which was highest in Apache County (52.7%). These trends in maternal mortality and severe maternal morbidity may be due in part to restricted access to reproductive health care. Title X providers offer services such as preconception health, pregnancy testing and counseling, and testing and

treatment for sexually transmitted infections (STIs). Additionally, Title X clinics provide referrals and hand-offs to other types of providers, such as OBGYNs for the purposes of continued prenatal care following a positive pregnancy test. Examining accessibility of reproductive health services in American Indian Areas and rural APNs may aid in addressing these disparities and improving maternal health outcomes.

However, it is important to note that the area of each census tract is loosely standardized based on population, leading to geographically larger tracts in rural areas. Additionally, the fact that a given tract is identified as an APN does not indicate that the entire tract population is high need, or that the same individuals within that tract are experiencing each risk factor. Thinking back to the original purpose of this analysis, the indication is that these APN communities identified in Apache County or rural Federal American Indian Areas should be prioritized for additional community engagement and needs assessment. The intent is not to assume that overlay analysis tells the whole story, but targets follow-up activities to better understand *why* these trends are present and what they represent. Additional methods of inquiry could utilize other geographic units, such as Tribal Census Tracts, to examine trends in more detail and verify if associations are statistically significant.[89]

Additionally, the cluster of large rural areas in the northeast corner of the state scoring as APNs may lead to other methods of provider recruitment or service delivery should Affirm conclude their current approach is not adequately serving these areas in proportion to this identified need. Specific emphasis should also be given to other health systems outside of Title X active in American Indian Areas, such as Indian Health Services, to determine the degree of accessibility for specific reproductive health services in these regions.

1.2. Comparison of Drive-Time Areas and Service Area Coverage

Analysis of current Title X provider sites and associated drive-time areas reveals several APNs throughout the state which fall outside of the coverage area for Affirm's current network. These gaps in coverage may be further exacerbated by actual barriers to patient mobility, considering the high end of the calculated drive-time area range was 30 minutes one-way. More conservative criteria for accessible drive-time distance would exclude several APNs which currently appear to be partially or completely within the effective service range. Depending on community perceptions of how distance and travel time affect accessibility, this may indicate a much higher number of tracts which fall outside of a reasonable service area.

Additional assessment and patient perspectives are needed to refine the service area model for future analyses. Just as a high-profile score does not indicate that the need for reproductive health services in an area is objectively higher, the fact that some areas fall inside or outside of Affirm's service range does not objectively qualify them as higher or lower priority areas for service expansion around the state. However, this type of visualization is useful in assessing how the current distribution of service providers and coverage areas compares to the areas where Affirm's target and priority populations currently live.

Finally, while the current model considers all non-Title X providers of publicly supported reproductive health services equally, additional work can be done to examine differences in provider types, fee structures, and services offered. Areas which currently fall outside of Affirm's service area, but appear to be within the service area of another like-service provider, may not actually have access to the full spectrum of Title X reproductive health services. Given the number of providers identified in the data set, this type of follow-up assessment is best considered on a case-by-case basis with specific areas of interest in mind.

2. Deliverables and Specific Aims

All established research aims were satisfied by the completion of project deliverables. A review of each specific aim and the relevant deliverables for each is below:

Research Aim 1

With Affirm, develop an interactive data map using ArcGIS to visualize reproductive health providers and coverage areas against population density, poverty status, insurance coverage, race/ethnicity, age, and access to transportation by census tract and PUMA.

Research Aim 1 was satisfied by the creation and final delivery of GIS map components to the community partner. Maps include both the variable layers initially identified based on Title X priorities, as well as additional factors requested by the community engagement team to support their work (BIPOC populations, non-English language spoken). Shapefiles were provided for all layers, along with a detailed data dictionary specifying design elements such as symbology and layer order for eventual upload to Affirm's Tableau dashboard.

Research Aim 2

Develop a user-friendly data organization tool in Microsoft Excel for analysis of ACS data, to facilitate Affirm's creation of future data maps and to direct the ongoing utilization of these maps as a tool to inform future expansion of the Title X provider network, community engagement efforts, and future assessment of service utilization and accessibility.

