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UNIVERSITY OF CALIFORNIA, MERCED

Estimating the Burden of Disease of Lung Cancer at the County-Level in California

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Public Health

by

Ritem Sandhu-Dhaul

Committee in charge:

Name: Paul Brown
Name: Sidra Goldman-Mellor
Name: Ricardo Cisneros

2018

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The Dissertation of Ritem Sandhu-Dhaul is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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University of California, Merced

2018

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Explanation of Acronyms

Acronym	Explanation
AACR	American Association for Cancer Research
ACA	Affordable Care Act
ACS	American Cancer Society
Alliance	Central California Alliance for Health
BIA	Budget Impact Analysis
CCR	California Cancer Registry
CDC	Centers for Disease Control
CDPH	California Department of Public Health
CE	Cost-Effectiveness
CMS	Center of Medicaid Studies
DALY	Disability-Adjusted Life-Year
EQ-5D	EuroQol™ Five-Dimensional Score
EYLL	Expected Years of Life Lost
GPCI	Geographic Practice Cost Index
LDCT	Low-Dose Spiral Computed Tomography
LNC	Lung Nodule Clinic
MS	Medicare Services
NACCHO	National Association of County & City Health Officials
NCI	National Cancer Institute
NICE	National Institute for Health and Care Excellence
NIH	National Institutes of Health
NLST	National Lung Screening Trial Research Team
NPCR	National Program of Cancer Registries
NSCLC	Non-Small Cell Lung Cancer
QALYs	Quality-Adjusted Life-Years
QOL	Quality of Life
RR	Rates of Return
ROI	Return on Investment
SEER	Surveillance, Epidemiology, and End Results Program
SJV	San Joaquin Valley
YLL	Years of Life Lost

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Acknowledgments

This dissertation is dedicated to my family, friends, teachers, and colleagues for their unconditional love and support. You have all made this accomplishment possible.

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Abstract

UNIVERSITY OF CALIFORNIA, MERCED

Estimating the Burden of Disease of Lung
Cancer at the County-Level in California

A dissertation submitted in partial satisfaction of the requirements
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by Ritem Sandhu-Dhaul

2018

An estimated 40,000 people in California suffered from lung cancer in 2014, including nearly 2,000 Medi-Cal recipients. Although the increased coverage by Center for Medicaid Studies and Medicare Services (CMS) and the Affordable Care Act (ACA) has resulted in greater access to preventive health care, coordinated strategies are needed to prevent lung cancer. Policymakers, LHDs and medical purchasers need accurate information on the costs of lung cancer in their region to identify cost-effective strategies. Thus, the purpose of this three-paper dissertation was to estimate the cost and lost QALYs of lung cancer in California counties, provide LHDs with a guide to conduct ROIs for newly, proposed interventions as well as help them understand the differences between cost studies, provide information concerning how to monetize outcomes, and finally, attempt to estimate the ROI of implementing a lung cancer screening program. An estimated 1.2 billion dollars is currently being spent on lung cancer in California, including $33.3 million on the Medi-Cal population. The burden of lung cancer also includes 259,889 lost QALYs from the overall population and 36,169 lost QALYs from the Medi-Cal population. ROI analysis is a great method for deciding whether or not to invest in new program because outcomes can be monetized. ROI estimates suggest a cost savings with early detection of lung cancer and an even higher return when outcomes such as QALYs lost are monetized and considered in the ROI analysis. In conclusion, LHDs and medical purchasers are not the decision makers when it comes to implementing new programs such as lung cancer screening; rather the process is a political one. This study demonstrates a method of estimating ROI for investing in a new lung cancer screening program to provide policymakers with estimates of the scope of the problems by region and county.

