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Los Angeles

The Maximal Covering Location Problem:

An Application in Reproductive Health Services

A dissertation submitted in partial satisfaction of

the requirements for the degree

Doctor of Public Health

by

Daniel Bryan Seargeant

2012

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ABSTRACT OF THE DISSERTATION

The Maximal Covering Location Problem:

An Application in Reproductive Health Services

by

Daniel Bryan Seargeant

Doctor of Public Health

University of California, Los Angeles, 2012

Professor Fred Hagigi, Co-Chair

Professor Stuart Schweitzer, Co-Chair

Access to reproductive health care services is of vital concern to a significant portion of the population. The demand for these important services in many communities and regions outstrips the ability of organizations to supply them. Consequently, reproductive health service organizations seeking to optimize decisions regarding resource allocation may need to evaluate numerous alternatives. Proven location or regional science optimization methodologies can be applied to such decisions using geographic information available through the internet and optimization software tools. Population information, distance, and travel time data from the internet along with optimization software installed as add-ins to spreadsheet programs provides organizations an opportunity to evaluate alternative location decision to either minimize patient

travel costs to health care services or maximize the total populations served through optimal site locations.

This dissertation illustrates how to use these optimization methods within a reproductive health services organization, Planned Parenthood of Orange and San Bernardino Counties. An overview of the services provided by Planned Parenthood and a profile of their patient population is provided as context to the location decision. Finding the optimal solution to objective functions is not the only factor to be considered in making health service location decisions. Consequently, the dissertation also provides information that is helpful in determining health service locations such as demographic, socio-economic, health status, and other provider locations within the San Bernardino County. This information establishes the need for the expansion of services.

Two different optimization problems are used in evaluating alternative health service locations for Planned Parenthood in the largest county in the U.S., San Bernardino County. These are the *P*-Median and Maximal Covering Location Problem. Each of these problems is solved using both miles and travel time as variables. The dissertation compares and contrasts the results of these two approaches and highlights the differences in using miles versus time as the key variable in the problem. Finally, specific location recommendations are made for expansion of services using the results of the analysis.

The dissertation of Daniel Bryan Seargeant is approved.

Paul Fu

Moira Inkelas

Fred Hagigi, Committee Co-Chair

Stuart Schweitzer, Committee Co-Chair

University of California, Los Angeles

2012

Dedication

This dissertation is dedicated to the public and private health professionals across the globe seeking to help women and men improve their reproductive health, to their commitment to reducing the number of unintended pregnancies and to the positive impact they have on the communities in which they serve.

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Acknowledgements

I wish to acknowledge Dr. Fred Hagigi for his unsurpassed dedication and commitment to helping his students, of which I am lucky to have been one. You are truly an inspiration and an unselfish advisor and instructor. I also acknowledge Dr. Stuart Schweitzer, teacher and committee co-chair, Dr. Paul Fu, teacher and committee member, and Dr. Moira Inkelas, committee member, for your assistance in making this possible.

A special acknowledgement is owed to my parents, who instilled the importance of education; and to the support of my entire family, especially my wife, Lori, who has shared this journey with me.

VITA

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Chapter 1: Introduction

A major objective of Planned Parenthood of Orange and San Bernardino Counties, (PPOSBC) is to meet the reproductive health needs of San Bernardino County, the largest county by size in the lower 48 states. San Bernardino (SB) County has seen substantial growth over the past few decades, with a total population of 2,035,210 people, including 443,217 females between the ages of 15 to 44, the primary target patient population for the reproductive health services of PPOSBC (U.S. Census Bureau, 2011). With only two health centers currently serving SB County, PPOSBC seeks to expand its operations to support the communities therein. This dissertation demonstrates the application of location science decision support models, i.e., the *p*-median problem and the Maximal Covering Model, in determining the optimal locations for additional family planning health centers in SB County. The dissertation includes:

A detailed review of Planned Parenthood of Orange and San Bernardino describing the patient population and the services provided by the PPOSBC health centers. Planned Parenthood affiliates are often depicted and perceived as merely abortion providers. This more in-depth review of PPOSBC is intended to provide a better understanding of the organization and the positive impact it has within the communities it serves;

Researched and compiled demographic and reproductive health-related statistics resulting in an assessment of the demand for reproductive health services throughout San Bernardino County;

Expansion locations determined by applying integer linear programming solutions to minimize the travel distance and time to health centers, as well as locations that will maximize the population's coverage;

Alternative scenarios using various evaluation methods for planning and future expansion efforts; and

A discussion of the strengths and weaknesses of the various models used and the limitations of the approach and scope of their application.

The results of this research and the dissertation provide substantial value in meeting the public's reproductive health needs within San Bernardino County and illustrate the application of location science in planning outpatient/clinic facilities using readily available information and tools. The application and benefits of the dissertation include:

The assessment of the reproductive health needs of the county will identify high priority areas and aid in determining appropriate areas for outreach and additional reproductive health educational activities;

The application of an integer linear program provides insight into the benefits of various alternative locations and aids in determining the appropriate number of health centers required to cover the needs of the county;

The integer linear program models used minimize the total travel burden on the patient population for any given number of health center locations developed;

The various scenarios for future expansion will aid in capital planning and be used in fund raising opportunities by demonstrating the value of additional centers and their potential locations.

The dissertation is presented in four chapters. The first chapter includes the introduction and a detailed review of PPOSBC in order to orient the audience about the organization in the context of this study. Chapter 2 provides an in-depth analysis of the economic and reproductive health care status of San Bernardino County in order to demonstrate the health needs of the

county, which support the expansion efforts by PPOSBC. Chapter 3 provides the literature support for the approach used in making locations decisions and details the methods used in the analysis. Finally, chapter 4 provides the data gathered, the analysis with parameters, and the results of the optimizations. Chapter 4 also includes a discussion of the analysis, the dissertation's limitations, and a conclusion.

Organizational Setting

An affiliate of the Planned Parenthood Federation of America (PPFA), Planned Parenthood of Orange and San Bernardino Counties (PPOSBC) has been providing reproductive health care, educational services, and political advocacy for reproductive health options and women's rights since 1964. PPOSBC is a California non-profit corporation with a 401(c) tax-exempt status. Although bound by an affiliation agreement with PPFA, PPOSBC is governed by a local board of directors made up of citizens of the two counties it serves and managed by an executive team who serve as employees of the organization. PPOSBC has exclusive rights to use the Planned Parenthood name within the two counties. Other independently governed Planned Parenthood affiliate organizations servicing areas of Southern California include: Planned Parenthood of Los Angeles, Planned Parenthood of Pasadena, Planned Parenthood of the Pacific-Southwest (covering San Diego, Riverside and Imperial Counties), etc.

PPOSBC and the two counties it serves have grown substantially in the last few decades. The combined population of the two counties now exceeds 5 million, including 1,082,000 women ages 15 to 44 that represent the vast majority of the patient base of PPOSBC (U.S. Census Bureau, 2011). Twenty percent of PPOSBC's target population does not have health insurance (California Health Interview Survey (CHIS), 2009). PPOSBC now operates six health centers in Orange County and two health centers in San Bernardino County. These eight health

centers offer a wide array of reproductive health services. These services are mainly focused on seeing patients for birth control, testing services or preventive health. PPOSBC offers a wide array of birth control methods: barrier, oral, patches, injectable, implants, intrauterine conception (IUC), and sterilization. Testing services include pregnancy and STD (chlamydia, gonorrhea, herpes, syphillus, and HIV). PPOSBC also performs preventive health services such as PAP tests, breast cancer examinations, and prenatal services. As an affiliate of PPFA, PPOSBC is also required to provide abortion services. Only two of its eight health centers, one in Orange County and one in San Bernardino County, provide surgical abortion services. Patients seeking a medication abortion in the privacy of their homes can also be seen at any PPOSBC health center.

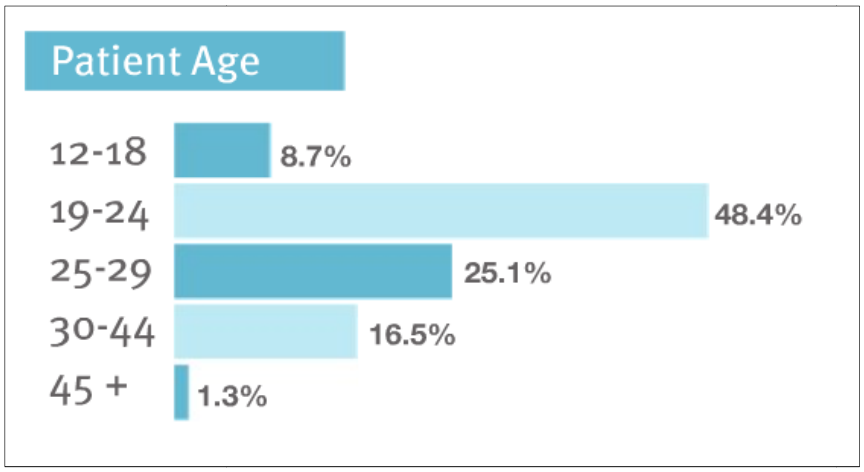
At over 20,000 square miles, San Bernardino County is the largest county in the 48 contiguous states (Key to the City, 2011). The two San Bernardino County PPOSBC locations, one in the city of San Bernardino and one in the city of Upland, are convenient to only a portion of the residents within the county. Serving the entire county is a challenge. Some residents travel substantial distances to reach the existing health centers. In order to serve the increasing number of patients and decrease the disparity of available services across the two counties, PPOSBC is seeking to expand their service locations in San Bernardino.

Patients Served

Over 90% of Planned Parenthood's patients are women of reproductive age. These are generally considered to be women ages 15 to 44. A breakdown of the PPOSBC patient population for both females and males by age is provided in *Figure 1: 2009–2010 Fiscal Year Patients by Age Group*. Patient volume has been growing steadily, as indicated in *Figure 2: 2008–2010 Fiscal Year Patient Growth by County* and *Table 1: 2008–2010 Fiscal Year Patient Growth by County.*

Figure 1: 2009–2010 Fiscal Year Patients by Age Group

Planned Parenthood of Orange and San Bernardino Counties



Source: Program Report 2009-2010, Planned Parenthood OSBC

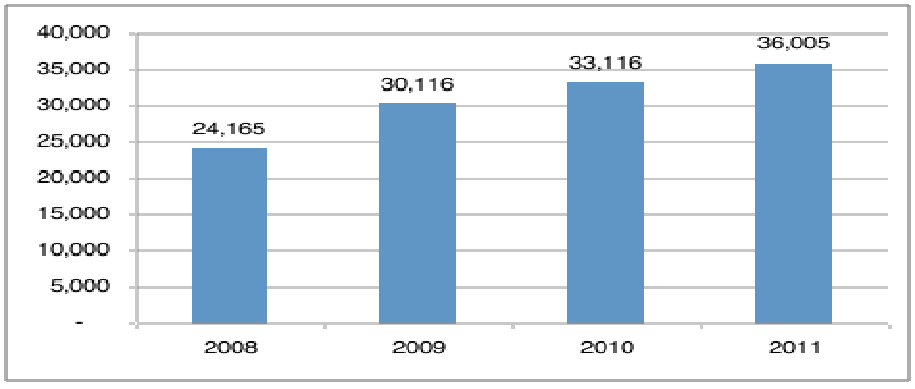
Table 1: 2008–2011 Fiscal Year Patient Visit Growth by County

Planned Parenthood of Orange and San Bernardino Counties

Counties	2008	2009	2010	2011	3 yr. Chg.
Orange County	77,407	87,420	94,556	105,812	36.7%
San Bernardino	24,165	30,116	33,116	36,005	49.0%
Total	101,572	117,536	127,672	141,817	39.6%

Figure 2: 2008–2011 Fiscal Year Patient Visit Growth San Bernardino

Planned Parenthood of Orange and San Bernardino Counties



The primary reasons for the large increase in the number of patients served were an increased need or demand for services due to the Great Recession and the ability of PPOSBC to expand service capabilities. PPOSBC is a safety-net provider using a sliding fee scale (reducing charges based on income levels) and does not turn away patients based on their inability to pay; and as such has virtually no commercial insurance healthcare business. As unemployment increased and more people lost insurance coverage during the Great Recession, PPOSBC was able to serve more patients. Because of this, seven of the health centers for PPOSBC are now open extended hours (10 hours per day) and are also open on weekends, including Sundays. PPOSBC has added staff in all of its sites to meet the expanded service hour requirements and to serve the ever-growing number of patients needing health care. In a few sites existing space was reconfigured to allow for additional exam rooms. However, the only real expansion of physical space within the last five years occurred in the Anaheim health center by leasing additional adjacent space. Three exam rooms, a lab service area, and other common use spaces were developed in this new space. The combination of longer operating hours and increased staff has enabled PPOSBC to grow at these levels without adding new health centers.

Health Care Services

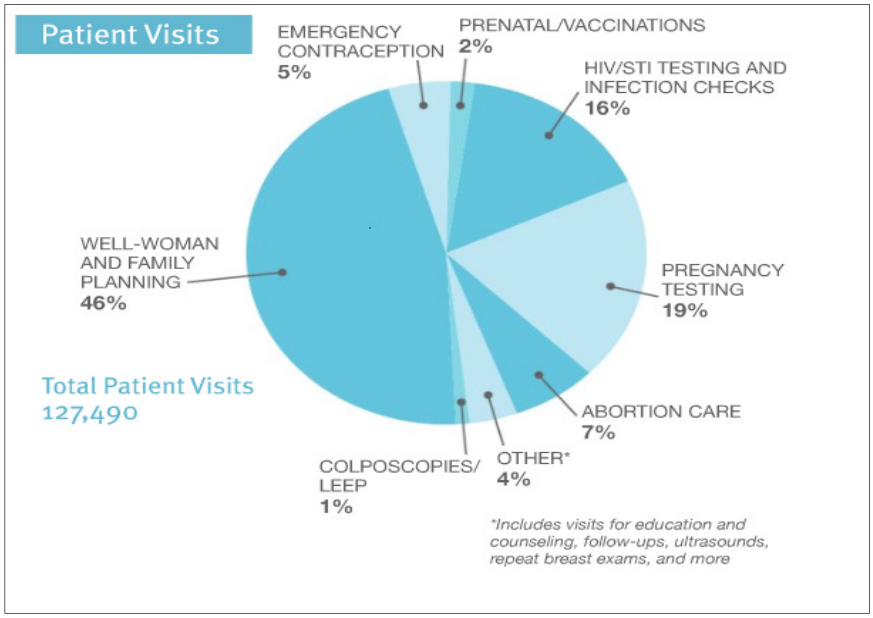
PPOSBC provides a wide range of men and women's health and reproductive services. They are a leading provider of reproductive health to communities throughout Orange and San Bernardino Counties. In the Fiscal Year Ended June 30, 2010, 127,000 patient visits were conducted by PPOSBC for a wide range of services, including prenatal care, cancer screenings, fertility testing, pregnancy testing and counseling, sexually transmitted disease diagnosis and treatment, contraception, sterilization, and medical and surgical abortion (PPOSBC, 2010). A breakdown of these visits by primary service is provided in *Figure 3: 2009-2010 Patient Visits*

by Primary Services. These services have also become increasingly complex with the substantial use of Long Acting Reversible Contraception (LARC). PPOSBC is a leading provider of Essure™, a new sterilization technique offering women an effective outpatient-based sterilization alternative in Orange and San Bernardino Counties. Some of these services are currently only available in Orange County, requiring San Bernardino County residents to make a significant commute to obtain these services or seek them from other providers.

As indicated in Figure 3, abortion care constitutes a very small percent of the services provided by PPOSBC, representing just 7% of the total visits. Contraception and well women examinations and testing services (both pregnancy and STI-related testing) are the main reasons patients visit PPOSBC. These services combined accounted for 86% of all visits in the 2010 Fiscal Year.

Figure 3: 2009–2010 Fiscal Year Patient Visits by Primary Service

Planned Parenthood of Orange and San Bernardino Counties



Source: Program Report 2009-2010, Planned Parenthood OSBC

Annual Examinations

A substantial number of patient visits to PPOSBC include an annual preventive health examination, generally referred to as a "well-women exam." Since the Family Planning, Care, Access and Treatment (FPACT) program allows the dispensation of up to thirteen monthly cycles of oral contraception, this may be the only health services visit some patients have each year. Other preventive health services are also performed during this annual exam, e.g., papanicolaou (Pap) tests, breast exams, etc. PPOSBC performed approximately 15,000 well-women examinations in 2010.

Contraception

Most of Planned Parenthood visits involve the dispensation or prescription of contraception. Contraceptive-related visits include a wide array of contraceptive methods, including hormone-based oral tablets, intrauterine contraception, hormonal implants, hormonal injections, vaginal rings, patches, and other barrier methods. Patient visits are common not only for the dispensation of these methods, but also the ongoing maintenance and management of contraception. Oral contraception is the leading method dispensed at PPOSBC with over 300,000 monthly cycles of contraception dispensed annually.

PPOSBC also dispenses emergency contraception, Plan-B or NextChoice (a generic equivalent), to patients over the age of 17 over the counter. Emergency contraception is effective in preventing pregnancy if taken within 72 hours of unprotected intercourse, contraceptive failure, or suspected failure. Studies have proven emergency contraception to be effective in preventing pregnancy if taken within four days of unprotected sexual activity (Piaggio, Kapp, & von Hertzen, 2011.) All contraceptive-related visits and well-women exams combined with

emergency contraception comprised 51% of all visits in the Fiscal Period 2009-2010 for PPOSBC.

The organization is making a concerted effort to use the most effective contraceptive methods available. This effort includes an organization-wide training program that ensures that all clinicians are capable of not only counseling and educating patients on all methods, but also administering all methods. Specifically, this has included training all clinicians on IUC, using both Mirena™ and Paraguard™. Although a detailed discussion of the various methods currently available and used at PPOSBC is beyond the scope of this review, a detailed analysis of the shift across methods was completed to show the trend toward more effective methods. These efforts are reflected in the annual volumes by contraceptive method. *Table 2: Annual Volumes by Contraceptive Method* shows the increase by method using both the Compound Annual Growth Rate (CAGR) and the total increase in the last three years.

Table 2: Annual Volumes by Contraceptive Method

	Actual Procedures and Dispensed Methods				Analysis	
Method	2008	2009	2010	2011	CAGR[1]	3 Yr Chg
Vasectomy	106	187	189	211	25.8%	99.1%
Essure	-	16	73	90	137.2%	462.5%
Paraguard	547	934	1,483	2,009	54.3%	267.3%
Mirena	631	1,413	2,692	3,635	79.3%	476.1%
Implanon	9	583	1,625	2,051	510.8%	22688.9%
Depo	8,126	8,616	8,327	8,973	3.4%	10.4%
Nuvaring	23,585	28,408	33,258	35,804	14.9%	51.8%
Orals	309,532	333,600	324,231	332,334	2.4%	7.4%
Patch	28,077	23,501	264	6,588	-38.3%	-76.5%
EC	66,606	81,356	98,381	96,162	13.0%	44.4%
Condoms	632,799	778,254	889,416	859,064	10.7%	35.8%

While some methods have seen little growth, such as oral contraceptives and depo-provera, the long acting reversible methods, Paragard, Mirena (both IUCs), and Implanon (an implant) have seen substantial increases. Essure (female sterilization) was initiated in 2009 and

has increased steadily since. The contraceptive patch was not dispensed for a period of time in 2010 and 2011. Although patients continued to be counseled and informed about this method during this period, patients wanting the patch were provided with a prescription to the pharmacy. In order to better measure the impact of this shift, a new measure is required. Consequently, the Monthly Contraceptive Equivalent is being developed and used at PPOSBC. This measure weights each method using a common unit of contraception–one month's worth. These weights are listed below in *Table 3: Monthly Contraceptive Equivalents (MCE) Values by Method.*

Table 3: Monthly Contraceptive Equivalents (MCE) Values by Method

	Monthly Contraceptive Equivalents (MCE)			
Method	Years	Months	Days	MCE
Vasectomy	25	300	9000	300
Essure	20	240	7200	240
Paraguard	10	120	3600	120
r	5	60	1800	60
Implanon	3	36	1080	36
Depo		3	90	3
Nuvaring		1	30	1
OC		1	30	1
Patch			10	0.33
EC			5	0.17
Condom			1	0.03

By using the MCE as weights with the number of raw units dispensed, the total Monthly Contraceptive Equivalents can be determined for a period, e.g., a year. MCEs are obtained by multiplying the volumes of each method by that method's weighting. The results for 2008 through 2011 for each method are reflected in *Table 4: Monthly Contraceptive Equivalents Trend Analysis by Method*. Oral contraception remains the largest single method of choice for

Planned Parenthood patients. However, the longer acting methods are increasing in use. These include both irreversible and reversible methods.

Table 4: Monthly Contraceptive Equivalents Trend Analysis by Method

	Monthly Contraceptive Equivalents			
Method	2008	2009	2010	2011
Vasectomy	31,800	56,100	56,700	63,300
Essure	-	3,840	17,520	21,600
Paraguard	65,640	112,080	177,960	241,080
Mirena	37,860	84,780	161,520	218,100
Implanon	324	20,988	58,500	73,836
Depo	24,378	25,848	24,981	26,919
Nuvaring	23,585	28,408	33,258	35,804
Oral	309,532	333,600	324,231	332,334
Patch	9,359	7,834	88	2,196
EC	11,101	13,559	16,397	16,027
Condom	21,093	25,942	29,647	28,635
Totals	534,672	712,978	900,802	1,059,831

Figure 4: Total Monthly Contraceptive Equivalents reflects the increase in MCEs. The three-year compound annual growth rate for MCEs at PPOSBC from 2008 to 2011 has been 25.6% each year. Total MCEs increased from 534,672 in 2008 to 1,059,831 in 2011. This is nearly double, or a 98.2% increase, in three years. Some of the increase is due to an increase in patients and not a shift in methods. The total number of unique or distinct patients receiving one of these methods grew from 47,668 2008 to 60,218 in 2011. This is an increase of 26.3% over the three years, which represents an 8.1% CAGR. *See Table 5: Patients Receiving a Contraceptive Method Within Each Year*. Contraception may not have been the primary reason each of these patients visited Planned Parenthood, but each of these patients left their visit with one or more of these methods.

Figure 4: Total Monthly Contraceptive Equivalents

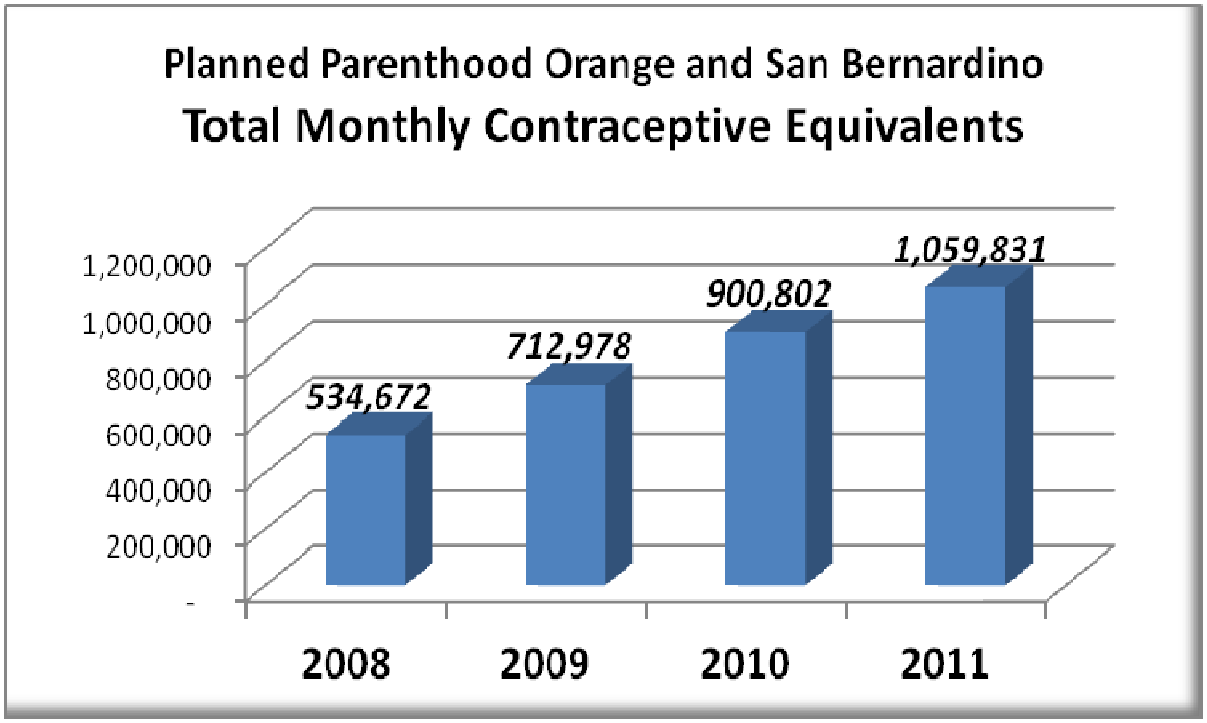
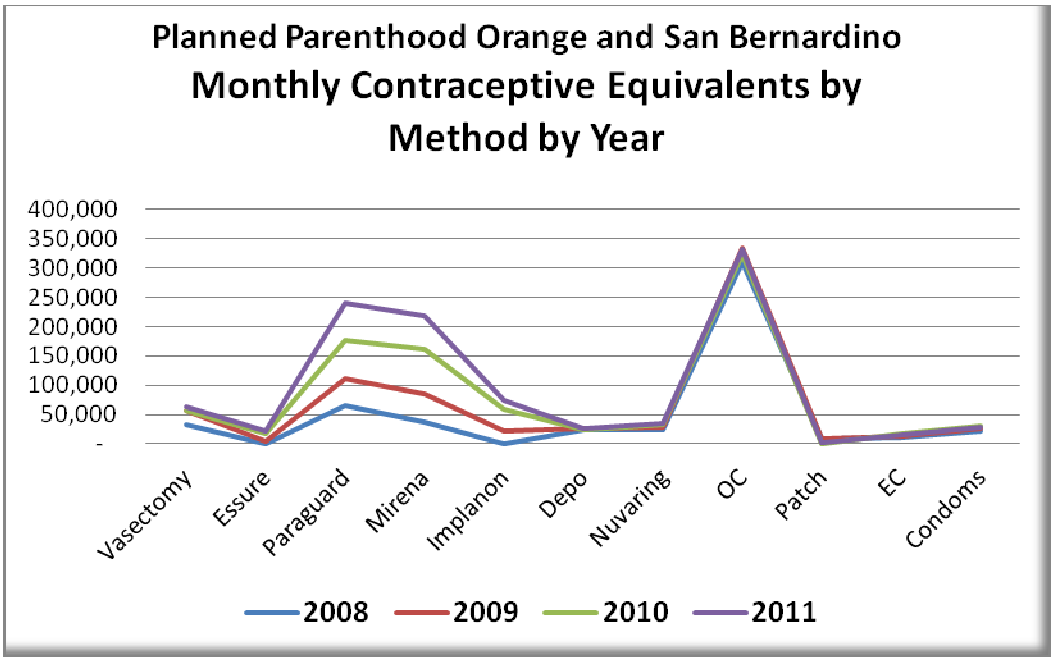


Table 5: Patients Receiving a Contraceptive Method Within Each Year

	2008	2009	2010	2011	CAGR	3YrChg
Distinct Patients	47,668	55,108	60,244	60,218	8.1%	26.3%

Figure 5: Monthly Contraceptive Equivalents by Method by Year presents the data in a different manner, such that the year-to-year shift is more noticeable by method. Paraguard, Mirena, and Implanon have increased every year. Combined, these three methods now account for the majority of monthly contraceptive equivalents dispensed, up to 50%; see *Figure 6: 2011 Monthly Contraceptive Equivalents Ratios,* which shows the composition of 2011 MCE.