Research Aim 2 was satisfied with the completion of a data management tool, specially formatted for use with U.S. Census ACS data in its native format. This tool includes user-friendly guides and a simplified user interface to maximize accessibility for future users to update data and pull reports without the need for specialized training or software expertise outside of basic familiarity with Excel.

Research Aim 3

With Affirm, develop a community needs assessment implementation plan which integrates the use of Geographic Information System (GIS) maps alongside an evidence-based qualitative research tool, to prioritize high-need communities for engagement, and to verify trends in map data based on the lived experience of patients.

Research Aim 3 was satisfied through close collaboration with Community Equity Partners, which informed both the design of the map deliverables as well as their community engagement activities. Deliverables for this aim include both the GIS map deliverable, which includes variables to be utilized during the community needs assessment process, as well as document outlining recommendations for how CEP can implement map tools as part of their ongoing work. This document is included in **Appendix B**.

3. Project Limitations

The design of this project sought to proactively identify and account for limitations in the various tools and techniques being used. GIS results and identified APNs are used to inform further assessment and community engagement efforts, rather than forming the basis of organizational decisions on their own. These considerations were made in part due to the following limitations.

ACS 5-year estimates are taken from self-reported survey data completed by only a small sample of the total population.[71] Survey results are then extrapolated to the total population. This approach is useful for providing annual updates between each 10-year Population and Housing Census, however doing so impacts the reliability of the data. Populations grow and shift over time, and despite best practices in sampling and methods to maximize participation, extrapolated data is inherently less accurate due to the assumptions made during the process. This limitation is formally recognized by the U.S. Census Bureau, and an annual report is published alongside each new dataset to document the sampling and collection process for the current year's data and any concerns impacting accuracy.[90]

The use of multi-year estimates also introduces an additional layer of projection which may compromise data accuracy. Five-year estimates have both advantages and disadvantages over the single-year numbers. On one hand, data from all 5 years in a given period allows ACS to include all responses from the entire period, and also account for changes year-to-year.[90] At the same time, these estimates present an even further level of abstraction. Finally, it is worth noting that these methods work best on large geographic areas, both with larger populations and more room for error. When assessing ACS data at the tract level, patterns within population-dense areas such as downtown Phoenix vary block-by-block, a level of specificity impossible to verify given then nature of the dataset.[91] Instead, this project focuses on ACS data as a tool to identify potential high-need areas or points of interest, but then leverages this information to target resources for more in-depth needs assessment at the community level.

The size of urban census tracts is prohibitively small, but an opposite trend in rural areas raises issues as well. Census tracts are standardized based on population and geography.[92] First, tracts are defined along "visible and identifiable features" such as county and state borders,

major roads, and geographic features such as rivers. Second, tracts are then standardized based on population size. All tracts have an estimated population between 1,200 and 8,000 people, optimally as close to 4,000 as possible.[92] Due to the large variability in population density across Arizona, this leads to rural census tracts which are much larger than those in urban areas. Arizona tracts range in land area from just 0.13 square miles to just over 5,000, an incredible difference when utilizing individual tracts to visualize need and target services to specific areas.[91] This is another limitation which is addressed by the integration of this project with ongoing community needs assessment, as discussion with community stakeholders in these areas could help pinpoint if need does indeed exist, how this need may be distributed within this large area, and where additional services could be based to maximize impact.

The profile scoring method utilized is useful for identifying geographic areas in which all factors of interest are above a defined limit. However, this approach cannot determine if all factors are present within the same segments of that population (i.e., if 10% of the population is uninsured and 10% is within the Title X target age range, this analysis cannot confirm the degree of overlap between those sub-populations). For this reason, PUMAs were integrated into the tool to enable future projects to look further into associations between risk factors in these communities.[92] Unlike census tracts, PUMAs are large enough to enable the Census Bureau to release de-identified individual-level data. While outside the scope of this project, the inclusion of PUMAs in the data management tool and final map products will provide Affirm with the capability to further explore this line of inquiry in the future, if they choose to do so.