Keywords: Costs, lung cancer, QALYs, ROI

Introduction

Lung cancer is the most common cause of cancer deaths in California (Medicaid, n.d.; American Cancer Society–ACS, 2013; California Cancer Registry–CCR, 2009; California Department of Public Health–CDPH, 2016). Moreover, risk factors for lung cancer include alcohol use, poor diet, and low socioeconomic status (a proxy risk factor). Nonetheless, lung cancer is 90% attributable to smoking (Centers for Disease Control – CDC, 2014). As with many solid tumors, increasing age is a significant factor associated with the occurrence of lung cancer because the greatest number of patients diagnosed with lung cancer are over the age of 50 (National Cancer Institute–NCI, 2015). Although there are programs to decrease tobacco usage, thousands of Californians continue to be affected by lung cancer by of continued smoking behaviors (see Figure 1).

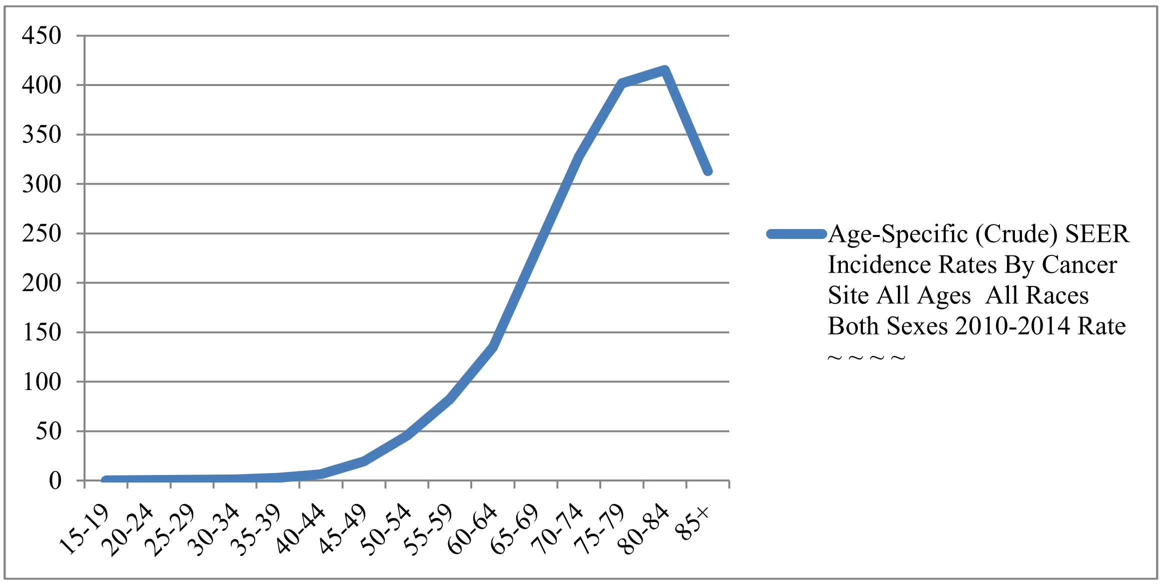

Figure 1. Estimated age-specific incidence rates for lung cancer in California, 2014. From National Institutes of Health, National Cancer Institute; Surveillance, Epidemiology, and End Results Program (SEER), Cancer Statistics, Interactive Tools, Fast Stats, By Data Type. Retrieved fromhttps://seer.cancer.gov/faststats/selections.php?#Output

The ACS (2015) posits that the age-specific cancer incidence rate increases with age until a decrease in the 85+ age group. Although research does not indicate mass screening for lung cancer, selective screening of high-risk target groups may be beneficial. Moreover, lung cancer makes a negative fiscal impact on the economy costing taxpayers billions of dollars in medical expenses every year. Many of these costs come from uninsured patients and ethnic minorities who do not seek treatment until later stages when treatment is more expensive and less successful (ACS, 2015). It is evident that early diagnoses could potentially save billions of dollars and thousands of lives (Mills,2011).

Figure 2 shows that in California, more than 70% of people with lung cancer are diagnosed at stage III or IV (Neubaur et al., 2010). Previous studies have found that people in vulnerable communities are diagnosed with lung cancer at a later stage and have worse health outcomes than others in California (Mills, 2011). Furthermore, inadequate access to diagnostic services, delays in detecting lung cancer, lack of coordinated treatment, and inadequate follow-up care are thought to be contributing factors to poor outcomes (Shavers & Brown, 2002; Shugarman et al., 2009). As might be expected, outcomes are worse for vulnerable populations, including people of Latino or Hispanic descent, immigrants, and people from low socioeconomic areas; with disparities in timely diagnosis, treatment, and outcomes for patients with lung cancer. Evidence shows that lung cancer is the leading cause of cancer death in women (ACS, 2018b). The rate of new cancer cases over the past 37 years has dropped for men (28%) while, alarmingly, it has risen for women (98%) (CDC, 2013). Furthermore, African Americans are more likely to die from lung cancer than any other race.