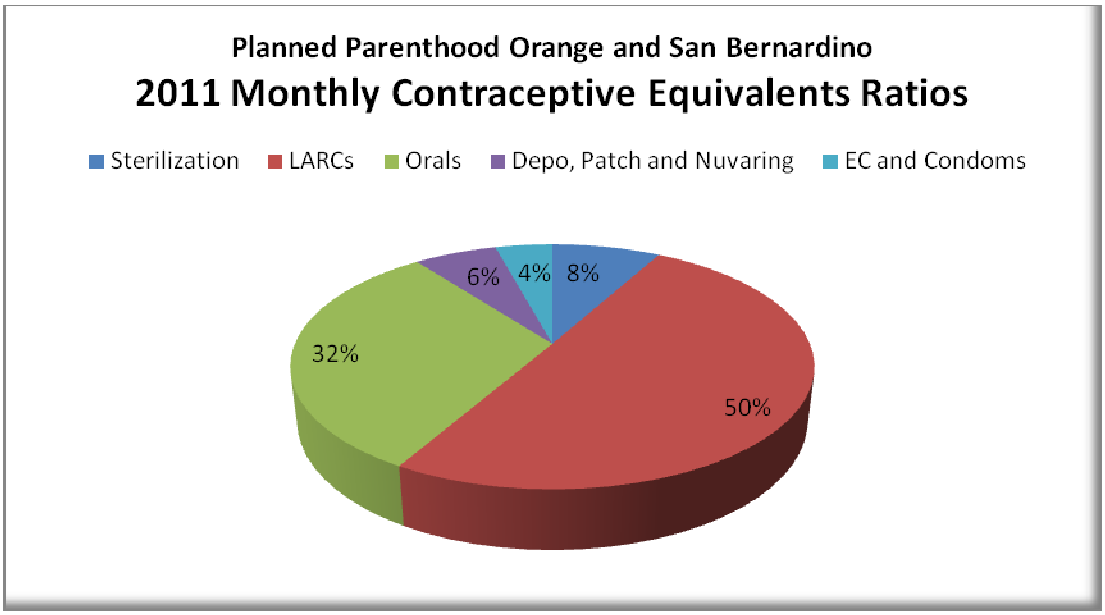
Figure 5: Monthly Contraceptive Equivalents by Method by Year



Additional research and analysis is planned to provide a stronger basis for the estimates used in calculating the MCEs. Both external and internal sources will be researched for developing a standard value for each method. However, as long as the same weights are used in evaluating programs or organizations, this new measure allows for the comparison of the effectiveness of various contraception programs. This concept can be extended to determine the cost effectiveness per MCE, which can be evaluated for the program as a whole or for each method, i.e., comparing the cost effectiveness of each method based on the normalized measure.

This analysis illustrates both the increase in contraception being provided over the last few years and the impact of the shift towards longer acting and more effective methods.

Figure 6: Monthly Contraceptive Equivalents Ratios



Testing Services

PPOSBC health centers perform a number of testing services that include moderately complex tests in the health centers as well as complex tests in their own Clinical Laboratory Improvement Amendment (CLIA) certified laboratory. The moderately complex tests performed onsite in each health center include wet mount tests for screening and diagnosing urinary tract infections, blood typing, and pregnancy testing. Specimens may also be collected to test for sexually transmitted infections (STIs). Three STI tests done internally by PPOSBC in a fully licensed, complex laboratory using state-of-the-art equipment are chlamydia, gonorrhea, and HIV. Other tests for diagnosing STIs such as syphilis and herpes are done in a reference laboratory.

The most prevalent STI in PPOSBC patients is chlamydia, with a total of 2,880 patients out of 52,493 patients tested, or 5.5% of patients tested, diagnosed with positive results in the calendar year for 2011. PPOSBC has a very high testing rate for this important condition for

sexually active females less than 26 years of age. Testing rates for this condition are closely monitored by health plans through Healthcare Effectiveness Data and Information Set (HEDIS) measures. PPOSBC is testing 78% percent of this high-risk population (sexually active females less than 26 years of age). Gonorrhea is less prevalent, but can be tested as a panel test with chlamydia using the same specimen on the BD (Becton, Dickinson) Viper™ using XTR™ technology. Positive gonorrhea patients in calendar year 2011 totaled 313 patients out of 60,449 tests run, or roughly 0.5% of tests. PPOSBC uses Evolis™ from Bio-Rad Technologies to test for HIV. Fortunately, just 18 positive cases were identified in 2011 out of 31,175 tests. For all combined tests, the high complexity laboratory at PPOSBC can process over 500 specimens per day.

Abortion Services

Abortion services at PPOSBC include both surgical abortions and medication abortions. Surgical abortions at PPOSBC are currently performed at one health center in Orange County and one day per week in San Bernardino. Medication abortions can be performed within the first nine weeks of a pregnancy using mifeprestone (RU486), which was developed in France and approved by the FDA for use in the United States in 2000. The number of medication abortions as a percent of total abortions is increasing. Abortion visits for both surgical and medication types accounted for roughly 7% of all visits at PPOSBC in the 2010 Fiscal Year.

Perinatal and Other Visits

PPOSBC has a small practice in perinatal patients who, for a number of reasons, may not qualify for the state-administered Medi-Cal program, which generally covers expectant mothers. In addition, PPOSBC provides basic fertility services for those wishing to become parents but having difficulty conceiving. Other services include vaccinating patients for HPV, follow-up

breast exams, and other reproductive health-related visits. These visits combined accounted for roughly 6% of total visits in FY 2010.

Colposcopy and LEEP Services

Another important types of service provided by PPOSBC are colposcopyies and loop electrosurgical excision procedures or LEEPs. These procedures are used to evaluate or excise abnormalities of the cervix or vagina. In some cases biopsies may be performed on abnormal tissues to determine the prevalence of cancerous cells. These services can be life-saving procedures should they diagnose cancer at an early stage, and account for approximately 1% of patient visits.

Sterilization Services

Although the number of sterilization patients may be small, sterilization is an important service for patients seeking permanent birth control. PPOSBC performs approximately 200 vasectomies per year, the service being offered one day per month in the Costa Mesa health center. PPOSBC has also begun performing a new sterilization procedure for female patients called Essure®. Essure® involves the insertion of small coils into the fallopian tubes using hysteroscopy. The fallopian tubes build up scar tissue around the implanted coils, effectively closing the tubes and preventing conception. PPOSBC performed nearly 100 Essure® procedures in FY 2011, making it one of the leading providers in this new technology in Orange County. These procedures are currently only done within Orange County. There are plans to expand these services to San Bernardino County, pending demand.

Chapter 2: Needs Statement

Background

California receives more public funding for family planning services than any other state, totaling $387.7 million in 2006 and accounting for 21% of the $1.8 billion of total public expenditures for family planning that year (Sonfield, Alrich, & Gold, 2008). While public funding sources provide only a portion of the total contraceptive services provided at large (the majority being provided by private insurance and managed care (Landry & Forrest, 1996) and (Sonenstein, Ku, & Schulte, 1995), they are a sizable source of family planning services delivered to lower income individuals. Sixty percent of publicly funded family planning clients are below the federal poverty level (Frost, 1994). Publicly funded family planning services are very effective in reducing unintended pregnancies and reducing abortions, and save money in the long run by avoiding pregnancy-related health care and medical care for newborns (Forrest & Samara, 1996). Family Planning Access Care and Treatment (FPACT), the Medicaid-waived program in California initiated in 1997, dispensed 6.4 million woman-months of contraception in 2002, averting an estimated 205,000 pregnancies and 79,000 abortions (Foster et al., 2006). This was nearly double the estimated 108,000 averted pregnancies in 1998 (Foster et al., 2004), demonstrating the efficacy and expansion of the program.

Planned Parenthood of Orange and San Bernardino Counties is a major recipient of public funds through the FPACT and MediCal programs, and is one of the largest publicly funded reproductive health providers in the two counties. PPOSBC is typically a provider of last resort health care, serving a patient population that does not have traditional commercial insurance. Minority, unmarried, and young women without insurance are three to four times more likely to seek care from a family planning clinic (Frost, 2001). The comprehensive family

planning services provided by PPOSBC play an important role in the reproductive health of the community. Women often receive a wider array of services in publicly funded settings than in private provider settings (Frost, 2008). Comprehensive reproductive health services may be difficult to obtain as many private providers do not disclose important information about legally available services based on their own moral convictions (Curlin, Lawrence, Chin, & Lantos, 2007). Public funded reproductive health services are often accessed by those with private insurance due to the relatively low cost of services and the confidentiality provided in the publicly funded service environment (Andersen, Giachello, & Aday 1986). Family planning services also provide an opportunity to deliver preconception care and preventative health care (Gold & Alrich, 2008; Klerman, 2006).

This chapter explores the reproductive health needs and status of California compared to the rest of the nation, the county of San Bernardino compared to other Southern California counties, and the status and needs of specific areas within San Bernardino County. The following information provides insight into where services are needed and supports the decision to expand family planning and reproductive health services within San Bernardino County.

Selected National and California Trends

The information in this section was compiled using the Centers for Disease Control (CDC) National GIS interactive tool for assessing AIDS, chlamydia, gonorrhea, and syphilis data. This information provides a broad perspective of key sexually transmitted diseases (STDs) in California and nationally.

Chlamydia

Chlamydia is a sexually transmitted disease caused by the chlamydia trachomatis bacterium. It is the most common bacterial sexually transmitted disease, with 1.3 million cases

reported nationally in 2010 (CDC, 2012a). Chlamydia is diagnosed with a lab test, generally using urine or other specimen from the cervix or penis. Symptoms may not always be present; however, some experience discomfort in the abdomen or lower back, and discharge or pain during urination. If left untreated, chlamydia may lead to pelvic inflammatory disease, increase the likelihood of eptopic pregnancies, and may lead to infertility in women. Chlamydia can be passed to babies born from infected mothers. It is normally treated with antibiotics, including azythromycin and doxycyline.

The incidence of chlamydia in California and across the nation has been steadily increasing. In the last ten years, the national rate of chlamydia has grown from just over 300 cases per 100,000 in 2000 to over 527 cases per 100,000 in 2010. California's rate is 512.4 per 100,000 in 2010, up from 357.8 in 2000. See *Figure 7: Chlamydia California and National Trends* for more information (CDC, 2012c).

Rates of chlamydia are twice as high for females both in California and nationally. In 2010, rates for females in California and nationally were 694.8 and 747, respectively; the male rates for the same year were 324.5 in California and 293.8 nationally. The incidence rate for chlamydia varies substantially across age groups. In 2010, the rate for ages 20-24 was a high of 2,110 per 100,000 in California and 2,270 per 100,000 nationally compared to rates for ages 40-44 of 142 and 93 per 100,000 in California and nationally, respectively. *Figure 8: Chlamydia Rates by Age Group, in California and Nationally 2010* provides additional information for all age groups. Due to the prevalence of chlamydia in young women, CDC guidelines suggest that all sexually active women under the age of 26 be tested for chlamydia.

Figure 7: Chlamydia California and National Trends

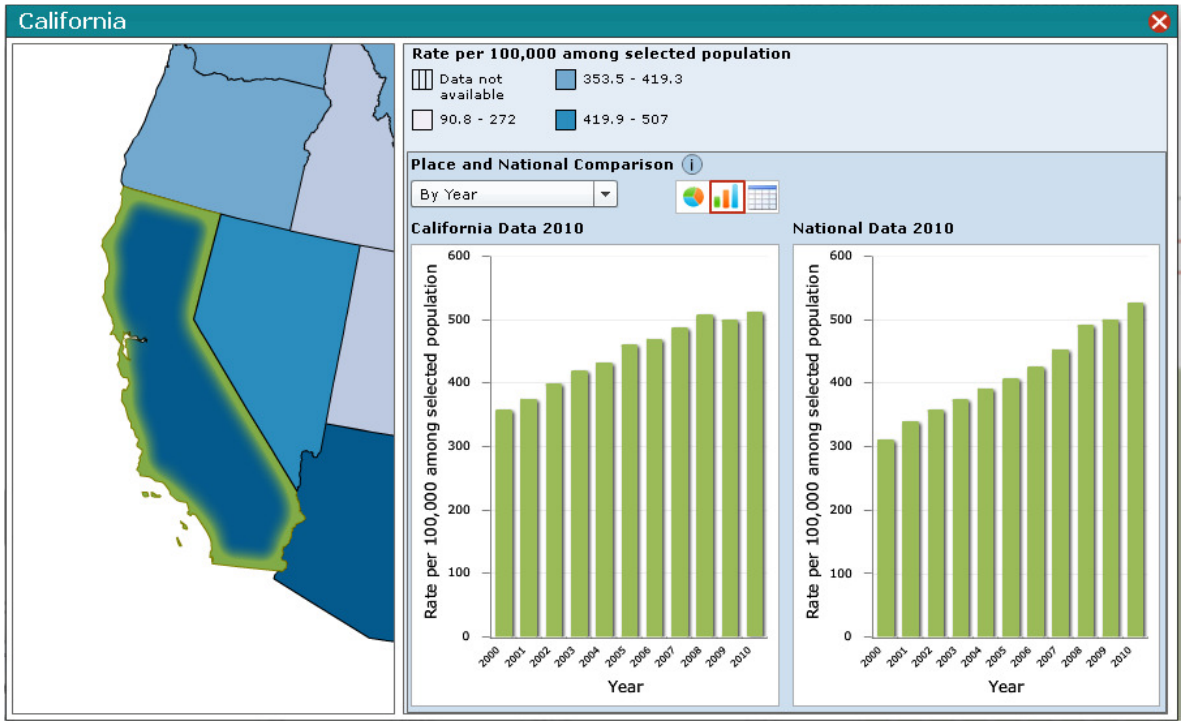
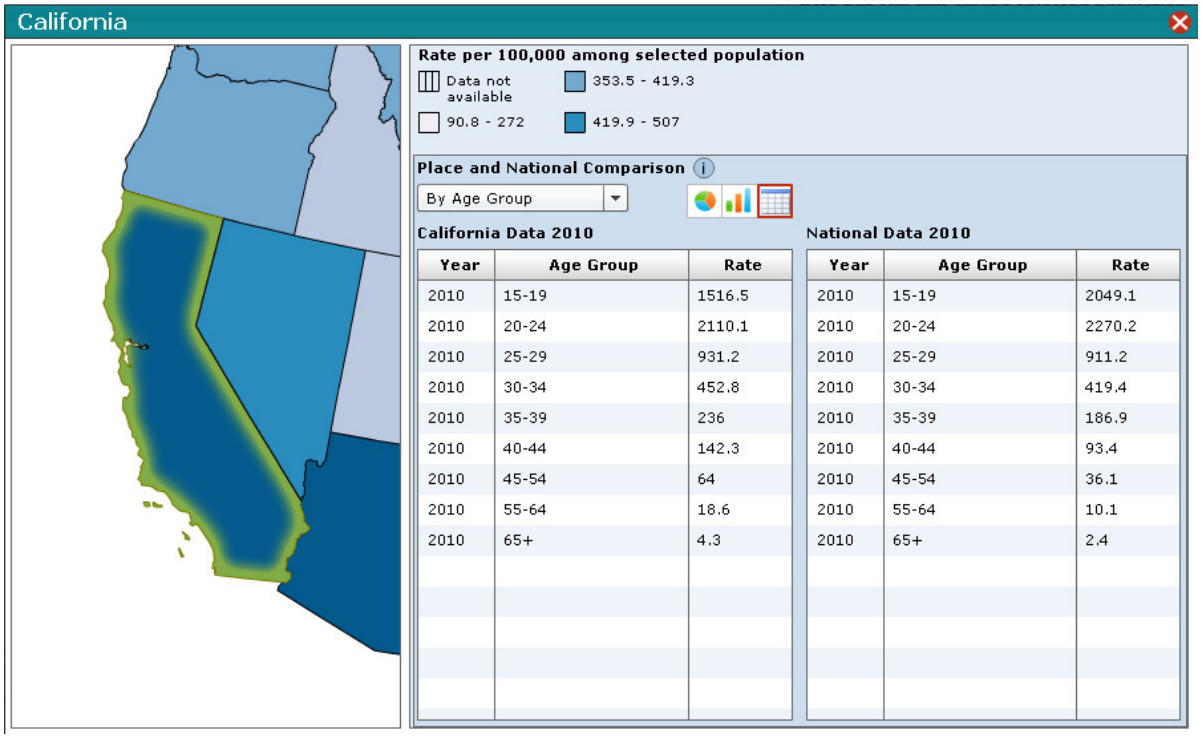


Figure 8: Chlamydia Rates by Age Groups in California and Nationally 2010



Year	Age Group	Rate
2010	15-19	1516.5
2010	20-24	2110.1
2010	25-29	931.2
2010	30-34	452.8
2010	35-39	236
2010	40-44	142.3
2010	45-54	64
2010	55-64	18.6
2010	65+	4.3

Year	Age Group	Rate
2010	15-19	2049.1
2010	20-24	2270.2
2010	25-29	911.2
2010	30-34	419.4
2010	35-39	186.9
2010	40-44	93.4
2010	45-54	36.1
2010	55-64	10.1
2010	65+	2.4

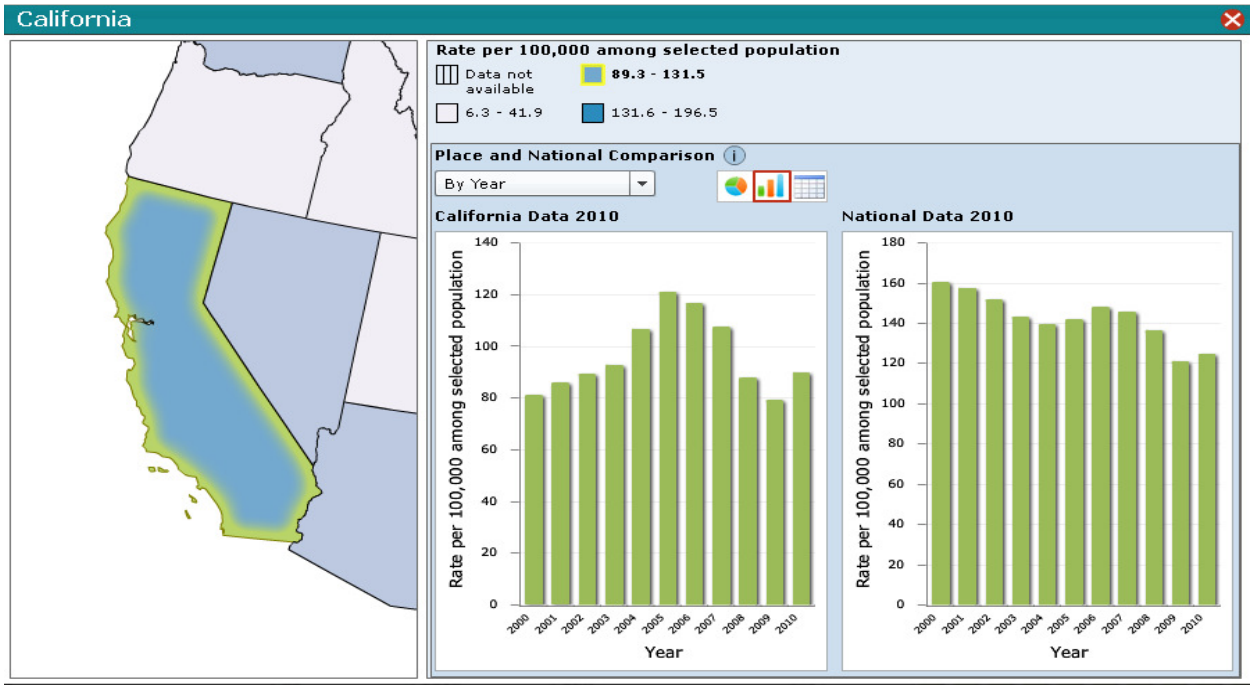
Gonorrhea

Gonorrhea is caused by the bacterium *Neisseria gonorrhoeae,* which is generally transmitted through sexual contact (CDC, 2012b). This bacterium grows in the reproductive tract of women, the urethra of women and men, and can be found in the mouth, throat, eyes, and anus. Symptoms in men vary widely from no symptoms to burning sensations during urination, discharge from the penis, and painful or swollen testicles. Most women who are infected have no symptoms, though some may experience a burning sensation during urination, vaginal bleeding, or discharge. Consequences of untreated gonorrhea include pelvic inflammatory disease, higher rates of ectopic pregnancies, and potential infertility. Men may develop epididymitis, which may lead to infertility if untreated.

Gonorrhea can also be transmitted to a baby during delivery, which can cause blindness, joint infections, and life-threatening blood infections in infants. Gonorrhea is diagnosed with a lab test of a specimen from an infected region or a urine test. It is treated with antibiotics, though drug-resistant strains of gonorrhea make treatment more difficult.

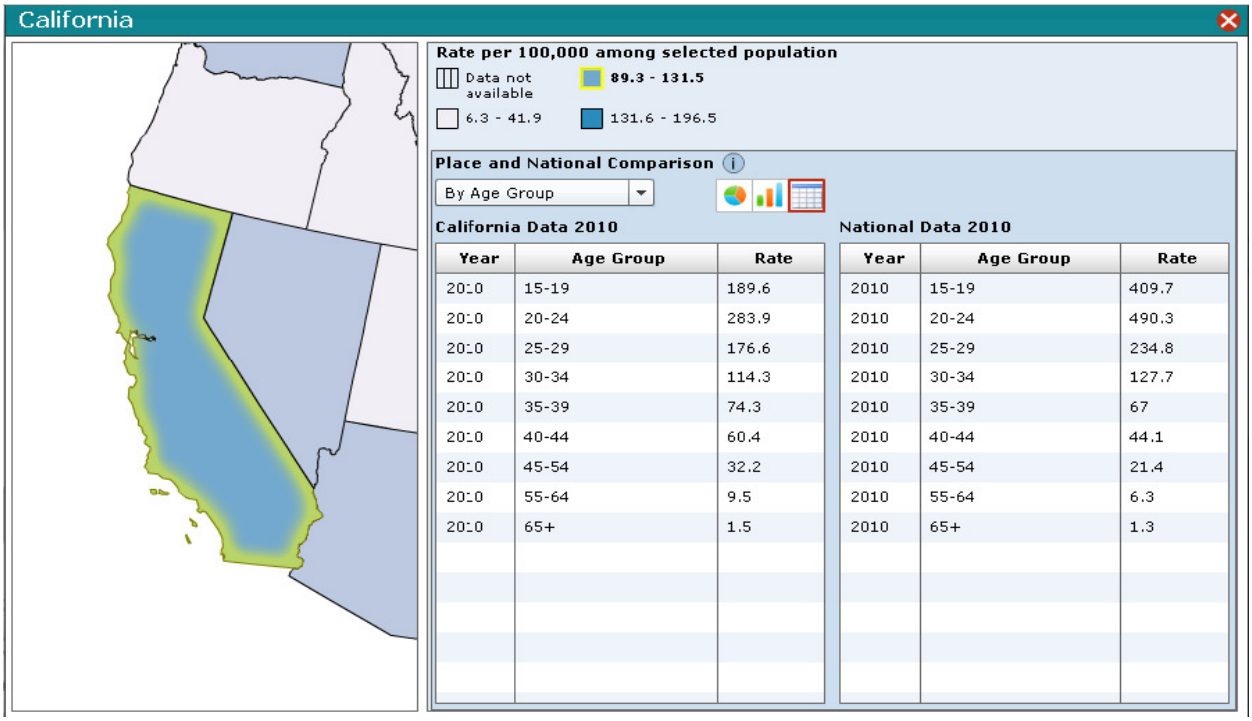
Gonorrhea rates in California and nationally have not trended in the same direction. While the national incidence of gonorrhea has been steadily dropping over the last ten years, California experienced an increase between 2000 and 2005, followed by four years of declining rates. Both the national and California rates increased slightly in 2010, with California at 90.1 cases per 100,000 and the nation at 124.8 cases per 100,000. In California, the rate peaked in 2005 at 121 cases per 100,000. 2000 saw the highest national rate of the last ten years at 160.4 cases. See *Figure 9: Gonorrhea California and National Trends* for rates over the last eleven years.

Figure 9: Gonorrhea California and National Trends



Females in California have a substantially lower rate, 71 per 100,000, than the national average of 130 in 2010. The California rate for males in 2010 was 108.5 cases, versus 118.4 nationally. Gonorrhea, like chlamydia, has a much higher prevalence in age groups less than 25 years of age. Rates for 2010, both nationally and in California, are the highest for 20-24 year olds, peaking at 490.3 and 203.9 cases per 100,000, respectively. *Figure 10: Gonorrhea Rates in California and Nationally by Age Group* provides the breakdown of gonorrhea by age groups for 2010.