Finally, the data for different types of reproductive health providers may be incomplete or inaccurate. Clinic data provided by Affirm regarding their own network is assumed to be comprehensive and correct, given the importance of accurate provider records to Affirm’s work

and the relatively small number of funded delegate providers. Furthermore, the small size of this dataset allowed for manual verification for each point on the map to ensure that the geocoding process placed these providers in the correct location, down to the specific address and building. However, the much larger data sets provided by Bedsider and the Guttmacher Institute required significant review and cleanup before being usable. While both data sets were intended to be comprehensive, there were also significant portions of the two sets which did not overlap, implying a degree of incompleteness for both clinic lists. Bedsider and Guttmacher rely on provider networks and public health agencies to report provider location data. Furthermore, the national scope of both organizations means they are receiving data from across the US, limiting their ability to verify data or provide quality control for accuracy or proper formatting. With this in mind, the data set of publicly-supported reproductive health providers created from these two lists must be assumed to have a number of omissions and errors. Rather than treat this as a comprehensive and definitive listing set in stone, it can instead be viewed as the *most* accurate picture of Arizona's low-cost reproductive health service network currently available at the time of its creation. Future community needs assessment or strategic planning making use of this data layer should verify other providers in a targeted region before making organizational decisions based on these details.

4. Recommendations for Community Partner

On January 9, 2023, newly elected Arizona Governor Katie Hobbs gave her inaugural State of the State address.[93] Of the topics covered by the Governor, one major emphasis was the importance of reproductive justice and access to care, culminating in a pledge to establish a state match for Title X funding. This match, combined with existing federal Title X award, will bring Arizona's total funding to over $12 million per year.

It is timely that this announcement should come at the culmination of this dissertation project, originally conceived in 2021, and focused on data-informed expansion of Arizona's Title X network to serve our highest-need communities. With this window of opportunity in mind, the following recommendations have been made to Affirm regarding best practices in utilizing these newly developed tools:

4.1. Recommendations for Affirm Executive Leadership

4.1.1. Provider Network Analysis

The newly curated database of publicly-funded reproductive health providers gives Affirm a comprehensive snapshot of Arizona's reproductive health safety net system. This tool can be used in multiple ways to inform expansion of Affirm's Title X delegate network. First, gaps in the current Title X network can be identified as potential areas for expansion, especially those which fall outside the Title X drive-time area but within an identified APN. Publicly-supported providers already identified within these priority areas can be strategically approached, either as collaborators or for recruitment into the Title X network.

In areas outside the drive time area for any reproductive health provider network, Affirm may work with current delegates to explore opportunities for expansion of traditional or mobile service sites. Following the example of the KOEP Solar Siting Potential in Kentucky platform, a similar assessment of potential locations could be easily completed to guide follow-up discussion and provider recruitment. New map layers considering additional criteria could be used to create a map of high potential locations for mobile clinics, following the same model implemented by KOEP.[47,48]

4.1.2. Data-informed service delivery to targeted demographics

The GIS map tool can be used to assess specific areas of interest throughout the state, whether

they are currently unserved by Title X or within current drive time areas. Through its integration with Affirm's Tableau system, map layers for single variables can be selected individually. A full table of descriptive statistics for a single census tract or PUMA can also be displayed. With this capacity, Affirm can work with delegates to better understand population trends in the communities surrounding existing or new service delivery sites. This information can be combined with other sources of community needs assessment and patient feedback to provide tailored services for each site based on the needs of the existing patient population. For example, providers in highly Spanish-speaking areas may benefit more from added resources or support for Spanish language speakers. Age demographics can also be compared to current patient population statistics, informing delegates of how well their populations served reflects the surrounding community.

4.1.3. Utilize Maps in Stakeholder Communication

As reported by Affirm's leadership team, the major stakeholder groups of concern are both internal (delegate agencies funded as part of the Title X network) and external (community leaders, partner agencies, and service recipients). One identified barrier to network expansion is resistance from local and county leadership to Title X services in their area. Delegate agencies may also be resistant to expanding into new areas where they are not currently active, based on provider perceptions of where need is highest or where services are most convenient to deliver.

However, the ability to both visualize areas of potential unmet need in a community, coupled with supplemental feedback from the community needs assessment, may help provide a compelling case for Affirm when advocating for service expansion into new regions and the adoption of new service delivery methods. Similar to KOEP's utilization of their tool, Affirm may selectively share GIS map products with local leaders or partners to better illustrate areas

where services are currently being delivered, gaps in the existing network, and patterns of potential need.

4.2. Recommendations for Affirm Community Engagement Team

An additional set of recommendations was provided both to Affirm's executive leadership, as well as the project team from CEP. The following recommendations reflect the specific action steps recommended for inclusion in the final Community Needs Assessment Implementation Plan, included in **Appendix B**.

4.2.1. Use GIS tools to Target Engagement Efforts

Given the limited resources available with which to conduct a state-wide community needs assessment for Title X, GIS tools can be used to identify key areas to target outreach and engagement efforts. The map of APNs and additional univariate demographic maps can be used to identify areas where Title X populations of interest make up a larger proportion of the total population. Additionally, map layers showing network coverage for different types of reproductive health providers can be used to target communities within or without the current Title X service area in different ways.

Finally, provider location and demographic map layers can be used to identify the types of community partners and leaders to engage. For example, non-Title X reproductive health providers within a targeted area can be engaged as relevant stakeholders. For communities with higher-than-average makeup of particular racial/ethnic groups, non-English language speakers, or particular age demographics, community organizations working with these sub-populations could be identified as potential collaborators.

4.2.2. Utilize GIS during Community Forums and Focus Groups

GIS products may be used not only to target community engagement efforts, but also as

tools to guide discussion and the collection of community feedback during focus groups and listening sessions. A map view of the immediate area surrounding a community can be presented as part of the forum agenda, and used to generate discussion about the quantitative data the map presents. Lines of discussion can focus on how well the patterns of high need and access relate to community members' lived experiences, and whether participants feel there are other factors which impact the accessibility of reproductive health services in their community. A specific example of how GIS products can be integrated into a community forum can be found in the Los Angeles Countywide Parks and Recreation Needs Assessment final report.[45]

4.2.3. Crowdsource Data Collection from Community Feedback

Following community forums and focus groups, a PPGIS approach could be beneficial to create additional GIS data layers for inclusion in the existing Tableau tool. Exact data to be collected would be identified based on results of these needs assessment activities, but may include:

- Point maps of other resources relevant to reproductive health access, as identified by community participants
- Community attitudes regarding the accessibility of particular service providers, or the overall need in specific neighborhoods
- A map of results from qualitative needs assessment, based on trends in community feedback collected in different areas

PPGIS applications may take a wide variety of forms to fulfill a variety of purposes. Overall, this component of the needs assessment project should depend on the types of stories

participants tell about need and accessibility of services in their community, and which types of data would help to faithfully tell those stories.

4.3. Opportunities for Additional Research

Finally, several opportunities for additional projects have been identified to continue this work and Affirm's utilization of GIS tools to drive data-informed decision making across the organization. The author has discussed potential opportunity to continue his collaboration with Affirm on some of these efforts, while also connecting executive leadership with other public health researchers who may be interested in partnering on the below projects. Overall, both the author and community partner agree that there is potential for continued work in this area, which could benefit both Affirm's practice in the field as well as public health research. Identified follow-up project opportunities include:

- Development of additional GIS map layers, including:
    - Using the data management tool, update GIS tools to include newly released 2021 ACS 5-year estimates
    - Additional layers for select racial/ethnic groups, to aid in targeting of community engagement efforts
    - Mapping additional data to visualize transportation access and community mobility, including public transportation stops near APNs
    - Calculating new APNs for youth ages 16-24 years old, and percentage of the population not in school or working. Affirm has identified "opportunity youth", or youth matching the above criteria, as a priority population

- Epidemiological study to compare the location where patients are served to their home zip codes, in order to better understand patient commuting behavior for seeking out reproductive health services
- PUMA analysis to refine the model of what constitutes APNs, and the to identify other risk factors which designate a community as high need