Figure 10: Gonorrhea Rates in California and Nationally by Age Group



Year	Age Group	Rate
2010	15-19	189.6
2010	20-24	283.9
2010	25-29	176.6
2010	30-34	114.3
2010	35-39	74.3
2010	40-44	60.4
2010	45-54	32.2
2010	55-64	9.5
2010	65+	1.5

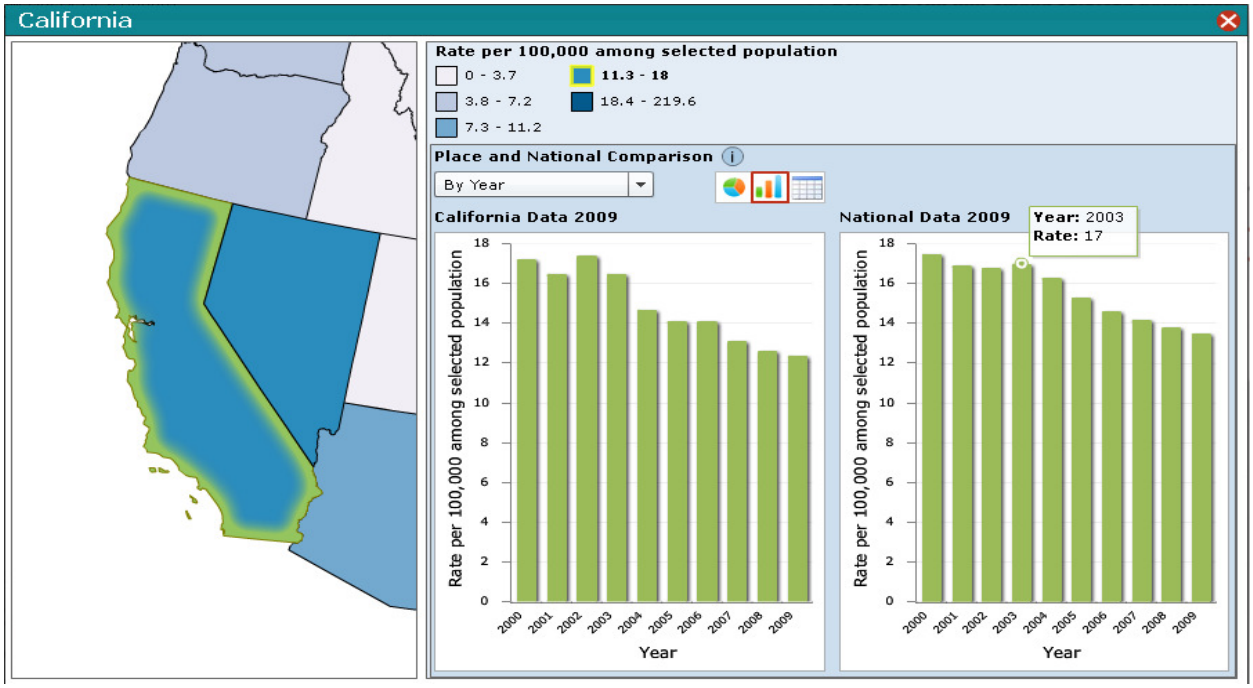
Year	Age Group	Rate
2010	15-19	409.7
2010	20-24	490.3
2010	25-29	234.8
2010	30-34	127.7
2010	35-39	67
2010	40-44	44.1
2010	45-54	21.4
2010	55-64	6.3
2010	65+	1.3

AIDS and HIV

Acquired immune deficiency syndrome (AIDS) is caused by the human immunodeficiency virus (HIV). Some people living with HIV experience no symptoms for years; however, HIV is still attacking the immune system. Others may experience flu-like symptoms a few weeks after being infected. Although advancements in HIV treatments have helped delay the progress of the disease, 35,962 cases of AIDS were diagnosed and 14,110 deaths were reported in the U.S. in 2007 (CDC, 2011). HIV weakens the immune system by attacking the CD4+T blood cells that are important in fighting disease. Higher incidence rates of cardiovascular, kidney, and liver diseases and cancers are associated with untreated HIV due to the weakened immune system. AIDS is the late stage of the infection wherein the immune system is seriously damaged. While the onset of AIDS can be delayed with a combination of drug therapies developed during the 1990s, there is no real cure for the disease.

California's rate of AIDS tracks very closely with the national averages, which has seen a decrease over the last ten years. In 2009, California had an incidence of 12.4 cases per 100,000, versus a national rate of 13.5. These rates are down from 17.2 in California and 17.5 nationally in 2000. However, the rate of diagnosed HIV cases has not seen this level of decline, remaining virtually flat at 21.1 to 20.9 nationally from 2006 to 2009. The number of people living with AIDS continues to grow, with a national incidence rate of 190.8 per 100,000 in 2008. In California, there were 226.9 per 100,000 living with AIDS in 2008, a substantial increase over the 2000 rate of 173 per 100,000. See *Figure 11: California and National AIDS Trends* for rates of AIDS over the last ten years.

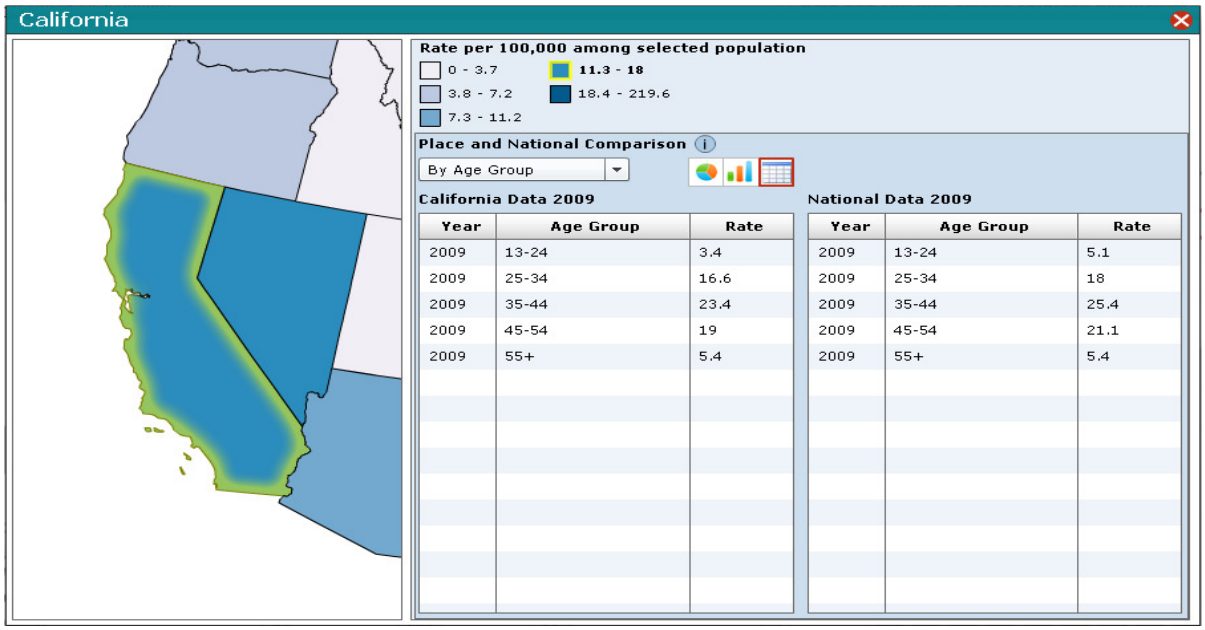
Figure 11: AIDS California and National Trends



The incidence of AIDS is much lower for females than males, with 3.3 cases for females versus 21.6 cases for men in California in 2009. National rates were 6.6 for women and 20.6 for men in that same year. The incidence of AIDS is highest for people ages 35-44, with California

having a rate of 23.4 cases diagnosed per 100,000 in this age group. The national rate also peaks for this age group at 25.4 cases per 100,000. *Figure 12: AIDS in California and Nationally by Age Group* illustrates the variation in AIDS rates across age groups.

Figure 12: AIDS in California and Nationally by Age Group



Racial Disparities of STDs

Racial disparities for the incidence of chlamydia, gonorrhea, and AIDS are substantial. *Table 6: Racial Disparities for Common STDs, Rates per 100,000* was compiled from the Center for Disease Control National GIS interactive tool. This data indicates the importance of meeting the reproductive health needs of minority communities, particularly the black community.

Table 6: Racial Disparities for Common STDs, Rates per 100,000

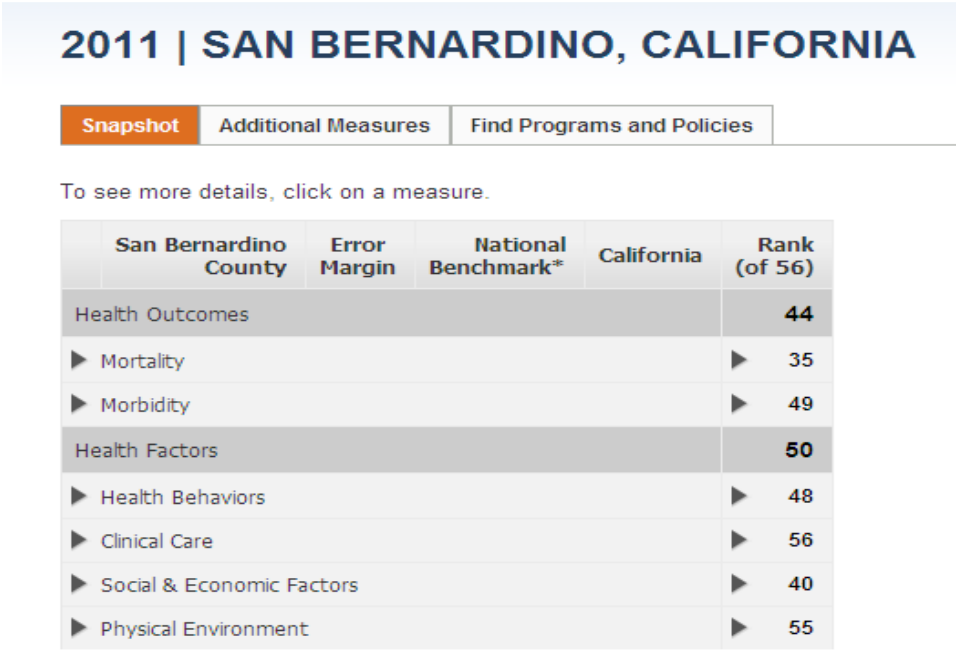
	Chlamydia 2010		Gonorrhea 2010		AIDS 2009	
Race	CA	National	CA	National	CA	National
Indian/Alaska Native	204.4	766.7	31.3	137.5	12.0	8.2
Asian/Pacific Islander	138.9	144.3	19.1	19.5	3.6	3.7
Black	1,260.4	1,505.9	387.9	559.7	42.2	55.2
Hispanic	464.6	520.0	55.3	70.3	13.5	18.8
White	151.0	166.2	37.7	27.8	10.2	5.5

Source: Compiled from the CDC National GIS Interactive Tool, 2012

San Bernardino County Health Status

San Bernardino is facing a number challenges in the fight to improve general public health. Poor environment, inadequate health services, and high-risk behaviors are all contributing to poor health outcomes for the SB County. The County Health Rankings Project (2012), conducted by the Population Health Institute at the University of Wisconsin and funded by the Robert Wood Foundation, shows San Bernardino near the bottom of 56 counties assessed in California, with a ranking of 44th for health outcomes and 50th for health factors, including 56th (or last) for clinical care–see *Figure 13: San Bernardino County Health Rankings Results*. Evaluated clinical care factors include insurance rates (reported at 26%), access to primary care physicians (calculated at 1,201:1), preventable hospital stays, and diabetic and mammography screenings.

Figure 13: San Bernardino County Health Rankings Results



2011 | SAN BERNARDINO, CALIFORNIA

Snapshot | Additional Measures | Find Programs and Policies

To see more details, click on a measure.

	San Bernardino County	Error Margin	National Benchmark*	California	Rank (of 56)
Health Outcomes					44
▶ Mortality					▶ 35
▶ Morbidity					▶ 49
Health Factors					50
▶ Health Behaviors					▶ 48
▶ Clinical Care					▶ 56
▶ Social & Economic Factors					▶ 40
▶ Physical Environment					▶ 55

Source: County Health Rankings Project, 2012

San Bernardino County also ranks low on a number of other key indicators for general health, particularly in the area of reproductive health as measured by the State of California Department of Health. In the recent report on the Health Status by County Results, San Bernardino County was consistently in the bottom quartile in the indicators of reproductive health status, ranking 44th in the incidence of AIDS in individuals over 13 years of age, ranking 48th in the incidence of chlamydia, and ranking 49th in the incidence of gonorrhea out of the 58 counties in the state (Scott, Agurto, Rodrian, & Bilot, 2011). These indicators are highlighted below in *Table 7: Health Status by County Results*, which compares San Bernardino's figures to both Orange County and California state figures.

Table 7: 2011 Health Status by County

California Department of Public Health

	Ranking - (58)		Rates per 100,000		
Mortality Indicators	SB	OR	SB	OR	CA
Mortality - All Causes	44	11	755.3	594.4	647.2
Mortality - All Cancer Deaths	38	17	164.2	148.3	154
Mortality - Female Breast Cancer	48	23	23.5	20.1	21.2
Mortality - Drug Induced	24	17	10.5	9.7	10.7
	Ranking - (58)		Rates per 100,000		
Morbidity Indicators	SB	OR	SB	OR	CA
AIDS 13 and Older	44	43	7.6	7.4	10.7
Chlamydia	48	33	396.9	258.2	382.4
Gonorrhea	49	32	67.7	27	70.2
	Ranking - (58)		Rates (see indicator)		
Infant and Natality Indicators	SB	OR	SB	OR	CA
Infant Mortality Under Age 1 (per 1,000)	47	22	6.4	4.8	5.3
Low Birth Weight Infants (per 100)	51	38	7.1	6.5	6.8
Births to Adolescent Mothers (per 1,000)	48	20	44.4	25.7	34.7
Prenatal Care Not Started 1st-Trimester (%)	18	2	18.6%	11.5%	17.3%

Source: County Health Status Profiles 2011 (Scott et al., 2011)

San Bernardino County Demographics

Current and Projected Population

San Bernardino County has a population of approximately 2,035,000 people, including a large Hispanic population of 49.2 %, or a total of 1,001,145 Hispanics or Latinos (U.S. Census Bureau, 2011). The Black population represents 8.9% of the total population, while Asians represent 6.3%. The Hispanic population is more likely to use publicly funded clinics than other ethnicities (Radecki & Bernstein, 1989). Hispanic access to care is hampered not only by economic-related conditions of income and health insurance, but also by a lack of consistent ties to a particular physician (Andersen et al., 1986).

The San Bernardino County population is growing and is expected to continue to do so at substantial rates. By the year 2050, San Bernardino County is expected to grow to 3.66 million, nearly the size of Orange County, which is expected to grow to 3.99 million (California, 2007). See *Table 8: Population Projections by County*.

Table 8: Population Projections by County

County	2010	2020	2030	2040	2050
San Bernardino	2,035,000	2,581,400	2,958,900	3,309,300	3,662,200
Ten Year Increase	26.5%	18.5%	14.6%	11.8%	10.7%
Orange	3,227.800	3,520,300	3,705,300	3,849,700	3,987,600
Ten Year Increase	13.8%	9.1%	5.3%	3.9%	3.6%

Source: California Department of Finance, 2007

Detailed population information by city or town for women with the primary target age of Planned Parenthood in San Bernardino will be provided in Chapter 4: Analysis and Results as a part of the location analysis.

Median and Per Capita Income

San Bernardino County ranks 37th in the state for infants, children, and adolescents (<18) living in poverty, with 19.7% of this population living below the Federal Poverty Level (Scott et al., 2011). The income levels for San Bernardino County residents are not evenly distributed throughout the county. The median family income ranges from a high of $103,106 in Chino Hills to a low of $40,017 in San Bernardino city. Relatively affluent areas include Chino Hills, Chino, Redlands, and Rancho Cucamonga. Areas with lower levels of median family income include San Bernardino, Apple Valley, Rialto, Victorville, Hesperia, and Ontario. *Figure 14: San Bernardino Median Income* shows the income for the major cities within San Bernardino County.

Per capita income disparity is greater than the median family income disparity within SB County. Average per capita incomes in the more affluent areas of Chino Hills, Redlands, and Rancho Cucamonga are approximately twice as high as in the lower income areas of San Bernardino, Rialto, Victorville, and Hesperia. *Figure 15: San Bernardino Per Capita Income by Area* illustrates the disparity of income across the county.

Figure 14: San Bernardino Median Income

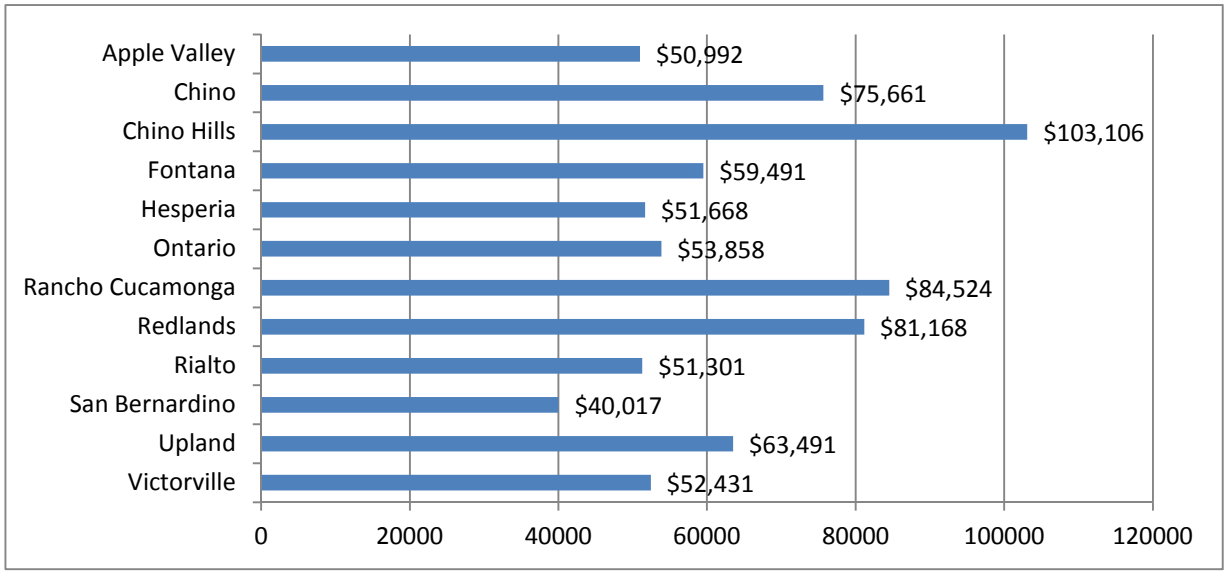
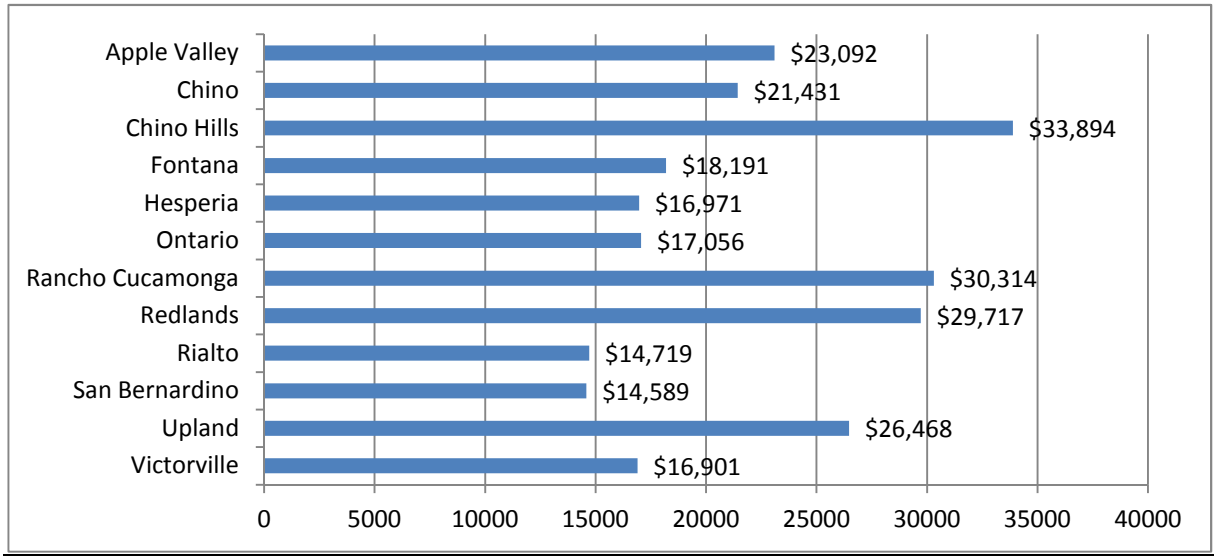


Figure 15: San Bernardino per Capita Income by Area



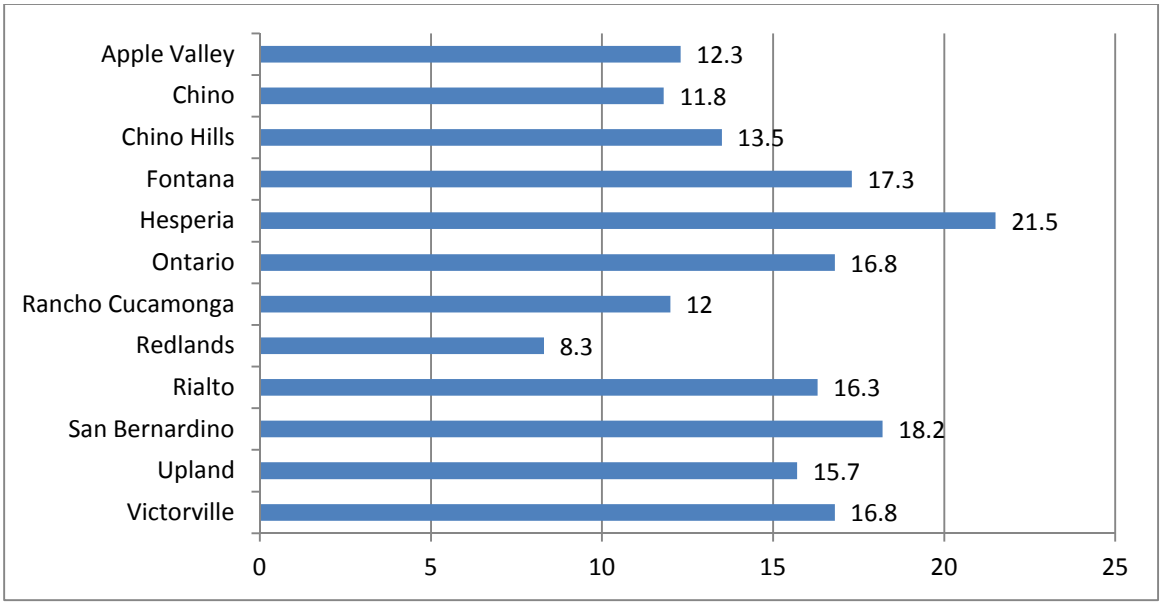
Unemployment

San Bernardino County is struggling with high unemployment levels. The unemployment rate for the Riverside-San Bernardino-Ontario Metropolitan Suburban Area or M.S.A. was 13.2% in May 2011, compared with rates of 11.4% for California and 8.7% for the nation

(Employment Development Department (EDD), 2011). These conditions increase the demand for publically funded reproductive health services throughout the county due to loss of insurance and income for the unemployed.

The rate of unemployment varies throughout the county. The highest unemployment in the county is in the community of Hesperia in the upper desert with a rate of 21.5%, followed by rates of 18.2% and 17.2% for San Bernardino city and Fontana, respectively. The lowest unemployment rates are in the communities of Redlands, with a rate of 8.3%, Chino with a rate of 11.8%, and Rancho Cucamonga with a rate of 12%. See *Figure 16: San Bernardino Unemployment Rates*.

Figure 16: San Bernardino Unemployment Rates



Uninsured Population

Health insurance rates also vary widely across the San Bernardino County. The largest uninsured population is in Fontana, followed by Ontario and Rialto. Each of these cities has over

40,000 people without private or public insurance. See *Figure 17: Individuals Without Health Insurance (Private or Public)* and *Figure 18: Percent of Population Without Health Insurance*.

Figure 17: Individuals Without Health Insurance (Private or Public)

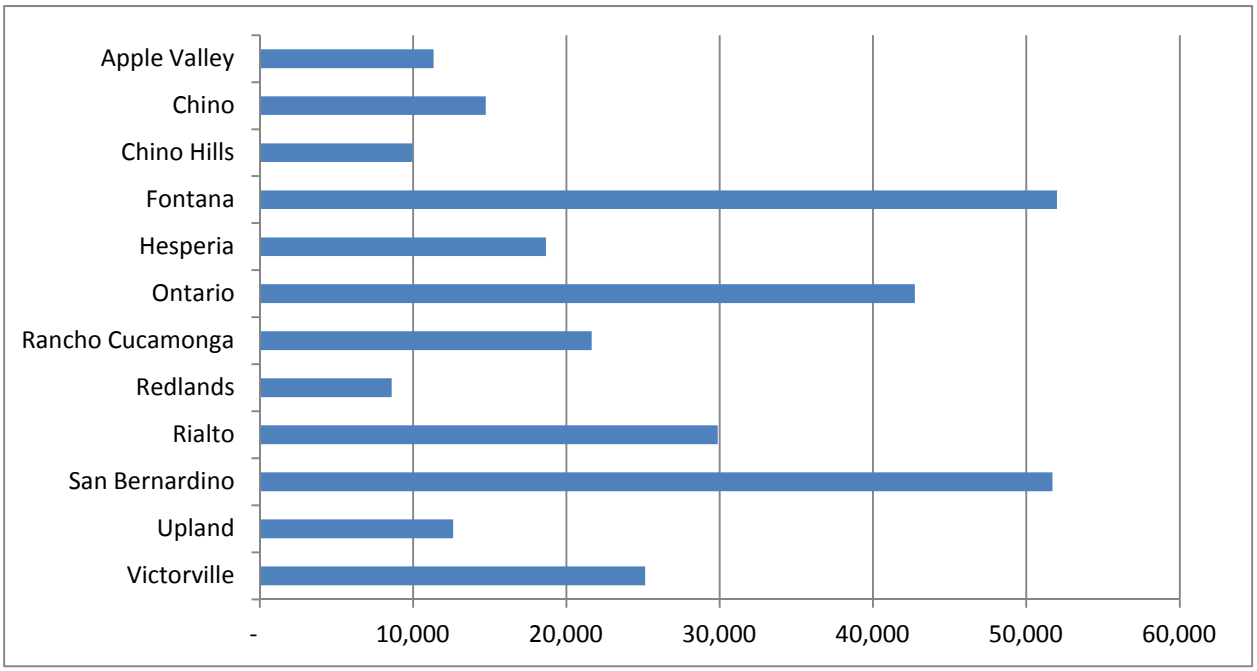
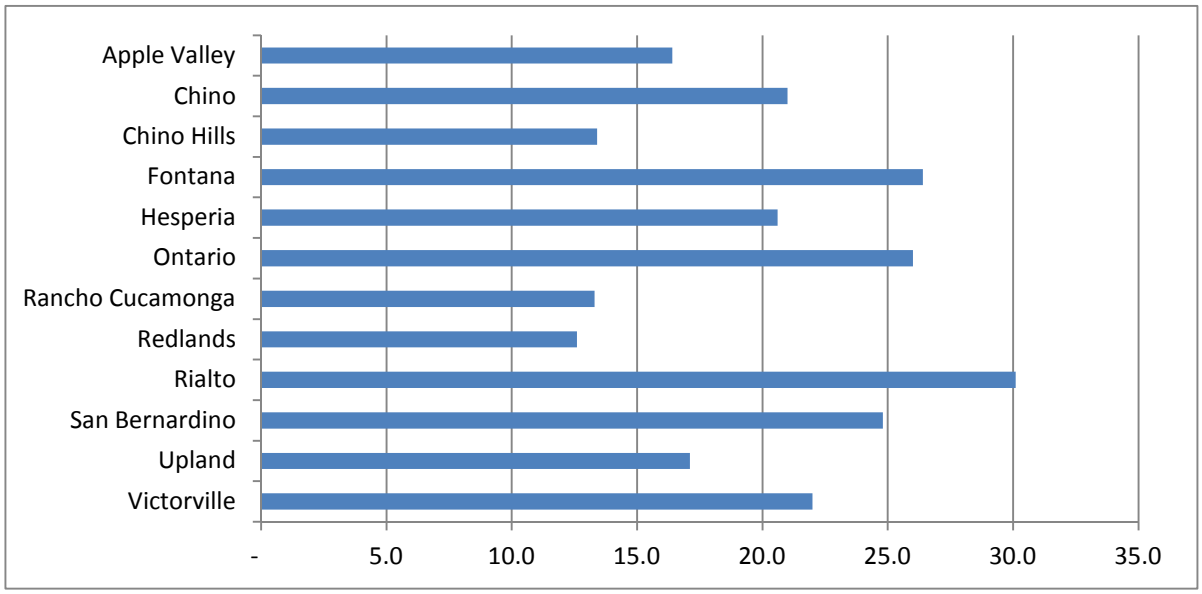


Figure 18: Percent of Population Without Health Insurance



The percentage of the population without insurance also varies across the county and reflects the employment and income disparity levels. Regions with relatively low percentages of uninsured individuals include Redlands, Rancho Cucamonga, and Chino Hills; higher percentages of uninsured populations exist in Rialto, Fontana, Ontario, and San Bernardino.