5. Self-Reflection

An important component of the DrPH dissertation process is self-reflection, examining not only the end products of research but also the learning which has taken place throughout the process. The following are the key takeaways of the author at the culmination of this experience:

5.1. Balancing the Conflicting Priorities of Research and Practice

From the earliest stages, this project demonstrated the often-conflicting priorities or values between the public health researcher and practitioner. Affirm was an exceptionally supportive community partner in this work, and this project was strengthened by several years of professional history between the author and this partner. Even despite these advantages, it was challenging at times to establish a project with academic rigor and a research component that would also meaningfully support and be utilized by the community partner.

Early discussions about the potential uses of GIS data analysis focused on the realistic ability of Affirm to act on any potential results. Affirm's senior leadership detailed the financial, legal, social, and political factors influencing the organization's strategic decisions. There was concern that the deliverables of this project would be unable to reflect this nuance, providing a set of recommendations with strong theoretical foundations but ultimately without any practical use (effectively a real-world spherical cow).

What was at first intended to be a short discussion of potential collaboration opportunities became a more drawn-out process. Through a series of less formal meetings, the author and Affirm staff were able to have frank discussions about the uses and limitations of GIS tools, and which types of deliverables would actually benefit Affirm's current priorities. The author contributed some initial map components to Affirm's 2022 Title X application, which helped to develop these ideas and identify other opportunity areas not immediately apparent in initial discussion.

While this process required more time and effort, what it produced was a meaningful foundation of mutual understanding and collaborative communication. Ideally, meaningful integration of research and practice must be driven by practice-informed researchers *and* research-informed practitioners. Buy-in and understanding of the process from both sides creates engaged stakeholders who understand the process from both angles, what it must achieve, and best practices that must be followed from both sectors.

5.2. New Process Development is Iterative

Having spent time hammering out the *what* of this project, the next considerable obstacle lay in clarifying the details of *how*. What initially appeared to be an analysis project quickly revealed itself to be more a challenge of design and process development. The analytical portions of this dissertation were relatively straightforward – even the novel approach to multifactor overlay analysis is simple in nature. However, the development of tools which integrated well with the practices and norms of an existing organization, the challenge of designing a functional tool with the resources available, and the question of training and support were all steps requiring considerable trial and error.

Ultimately, the solutions were iterative change and regular communication. Throughout

this process, key team members from Affirm have been available for weekly or biweekly meetings to look over the tools, ask questions about what they saw, and give feedback on what did and did not work well from their perspective. This also ensured that the usability of tools was not being determined solely by their creator, but also with direct feedback from the intended user.

This lesson has broad implications, not only in the context of partnerships but also in regard to initiatives serving the community at large. The scope of public health challenges makes instant success incredibly unlikely in even seemingly straightforward scenarios. Interventions should not only be theoretically sound, but must be designed and delivered in a way that reflects community need and preferences. Ultimately, this is best accomplished by emphasizing evaluation and process improvement plans in project designs from the very beginning, and considering these improvement steps as important parts of the project timeline.

5.3. Public Health Policy and Shifting Windows of Opportunity

The period during which this project was implemented has been marked by a series of unprecedented upheaval in Arizona's reproductive health landscape. First, the overturn of *Roe v. Wade* had an immediate but unclear effect on abortion access across the United States. Here in Arizona, this decision was followed by a series of legal challenges regarding the legal status for several reproductive health services under existing state and territorial law, including not only abortion but most forms of contraception as well. Finally, 2023 has begun with a new commitment from the Governor to invest state funds toward improving reach and accessibility.

Within the context of a dissertation project, this degree of upheaval during the completion of a multi-year project was distressing, but also presented new opportunities for how this work could be utilized. While legal challenges were ongoing and the legal landscape within Arizona

uncertain, Affirm was able to factor GIS tools into discussions about how responses may be coordinated within the network and to the general public. The inclusion of reproductive health providers within 100 miles of the Arizona border, while initially a minor emphasis of the project, suddenly presented a much stronger potential use case.