San Bernardino County Provider Information

An understanding of existing providers, and their location, size, and patient mix, is important in determining expansion locations for health services organizations. This information may help identify areas or locations with a lack of providers, or areas with an excess supply of providers. This section uses publicly available resources from the Department of Health Services, Office of Statewide Health Planning & Development Department, the Office of Family Planning, FPACT data, and other local sources to identify safety net providers similar to Planned Parenthood.

General Provider Information

When adjusted for population, San Bernardino County has fewer health care providers than either Los Angeles or Orange County. The average number of persons per physician in San Bernardino County is estimated at 601, versus 356 for Orange County and 384 for Los Angeles County (Jew-Lochman, 2006). Selected provider information for San Bernardino and Orange is provided in *Table 9: Provider Information by County*.

Table 9: Provider Information by County

County	Physicians	Avg. Persons Per Doctor	Dentists	Avg. Persons Per Dentist	Community and Free Clinics
San Bernardino	3,173	601	1,080	1,831	16
Orange	8,533	356	3,221	950	31

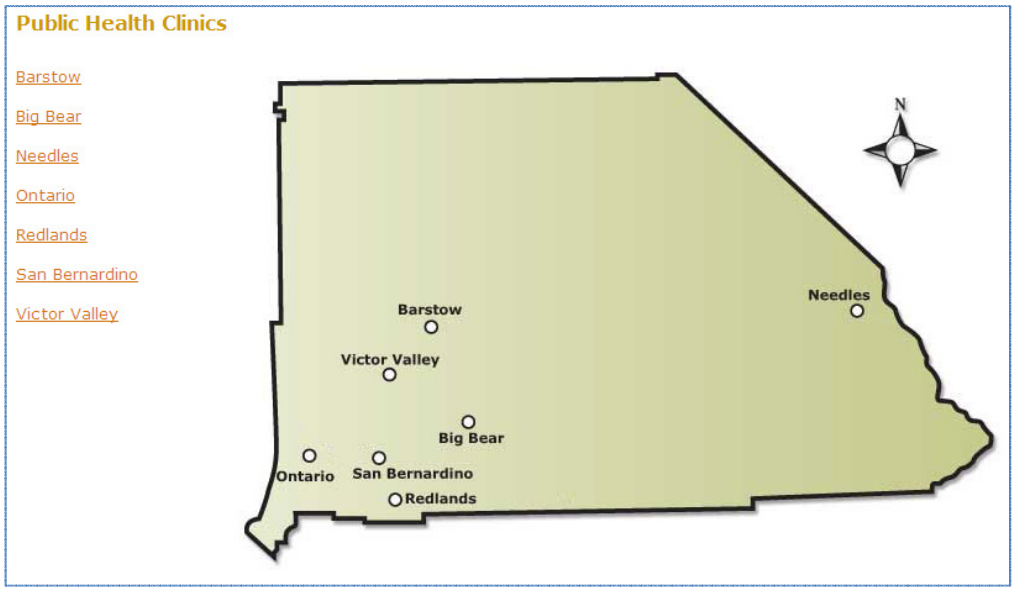
Source: Jew-Lochman, 2006

San Bernardino County had a total of 683 MediCal Physicians in 2003 compared to 1,881 in Orange County, even though the total MediCal eligible populations were virtually equal in that year at 346,000, or 18.5% of the total population in San Bernardino, and 349,000, or 11.6% of the Orange County population (Jew-Lochman, 2006).

San Bernardino County Health Services

The County of San Bernardino operates a number of health service facilities, including seven outpatient clinics throughout the county. *Figure 19: San Bernardino County Operated Clinics* illustrates their locations. Some of these clinics operate on a very restricted schedule. For example, the Barstow and Big Bear clinics are open only one day per week. Other clinics restrict their services. For example, the Needles clinic only provides reproductive health services on every other Thursday. The Ontario, Redlands, San Bernardino, and Victor Valles (located in Hesperia) clinics, however, are open five days per week, Monday to Friday, from 8:00 a.m. to 5:00 p.m., and offer a broad range of services, including reproductive health. Additionally, these health centers offer once or twice weekly afternoon young adult reproductive health services for people 21 years of age or younger.

Figure 19: San Bernardino County Operated Clinics



Private Community Clinics

Licensed community clinic providers are required to submit data to the Office of Statewide Health Planning Department (OSHPD) each year. This data is available from OSPHD's website at www.oshpd.ca.gov. Filtering this data for primary community clinics for San Bernardino County is the best source for finding clinics similar to Planned Parenthood. A search found seventeen primary clinics operating within the county. *Table 10: San Bernardino Licensed Community Clinics 2010* lists the clinics with operating licenses as of 2010, while *Table 11: San Bernardino Licensed Community Clinics 2010 with Encounters by Funding Source* lists them according to the type of financing used to fund the encounter.

Four of the community clinics are operating as Federally Qualified Health Centers: Inland Empire Community Health Center, operated by Community Health Systems, Inc.; Whitney Young Family Health Center and Inland Family Community Health, both operated by Inland Behavioral and Health Services, Inc.; and San Manuel Indian Health Clinic, operated by Riverside-San Bernardino County Indian Health, Inc. Both of the Chino Hills Primary Care

Centers are extensions of the Pomona Valley Hospital Medical Center. Three of the health centers are operated by right to life organizations and offer a limited level of service: Alternative Avenues Women's Resource Center in Montclair; Pregnancy Counseling Center operated by Mountain Right to Life, Inc.; and the High Desert Pregnancy Clinic operated by the Right to Life League of Southern California.

Nearly all of the licensed clinics within San Bernardino are in either the West End or within the San Bernardino Valley Region. *Figure 20: Map of San Bernardino Licensed Clinics* shows the clustering of community clinics within the county. Figures 21 and 22 are maps showing the precise locations of each health clinic for the San Bernardino Valley and West End regions. Only two community clinics in San Bernardino County exist outside of these regions. Both are in the Yucca Valley area: Yucca Family Medical Care had approximately 22,780 encounters in 2010 and the High Desert Pregnancy center, which offers extremely limited services for pregnancy counseling, performed around 1,000 visits in 2010.

Table 10: San Bernardino Licensed Community Clinics 2010

NO.	CLINIC NAME	CITY	TYPE
1	INLAND EMPIRE COMMUNITY HEALTH CENTER	BLOOMINGTON	FQHC
2	CHINO HILLS PRIMARY CARE CENTER–Grand Ave.	CHINO HILLS	Hospital OP
3	CHINO HILLS PRIMARY CARE CENTER–Chino Ave.	CHINO HILLS	Hospital OP
4	ALTERNATE AVENUES WOMEN'S RESOURCE CENTER	MONTCLAIR	Reproductive
5	KIDS COME FIRST COMMUNITY CLINIC	ONTARIO	
6	AHF HEALTHCARE CENTER - UPLAND	RANCHO CUCAMONGA	
7	SAC - ARROWHEAD	SAN BERNARDINO	
8	SAC–NORTON	SAN BERNARDINO	
9	WHITNEY YOUNG FAMILY HEALTH CLINIC	SAN BERNARDINO	FQHC
10	PREGNANCY COUNSELING CENTER	SAN BERNARDINO	Reproductive
11	INLAND FAMILY COMMUNITY HEALTH CENTER	SAN BERNARDINO	FQHC
12	PP/ORANGE AND SAN BERNARDINO CO. INC	SAN BERNARDINO	Reproductive
13	SAN MANUEL INDIAN HEALTH CLINIC	SAN BERNARDINO	FQHC
14	H STREET CLINIC, LLC	SAN BERNARDINO	
15	PP/ORANGE-SAN BERNARDINO COUNTIES	UPLAND	Reproductive
16	YUCCA FAMILY MEDICAL CARE INC	YUCCA	
17	HIGH DESERT PREGNANCY CLINIC, INC.	YUCCA VALLEY	Reproductive

Source: California Office of Statewide Health Planning and Development (OSHPD), 2012

San Bernardino City and the surrounding communities in the eastern valley region have eight licensed community clinics. This region is home to all four of the FQHCs within the county and some of the largest health centers: Inland Family Community and SAC–Norton, a health center associated with the Adventist and Loma Linda University. These health centers had a combined total of 123,618 visits in 2010, or 57.5% of all health encounters by licensed clinics within SB County.

Figure 20: Map of San Bernardino Licensed Clinics

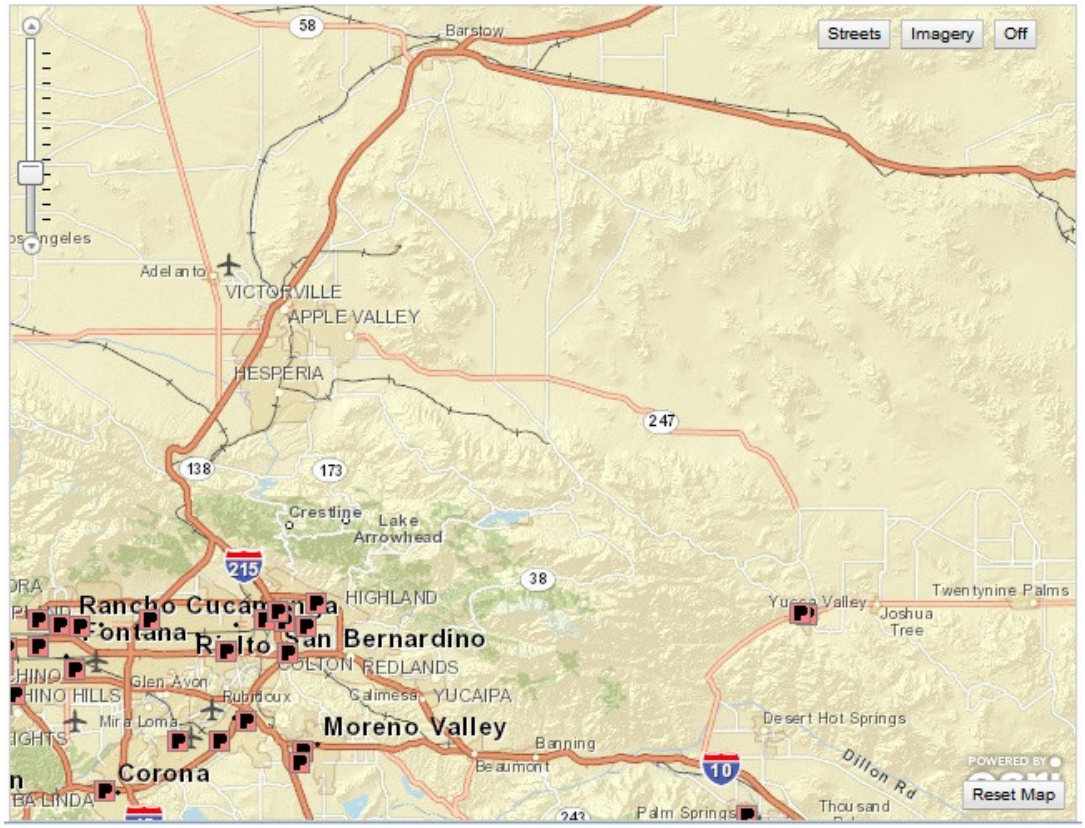


Figure 21: San Bernardino East Valley Community Health Centers Map

The West End of San Bernardino Valley contains eight health centers with a combined total of 67,248 encounters in 2010, or 31.3% of all licensed clinic encounters for SB County. In addition, the West End has access to other providers just outside of the county line, including the Pomona Valley Hospital Medical Center, East Valley Community, and Planned Parenthood Pomona Los Angeles.

Figure 22: San Bernardino West End Health Centers Map

The distribution of health centers is logical given the history of development within San Bernardino County and the rapid growth of the central San Bernardino areas and high desert areas over the last decade. Growth between San Bernardino city (and its surrounding communities) and the West End area of Upland has been substantial. Health services development has not kept pace with the fast growing communities of Rancho Cucamonga and Fontana in the southern portion of the county, or the significant growth of the high desert communities. As housing prices increased in the urban areas, cheaper land provided affordable development opportunities, creating these high growth communities.

Table 11: San Bernardino Licensed Community Clinics 2010 with Encounters by Funding Source

NO.	CLINIC NAME	FPACT	MediCal	Medicare	Priv. Ins.	Cash[1]	Total
1	INLAND EMPIRE COM. HEALTH CENTER	1,284	2,835	1,092	239	8,300	16,982
2	CHINO HILLS PRIMARY CARE CENTER–Grand Ave.	0	765	2,644	8,478	1,064	15,301
3	CHINO HILLS PRIMARY CARE CENTER–Chino Ave.	0	1,005	1,901	16,715	1,824	24,977
4	ALTERNATE AVENUES WOMEN'S RESOURCE CTR	0	1,222	-	-	1,232	2,454
5	KIDS COME FIRST COMMUNITY CLINIC	11	612	-	-	2,258	5,968
6	AHF HEALTHCARE CENTER - UPLAND	0	245	238	135	515	1,168
7	SAC - ARROWHEAD	1,440	1,123	50	21	462	3,917
8	SAC–NORTON	2,227	4,618	1,082	773	8,243	29,347
9	WHITNEY YOUNG FAMILY HEALTH CLINIC	746	774	167	6	1,187	4,287
10	PREGNANCY COUNSELING CENTER	0	0	-	-	2,533	2,533
11	INLAND FAMILY COM. HEALTH CENTER	2,692	6,764	1,207	104	9,013	29,433
12	PP/ORANGE AND SAN BERNARDINO CO. INC	10,815	1,444	-	54	1,393	15,279
13	SAN MANUEL INDIAN HEALTH CLINIC	0	1,663	346	1,244	13,861	17,216
14	H STREET CLINIC, LLC	113	111	36	-	4,364	4,624
15	PP/ORANGE-SAN BERNARDINO COUNTIES	14,035	810	-	23	1,615	17,380
16	YUCCA FAMILY MEDICAL CARE INC	175	12,858	5,424	2,725	482	22,778
17	HIGH DESERT PREGNANCY CLINIC, INC.	0	0	-	-	1,172	1,172
	TOTALS	33,538	61,909	14,187	30,517	59,519	214,816
	PERCENT OF ENCOUNTERS	15.6%	28.8%	6.6%	14.2%	27.7%	100.0%[1]
	PLANNED PARENTHOOD PERCENT OF TOTAL	74.1%	7.6%	0.0%	0.3%	5.1%	15.2%

Source: California Office of Statewide Health Planning and Development (OSHPD), 2012

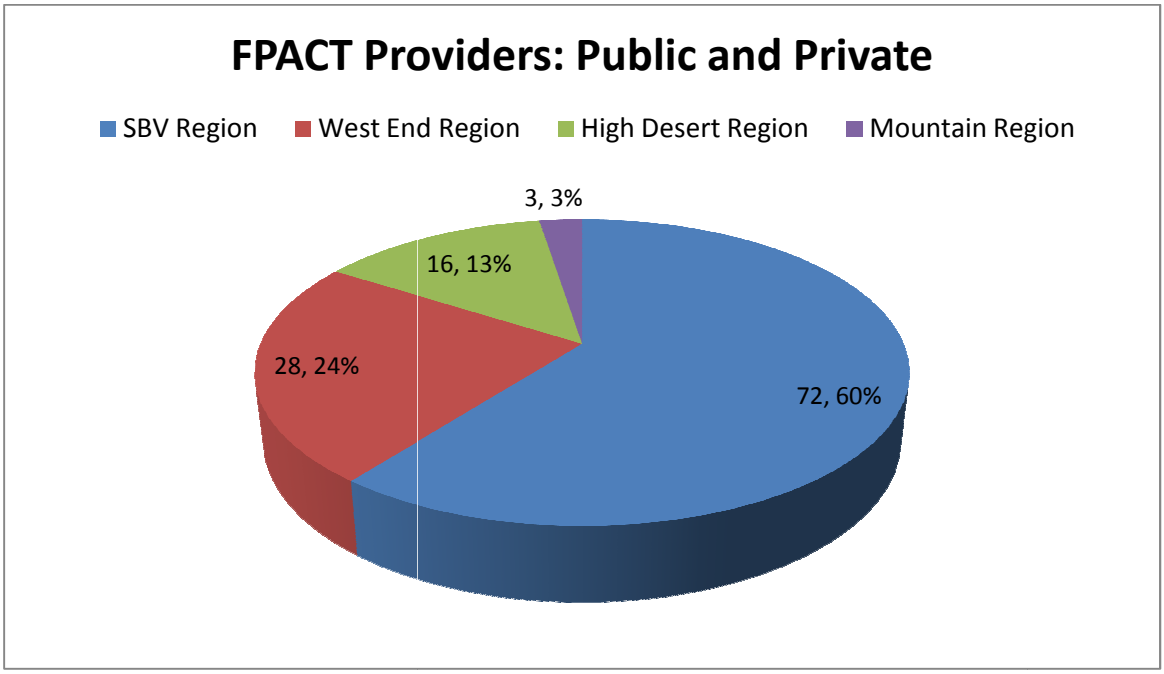
[1] Note: Cash includes free care
[2] Note: Values will not cross-foot as "Other Sources" account for 7.1% of the total.

Although alternatives to Planned Parenthood's reproductive health services exist, the two health centers operated by PPOSBC see 74.1% of all FPACT patients seen by these community health clinics. This attests to the name recognition, extended hours of operation, and the focus on reproductive health services of Planned Parenthood that drive patients to seek out their services and to be a provider of choice for reproductive care.

FPACT Providers

According to the FPACT website, there are 119 FPACT providers in San Bernardino. Of these, 60%, or 72, of them are in the San Bernardino East Valley Region, 24%, or 28, are in the West End Region, 13%, or 16, are in the High Desert Region, and three percent, or 3, are in the Mountain Region. See *Figure 23: FPACT Providers by Region*. When adjusted for population, the most providers per capita were in the San Bernardino Valley Region, with 8.9 providers per 100,000 people, nearly twice the level of the High Desert Region at 4.7 per 100,000.

Figure 23: FPACT Providers by Region



A more detailed look at the FPACT providers is presented in *Table 12: FPACT Providers by City in San Bernardino*. The table includes cities or towns without an FPACT provider, as well as the ratio of providers to population. There are clearly some communities that would benefit from a broader array of providers participating in the FPACT program providing reproductive health services to their general population.

Table 12: FPACT Providers by City in San Bernardino

City	Number Provider Locations	Total Population	Average Providers per 100,000	People Per Provider
ADELANTO	0	31,765	-	
APPLE VALLEY	5	69,135	7.23	13,827
BARSTOW	4	22,639	17.67	5,660
FORTIRWIN	0	8,845	-	
HESPERIA	3	90,173	3.33	30,058
HOMESTEAD VALLEY	0	3,032	-	
JOSHUA TREE	0	7,414	-	
LENWOOD	0	3,542	-	
LUCERNE VALLEY	0	5,811	-	
MOUNTAIN VIEW ACRES	0	3,130	-	
NEEDLES	1	4,844	20.64	4,844
OAKHILLS	0	8,879	-	
PHELAN	0	14,304	-	
PINONHILLS	0	7,272	-	
TWENTYNINE PALMS	0	25,048	-	
SILVERLAKES	0	5,623	-	
SPRINGVALLEY LAKE	0	8,220	-	
VICTORVILLE	3	115,903	2.59	38,634
YUCCA VALLEY	0	20,700	-	
Total	16	456,279	3.51	28,517
BIG BEAR CITY	0	12,304	-	
BIG BEAR LAKE	1	5,019	19.92	5,019
CRESTLINE	0	10,770	-	
LAKE ARROWHEAD	1	12,424	8.05	12,424
RUNNING SPRINGS	1	4,862	20.57	4,862
WRIGHTWOOD	0	4,525	-	
Total	3	49,904	6.01	16,635

(continued)

City	Number Provider Locations	Total Population	Average Providers per 100,000	People Per Provider
BLOOMINGTON	1	23,851	4.19	23,851
COLTON	7	52,154	13.42	7,451
FONTANA	15	196,069	7.65	13,071
GRAND TERRACE	0	12,040	-	
HIGHLAND	1	53,104	1.88	53,104
LOMA LINDA	5	23,261	21.50	4,652
MENTONE	0	8,720	-	
MORONGO VALLEY	0	3,552	-	
MUSCOY	0	10,644	-	
REDLANDS	7	68,747	10.18	9,821
RIALTO	7	99,171	7.06	14,167
SAN BERNARDINO	29	209,924	13.81	7,239
YUCAIPA	0	51,367	-	
Total	72	812,604	8.86	11,286
CHINO	5	77,983	6.41	15,597
CHINO HILLS	0	74,799	-	
MONTCLAIR	7	36,664	19.09	5,238
ONTARIO	11	163,924	6.71	14,902
RANCHO CUCAMONGA	1	165,269	0.61	165,269
SAN ANTONIA HEIGHTS	0	3,371	-	
UPLAND	4	73,732	5.43	18,433
Total	28	595,742	4.70	21,277
Grand Total	119	1,914,529	6.22	16,088

Planned Parenthood Sister Affiliates Health Centers

There are other Planned Parenthood affiliates that may serve San Bernardino patients. Planned Parenthood of Los Angeles operates an affiliated health center in Pomona, California. It is identified in Figure 16. Planned Parenthood of the Pacific-Southwest, which operates affiliates in the San Diego, Riverside and Imperial Counties, has three affiliates in Riverside County that San Bernardino residents may access. These are in Riverside, Moreno Valley, and in Palm Desert. Because these other affiliates offer the full range of Planned Parenthood services, they will be considered in the analysis as available sites and those communities surrounding these locations will be considered as “covered” in the analysis.

Summary Needs Statement

This chapter has examined key elements of reproductive health both nationally and in California. More importantly, it contains information on the population, demographics, health status, and provider community of San Bernardino County in order to provide background information on expansion locations for Planned Parenthood of Orange and San Bernardino Counties. In summary:

1. Reproductive health concerns persist in the United States and California, as evidenced by the rising rates of STDs such as chlamydia, the significant number of people living with HIV, and the number of deaths associated with AIDS.
2. San Bernardino County ranks extremely low in comparison to other counties on a broad array of health outcomes and health factors, including key reproductive health outcomes such as incidence of breast cancer, low-birth weight deliveries, teenage pregnancy rates, and sexually transmitted diseases.
3. San Bernardino needs additional providers to serve an expanding number of communities. Areas such as the High Desert do not have a pro-rata share of service providers in both MediCal and the FPACT programs.
4. Important determinants of health, such as income and insurance coverage, are not uniformly distributed across the communities of San Bernardino County. Rialto, Fontana, San Bernardino, Victorville, and other High Desert Communities lag the more affluent areas of Redlands, Rancho Cucamonga, and Chino Hills.
5. While other safety net providers exist within the SB County, Planned Parenthood is the largest single provider of FPACT services to the county, accounting for 74% of all such encounters.

Based on these facts, San Bernardino County is a primary expansion target for Planned Parenthood of Orange and San Bernardino Counties.

Problems Statement and Public Health Implications

PPOSBC has limited resources and seeks to maximize the benefits and utilization of new health centers. In order to plan for the expansion of services, PPOSBC must determine the needs of various communities and ultimately decide which location(s) should be considered for potential expansion. PPOSBC requires a methodology and framework to make these important decisions in a subjective and responsible manner. A decision process or methodology that will help support the location decisions and gain traction with stakeholders, including board members, community leadership, donors, etc., is required.

This dissertation and its analysis and models provide valuable information to PPOSBC decision-makers in selecting future sites for health centers in San Bernardino. The dissertation has the benefit of directly impacting the public's ability to access reproductive health care by locating services for maximum coverage. Lastly, the dissertation demonstrates the application of basic location science in PPOSBC's expansion efforts and thus serves as an example of how to support similar decisions in the planning efforts of other health service organizations.

Chapter 3: Approach and Methods

Introduction

Chapter 3: Approach and Methods discusses the location optimization analysis framework used to provide PPOSBC information to support decisions related to the expansion of services within San Bernardino County. Discussion of alternative mathematical optimization models is limited; an evaluation of the numerous solution alternatives is beyond the scope of the dissertation and was thus omitted. A brief discussion of the application of location science in health services is included to support the use of optimization models in assisting PPOSBC and other similar organizations with facility location or expansion decisions. This chapter illustrates how the increase of publicly available data, the ease of access to such data via the internet, and advances in software technology facilitate the application of mathematically complex models in location decisions. The aforementioned factors enable smaller health service organizations, both non-profit and profit-oriented, to gain insight into their current facility distribution, location decisions, and patients.

This chapter identifies the models applied to the San Bernardino County expansion problem and the variables and data required by these models. Data sources and solver, or optimization, software is also identified. Lastly, a brief discussion of the approach and methods is included, along with the identification of the limitations of the approach and methods selected.

Location Science

Location science, or regional science, applies mathematical models to a wide variety of decisions related to the optimal placement of resources subject to certain constraints. Optimal placement is generally expressed through the maximization or minimization of functional objective statements using integer linear programming. Capital investment, operating costs, total

distance to market, and travel time are common functional objectives, which are optimized, or minimized, as a result of locating the resource in a specified location as opposed to all possible alternatives. This body of knowledge and its study are generally conducted in the Operations Research, Management Science, or Environmental Sciences fields.