Under Complexity Leadership Theory, this type of unpredictable change in context and opportunity is considered typical and expected.[61] Rather than remain tied to the original goals set at the outset of a project or planning period, leaders can continue to monitor and weigh circumstances and organizational needs to constantly readjust and reevaluate their plans. While this philosophy may be less actionable within the scope of an academic project, it is a helpful object lesson that I will carry over into my future work. We cannot always foresee the context we will work under tomorrow, or the opportunities that will present themselves, but a flexible and agile mindset can allow a public health organization to be innovative and responsive in carrying out its mission.

6. Evidence of Competencies Met

This dissertation project meets the following competencies of the DrPH in Maternal and Child Health:[94]

- Design a qualitative, quantitative, mixed methods, policy analysis or evaluation project to address a public health issue
- Explain the use and limitations of surveillance systems and national surveys in assessing, monitoring and evaluating policies and programs to address a population's health

- Propose strategies for health improvement and elimination of health inequities by organizing stakeholders, including researchers, practitioners, community leaders and other partners
- Propose strategies to promote inclusion and equity within public health programs, policies and systems
- Apply and integrate appropriate measures of MCH with behavior change theory into a study design for research study or a program evaluation.
- Demonstrate the ability to use MCH knowledge to develop and advocate for an MCH policy or program.

The GIS data mapping portion of this project was used to visualize and assess areas of service coverage and need for reproductive health services across the state. Proper use of ACS data throughout this project demonstrated an understanding of the capabilities and limitations of the data set. ACS has a large library of data manuals, and there exists an extremely large body of literature on proper use of this resource. The community engagement component of this project sought to address some of these limitations, and drew heavily from DrPH coursework topics on Community Based Participatory Research, the Health Belief Model, and fundamentals of Diversity, Equity, and Inclusion in public health. **Table 10** outlines the specific project components and dissertation sections which demonstrate evidence of each competency met.

Table 10: Project components providing evidence for DrPH competencies met as part of this dissertation project

Competency	Evidence of Satisfaction	Description
Design a qualitative, quantitative, mixed methods, policy analysis or evaluation project to address a public health issue	• Project Narrative, Section 4, Methods • GIS Map Deliverable • Implementation Plan Recommendations	The core components and deliverables of this dissertation project satisfy this competency.
Explain the use and limitations of surveillance systems and national surveys in assessing, monitoring and evaluating policies and programs to address a population's health	• Discussion, Section 2, Project Limitations • Project Narrative, Section 4.3 • Discussion, Section 4.2	The Methods section demonstrates a consideration and potential solutions for project limitations and seeks to address them in the project design. The Discussion section further outlines the limitations of ACS data and GIS tools, which inform recommendations for the Community Engagement team.
Propose strategies for health improvement and elimination of health inequities by organizing stakeholders, including researchers, practitioners, community leaders and other partners	• Project Narrative, Section 4.3, Integration with Community Needs Assessment • Discussion, Section 4.1 • Discussion, Section 4.2	Project Narrative describes collaborative work with community engagement team during project development. Final community needs assessment deliverable includes considerations for this type of collaborative approach between stakeholder groups.
Propose strategies to promote inclusion and equity within public health programs, policies and systems	• Project Narrative, Section 4.3, Integration with Community Needs Assessment • Discussion, Section 4.2	Project Narrative describes collaborative work with community engagement team to supplement the inclusion and equity efforts of their work with the GIS map deliverable.
Apply and integrate appropriate measures of MCH with behavior change theory into a study design for research study or a program evaluation.	• Project Narrative, Section 2.3, Theoretical Basis	Background section identifies primary theoretical basis and outlines how each cited theory was integrated into the project design.
Demonstrate the ability to use MCH knowledge to develop and advocate for an MCH policy or program	• Discussion, Section 4.1 • Discussion, Section 4.2	Final deliverable package provided to community partner includes high-level strategy recommendations on future use of deliverables in strategic planning, decision-making, and advocacy. Recommendations cite specific public health literature and theory.