Location science has a wide range of applications, from switching centers in communication networks (Hakimi, 1965) to bus stop locations (Gleason, 1975) to animal reserves (Church, Stoms, & Davis, 1996). The applications of location science in health services are varied and extensive. Three types of location models comprise the majority of health services applications: *p*-median, set covering of location, and maximal covering (Daskin & Dean, 2004). Here are just a few examples of such applications:

1. Emergency Services: Locating emergency response services, e.g., ambulance services, etc., where coverage is maximized and response times are minimized (Alsalloum & Rand, 2006; Doerner, Gurjahr, Hartl, Karall, & Reimann, 2005). This application area has also benefited from the use of probabilistic models to maximize availability of servers based on the probability that responders are busy on existing calls when requests are received (ReVelle & Hogan, 1989). The applications of location models for emergency medical services, including fire station locations, are well documented. Toregas, Swain, Revelle, and Bergman (1971) developed the Location Set Covering Problem (LSCP), which requires that emergency service facilities be located such that all demand points are covered within a specified time or distance (Toregas et al., 1971). For a comprehensive, yet concise, review of the most prevalent location models used in emergency services, see “Operations Research

Models for the Deployment of Emergency Services Vehicles," *EMS Management Journal* (Goldberg, 2004).

2. Acute Care Hospital Systems: Locating hospitals and determining appropriate levels of service; optimizing the site locations of hospitals in Israel (Mehrez, Sinuany-Stern, Arad-Geva, & Binyamin, 1996); configuring hospital networks with service level analysis in Canada (Santibanez, Bekiou, & Yip, 2009).
3. Multi-Level Health Service: Minimizing travel and facility costs in the evaluation and design of a multi-level health system configuration (Dokmeci, 1977); developing a hierarchical health service delivery system in Honduras (Moore & ReVelle, 1982).
4. Developing Country Health Services: Reducing maternal deaths in Bangladesh through careful planning and locating of emergency obstetrics care centers (Khan, Ali, Ferdousy, & Al-Mamun, 2001); placing health workers in remote towns and villages in Columbia considering access to water, electricity, distance, and even elevation change between sites (Bennett, Eaton, & Church, 1982).

With a variety of potential variables and constraints that can be incorporated within health service location decision models, location science has proven successful in aiding health service location decisions.

Historically the use of location science has been relatively expensive, requiring expertise to formulate the problem, resources to gather and compile the data, computer resources for problem setup, and access to programs capable of solving large-scale integer programming problems. Consequently, location science has generally been applied to public facilities with critical response times, e.g. fire stations and emergency response, or where fixed costs are substantial, such as with hospitals or hospital networks. The application of location science for

general outpatient service locations has been limited. However, several developments have made the application of location science both cheaper and easier: (a) the advancement of computer software technology, including spreadsheet technology and solver add-ins and (b) the ease of access to data via the internet. These advances allow management personnel or analysts to more easily apply location science and construct simple models to inform their organizations. Additionally, users may now vary both the models and the parameters or assumptions used within the models to evaluate their impact on solutions and gain further insight into location decisions.

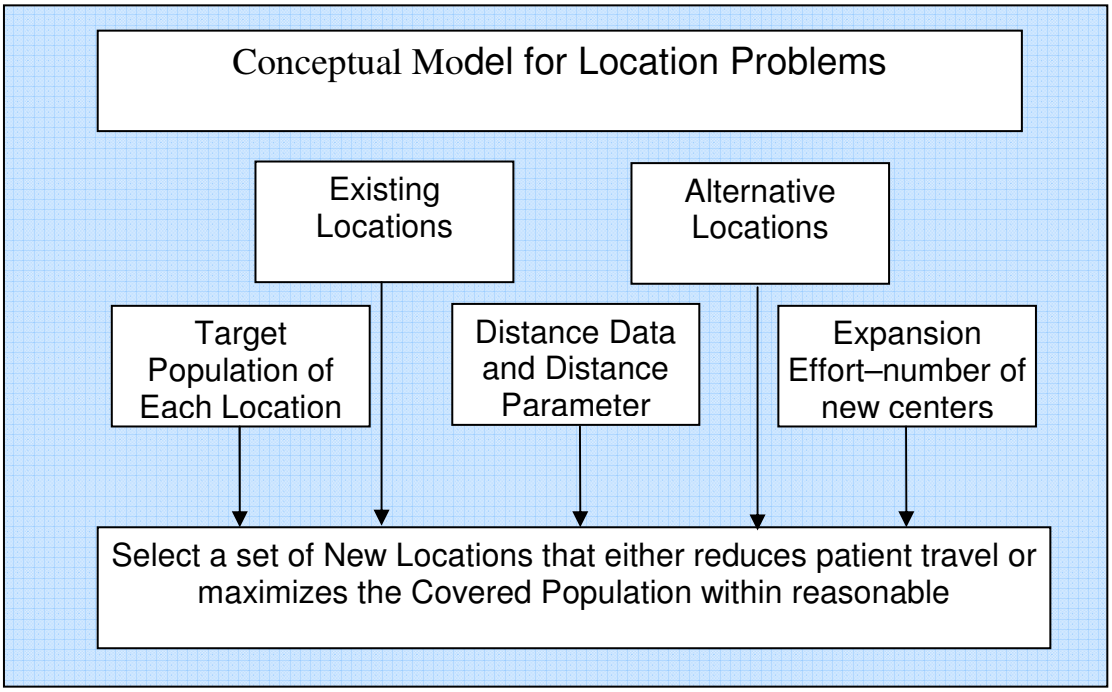
Solution Approach

Location science was used to assist PPOSBC with expansion decisions in San Bernardino County and to demonstrate its application in a community health services environment. Two approaches were used to evaluate the impact of the expansion of services under two different parameters. The first approach is the impact an additional PPOSBC health center (or health centers) will have on the community in terms of access and availability as measured by both miles driven and time to travel. This is a customer-centric solution, with its focus on reducing patient costs and time to access care. The optimization formulation used in this approach is the *p*-median problem. The second approach is to maximize the target population living in near proximity to additional health centers. Near proximity was measured using both miles driven and time to travel. Near proximity is relative and may vary from one location to another. The target population residing within a specified distance or time to travel range will be considered a "covered" population and served by the closest health center. This solution approach is an application of the maximal location coverage problem, or MLCP.

Solution and Data Model

The general constructs and data for the *p*-median problem and the Maximal Covering location problem are represented below as a diagram in Figure 24. The diagram illustrates the key inputs and data required for the optimal location set. Current PPOSBC sites in the cities of Upland and San Bernardino were assumed to remain in their current locations. The number of potential sites required was reduced when alternative sources of care were identified and added to the model; e.g., Planned Parenthood of Los Angeles and Planned Parenthood of San Diego and Riverside County locations were added as given sites with some assumed coverage within the bordering areas of San Bernardino. Consequently, there are a limited number of practical alternative sites that need to be evaluated given the current locations, concentration of populations in San Bernardino County, and the limited resources available to expand operations.

Figure 24: Location Problem Solution Diagram



P-Median Location Problem

The *p*-median problem is the most well-known and studied location problem (Marianov & Serra, 2011). The *p*-median problem seeks to find a point or a set of points where the distance(s) (or travel times) between the selected point(s) and all other points on the plan is minimized. In the early 20th century, Alfred Weber applied weights to the points to simulate demand, and in the mid-1960s, Hakimi formulated the discrete representation of the model, which led to the integer programming formulation (Reese, 2005). Numerous solution alternatives to the *p*-median problem have been proposed and compared. A report on the *p*-median problem by Joshua Reese, "Methods for Solving the *p*-Median Problem: an Annotated Bibliography," has 120 cited sources (Reese, 2005)[1]. The *p*-median problem is often used to locate transportation hubs, warehouses, production facilities, etc. The inclusion of the model in this setting is to show the difference between the solutions generated by this formulation and the more commonly used health services coverage model.

Maximal Covering Location Problem

The Maximal Covering Location Problem (MCLP), (Church & ReVelle, 1974) was used in this dissertation to determine the location of additional reproductive health centers in San Bernardino for Planned Parenthood of Orange and San Bernardino Counties. The maximum coverage problem can be formulated as the following integer linear problem (this presentation reflects the application of the problem for a set of health centers maximizing coverage to a target population):

Maximize $\sum_{e_j \in E} y_j$ (maximizing the sum of the covered target population).

[1] Reese also published a supplement to his report that includes 209 sources related to the *p*-median problem that either did not meet the inclusion criteria or were not located.

Subject to:

1) $\sum x_i \leq k$; (no more than k number of health centers is selected)

2) $\sum_{e_j \in S_i} x_i \geq y_j$; (if $y_j \geq 0$ then at least one set of health centers $e_j \in S_i$ is selected)

3) $0 \leq y_j \leq 1$; (if $y_j = 1$ then e_j is a covered target population)

4) $x_i \in \{0,1\}$ (if $x_i = 1$ then S_i is selected for the cover).

Data and Software

Applying the *p*-median problem and the maximum coverage model requires the gathering of three basic types of data, or variables, for each location. These are:

Population data: the total number of individuals identified as the target customer population by location. For this application, the target population is defined as females between 15 and 44 years of age.

Distance data: the distance of each location to all alternative locations. A distance parameter is used to determine whether or not a non-selected location is considered a covered population. This parameter can be determined for each selected location; it does not need to be constant for all locations.

Existing provider data: analysis of alternative providers within the geography area being considered for expansion. Alternative PPOSBC locations and other alternative providers who may provide reproductive health services to target customer populations are identified.

Population Data

Target population statistics have been gathered for the major cities and towns within the county using U.S. Census data, which can be found at www.census.gov. Since moderate levels of

aggregation of data in maximum coverage models have proven immaterial (Daskin, Haghani, Khanal, & Malandraki, 1989), populations by zip code were not required. The aggregation of the general population into major cities and towns rather than zip codes, and their respective distances from any selected site, were assumed not to pose a problem or introduce material errors into the optimal solution.

Distance and Time Data

The distance from one location to all other locations was gathered using readily available GIS sources, e.g., Google Maps. This data was required to determine the population considered covered within a specified distance factor for any site selected as a potential location. Time traveled was also considered, though commute and traffic patterns impact the total investment of time in driving. Travel time and distance were used to determine how these two solutions compared to one another for both the *p*-median and Maximal Covering.

The specified distance or travel time used to define a covered population can vary by site selected. An analysis of the population from existing sites was completed to assist in choosing an appropriate distance to determine if a surrounding city/town was considered covered. Using the average distance traveled by patients to existing health centers helped establish the distance used for future locations when considering if surrounding locations should be considered covered.

Provider Data

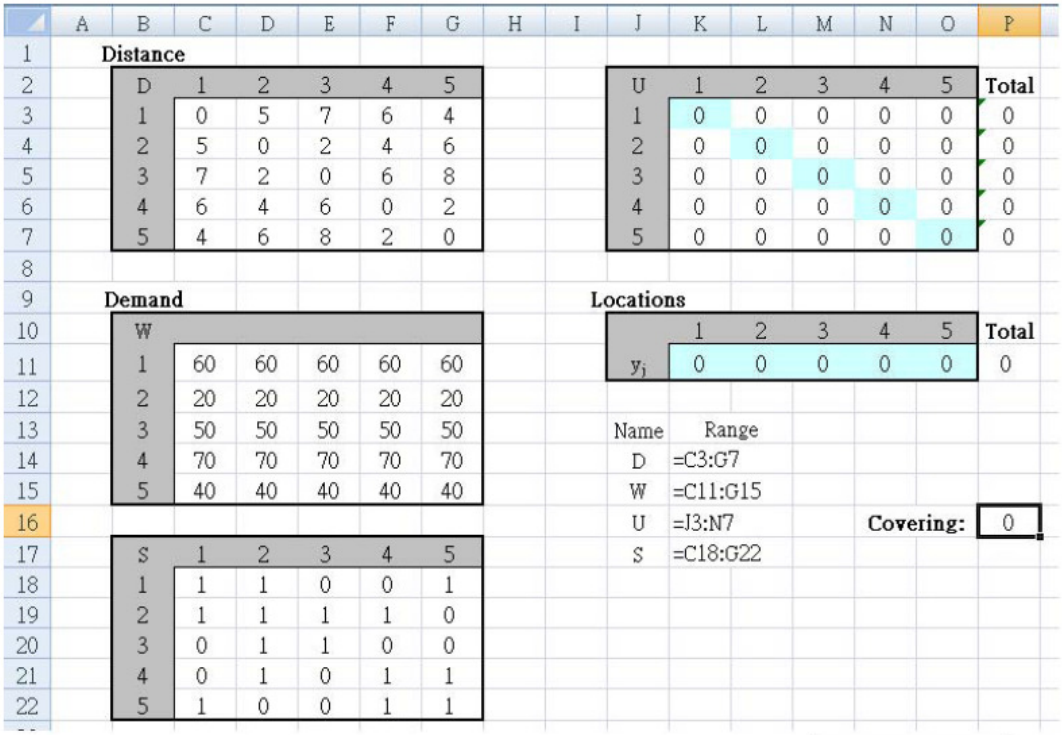
PPOSBC is not the only provider of reproductive health services in SB County, and other providers of reproductive health services that could adequately cover the needs of the local population were considered in the model, including Planned Parenthoods in both Riverside and Los Angeles counties. Populations living within defined distances of these and other providers were considered "covered" when applying the location model. In order for providers to be

considered adequate alternatives to the health services provided by PPOSBC they must offer a full array of reproductive health services and avail themselves to the public at least five days a week. Additionally, alternative providers should be open to walk-in patients and present themselves as accepting the general public at large, versus a private provider.

Solver Software

MS Excel™ and a solver add-in program from Frontline Systems, Inc., *Frontline Solvers–Premium Solver Pro v11.5.0,* were used in solving the linear problems, to perform sensitivity analysis, and to run multiple iterations of the problem under differing scenarios, such as time versus distance and changing the covered distance variable. Wen-Chen Lee and Neng-Shu Yang published examples of MS Excel ™ being used to solve both the *p*-median and the Maximal Covering location problems (Yee and Lang, 2009). An example is included in *Figure 25: Maximal Covering Location Problem Example*. Lee and Yang's examples were used to set up the arrays needed to solve the problems using the population, distance, time, and covered locations. While the standard Solver in Excel can solve these simple examples, more complex problems with larger data sets require an add-in product. Frontline Systems, Inc. has an easy to use and a robust add-in to Excel, *Frontline Solvers.* A trial version was downloaded from their website at www.solver.com and successfully used to test sample data prior to the purchase of the *Premium Solver Pro v11.5.0.* The program included a number of useful tools, such as how-to videos, to facilitate adoption.

Figure 25: Maximal Covering Location Problem Example



Distance

D	1	2	3	4	5
1	0	5	7	6	4
2	5	0	2	4	6
3	7	2	0	6	8
4	6	4	6	0	2
5	4	6	8	2	0

U	1	2	3	4	5	Total
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0

Demand

W					
1	60	60	60	60	60
2	20	20	20	20	20
3	50	50	50	50	50
4	70	70	70	70	70
5	40	40	40	40	40

Locations

	1	2	3	4	5	Total
y_j	0	0	0	0	0	0

Name	Range
D	=C3:G7
W	=C11:G15
U	=J3:N7
S	=C18:G22

Covering: 0

S	1	2	3	4	5
1	1	1	0	0	1
2	1	1	1	1	0
3	0	1	1	0	0
4	0	1	0	1	1
5	1	0	0	1	1

Cell	Formulas	Copied to
P16	=SUMPRODUCT(W,S,U)	
P3	=SUM(K3:O3)	P4:P7
K11	=K3	
L11	=L4	
M11	=M5	
N11	=N6	
O11	=O7	
P11	= SUM(K11:O11)	
C18	= IF <= 5, 1(True), 0(False)	C18:G22

Solver settings:
Max: P16
By changing: U
Subject to:
U = Binary
P3:P7 = 1
K3:K7 <= K3
L3:L7 <= L4
M3:M7 <= M5
N3:N7 <= N6
O3:N7 <= O7
P11 = p

Source: Lee and Yang, 2009

Approach Limitations

Although PPOSBC is a two-tier service delivery organization using surgical sites and non-surgical sites, a hierarchical model was not considered to analyze the alternative service offerings through different types of health centers due to insufficient demand and provider limitations. At this time, however, the San Bernardino Health Center offers surgical services one

day a week. Though these services require a higher level of facilities, resources, and service professionals, there is the ability to expand their availability by adding more surgical days to meet any increase in demand. Hierarchical models are available and have been used for multi-tiered delivery networks (Moore & ReVellle, 1982). For a comprehensive review of hierarchical models see (Sahin & Sural, 2007).

The analysis assumed that there is no capacity limitation for any given location. Consequently, this location analysis is not considered a Capacitated Facility Location Problem. Capacitated Facility Location Problems are highly studied, used for production or service centers, and are a viable alternative to determining optimal locations (Liao & Guo, 2008). Although personnel are shared across PPOSBC locations for certain services, e.g., colposcopy services, no resource coordination constraints were assumed and such limitations were not evaluated. Resource coordination constraints have been evaluated in location analysis using dynamic logistics coordination models (Wei, 2007).

Partial coverage was not considered in this analysis, but could have provided additional insights into the planning of services (Karasakal & Karasakal, 2004).

San Bernardino County has seen substantial increases in population and growth, and population shifts will continue to occur. This analysis was limited to the existing population data. Although the adolescent and children population was considered in the analysis to help forecast future demand as the existing population ages, the model is static. Dynamic models do exist and can be helpful in making decisions based on changes in demand and facilities (Gunawardane, 1982). The future San Bernardino county population, developed by the state of California, is presented in chapter 2; however, obtaining forecasted data by city within San Bernardino County is problematic.

Chapter 4: Analysis and Results

Introduction

This chapter includes the data, models, and analyses performed with results in determining the optimal location for expanded services for Planned Parenthood of Orange and San Bernardino Counties (PPOSBC) within the San Bernardino County. This chapter provides detailed documentation, including tables, screen shots, and other graphics, in order to illustrate the required formatting of the data in MS Excel, the Frontline Solver set-up, and the results of the various approaches used. This detailed, step-by-step approach is used in order that others wanting to make similar health service locations decisions may be able to use this information in setting up their analyses. For ease of presentation and reading, subsets of data are used in this chapter. Examples of all major tables used in these models are attached as appendices and are incorporated into the narrative by reference.

Populations Data and Analysis

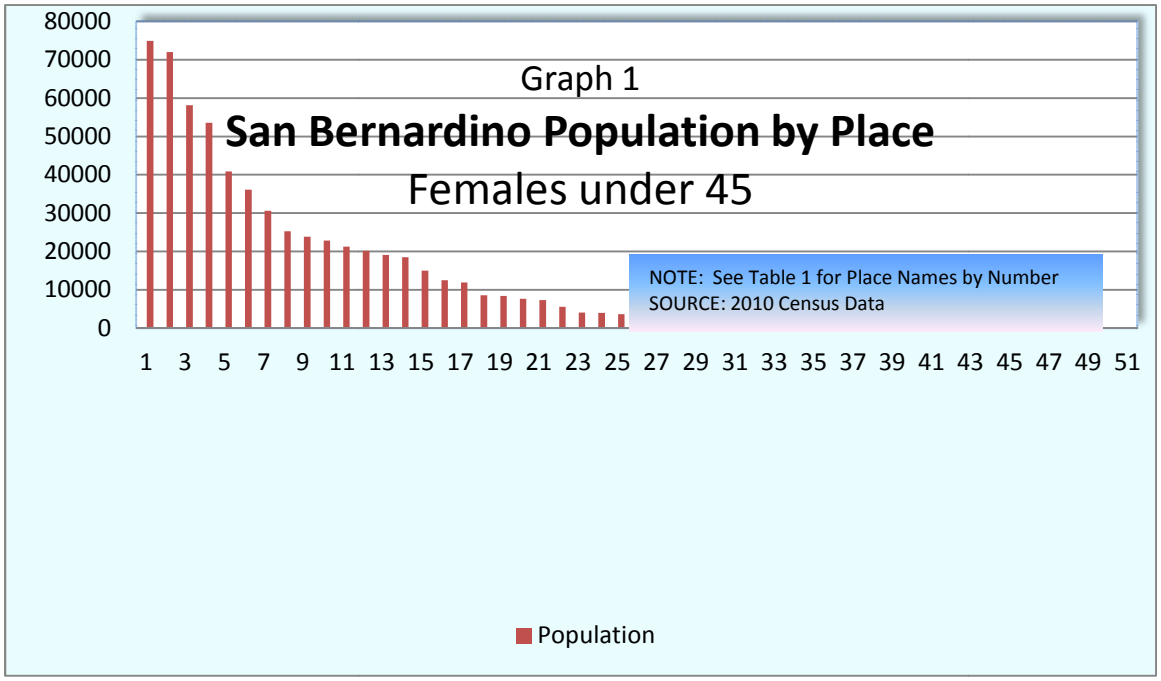
The 2010 Census data provide the best source of population data for the analysis of the patient population in San Bernardino County. Census data is easily accessible via the internet and can be obtained either through FTP or downloads from web pages. For this analysis, population data for census-designated places were obtained from the Factfinder2.gov website via downloads from viewed data. The process of filtering by state, county, and place is easy and straightforward. Because the target market population for PPOSBC is mainly females of reproductive years, the age and sex group table were used. After geographic filters were set for California and San Bernardino County, this data was downloaded in a comma delimited (csv) format. The level of detail in the view and the download is set for all “Places.” Once the data was downloaded, it was easily manipulated to provide totals by place for all females of certain age

bands using MS Excel[2]. Since facility location placements are long-term decisions, this analysis used all females less than 44 years of age, rather than simply the current target market for PPOSBC, which is ages of 15 to 44, generally referred to as the reproductive years. The results of this process are provided in *Appendix I: San Bernardino Female Population 2010 by Place***.** This list contains all of the census-designated places (CDP) in the county, which include incorporated cities, towns, and other CDPs. The list has been sorted in descending order of population and includes a calculated percent of the total and a cumulative percentage.

The 2010 census for San Bernardino County includes data for 51 places. The population distribution is heavily skewed, with a substantial amount of the population concentrated in a relatively small number of places. This is illustrated by *Figure 26: San Bernardino Population by Place, Females Under 45*. Placing health centers in more populated or centralized locations is more practical than placing them in remote locations or locations with extremely small numbers of potential patients. Therefore, this analysis will use places accounting for 95% of the population, totaling 27 locations. This substantially reduces the amount of data that must be gathered. For example, gathering data for mileage across 51 places requires that 1,275 distinct data points be collected. This is doubled if both time and distance are evaluated to 2,550 data points. This is reduced to 351 (or 702 for miles and time) distinct data points using 27 locations rather than 51. By eliminating the 24 places that only account for 5% of the target population, the number of data points required is reduced by nearly 73%. It is assumed that the omission of the less populated locations, 24 with a total population of just 30,634 or a mean of just 1,276 per place, will not significantly change the results of the analysis.

[2] Note: this analysis was performed using Excel 2007. Earlier versions of Excel may not have enough columns to store the entire set of data contained in the download. Other alternatives are available such as MS Access or FTP downloads.

Figure 26: San Bernardino Population by Place, Females Under 45



The 27 locations used throughout the remainder of this analysis are listed in *Table 13: San Bernardino Top Population Places 2010–Females Under 45*. The target population for the 27 remaining locations ranges from a high of approximately 75,000 for the city of San Bernardino to a low of approximately 3,100 for Lake Arrowhead. The mean population for these places is 22,705 with a median of 18,483.

The population data have been reorganized into a matrix in order to be used in the optimization model. This allows other variables organized in a similar fashion to use this data in a SUMPRODUCT formula within Excel. The population data used throughout the model is included in *Appendix B: San Bernardino Population Data–Model Format*.

Table 13: San Bernardino Top Population Places 2010–Females Under 45

No.	GEO.id2	Geography	Females Less Than 44	% Total	Cum. %
1	665000	San Bernardino city	74,931	11.6%	11.6%
2	624680	Fontana city	71,989	11.2%	22.8%
3	653896	Ontario city	58,099	9.0%	31.9%
4	659451	Rancho Cucamonga city	53,556	8.3%	40.2%
5	682590	Victorville city	40,849	6.3%	46.5%
6	660466	Rialto city	36,144	5.6%	52.1%
7	633434	Hesperia city	30,634	4.8%	56.9%
8	613210	Chino city	25,314	3.9%	60.8%
9	613214	Chino Hills city	23,826	3.7%	64.5%
10	681344	Upland city	22,861	3.6%	68.1%
11	659962	Redlands city	21,278	3.3%	71.4%
12	602364	Apple Valley town	20,168	3.1%	74.5%
13	614890	Colton city	19,088	3.0%	77.5%
14	633588	Highland city	18,483	2.9%	80.4%
15	687042	Yucaipa city	15,008	2.3%	82.7%
16	648788	Montclair city	12,532	1.9%	84.6%
17	600296	Adelanto city	11,972	1.9%	86.5%
18	607064	Bloomington CDP	8,558	1.3%	87.8%
19	680994	Twentynine Palms city	8,404	1.3%	89.1%
20	642370	Loma Linda city	7,708	1.2%	90.3%
21	604030	Barstow city	7,357	1.1%	91.5%
22	687056	Yucca Valley town	5,621	0.9%	92.3%
23	656826	Phelan CDP	4,132	0.6%	93.0%
24	650132	Muscoy CDP	3,971	0.6%	93.6%
25	625114	Fort Irwin CDP	3,692	0.6%	94.2%
26	630658	Grand Terrace city	3,689	0.6%	94.7%
27	639444	Lake Arrowhead CDP	3,183	0.5%	95.2%
	Total	Target Population in Model	613,047	95.2%	

Source: 2010 Census (U.S. Census Bureau, 2011)

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Mileage Data

The population analysis provides a basis for narrowing the possible locations to be considered for health center locations to 27. The distance from each of the 27 potential locations to each other location must to be determined as part of the analysis. The mileage analysis can be calculated using a Euclidean approach or a route-based driving distance method. The Euclidean distance can be calculated using the longitude and latitude of each location. The driving distance method requires manually looking up the driving directions between each location using Mapquest, Google Maps, or Bing, and is dependent on the route taken. These approaches may substantially differ depending on natural barriers, such as mountain ranges, etc., and the availability of direct routes. Although the driving distance method requires manual processing and is thus more time consuming, it better reflects the actual distance patients will need to travel from each location to an existing or future health center location, and therefore will be used in this analysis.

Google Maps was used to obtain the mileage data used in this analysis. Using Google Maps' directions feature, all 27 locations were entered with each other location selected as a destination. If more than one route option was offered, the shortest route was used in the model. As previously mentioned, this approach required 351 inquires. The results were entered into a standard mileage chart using a symmetrical matrix. A portion of this mileage matrix is included below as *Table 14: San Bernardino Mileage Chart (partial)*. The columns are numbered and each column represents the place in the correspondingly numbered row of data. For example, Column 1 is Adelanto city, Column 2 is Apple Valley town, Column 3 is Barstow, etc. This was assigned a Range Name of "D" for distance in Excel to be more easily referenced in the objective formula.

Table 14: San Bernardino Mileage Chart (partial)

Distance	D	1	2	3	4	5	6	7	8
Adelanto city	1	0.0	19.9	44.3	48.9	55.8	62.2	42.7	39.2
Apple Valley town	2	19.9	0.0	38.4	55.9	62.8	69.2	49.7	46.2
Barstow city	3	44.3	38.4	0.0	78.7	85.6	92.0	72.6	69.1
Bloomington CDP	4	48.9	55.9	78.7	0.0	21.0	27.4	5.9	4.1
Chino city	5	55.8	62.8	85.6	21.0	0.0	4.2	26.6	20.4
Chino Hills city	6	62.2	69.2	92.0	27.4	4.2	0.0	32.5	26.3
Colton city	7	42.7	49.7	72.6	5.9	26.6	32.5	0.0	9.3
Fontana city	8	39.2	46.2	69.1	4.1	20.4	26.3	9.3	0.0

Source: Google Maps, 2012

The entire mileage chart used in the modeling is attached as *Appendix C: San Bernardino Mileage Data–Model Format (surrounding Planned Parenthood Health Centers outside of SB County omitted).*[3]

Driving Time Data

In many urban centers, traffic patterns vary greatly and therefore travel time is often used instead of distance when considering travel. Many living in San Bernardino County, particularly in the Upper Desert area, commute long distances and the freeway system in and around the southern corridor of San Bernardino can be busy and crowded to the point of stop-and-go traffic. Consequently, the same methodology used for capturing the driving distance data was also used to gather the average travel time data between each location. The travel time in minutes for each route selected for the distance between all 27 locations was found using Google Maps. If more than one time was given, such as "During Traffic Hours," the longer time was selected in order to capture the worst traveling conditions. The travel time data were used to recalculate the

[3] NOTE: The initial models were set up and solved using only the two San Bernardino health centers located in the cities of San Bernardino and Upland. The surrounding health centers from Planned Parenthoods in Los Angeles and Riverside Counties were not initially included. There are four additional health centers that were added to the models within these two counties. This brought the total locations evaluated to 31. Although, the mileage and travel time were considered, no population was assigned to these locations. Only the San Bernardino target population was given consideration in the model.

optimization models using travel time rather than travel distance in order to evaluate the impact on the location decisions.

The travel time data were arranged into a matrix in the same manner as the travel distance data. A portion of the travel time matrix is included below as *Table 15: San Bernardino Travel Time Chart (partial)*. Again, the columns are numbered and represent the place in the corresponding numbered row of data. This was assigned a Range Name of "T" for time in Excel so that it could more easily be referenced.

Table 15: San Bernardino Travel Time Chart (partial)

Travel Time	T	1	2	3	4	5	6	7	8
Adelanto city	1	0	29	52	56	65	69	51	55
Apple Valley town	2	29	0	45	59	68	72	54	59
Barstow city	3	52	45	0	79	89	93	74	79
Bloomington CDP	4	56	59	79	0	26	30	9	8
Chino	5	65	68	89	26	0	10	31	27
Chino Hills city	6	69	72	93	30	10	0	38	34
Colton city	7	51	54	74	9	31	38	0	9
Fontana city	8	55	59	79	8	27	34	9	0

Source: Google Maps, 2012

The entire travel time chart as formulated for the optimization problem is included in *Appendix D: San Bernardino Travel Time Data–Model Format (surrounding Planned Parenthood Health Centers outside of SB County included).*

P-Median Mileage Model and Results

The *p*-median problem was presented in Chapter 3–Methods. This section contains the application of the *p*-median problem for analyzing alternative facility location sites in San Bernardino. This optimization location approach will be compared to the Maximal Covering Location Problem approach, which seeks to minimize the total distance from facility location to all designated demand nodes. The *p*-median approach in a health services context is used to

minimize the travel distance for patients seeking health center service locations. The distance is weighted by the population in each location. The population data is illustrated in *Table 16: San Bernardino Population (partial)*. This was given a Range Name of "W" in Excel.

An unknown variable matrix was established as a symmetrical matrix and is illustrated below as *Table 17: San Bernardino Variable Matrix*. Again, the columns are numbered and represent the place in the corresponding numbered row of data. This was assigned a Range Name of "U" in Excel so it could be easily referenced. An example of a complete solution matrix is attached as *Appendix E: San Bernardino Variable Table "U"–Model Format–P-Median Solution for Travel Time for Eight Health Centers* (adding two new centers: Victorville and Fontana). The variable matrix starts out with all values set to zero. As demand sites are selected and assigned to a selected location, the values are set to one.

A solution set is defined below the variable matrix using formulas to reference the selected locations included in the solution, by example please see the last row in Appendix E. This row identifies the site selected using a formula to reference the respective row for that column. The total to the far right of this row is a SUM function that totals the number of selected sites, i.e., the P–value.

The objective function was to minimize the weighted travel distance. This was calculated in MS Excel using a SUMPRODUCT function in a matrix manner as follows: = SUMPRODUCT (D,W,U), where D is the distance matrix (example at Table 14), W is the Population (example at Table 16), and U is the Unknown Variable matrix (example at Table 17). The basic model set-up for the Excel add-in program *Risk Solver Platform* by Frontline Solvers is presented in *Figure 27: P-Median Solver Set-up*. In this model, the formula was entered into

the spreadsheet at cell BK2, which appears under the Objective folder in the Optimization in Figure 27.

Table 16: San Bernardino Population (partial)

Population (Demand)	W					
Adelanto city	1	11,972	11,972	11,972	11,972	11,972
Apple Valley town	2	20,168	20,168	20,168	20,168	20,168
Barstow city	3	7,357	7,357	7,357	7,357	7,357
Bloomington CDP	4	8,558	8,558	8,558	8,558	8,558
Chino	5	25,314	25,314	25,314	25,314	25,314
Chino Hills city	6	23,826	23,826	23,826	23,826	23,826
Colton city	7	19,088	19,088	19,088	19,088	19,088
Fontana city	8	71,989	71,989	71,989	71,989	71,989

Table 17: San Bernardino Variable Matrix (partial)

Unknowns	U	1	2	3	4	5	6	7	8
Adelanto city	1	0	0	0	0	0	0	0	0
Apple Valley town	2	0	0	0	0	0	0	0	0
Barstow city	3	0	0	0	0	0	0	0	0
Bloomington CDP	4	0	0	0	0	0	0	0	0
Chino	5	0	0	0	0	0	0	0	0
Chino Hills city	6	0	0	0	0	0	0	0	0
Colton city	7	0	0	0	0	0	0	0	0
Fontana city	8	0	0	0	0	0	0	0	0

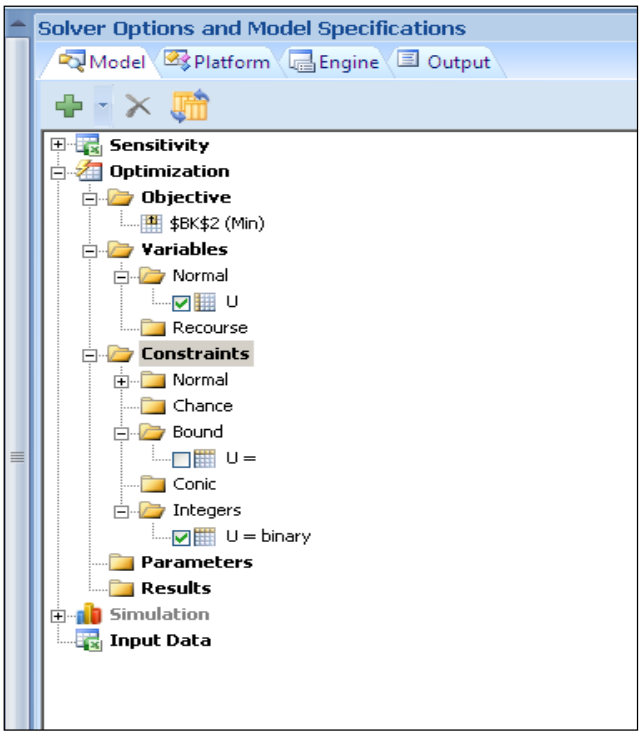
The model also required a number of constraints; otherwise every location would be selected to minimize the objective function. These constraints were entered into the Risk Solver Platform software using either the Menu bar or the Model Tab. *Figure 28: P-Median Solver Constraint Set-up (partial) Risk Solver Platform by Frontline Software* shows a partial list of these constraints and is referenced below. The constraints in this particular model include:

1. This is a binary problem since places are either assigned to a location or not; this is indicated by a one or zero in the Unknown variable table; see Figure 28–this

constraint statement is defined in this example as “U = Binary” (under Integers, under Constraints folder);

2. If a location is not selected, then no other location can be assigned to it; See Figure 29–this constraint statement is defined in this example model as $AA$62:$AA$88<=$AA$85;
3. Existing locations remain and must be selected in the solution (e.g., San Bernardino, and Upland); see Figure 29–this constraint statement is defined in this example as $AA$92=1 represents Upland must be selected);
4. All locations must be assigned to a location; See Figure 29 - $AE$62:$AE$88=1
5. A specified number of locations are selected; see Figure 29–this constraint in this example is defined as $AE$92=3.

Figure 27: *P*-Median Solver Set-up



Risk Solver Platform by Frontline Software

Figure 28: *P*-Median Solver Constraint Set-up (partial)
Risk Solver Platform by Frontline Software

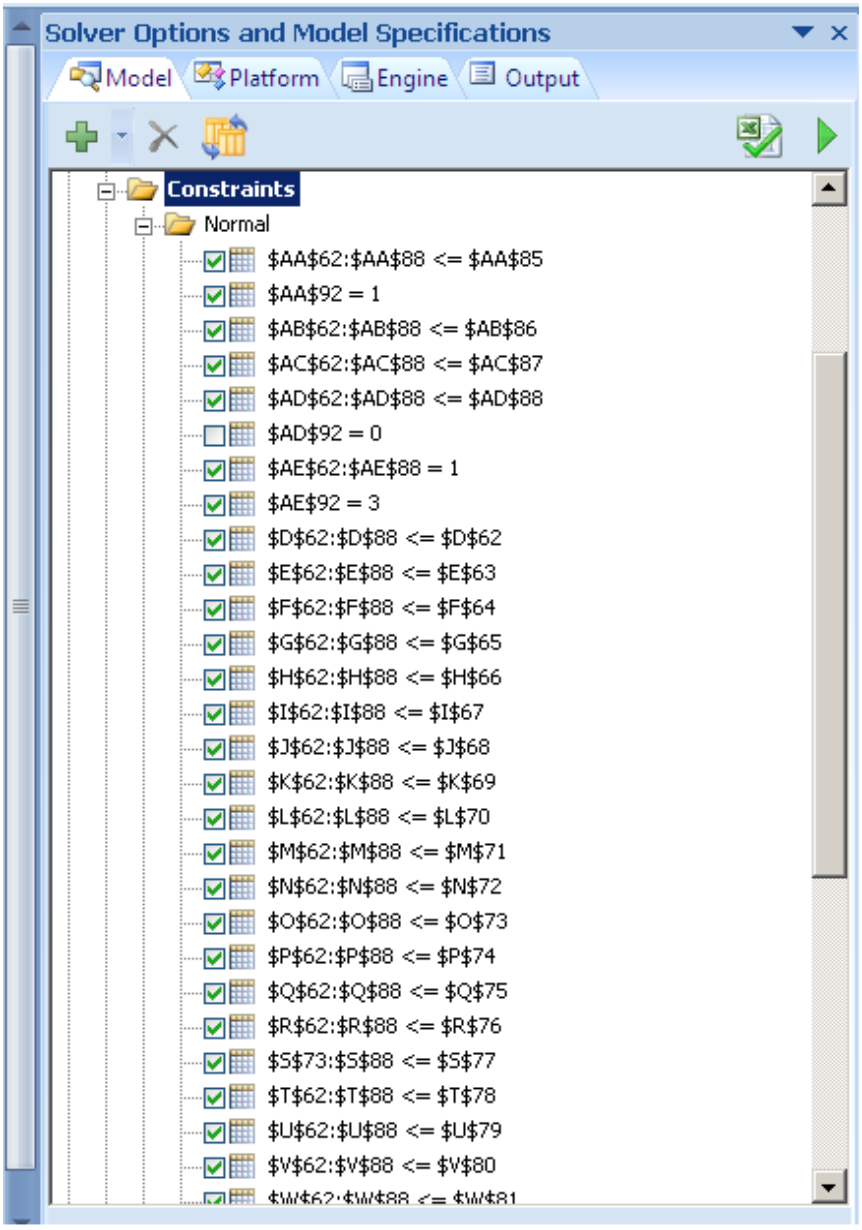


Table 18: P-Median Solution Matrix for P=3 shows the optimization results for the previously defined problem, which is seeking to locate the next optimal location. The solution to this model was to select Victorville (location no. 25) as the next location to minimize total travel

for all target patients. Total weighted miles were reduced significantly with the addition of a Victorville health center, from 8,633,897 to 4,471,274 for a 48.28% reduction in people miles. This model was developed to establish the basic spreadsheet framework for optimization and to evaluate the current conditions for PPOSBC, which is now limited to two locations, San Bernardino and Upland. This model validates previous analysis and results performed at PPOSBC using a similar approach with 2009 American Community Survey Data using the MCLP model with three health centers. The previous solution was calculated for one additional health center using a greedy algorithm heuristic approach, resulting in Victorville as the optimal location.

Table 18: *P*-Median Solution Matrix for P=3

Locations	U	20	21	22	23	24	25	26	27	Total
Adelanto city	1	-	-	-	-	-	1	-	-	1
Apple Valley town	2	-	-	-	-	-	1	-	-	1
Barstow city	3	-	-	-	-	-	1	-	-	1
Bloomington CDP	4	-	-	1	-	-	-	-	-	1
Chino city	5	-	-	-	-	1	-	-	-	1
Chino Hills city	6	-	-	-	-	1	-	-	-	1
Colton city	7	-	-	1	-	-	-	-	-	1
Fontana city	8	-	-	1	-	-	-	-	-	1
Fort Irwin CDP	9	-	-	-	-	-	1	-	-	1
Grand Terrace city	10	-	-	1	-	-	-	-	-	1
Hesperia city	11	-	-	-	-	-	1	-	-	1
Highland city	12	-	-	1	-	-	-	-	-	1
Lake Arrowhead CDP	13	-	-	1	-	-	-	-	-	1
Loma Linda city	14	-	-	1	-	-	-	-	-	1
Montclair city	15	-	-	-	-	1	-	-	-	1
Muscoy CDP	16	-	-	1	-	-	-	-	-	1
Ontario city	17	-	-	-	-	1	-	-	-	1
Phelan CDP	18	-	-	-	-	-	1	-	-	1
Rancho Cucamonga city	19	-	-	-	-	1	-	-	-	1
Redlands city	20	-	-	1	-	-	-	-	-	1
Rialto city	21	-	-	1	-	-	-	-	-	1
San Bernardino city	22	-	-	1	-	-	-	-	-	1
Twentynine Palms city	23	-	-	-	-	-	1	-	-	1
Upland city	24	-	-	-	-	1	-	-	-	1
Victorville city	25	-	-	-	-	-	1	-	-	1
Yucaipa city	26	-	-	1	-	-	-	-	-	1
Yucca Valley	27	-	-	-	-	-	1	-	-	1
Locations	U	20	21	22	23	24	25	26	27	Total
	Yj	-	-	1	-	1	1	-	-	3

NOTE: The above table is a partial view of the total Locations matrix. Columns 1 to 19 are not shown. None of these locations are selected sites in this model.

Table 19: P-Median Solution Matrix for P=7, Including Neighboring Planned Parenthood shows the results of the optimization for the previously defined problem: seeking to locate the next optimal location considering preexisting Planned Parenthoods in surrounding counties. As indicated in the Needs Assessment, there are four Planned Parenthood health centers in proximity to San Bernardino residents: Pomona, operated by Planned Parenthood of Los Angeles, and Riverside, Moreno Valley and Rancho Mirage, operated by Planned Parenthood of the Pacific Southwest. The optimization results remained the same when Victorville (location no. 29 in this model) was selected as the next location to minimize total travel for all target patients. The results indicate which locations were already "assigned" to the nearest selected facility location. For example, the communities of Chino and Chino Hills are closest to the Pomona Planned Parenthood, while the communities of Twentynine Palms and Yucca Valley are closest to Rancho Mirage, etc. The results also reflect which SB locations are best served by the closest existing health center, e.g. Chino City and Chino Hills are closest to PPLA Pomona, while Twentynine Palms and Yucca Valley are closest to PP Rancho Mirage, etc.

By relaxing the *p*–value, the number of health centers included in the solution set, the model can be rerun to determine the next optimal location with a minimized travel distance for patients. For $p = 8$, the next optimal solution location is Fontana. By relaxing the value incrementally, the results illustrate where to locate the next health center to minimize total miles and the impact of each additional health center on the objective function–total miles. These results by location, the actual total miles, the improvement in total miles, and the percent improvement from the existing baseline configuration of the six existing health centers using the

p-median optimization approach are included below in *Table 20: P-Median Location and Mileage Results*.

Table 19: *P*-Median Solution Matrix for P=7, Including Neighboring Planned Parenthoods

Locations	U	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Adelanto city	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Apple Valley town	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Barstow city	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Bloomington CDP	4	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Chino city	5	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Chino Hills city	6	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Colton city	7	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Fontana city	8	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Fort Irwin CDP	9	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Grand Terrace city	10	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Hesperia city	11	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Highland city	12	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Lake Arrowhead CDP	13	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Loma Linda city	14	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Montclair city	15	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Moreno Valley PP	16	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Muscoy CDP	17	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Ontario city	18	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Rancho Mirage PP	19	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Pomona PP	20	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Phelan CDP	21	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Rancho Cucamonga city	22	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Redlands city	23	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Rialto city	24	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Riverside PP	25	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
San Bernardino city	26	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Twentynine Palms city	27	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Upland city	28	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Victorville city	29	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Yucaipa city	30	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Yucca Valley	31	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Locations	U	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Selected	Yj	1	-	-	1	1	-	-	-	-	1	1	-	1	1	-	-	7

NOTE: The above table is a partial view of the total Location matrix. Columns 1 to 15 are not shown. No sites were selected for these locations.

Table 20: *P*-Median Location and Mileage Results

P - Value	Locations	Total Miles	Difference	% Chg. from Baseline
6–Existing centers	San Bernardino, Upland, Pomona, Riverside, Moreno Valley and Ranch Mirage	8,633,897	NA	NA
7	Victorville	4,471,274	4,162,623	48.2%
8	Fontana	3,746,653	724,621	8.4%
9	Twentynine Palms	3,129,753	616,900	7.1%
10	Redlands	2,729,325	400,428	4.6%
11	Barstow	2,373,173	356,152	4.1%
12	Hesperia	2,110,262	262,911	3.0%
13	Chino City	1,862,927	247,335	2.9%
14	Rancho Cucamonga	1,627,281	235,646	2.7%
15	Rialto	1,447,655	179,626	2.1%
16	Fort Irwin	1,283,361	164,294	1.9%
17	Ontario	1,124,784	158,577	1.8%
18	Adelanto	972,740	152,044	1.8%
19	Apple Valley	827,530	145,210	1.7%
20	Yucaipa	684,954	142,576	1.7%

The results in Tables 20 and 21 for the *p*-median solution reflect the difficulty of serving a geographic area as large as San Bernardino County. A small number of residents living a long distance away can and do impact the results in the optimization approach, as illustrated by the inclusion of Twentynine Palms (ranked 19th in total target population with only 8,404 residents) as the third potential expansion location. Using a mileage-weighted approach allows a small population that is many miles away to take precedence over substantially larger populations requiring services. It is not feasible for PPOSBC to open a health center in such a remote location due to the small number of residents in the immediate area. Such a result can be omitted by using another constraint to identify it as a non-viable solution. This is done by adding a

constraint that disallows Twentynine Palms (or any other less populated location, e.g., Yucca Valley) from being selected as a facility location. This is accomplished by setting that location's selection cell to "0" as a normal constraint within the optimization model. When this approach is used, the optimization model selects Redlands as the next optimal site.

The *p*-median mileage optimization model provides valuable information about alternative health center configurations for SB County for PPOSBC. It validates the current expansion efforts and provides alternative solutions that minimize travel distance to future PP available health services.

P-Median Travel Time Model and Results

The aforementioned approach to determining the optimal location of additional health centers in San Bernardino County using mileage can also be completed using travel time. All of the general parameters and constraints can be used. The objective function is changed to reduce the total travel time rather than the total distance. In the model, time in minutes replaced miles and each value of *p* was recalculated. All the previously stated constraints were retained. *Table 21: P-Median Location and Travel Time Results* contains the results of re-evaluating the location problem using travel time.

Although the results are similar to those based on mileage in Table 8, substantial differences appear after a *P* value of 9. Rancho Cucamonga moves up four positions into the fourth expansion location replacing Redlands. Barstow drops seven positions from the fifth expansion location based on miles to the twelfth.

Both the mileage and the time-based approaches indicate that the delivery network would increase its efficiency if an additional site were added in Victorville, thanks to a large drop in miles traveled and time required to access a health care facility. Adding Victorville would reduce

the total miles traveled by 48.2%. Time is less impacted on a percentage basis, with a reduction of just 36.4% from the existing six health centers configuration in San Bernardino and nearby counties. Still, Victorville remains the best option for an additional site. Fontana would be the second potential additional health center for PPOSBC. Adding Fontana would reduce miles traveled by an additional 8.4%, and reduce total time by 11.0% (a greater reduction than produced by adding Victorville).

Table 21: *P*-Median Location and Travel Time Results

P - Value	Locations	Total Time in Weighted Min.	Difference	% Chg. from Baseline
6–Existing centers	SB, Upland, Pomona, Riverside, Moreno Valley and Ranch Mirage	12,236,191	NA	NA
7	Victorville	7,783,644	4,452,547	36.4%
8	Fontana	6,436,494	1,347,150	11.0%
9	Twentynine Palms	5,696,557	739,937	6.0%
10	Rancho Cucamonga	5,107,441	589,116	4.8%
11	Chino City	4,532,659	574,782	4.7%
12	Redlands	3,962,528	570,131	4.7%
13	Hesperia	3,498,886	463,642	3.8%
14	Fort Irwin	3,074,306	424,580	3.5%
15	Ontario	2,667,613	406,693	3.3%
16	Rialto	2,306,173	361,440	3.0%
17	Yucaipa	2,036,029	270,144	2.2%
18	Bartow	1,771,177	264,852	2.2%
19	Adelanto	1,519,765	251,412	2.1%
20	Chino Hills	1,281,505	238,260	1.9%

The diminishing returns, or the reduction in miles traveled and time by adding each additional health center location, are evident in the Percent Change from Baseline columns of Table 20 and Table 21.

The results in Table 21 for the *p*-median travel time solution reflects the same issue as in Table 20 for the *p*-median solution regarding a small, far away population. Twentynine Palms

(ranked 19th in total target population with only 8,404 residents) was again identified as the third best potential expansion location. Using the *p*-median approach allows a small population that is many miles away to take precedence over substantially larger populations requiring services. Adding the constraint to not select Twentynine Palms or Yucca Valley as viable options allows Rancho Cucamonga, Chino City, and Redlands to become the next optimal choices behind Victorville and Fontana, respectively.

The time-based model offers additional insight into the impact of adding new health centers: the differences between the two *p*-median models suggest that reducing miles may not necessarily optimize convenience if measured by saving patients travel time. Locations along major freeways may be further in distance, but take less time to travel to for patients. These may be more desirable sites. Additionally, patient populations within locations that do not have easy access to freeways or high-speed roads may take more time to travel to neighboring locations despite their proximity.

Maximum Coverage Location Mileage Model, Scenarios and Results

As discussed in the Methods chapter, the Maximal Covering Location Problem (MCLP) is a commonly used approach for determining optimal locations of facilities. The MCLP approach uses much of the same data as the *p*-median problem. However, the problem set-up requires additional steps and some minor alterations.

The distance between locations is required by the MCLP in order to determine if a site is considered covered by a selected location. The distance data gathered by the *p*-median problems can be used; the same table, Table 14, is used for the MCLP. However, an additional table must be added to reflect the covered locations. In the MCLP model, *Table 22–San Bernardino MCLP Covered Location Table (partial)* was used rather than the actual distance matrix. This table uses

a threshold distance to indicate which sites are covered, based on the miles between each site. The table was generated using the travel distance between each site and a variable d_s, the distance beyond which a site is considered uncovered. The variables d_s do not have to be the same for all locations. Table 22 was created using a conditional formula in Excel. If the distance between location *i* and location *j* was less than or equal to d_s, then the value was set to "1", if not, then the value was set to "0." For example, Bloomington, Colton, and Fontana are within 10 miles of one another. In the development of the model, the site table was defined using a range name of "S" for ease of reference. An example of an entire covered location table used for the MCLP model is attached as *Appendix F: San Bernardino Covered Location Table "S"–Model Format–MCLP 10 Mile Distance.*

Table 22: San Bernardino MCLP Covered Location Table (partial)

Unknowns	S	1	2	3	4	5	6	7	8
Adelanto city	10	1	0	0	0	0	0	0	0
Apple Valley town	10	0	1	0	0	0	0	0	0
Barstow city	10	0	0	1	0	0	0	0	0
Bloomington CDP	10	0	0	0	1	0	0	1	1
Chino	10	0	0	0	0	1	0	0	0
Chino Hills city	10	0	0	0	0	0	1	0	0
Colton city	10	0	0	0	1	0	0	1	1
Fontana city	10	0	0	0	1	0	0	1	1

The population of each location is required to determine the total population covered by each site and the total population covered by any given configuration of selected sites. The population data from Table 16 can be used in its existing format with the same matrix or table structure in the MCLP model as we used in the *p*-median problem. This table can be defined as a range name of "W" to represent the demand.

A variable table is used in the same manner as the *p*-median problem; for example Table 17 can be used for the MCLP and defined as a range name "U" in Excel.

Using the three tables to define the sites within a specified distance, the population or demand and the unknown or solution table, the objective function in Excel is defined as =SUMPRODUCT(S, W, U). The MCLP maximizes this objective function; see Objective folder in *Figure 29: MCLP Optimization Model* where this formula has been given the Range Name "Covered_Population."