APPENDICES

Appendix A – Data Management Tool and User Manual Summary

A data management tool was developed in order to enable Affirm to run their own APN analyses and create custom maps. The user manual was integrated into the tool itself, for the purposes of user-friendliness and to ensure proper use of the tool. The combined data management tool and user manual contain the following sections:

- **User Manual** – Text-only section containing instructions for the tool's use. Locked for editing. Covered topics include:
    - **Introduction** – Overview of data sources and purpose of the tool.
    - **Tool Overview** – Overview of the tool's format and contents.
    - **Using the Tool** – Instructions for how to edit unlocked user entry fields, or how to unlock the entire tool for editing as needed.
    - **Accessing ACS Data** – Guide to accessing and downloading ACS data reports with the proper criteria and format for use with this tool, directly from the U.S. Census Bureau data page.
    - **Updating the Data Tool** – Guide to uncompressing and importing data into the Data Management Tool, including use of the integrated join validation fields.
- **Stats** – Page displaying raw ACS data, along with the Join Validation tool to be used when adding or updating data manually. Locked for editing.
- **Scores** – Page containing formulae for variable activation and scoring based on identified cutoff values. Locked for editing.

- **Set Profile** – Primary page for user interactions. Contains step-by-step instructions to guide user through variable selection, setting of variable cutoffs, and reviewing score distribution prior to final output. Specific color-coded cells unlocked for editing by user. All other fields locked for editing.
- **Copy Out** – Displays output of final calculated profile scores alongside Geographic IDs, to be copied by the user into Affirm's SharePoint system. Values will then auto-populate onto Affirm's custom Tableau dashboard map tool. Locked for editing.

Appendix B – Recommendations for Community Engagement Implementation Plan

2022-2023 Affirm Community Needs Assessment
Recommendations for Additional Action Items to Incorporate GIS Data into Project Plan

The following is intended as a supplement to the existing proposed implementation plan developed by Collective Equity Partners (CEP) for the Title X Community Needs Assessment. The following items have been added to the existing plan where recommended, in order to integrate new map tools into the process in ways which will support more effective work and more meaningful outcomes.

Project Phase	Action Steps Already Identified by CEP	Recommended Additional Action Steps to Incorporate GIS
Phase 1 **Discovery and Planning**	• Gather context about existing agency partners • Review existing organizational data for regions and delegates • Review existing relationships with community stakeholders • Identify any specific goals regarding new data collection	• Meet with GIS Project team to understand how this work can contribute to community engagement efforts • Review existing variables to be included in maps, and suggest additional variables to include
Phase 2 **Landscape Analyses**	• Identify existing quantitative data for each county • Examine Affirm's organizational culture and approach to services • Review background and population served by each delegate • Network mapping through informal interviews with key community contacts • Recruit community leaders/organizations for Phase 3 • Develop a summary report providing an overview of each county • Present progress to Affirm Board of Directors	• Review working draft of map products • Request additional map visualizations to aid in landscape analysis

Project Phase	Action Steps Already Identified by CEP	Recommended Additional Action Steps to Incorporate GIS
Phase 3 **Co-creating Engagement Plan**	• Develop an engagement plan in collaboration with leaders/organizations identified in Phase 2 • Conduct a series of conversations with each stakeholder group to inform the engagement plan specific to each county • Award mini-grants to community leaders contributing to the needs assessment project	• Review map of Affirm provider locations and APNs • Identify potential mappable data to be collected
Phase 4 **Data Collection**	• Coordinate data collection infrastructure, utilizing community leaders and organizations in collecting the data across all counties • Conduct surveys, focus groups, and community forums	• Utilize GIS maps to target survey collection • Utilize GIS maps to select locations and recruit participants for focus groups and community forums • Utilize GIS maps to guide discussion during focus groups and community forums
Phase 5 **Analyzing and Summarizing Data**	• Aggregate data • Analyze collected data • Provide a summary report of the findings • Prepare community engagement framework that Affirm can use moving forward in their work • Convene participating community leaders and organizations to share findings • Present findings to the Affirm Board of Directors	• Utilize Tableau map tool to visualize geographic data collected • Identify needs and opportunities for future GIS analysis based on needs assessment results

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