The optimization is subject to the defined constraints. These constraints are very similar to those imposed by the *p*-median problem, and illustrated in *Figure 30: MCLP Optimization Model Normal Constraints (partial)*. They are:

Since places are either covered or not covered, this is a binary problem. This is indicated by a one or zero in the variable table, "U"; see Figure 30–this constraint statement is defined in this example as "U = Binary" (under Integers, under Constraints folder);

If a location is not selected, it does not cover any other location; See Figure 31–in this problem, an example of this type of constraint statement is $AA$70:$AA$100<=$AA$93;

Existing locations remain and must be selected in the solution; see Figure 31–this constraint statement is defined as $AB$104=1, representing PP Riverside as a location that must be selected in this model;

All locations can only be covered by one location; See Figure 31 - $AI$70:$AI$100<=1 where the Variable table is cross-footed in column AI, rows 70 to 100.

A specified number of locations are selected; see Figure 31–the constraint in this example is defined as $AI$104=6. In this model, the existing six PP locations are used to determine the covered population.

Figure 29: MCLP Optimization Model

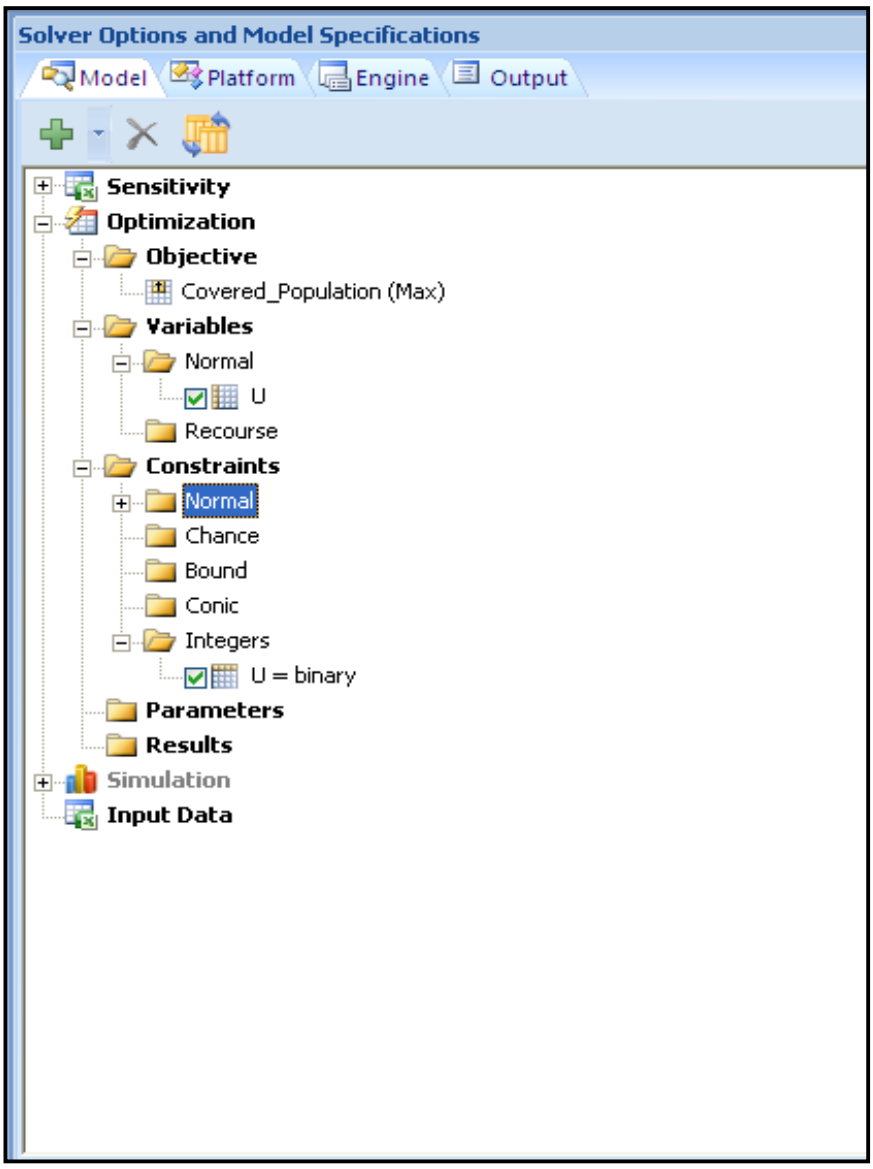
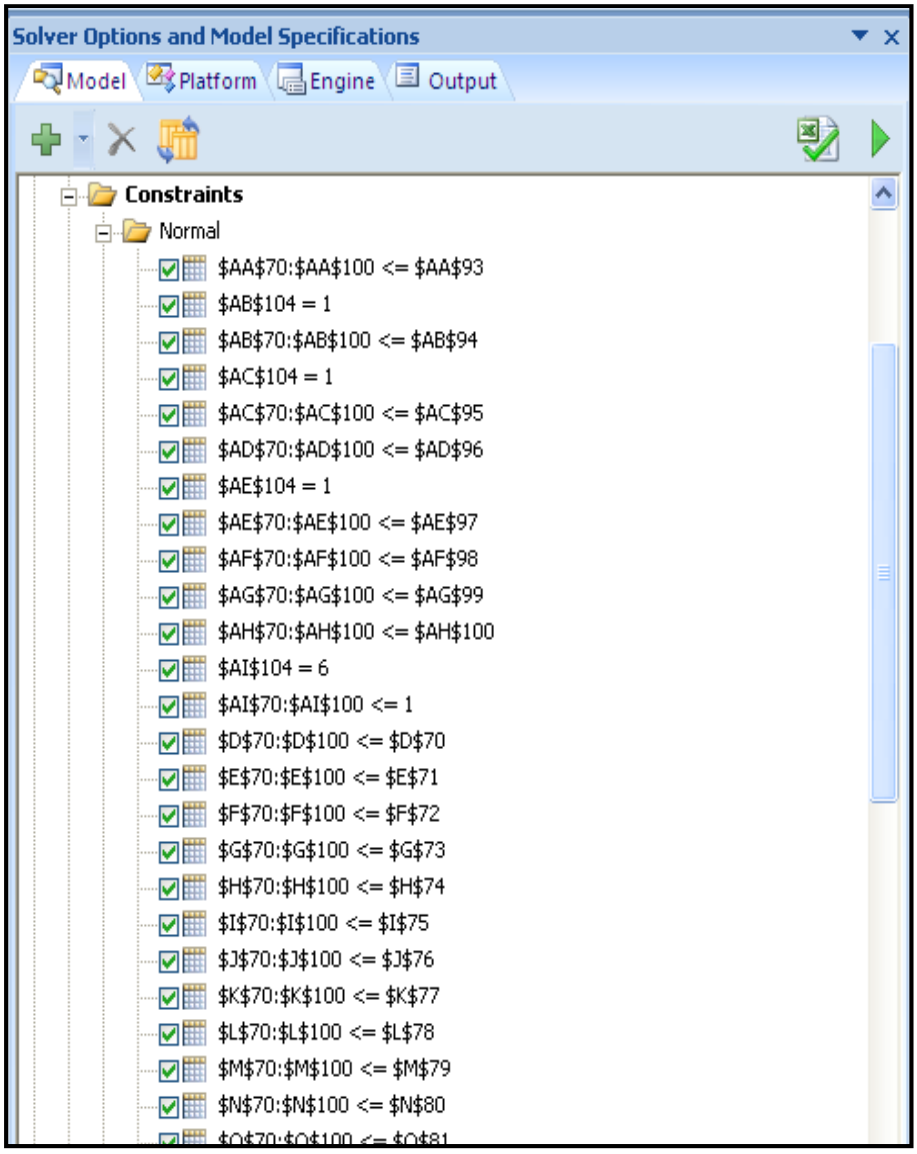


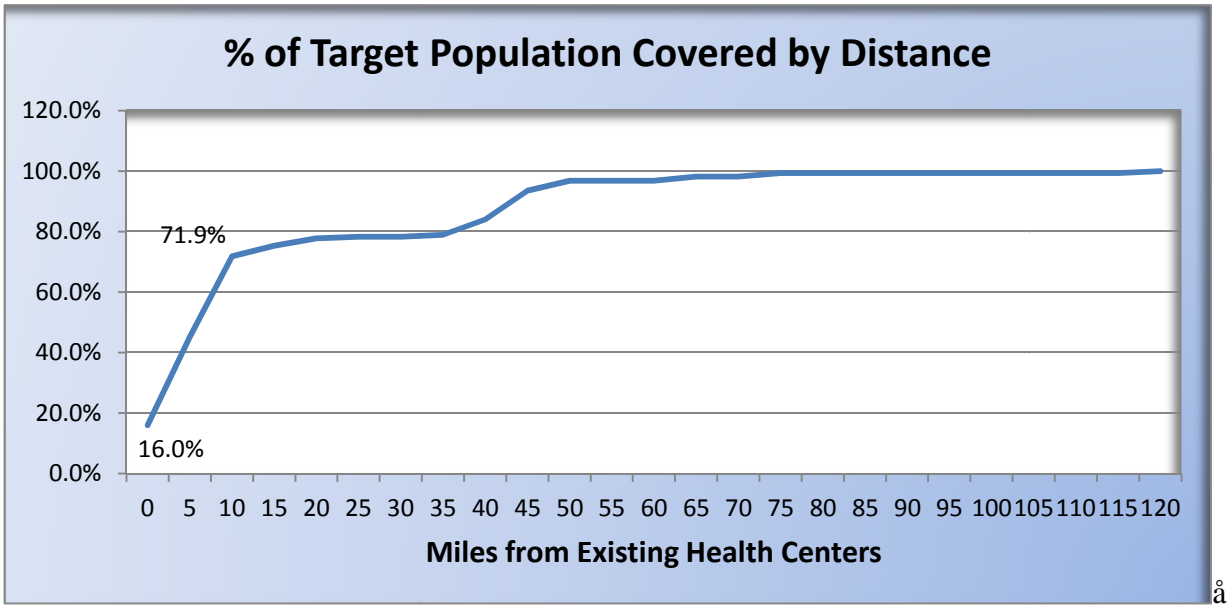
Figure 30: MCLP Optimization Model Normal Constraints (partial)



The MCLP model was used to complete a mileage analysis to determine total population covered by the existing six PP health centers. The optimization was solved multiple times by varying the distance, d_s , and was used to calculate the covered population for the existing health centers for each distance parameter. This analysis provides insight into the dispersion of the population and the number of uncovered population in each scenario. The results of the analysis

are depicted in *Figure 31: Maximum Coverage with Existing Health Centers*. The graph illustrates the percent of the target population covered as the distance, d_s, is increased.

Figure 31: Maximum Coverage with Existing Health Centers



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Only 16.0% of the target population, or 97,792 people, live within the cities of Upland and San Bernardino, based on the MCLP analysis using the existing six health centers. A total of 71.9% of the San Bernardino County target population, or 440,749 people, reside within 10 miles of the existing six PP Health Centers. This percentage rises to 75.4%, or a total of 462,027 people, with the addition of another mile, since Redlands is 10.9 miles from the San Bernardino health center and has a target population of 21,278 people.

The results of using the MCLP model with a 10 mile radius from the existing centers are included in *Table 23: MCLP Distance Results–10 Miles Radius with Existing Health Centers.* These results have been formatted to show which locations are within 10 miles of the existing centers and which health center satisfies the condition *first*. For example, Pomona PP, location number 20, is within 10 miles of Chino City, Chino Hills, Montclair, and Ontario. However, the results do not show which health center is closest to each location. Montclair and Ontario are

actually closer to the Upland Health Center than the Pomona Health Center. This is more clearly shown in *Table 19: P-Median Solution Matrix For P=7, Including Neighboring Planned Parenthoods*, which demonstrates the results when the objective function was minimizing miles traveled from one location to the closest health center. The differing results illustrate the value of using multiple models to analyze and support location decisions.

The vast majority of the 172,298 residents of SB County, or 18.9% of the target population not living within 10 miles of existing health centers, live in the High Desert area in the communities of Victorville (40,849), Hesperia (30,634), Apple Valley (20,168), Adelanto (11,972), Barstow (7,357), and Phelan (4,132). In evaluating the uncovered population in the MCLP model, it is logical that a High Desert location be selected to increase the covered population within the SB County.

Since Victorville was identified as the next site in both *p*-median models for distance and time traveled, it is logical to select it as the next site. However, in order to consider the major areas of the High Desert that would be covered by a Victorville site, the value d_s had to be increased beyond 10 miles. Consequently, a value of 35 miles was selected in order to capture the Barstow location from Victorville. Relaxing the number of sites selected and recalculating the model provides the next available site to maximize the number of residents covered. With the d_s value set at 35 miles and the number of selected locations set to seven, the next optimal location identified by the optimization model was Victorville.

Table 23: MCLP Distance Results–10 Miles Radius with Existing Health Centers

Locations	U	16	19	20	25	26	28	Total	Covered Pop.	Uncovered Pop.
Adelanto city	1	-	-	-	-	-	-	-		11,972
Apple Valley town	2	-	-	-	-	-	-	-		20,168
Barstow city	3	-	-	-	-	-	-	-		7,357
Bloomington CDP	4	-	-	-	-	1	-	1	8,558	
Chino city	5	-	-	1	-	-	-	1	25,314	
Chino Hills city	6	-	-	1	-	-	-	1	23,826	
Colton city	7	-	-	-	-	1	-	1	19,088	
Fontana city	8	-	-	-	-	1	-	1	71,989	
Fort Irwin CDP	9	-	-	-	-	-	-	-		3,692
Grand Terrace city	10	-	-	-	1	-	-	1	3,689	
Hesperia city	11	-	-	-	-	-	-	-		30,634
Highland city	12	-	-	-	-	1	-	1	18,483	
Lake Arrowhead CDP	13	-	-	-	-	-	-	-		3,183
Loma Linda city	14	-	-	-	-	1	-	1	7,708	
Montclair city	15	-	-	1	-	-	-	1	12,532	
Moreno Valley PP	16	1	-	-	-	-	-	1	-	
Muscoy CDP	17	-	-	-	-	1	-	1	3,971	
Ontario city	18	-	-	1	-	-	-	1	58,099	
Rancho Mirage PP	19	-	1	-	-	-	-	1	-	
Pomona PP	20	-	-	1	-	-	-	1	-	
Phelan CDP	21	-	-	-	-	-	-	-		4,132
Rancho Cucamonga	22	-	-	-	-	-	1	1	53,556	
Redlands city	23	-	-	-	-	-	-	-		21,278
Rialto city	24	-	-	-	-	1	-	1	36,144	
Riverside PP	25	-	-	-	1	-	-	1	-	
San Bernardino	26	-	-	-	-	1	-	1	74,931	
Twentynine Palms	27	-	-	-	-	-	-	-		8,404
Upland	28	-	-	-	-	-	1	1	22,861	
Victorville city	29	-	-	-	-	-	-	-		40,849
Yucaipa city	30	-	-	-	-	-	-	-		15,008
Yucca Valley	31	-	-	-	-	-	-	-		5,621
Locations	U	16	19	20	25	26	28	Total		
Selected	Yj	1	1	1	1	1	1	6	440,749	172,298

Note: The above table does not show all columns for the solution set. Columns without a selected location are not showing.

An additional health center in Victorville would result in a total covered population of 595,330, or 97.1% of the total target population of 617,037 in the SB County. This is a 22.9% improvement over the existing covered population of 484,350 using the same 35 mile d_s value with the existing six health centers. A seventh location in Victorville would add another 110,980 covered residents. The results of this model are included in *Table 24: MCLP Results–35 Miles Radius with New Health Center.* The three remaining uncovered locations are Twentynine Palms, Fort Irwin, and Yucca Valley with a combined population of just 17,717.

Not all locations need to use the same d_s value. Using alternative d_s values can support additional planning scenarios and provide insight into alternative locations and their ability to cover the desired population. In this case, an alternative scenario would be having a shorter travel distance for the cities along the southern corridor of the county, which is more densely populated, and using a greater distance value in the less densely populated High Desert.

The impact additional health centers would have on the covered population was evaluated by running the MCLP model using a 7 mile radius for locations in the southern portion of the county and leaving the High Desert locations with a 35 mile radius. The results of this model can be found in *Table 25: MCLP Scenario Results*. Each scenario uses a different number of health centers. The covered population and the selected locations beyond the current health centers (using the same constraints as previously discussed) are included.

The results in Table 25 illustrate the dynamic nature of the location selection in each scenario. Based on these assumptions, the central area between Upland and San Bernardino is not covered. Consequently, Fontana would be the next health center added to cover the central area. The location selected to cover this area would move from Fontana to Rialto to Bloomington

as additional health centers were added to cover additional locations and maximize covered locations and their populations.

Table 24: MCLP Distance Results–35 Miles Radius with New Health Center

Locations	U	16	19	20	25	26	28	29	Total	Covered Pop.	Uncovered Pop.
Adelanto city	1							**1**	1	11,972	
Apple Valley town	2							**1**	1	20,168	
Barstow city	3							**1**	1	7,357	
Bloomington CDP	4	1							1	8,558	
Chino city	5	1							1	25,314	
Chino Hills city	6			1					1	23,826	
Colton city	7	1							1	19,088	
Fontana city	8	1							1	71,989	
Fort Irwin CDP	9										3,692
Grand Terrace city	10	1							1	3,689	
Hesperia city	11							**1**	1	30,634	
Highland city	12	1							1	18,483	
Lake Arrowhead	13					1			1	3,183	
Loma Linda city	14	1							1	7,708	
Montclair city	15	1							1	12,532	
Moreno Valley PP	16	1							1	-	
Muscoy CDP	17	1							1	3,971	
Ontario city	18	1							1	58,099	
Rancho Mirage PP	19		1						1		
Pomona PP	20			1					1		
Phelan CDP	21					1			1	4,132	
Rancho Cucamonga	22	1							1	53,556	
Redlands city	23	1							1	21,278	
Rialto city	24	1							1	36,144	
Riverside PP	25				1				1		
San Bernardino	26					1			1	74,931	
Twentynine Palms	27										8,404
Upland city	28						1		1	22,861	
Victorville city	29							**1**	1	40,849	
Yucaipa city	30	1							1	15,008	
Yucca Valley	31										5,621
Locations	U	16	19	20	25	26	28	29	Total		
Selected	Yj	1	1	1	1	1	1	1	7	595,330	17,717

Note: The above table does not show all columns for the solution set. Columns without a selected location are not showing.

Each scenario adds to the covered population by picking up additional covered locations. The total covered population and the increase in coverage achieved by adding an additional location is indicated in *Table 25: MCLP Distance Scenario Results.*

Table 25: MCLP Distance Scenario Results

Scenario - Number of Centers	Locations Selected by MCLP using 7 and 35 miles	Total Covered Population	% of Total Target Population	Difference	% Chg. from Baseline
6–Existing centers	San Bernardino, Upland, Pomona, Riverside, Moreno Valley and Rancho Mirage	338,514	55.2%	NA	NA
7	Fontana	449,695	73.4%	111,181	32.8%
8	Bloomington and Victorville	530,041	86.5%	80,346	17.9%
9	Bloomington, Chino and Victorville	555,355	90.6%	25,314	4.8%
10	Bloomington, Chino City, Loma Linda and Victorville	580,322	94.7%	24,967	4.5%
11	Adds Yucaipa	595,330	97.1%	15,008	2.6%
12	Adds Yucca Valley	609,355	99.4%	14,025	2.4%
13	Adds Fort Irwin	613,047	100.0%	3,692	0.6%

Maximum Coverage Location Time Model, Scenario and Results

The Maximum Coverage Location Problem can also be set up using travel time rather than travel distance. The same model constraints are valid, but distance (d_s) is replaced with time (t_s). The time-based approach allows for evaluation of how much of the target population resides within a certain number of minutes to existing or future health center locations.

As with the travel distance MCLP, different travel times were used to evaluate the existing network and the covered population at various travel times. The results of this analysis are very similar to the distance results. The covered population increased steeply as travel time

was increased. Increasing travel time from 10 to 20 minutes more than doubled the covered target population, from 223,655, or 36.5% of the target population, to 462,027, or 75.4%. However, the coverage rate stays relatively flat until time is increased enough to capture the High Desert populations. A travel time of 40 minutes from current health centers will capture 79% of the target population, but 55 minutes captures 96.8%, or 593,594, of the total 613,047 target population. The analysis of the covered target population using travel time rather than travel distance is included in *Table 26: MCLP Time Analysis–Existing Health Centers*. These results again indicate the need to locate a health center in the High Desert area to increase the covered population within a shorter travel time.

Table 26: MCLP Time Analysis–Existing Health Centers

Time	Covered Population	% of Target
5	97,792	16.0%
10	223,655	36.5%
15	364,724	59.5%
20	462,027	75.4%
25	462,027	75.4%
30	477,035	77.8%
35	477,035	77.8%
40	484,350	79.0%
45	555,833	90.7%
50	573,426	93.5%
55	593,594	96.8%
60	593,594	96.8%

Different times were used with the MCLP time-based model with very similar results to the distance-based approach. Using both 20 minute and 40 minute travel time parameters in the model, Victorville was the next location to maximize the covered population with 553,678, or 90.3%, of target population covered by the 20 minute parameter and 595,330, or 97.1%, of target population covered by the 40 minute parameter. This is a substantial improvement over the existing levels of coverage within those travel times. The population covered by the 20 minute

travel time improves by 91,651, or 19.8%, by adding Victorville as the next site; and the population covered by the 40 minute travel time improves by 110,980, or 22.9%.

As with the MCLP distance-based approach, not all sites needed to be evaluated using the same standard time. Each location had its own time parameter necessary in order for a location to be considered covered by the next closest selected site. In the distance-based approach, a 7 mile parameter was used for the more densely populated southern corridor of the county and a 35 mile parameter was used for the outlying High Desert areas. In the time-based approach, 15 minute and 40 minute parameters were selected in order to evaluate the growth of the network. *Table 27: MCLP Travel Time Scenario Results* contains the results of the analysis as an increasing number of health centers were added to the model. The results are very similar to the travel distance results, except that the total population is covered with one less scenario, resulting in no selection for Loma Linda. Additionally, Montclair was selected over neighboring Ontario in Scenario 9.

Table 27: MCLP Travel Time Scenario Results

Scenario - Number of Centers	Locations Selected by MCLP using 15 and 40 minutes	Total Covered Population	% of Total Target Population	Difference	% Chg. from Baseline
6–Existing centers	San Bernardino, Upland, Pomona, Riverside, Moreno Valley and Rancho Mirage	372,039	60.0%	NA	NA
7	Victorville	483,019	79.0%	110,980	29.8%
8	Victorville and Fontana	550,008	90.5%	71,989	19.3%
9	Victorville, Fontana and Chino Hills	580,322	94.7%	25,314	56.8%
10	Victorville, Fontana, Chino Hills, Victorville and Yucaipa	595,330	97.1%	14,025	4.0%
11	Adds Yucca Valley to Scenario 10	609,355	99.4%	14,025	2.8%
12	Adds Fort Irwin to Scenario 11	613,047	100.0%	3,692	1.0%

Optimization Method Comparison and Discussion

Expansion planning comparisons.

The ability to analyze multiple scenarios using alternative methods is facilitated by spreadsheet technology. Constraints and parameters are easily changed within optimization models and recalculated to evaluate results. This analysis focused on the application of the *p*-median and Maximum Coverage Location Problem in evaluating potential expansion locations for PPOSBC in San Bernardino County. Each model type was run using two different parameters: (a) distance using road miles between locations, and (b) travel time between locations. Constraints were varied in order to assist in determining the optimal site to expand services within the SB County.

The four approaches and their objective functions are listed below. The results are summarized in *Table 28: Health Center Expansion Optimization Summary***.**

1. *P*-median approach using miles (minimize travel distance)
2. *P*-median approach using travel time (minimize travel time)
3. MCLP approach using a ten mile parameter for distance (maximize coverage within 10 miles of health centers)
4. MCLP approach using a 15 minute parameter for travel time (maximize coverage within 15 minutes of health centers)

Table 28: Health Center Expansion Optimization Summary

Scenario	*P*-Median Mileage	*P*-Median Time	MCLP Distance–Using 10 Miles	MCPL Time–Using 15 Min.
Add First	Victorville	Victorville	Victorville	Victorville
Add Second	Fontana	Fontana	Redlands	Fontana
Add Third	Twentynine Palms	Twentynine Palms	Adelanto	Chino City
Add Fourth	Redlands	Rancho Cucamonga	Twentynine Palms	Yucaipa
Add Fifth	Barstow	Chino City	Barstow	Adelanto
Comments	Fifth health center reduces miles by 72.5% to 2,373,273, down from 8,833,897	Fifth health center reduces time 63.0% to 4,532,659, down from 12,236,191	Total population covered with fifth center is 596,419 or 97.3% of target	Total population covered with fifth center is 580,658 or 94.7% of target

These results clearly identified Victorville as the optimal location for the first health center to add within the county beyond San Bernardino and Upland. Based on the results of three of the four decision support optimization models, the next opportunity to expand should include either Fontana or Rialto. Neither was selected as the second expansion site in the MCLP 10 Mile Model because they are just 9.5 miles from the San Bernardino health center (within the 10 mile threshold) and thus already considered a covered population. The neighboring communities of Fontana and Rialto are in the heart of the southern corridor of the county and slightly east of the mid-point between Upland and San Bernardino. An additional health center in either of these communities would relieve both San Bernardino and Upland of potential capacity concerns and overcrowding.

The next optimal location for a health center in the county is not clearly identified. The results across the various models are inconsistent in identifying the next health center to be added. As previously discussed, Twentynine Palms was eliminated as a location due to the small target population located there. Once Twentynine Palms was eliminated, the four models returned three different locations for the third expansion site: Redlands (selected twice since it

was not selected as the second expansion site and was the second site selected for the MCLP using a ten miles parameter), Rancho Cucamonga, and Chino City. Arguments can be made for and against each of the three sites named as the optimal location site by the four models using the aforementioned assumptions.

Redlands both minimizes the distance in miles residents must travel to a health center and adds coverage for the greatest number of people not covered within 10 miles of the previously selected sites. A health center in this vicinity would cover the Highland and Yucaipa communities and potentially be used by residents living along Interstate 10 east of Redlands, e.g., Beaumont, Banning, and Cabazon. The mountain communities of Lake Arrowhead, Running Springs, Big Bear Lake, and Big Bear City might also use this location due to its proximity to the Foothill Freeway, which has easy access to the mountain roads of 330 and 18. However, the main argument for not expanding in Redlands is its proximity to the San Bernardino Health Center. It is only 10.9 miles and 15 minutes from the San Bernardino Health Center. Redlands falls just outside the 10 mile threshold assumption, yet just within the 15 minute time limit. The communities of Beaumont, Banning, and Cabazon have alternative access to the PP Moreno Valley, west on Interstate 60. Additionally, the San Bernardino Health Center was recently expanded from four exam rooms to eight full exam rooms to accommodate more patients in the immediate area of San Bernardino.

Rancho Cucamonga is a rapidly growing city along Interstate 15 and Interstate 10. The completion of the 210 Freeway has increased access to this community. It has the fourth largest target population with 53,556 females less than 44 years of age and is between the second largest target population, 71,989 in Fontana, and the third largest target population, 58,097 in Ontario. Rancho Cucamonga continues to grow along Interstate 15 and into the foothills of the San

Bernardino Mountains. While the Upland Health Center is just 4.4 miles and 11 minutes from Rancho Cucamonga, it is one of PPOSBC's busiest centers and has only four full exam rooms. A Rancho Cucamonga health center would certainly relieve some of the crowding in Upland and be an easily accessible location.

If selected, Chino City would be PPOSBC's most southerly location within the county and could facilitate access not only for Chino City residents but also for those of Chino Hills and southern Ontario. While Ontario's 58,097 residents are currently considered "covered" by Upland, they could just as easily access a Chino City location to the south. Chino City and Chino Hills have a combined target population of nearly 50,000 females less than 44 years of age and have seen growth along the 71 Freeway and in the surrounding areas. Chino City is easily accessed from the 60 Freeway and a health center there would be convenient for Ontario Airport employees or anyone traveling down the 60 Freeway on a daily commute. However, Chino City is only 6.4 miles and 15 minutes from PP Pomona operated by Planned Parenthood of Los Angeles.

Decision support optimization models such as those used in this analysis provide insight into alternative health services configurations within the county, but are not a substitute for subjective analysis of alternatives. Based on the information provided from the models, a reasonable solution for expanded services for the county includes:

Adding a third health center in the Upper Desert area in Victorville with easy access to Interstate 15.

If a fourth health center were added, the northern area of Fontana, e.g. Rancho Fontana, with easy access to the 210 Freeway to draw Rialto and Rancho Cucamonga residents, would be the optimal location. If the expansion of a sixth health center were planned for

the county, it would more advantageous to move this location further east or even into Rialto.

If a fifth health center were to be added, the optimal location would be northern Chino City off the 60 Freeway, in order to provide services to Chino Hills, Chino City, southern Ontario, and commuters traveling the 60 Freeway.

If a sixth health center were to be added to SB County, the optimal location would be Rancho Cucamonga.

Capacity analysis.

While the results of the *p*-median problems for San Bernardino provide valuable information regarding the next potential site, the models also provide information on potential capacity issues and appropriate resource allocation. The PPOSBC San Bernardino Health Center is closest to 11 of the 31 largest locations in San Bernardino after adding the High Desert Victorville location. The total population of these 11 locations plus San Bernardino is 284,030, which is 46.3% of the total target population in the county. Adding a fourth location in this region of San Bernardino would reduce the ratio of people to health center. The fourth health center indicated by both the *p*-median mileage and travel time approaches is Fontana. Fontana, Rialto, and Bloomington were also selected as sites using the MCLP model under varying scenarios, further indicating the need to add a health center central to the southern corridor of the county. Using the various expansion plan scenarios, the *p*-median model can be used to determine the potential covered population based on shortest travel time. Using the recommended health center expansion plans above, the travel time to the nearest health center was used to evaluate potential capacity concerns. The results are reflected in *Table 29: Population Distribution to Closest Health Center Based on Travel Time.* The table illustrates the

shift of the population from one health center to another as additional health centers are added to the county. Both Pomona and Rancho Mirage, although not part of the PPOSBC organization, are closest to certain San Bernardino locations.

The analysis uses the entire population of a city to calculate the number assigned to the next closest health center. In reality, residents may find a closer health center depending on where within a city they live. For example, Ontario in general is closest to Upland, but many residents on the southern side of Ontario would be closer to a Chino City location.

Table 29: Population Distribution to Closest Health Center Based on Travel Time

Health Center	Current Configuration	Adding Victorville	Add Fontana	Add Chino City	Add Rancho Cucamonga
San Bernardino	402,834	284,030	167,339	167,339	167,339
Upland	159,830	159,830	159,830	134,516	80,960
Pomona	36,358	36,358	36,358	12,532	12,532
Rancho Mirage	14,025	14,025	14,025	14,025	14,025
Victorville	NA	118,804	118,804	118,804	118,804
Fontana	NA	NA	116,691	116,691	116,691
Chino City	NA	NA	NA	49,140	49,140
Rancho Cucamonga	NA	NA	NA	NA	53,556
Total Pop.	613,047	613,047	613,047	613,047	613,047

This analysis was useful in determining potential health center capacity requirements under existing assumptions and conditions. For example, San Bernardino is closest to the largest target population even after adding four additional health centers using the optimization decision support tools to direct the expansion plans. This clearly supports the recent decision to expand the health center. However, there are a few key factors that also impact health services demand for each health center and are not directly considered, such as are non-Planned Parenthood

alternative providers, the socioeconomic status of the surrounding population, and residents' knowledge of locations and services.

Budget Constraints

Budget constraints limit the number of health centers that can be established within the county. The ability to expand is restricted by available resources. The capital budget currently available for expansion at PPOSBC is limited to one health center in the 2012 calendar year. Consequently, it is only viable to add a Victorville location at this time.

Future expansion in San Bernardino County is dependent on a number of factors, including:

1. Continued financial performance of existing operations;
2. Contributions from donors;
3. Ability to successfully conduct capital campaigns; and
4. Health reform and the implications on current operations and financial performance.

The previous models were expanded beyond current expansion plans in order to illustrate the impact of additional health centers on the optimal network configuration. Under certain assumptions, it is possible that optimally selected sites would be replaced as locations were added. The network of locations is dynamic and may be reconfigured to optimize coverage. This is illustrated by the results in Tables 25 and 27. The analysis was also expanded beyond the current budget constraint to provide helpful information for board members, prospective donors, and others community stakeholders. This information will allow them to understand the impact of additional health centers in terms of added coverage and potential locations. Evaluating alternative health service models using these optimization models helps develop fund raising campaigns by:

1. Creating a vision and plan for the organization;
2. Establishing fund raising goals;
3. Identifying locations to target for fund raising, e.g. selected or affected communities; and
4. Providing an objective basis for location decision-making that is supportable and more likely to be accepted by stakeholders.

Limitations and Conclusions

Limitations

There are limitations of using linear problems to solve optimal location decisions. Although PPOSBC is a two-tier service delivery organization using both surgical and non-surgical sites, a hierarchical model (Moore & ReVellle, 1982) was not considered to analyze the alternative service offerings through different types of health centers due to insufficient demand and provider limitations. The San Bernardino Health Center currently offers surgical services one day a week. Although these services require a higher level of facilities, resources, and service professionals, it is possible to expand their availability by adding more surgical days.

This analysis was also limited by not considering capacity limitation for any given location. A Capacitated Facility Location Problem can be used as an alternative approach to determining the optimal location (Liao & Guo, 2008). In this analysis, however, potential capacity issues were evaluated in terms of total covered populations per health center. Any existing capacity limitations will be positively impacted as health centers are added. This is illustrated in *Table 29: Population Distribution to Closest Health Center based on Travel Time.*

This analysis also assumed that staffing resources would be available in the selected locations. No resource constraints were included in the decision models. However, such

constraints are real and would impact decisions. For example, the ability to find clinicians in small, outlying communities, such as Twentynine Palms or Barstow, would impose constraints on expansion to these areas. Personnel are shared across PPOSBC locations for certain services, e.g.. colposcopy services; however, no resource coordination constraints were assumed and such limitations were not evaluated. Resource coordination constraints have been evaluated in location analysis by using dynamic logistics coordination models (Wei, 2007).

Partial coverage was not considered in this analysis, but such analysis can provide additional insights into the planning of services (Karasakal & Karasakal, 2004). The population outside of the San Bernardino County was also not included in this analysis. County boundaries are often arbitrary and may even divide a city. Limiting the population to San Bernardino cities was reasonable due to the close proximity of both the Los Angeles Planned Parenthood (Pomona) and Greater South Pacific health centers (Riverside, Moreno Valley, and Rancho Mirage.) It is highly likely that cities bordering San Bernardino County are closer to these health centers and/or considered covered by them.

This analysis was limited to the highest populated 27 locations, representing 95% of the total target population. It was assumed that if the less populated locations were omitted, giving a total of 24 with a combined population of 30,634, or an average of just 1,276, would not significantly change the results of the analysis.

The analysis is based on population, mileage, and travel time for census designated locations. A more granular approach, e.g., using zip code level data, may yield different results. Such an approach would substantially increase the number of data points necessary to collect and many assumptions would need to be made regarding the most central address to be used in determining mileage and travel time. This limitation was assumed to have little impact on the

results, since moderate levels of aggregation of data in maximum covering models have been proven immaterial (Daskin et al., 1989).

Conclusion

Location models using linear programming solutions are a valuable tool for analyzing alternative placement sites for health service facilities. Spreadsheet technologies coupled with advanced solver add-ins provide a feasible and easy means of evaluating numerous scenarios and model types. Assumptions are easy to change and results can be easily recalculated, allowing for a wide array of assumptions.

Different model types can be used to provide in-depth insight by changing the objective function, altering assumptions, or adding or removing constraints. Combining results further enhances decision-making.

The model types evaluated for PPOSBC have both advantages and disadvantages. In this analysis, the *p*-median models provided optimization solutions for minimizing travel distance and time, clearly showing which sites would be closest to selected sites when solving the objective function. However, the *p*-median problem approaches do not optimize the covered population and may select sites that would be extremely remote with small populations. In these models, distance and time can outweigh the population values and result in selected locations that are outliers.

The Maximal Covering Location Problem approach addresses this shortcoming. The objective function is changed from minimizing travel distance or time to covering the maximum population in select alternative locations. Travel distance or time serve as variables and can be adjusted to determine the covered population. The solution set is sensitive to this variable, and will depend on how many sites are selected and the value of the variable for distance or time.

The appropriate travel distance or time is likely to be subjective. The MCLP approach offers a more robust set of alternative configurations as constraints and variables are changed, which provides a valuable method of evaluating alternatives and assists in facilities and financial planning of health services.

Appendix A: San Bernardino Population by Place

No.	GEO.id2	Geography	Females Less Than 44	% Total	Cum. %
1	665000	San Bernardino city	74,931	11.6%	11.6%
2	624680	Fontana city	71,989	11.2%	22.8%
3	653896	Ontario city	58,099	9.0%	31.9%
4	659451	Rancho Cucamonga city	53,556	8.3%	40.2%
5	682590	Victorville city	40,849	6.3%	46.5%
6	660466	Rialto city	36,144	5.6%	52.1%
7	633434	Hesperia city	30,634	4.8%	56.9%
8	613210	Chino city	25,314	3.9%	60.8%
9	613214	Chino Hills city	23,826	3.7%	64.5%
10	681344	Upland city	22,861	3.6%	68.1%
11	659962	Redlands city	21,278	3.3%	71.4%
12	602364	Apple Valley town	20,168	3.1%	74.5%
13	614890	Colton city	19,088	3.0%	77.5%
14	633588	Highland city	18,483	2.9%	80.4%
15	687042	Yucaipa city	15,008	2.3%	82.7%
16	648788	Montclair city	12,532	1.9%	84.6%
17	600296	Adelanto city	11,972	1.9%	86.5%
18	607064	Bloomington CDP	8,558	1.3%	87.8%
19	680994	Twentynine Palms city	8,404	1.3%	89.1%
20	642370	Loma Linda city	7,708	1.2%	90.3%
21	604030	Barstow city	7,357	1.1%	91.5%
22	687056	Yucca Valley town	5,621	0.9%	92.3%
23	656826	Phelan CDP	4,132	0.6%	93.0%
24	650132	Muscoy CDP	3,971	0.6%	93.6%
25	625114	Fort Irwin CDP	3,692	0.6%	94.2%
26	630658	Grand Terrace city	3,689	0.6%	94.7%
27	639444	Lake Arrowhead CDP	3,183	0.5%	95.2%
28	606406	Big Bear City CDP	3,102	0.5%	95.7%
29	646884	Mentone CDP	2,806	0.4%	96.2%
30	617162	Crestline CDP	2,751	0.4%	96.6%
31	652760	Oak Hills CDP	2,580	0.4%	97.0%
32	673700	Spring Valley Lake CDP	2,224	0.3%	97.3%
33	637554	Joshua Tree CDP	2,079	0.3%	97.7%
34	657302	Piñon Hills CDP	1,935	0.3%	98.0%
35	644420	Lucerne Valley CDP	1,480	0.2%	98.2%
36	671964	Silver Lakes CDP	1,339	0.2%	98.4%

(continued)

Appendix A (continued)

No.	GEO.id2	Geography	Females Less Than 44	% Total	Cum. %
37	650734	Needles City	1,312	0.2%	98.6%
38	663316	Running Springs CDP	1,287	0.2%	98.8%
39	641194	Lenwood CDP	1,199	0.2%	99.0%
40	606434	Big Bear Lake city	1,124	0.2%	99.2%
41	686594	Wrightwood CDP	1,121	0.2%	99.3%
42	649684	Mountain View Acres CDP	950	0.1%	99.5%
43	664462	San Antonio Heights CDP	810	0.1%	99.6%
44	649348	Morongo Valley CDP	791	0.1%	99.7%
45	634392	Homestead Valley CDP	585	0.1%	99.8%
46	670728	Searles Valley CDP	463	0.1%	99.9%
47	603512	Baker CDP	274	0.0%	99.9%
48	606635	Big River CDP	213	0.0%	100.0%
49	644644	Lytle Creek CDP	116	0.0%	100.0%
50	652715	Oak Glen CDP	88	0.0%	100.0%
51	607172	Bluewater CDP	5	0.0%	100.0%
All	All	Total Females Less Than 44	643,681	100.0%	200.0%

Source: 2010 Census (U.S. Census Bureau, 2011)

Appendix B: San Bernardino Population Data–Model Format

(Surrounding cities outside of SB County omitted)

W																											
1	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972	11,972
2	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168	20,168
3	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,357
4	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558	8,558
5	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314	25,314
6	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826	23,826
7	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088	19,088
8	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989	71,989
9	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692	3,692
10	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689
11	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634	30,634
12	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483	18,483
13	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183
14	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708	7,708
15	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532	12,532
16	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971
17	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099	58,099
18	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132	4,132
19	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556	53,556
20	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278	21,278
21	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144	36,144
22	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931	74,931
23	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404	8,404
24	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861	22,861
25	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849	40,849
26	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008	15,008
27	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621	5,621

Source: 2010 Census (U.S. Census Bureau, 2011)

Appendix C: San Bernardino Mileage Data–Model Format

(Surrounding Planned Parenthood Health Centers outside of SB County omitted)

Distance	D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Adelanto city	1	0	20	44	49	56	62	43	39	85	46	17	52	52	46	53	36	50	21	44	50	43	41	100	50	13	59	81
Apple Valley town	2	20	0	38	56	63	69	50	46	87	53	11	53	59	53	60	43	56	29	51	57	50	48	81	57	7	66	62
Barstow city	3	44	38	0	79	86	92	73	69	45	76	40	76	82	76	82	66	79	52	74	80	73	71	99	80	32	89	80
Bloomington CDP	4	49	56	79	0	21	27	6	4	124	9	43	16	33	9	18	15	15	39	14	13	3	10	92	16	48	22	71
Chino city	5	56	63	86	21	0	4	27	20	131	25	50	37	51	30	5	29	6	45	12	34	25	31	109	8	55	43	87
Chino Hills city	6	62	69	92	27	4	0	33	26	137	31	56	43	57	36	9	35	12	51	18	40	31	37	115	14	61	49	93
Colton city	7	43	50	73	6	27	33	0	9	117	5	37	12	26	6	23	9	20	32	19	10	6	3	89	21	42	18	68
Fontana city	8	39	46	69	4	20	26	9	0	114	12	33	18	32	13	17	11	14	29	10	17	5	9	96	15	49	26	75
Fort Irwin CDP	9	85	87	45	124	131	137	117	114	0	121	85	121	127	121	128	111	124	97	119	125	118	116	145	125	77	134	125
Grand Terrace city	10	46	53	76	9	25	31	5	12	121	0	40	13	30	4	27	12	24	36	23	10	10	7	90	25	46	19	68
Hesperia city	11	17	11	40	43	50	56	37	33	85	40	0	40	37	41	47	31	44	16	38	45	37	36	89	45	8	67	70
Highland city	12	52	53	76	16	37	43	12	18	121	13	40	0	24	9	34	10	31	34	24	6	13	6	86	31	43	15	64
Lake Arrowhead CDP	13	52	59	82	33	51	57	26	32	127	30	37	24	0	30	48	25	45	41	39	30	28	23	110	45	51	39	88
Loma Linda city	14	46	53	76	9	30	36	6	13	121	4	41	9	30	0	27	12	24	36	23	5	10	7	86	25	45	15	64
Montclair city	15	53	60	82	18	5	9	23	17	128	27	47	34	48	27	0	26	3	42	8	31	22	27	110	4	52	39	89
Muscoy CDP	16	36	43	66	15	29	35	9	11	111	12	31	10	25	12	26	0	23	26	18	16	6	6	96	24	36	25	74
Ontario city	17	50	56	79	15	6	12	20	14	124	24	44	31	45	24	3	23	0	39	6	27	19	24	107	3	49	36	86
Phelan CDP	18	21	29	52	39	45	51	32	29	97	36	16	34	41	36	42	26	39	0	35	41	33	32	109	41	22	50	90
Rancho Cucamonga city	19	44	51	74	14	12	18	19	10	119	23	38	24	39	23	8	18	6	35	0	28	13	17	107	4	44	36	86
Redlands city	20	50	57	80	13	34	40	10	17	125	10	45	6	30	5	31	16	27	41	28	0	14	11	80	29	49	10	59
Rialto city	21	43	50	73	3	25	31	6	5	118	10	37	13	28	10	22	6	19	33	13	14	0	5	94	19	42	23	72
San Bernardino city	22	41	48	71	10	31	37	3	9	116	7	36	6	23	7	27	6	24	32	17	11	5	0	90	25	41	20	69
Twentynine Palms city	23	100	81	99	92	109	115	89	96	145	90	89	86	110	86	110	96	107	109	107	80	94	90	0	108	88	74	22
Upland city	24	50	57	80	16	8	14	21	15	125	25	45	31	45	25	4	24	3	41	4	29	19	25	108	0	48	37	87
Victorville city	25	13	7	32	48	55	61	42	49	77	46	8	43	51	45	52	36	49	22	44	49	42	41	88	48	0	59	68
Yucaipa city	26	59	66	89	22	43	49	18	26	134	19	67	15	39	15	39	25	36	50	36	10	23	20	74	37	59	0	53
Yucca Valley	27	81	62	80	71	87	93	68	75	125	68	70	64	88	64	89	74	86	90	86	59	72	69	22	87	68	53	0

Source: Google Maps, 2012

Appendix D: San Bernardino Travel Time Data–Model Format

(Surrounding Planned Parenthood Health Centers outside of SB County included)

Variables	T	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Adelanto city	1	0	29	52	56	65	69	51	55	131	54	30	53	68	55	61	63	45	60	118	67	32	54	59	55	61	50	116	59	21	72	94
Apple Valley town	2	29	0	45	59	68	72	54	59	63	57	24	57	72	58	64	68	49	64	114	72	39	58	62	58	66	53	90	63	9	75	68
Barstow city	3	52	45	0	79	89	93	74	79	87	77	50	77	92	79	84	90	69	84	133	88	59	78	83	78	88	74	112	83	36	95	90
Bloomington CDP	4	56	59	79	0	26	30	9	8	161	12	52	21	43	13	21	22	21	21	77	24	46	20	17	10	21	14	99	19	52	30	74
Chino city	5	65	68	89	26	0	10	31	27	167	26	59	42	62	34	12	33	37	14	97	19	53	25	38	32	32	34	115	18	58	50	90
Chino Hills city	6	69	72	93	30	10	0	38	34	174	33	65	48	69	40	21	37	44	20	101	15	59	32	44	39	32	41	122	25	65	57	97
Colton city	7	51	54	74	9	31	38	0	9	155	9	46	16	37	10	28	20	15	28	74	30	40	27	14	13	19	8	96	26	46	27	71
Fontana city	8	55	59	79	8	27	34	9	0	158	19	49	26	47	20	23	29	21	23	83	26	43	18	24	10	27	18	105	22	39	37	80
Fort Irwin CDP	9	131	63	87	161	167	174	155	158	0	157	130	157	172	159	164	168	149	164	214	167	139	159	163	158	166	154	193	163	115	175	170
Grand Terrace city	10	54	57	77	12	26	33	9	19	157	0	48	17	39	9	30	14	17	29	75	33	42	29	14	17	12	11	95	29	48	27	70
Hesperia city	11	30	24	50	52	59	65	46	49	130	48	0	49	57	50	56	59	41	56	114	58	30	50	54	50	58	45	109	54	15	67	87
Highland city	12	53	57	77	21	42	48	16	26	157	17	49	0	37	15	38	29	18	38	72	42	43	34	11	23	27	14	92	37	49	24	67
Lake Arrowhead CDP	13	68	72	92	43	62	69	37	47	172	39	57	37	0	42	60	51	38	60	102	62	56	54	43	43	49	37	124	59	63	56	99
Loma Linda city	14	55	58	79	13	34	40	10	20	159	9	50	15	42	0	33	21	20	33	72	34	45	32	12	20	19	14	93	32	51	25	68
Montclair city	15	61	64	84	21	12	21	28	23	164	30	56	38	60	33	0	36	34	9	96	7	49	15	35	29	35	32	116	8	55	48	91
Moreno Valley PP	16	63	68	90	22	33	37	20	29	168	14	59	29	51	21	36	0	29	33	65	40	53	35	25	29	14	22	88	35	59	34	63
Muscoy CDP	17	45	49	69	21	37	44	15	21	149	17	41	18	38	20	34	29	0	33	83	37	35	27	23	14	27	14	105	32	41	36	80
Ontario city	18	60	64	84	21	14	20	28	23	164	29	56	38	60	33	9	33	33	0	96	12	50	14	35	29	31	33	117	7	55	48	92
Rancho Mirage PP	19	118	114	133	77	97	101	74	83	214	75	114	72	102	72	96	65	83	96	0	101	108	95	66	83	77	77	74	95	114	63	49
Pomona PP	20	67	72	88	24	19	15	30	26	167	33	58	42	62	34	7	40	37	12	101	0	52	18	38	32	33	35	119	11	58	51	94
Phelan CDP	21	32	39	59	46	53	59	40	43	139	42	30	43	56	45	49	53	35	50	108	52	0	44	49	45	52	40	126	49	31	62	104
Rancho Cucamonga city	22	54	58	78	20	25	32	27	18	159	29	50	34	54	32	15	35	27	14	95	18	44	0	34	21	34	29	116	11	48	47	91
Redlands city	23	59	62	83	17	38	44	14	24	163	14	54	11	43	12	35	25	23	35	66	38	49	34	0	22	34	15	87	33	52	18	62
Rialto city	24	55	58	78	10	32	39	13	10	158	17	50	23	43	20	29	29	14	29	83	32	45	21	22	0	27	10	104	26	48	36	79
Riverside PP	25	61	66	88	21	32	32	19	27	166	12	58	27	49	19	35	14	27	31	77	33	52	34	34	27	0	20	101	33	58	36	76
San Bernardino city	26	50	53	74	14	34	41	8	18	154	11	45	14	37	14	32	22	14	33	77	35	40	29	15	10	20	0	99	32	45	30	74
Twentynine Palms city	27	116	90	112	99	115	122	96	105	193	95	109	92	124	93	116	88	105	117	74	119	126	116	87	104	101	99	0	115	96	84	28
Upland city	28	59	63	83	19	18	25	26	22	163	29	54	37	59	32	8	35	32	7	95	11	49	11	33	26	33	32	115	0	57	50	93
Victorville city	29	21	9	36	52	58	65	46	39	115	48	15	49	63	51	55	59	41	55	114	58	31	48	52	48	58	45	96	57	0	66	76
Yucaipa city	30	72	75	95	30	50	57	27	37	175	27	67	24	56	25	48	34	36	48	63	51	62	47	18	36	36	30	84	50	66	0	60
Yucca Valley	31	94	68	90	74	90	97	71	80	170	70	87	67	99	68	91	63	80	92	49	94	104	91	62	79	76	74	28	93	76	60	0

Source: Google Maps, 2012

Appendix E: San Bernardino Variable Table "U"–Model Format

(*P*-Median Solution for Travel Time for Eight Health Centers - adding two new centers: Victorville and Fontana)

Locations	U	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Adelanto city	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Apple Valley town	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Barstow city	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Bloomington CDP	4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Chino city	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Chino Hills city	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Colton city	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Fontana city	8	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Fort Irwin CDP	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Grand Terrace city	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Hesperia city	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Highland city	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Lake Arrowhead CDP	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Loma Linda city	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Montclair city	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Moreno Valley PP	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Muscoy CDP	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Ontario city	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Rancho Mirage PP	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Pomona PP	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Phelan CDP	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Rancho Cucamonga city	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Redlands city	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Rialto city	24	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Riverside PP	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
San Bernardino city	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Twentynine Palms city	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Upland city	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Victorville city	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Yucaipa city	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Yucca Valley	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Locations	U	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Selected	Yj	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-	-	1	1	-	1	1	-	-	8

Appendix F: San Bernardino Covered Location Table "S"–Model Format

(MCLP 10 Mile Distance)

Distance	S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Adelanto city	10	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Apple Valley town	10	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Barstow city	10	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bloomington CDP	10	0.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Chino city	10	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Chino Hills city	10	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Colton city	10	0.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Fontana city	10	0.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Fort Irwin CDP	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grand Terrace city	10	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Hesperia city	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Highland city	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Lake Arrowhead CDP	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loma Linda city	10	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Montclair city	10	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Moreno Valley PP	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Muscoy CDP	10	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Ontario city	10	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Rancho Mirage PP	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pomona PP	10	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Phelan CDP	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rancho Cucamonga city	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Redlands city	10	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Rialto city	10	0.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Riverside PP	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
San Bernardino city	10	0.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Twentynine Palms city	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Upland city	10	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Victorville city	10	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Yucaipa city	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Yucca Valley	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0

Appendix G: San Bernardino Variable Table "U"–Model Format

(MCLP Solution for Time for Nine Total Health Centers (adding Bloomington, Montclair and Victorville)

Locations	U	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Adelanto city	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Apple Valley town	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Barstow city	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Bloomington CDP	4	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Chino city	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Chino Hills city	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Colton city	7	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Fontana city	8	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Fort Irwin CDP	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grand Terrace city	10	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Hesperia city	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Highland city	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Lake Arrowhead CDP	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Loma Linda city	14	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Montclair city	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Moreno Valley PP	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Muscoy CDP	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Ontario city	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Rancho Mirage PP	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Pomona PP	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Phelan CDP	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Rancho Cucamonga city	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Redlands city	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Rialto city	24	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Riverside PP	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
San Bernardino city	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Twentynine Palms city	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upland city	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Victorville city	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Yucaipa city	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yucca Valley	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Locations	U	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Selected	Yj	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	1	1	-	1	1	-	-	9

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