Examining lung cancer rates in the San Joaquin Valley (SJV) of California is of interest for several reasons. The SJV comprises many poor, agricultural communities with substantial racial and ethnic minority populations. Ethnic minority residents include the second largest Hmong population in the country (Fresno) and significant Latino populations. Also, the region is one of the fastest growing in California. The California Department of Finance projects that by 2040, the valley will be home to 12 million people—almost double the current population of 6.5 million. Whereas nonHispanic Whites account for half of the population, the southern region of the SJV has Latino populations that form as much as 46% of the local population. There is also a large number of Asians at 10% of the population. Moreover, the SJV has six of the 10 most polluted cities in California; with significant rates of asthma, allergies, and Valley Fever (Cabato, 2016). These conditions, caused or exacerbated by poor air quality, may be linked to increased rates of lung cancer (Mills, Yang, & Dodge, 2007). Additionally, smoking prevalence among men in the SJV is higher than men in other parts of the state (Mills, Yang, & Dodge, 2007). Finally, because of the enormous reliance on agriculture production, farm workers suffer from cellular effects in the lungs from being exposed to carcinogens and particulate matter (Smith et al., 2003). These facts suggest that lung cancer rates may be disproportionally higher in the SJV than other regions (NCI, 2014b).

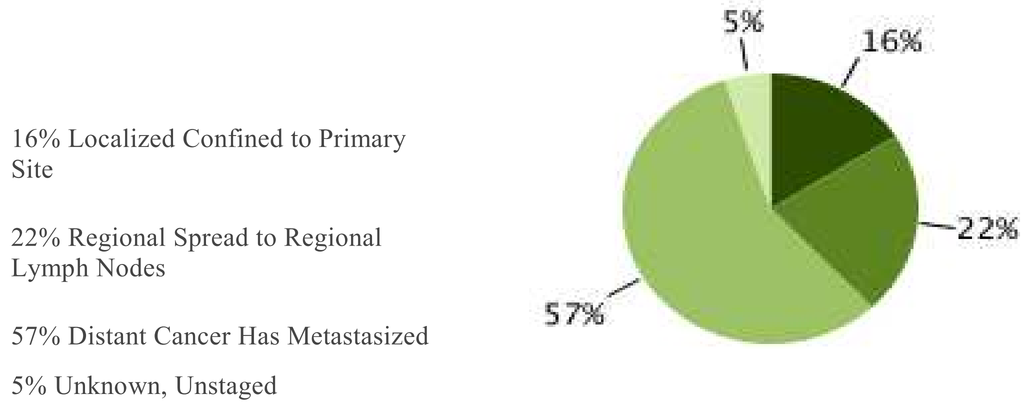

Figure 2. Percent of cases by stage. From National Institutes of Health (NIH), National Cancer Institute; Surveillance, Epidemiology, and End Results Program (SEER), Cancer Statistics, Reports on Cancer, Cancer Stat Facts, Lung and Bronchus Cancer. Retrieved from https://seer.cancer.gov/statfacts/html/lungb.html

Impacts

Data collected by the National Cancer Institute (NCI, 2015) from 2004–2010 suggests that 17% of people whose physicians diagnosed them with lung cancer are alive five years later. Moreover, people who show no symptoms but whose cancer is detected in time have an 88% chance of living another full decade (Bourzac, 2014). Hence, early diagnosis of lung cancer has a positive association with life expectancy, which affects a person's quality of life.

People with cancer often experience symptoms of disease and treatment that contribute to distress and diminish their quality of life. In fact, an increased financial burden as a result of cancer care costs is the most reliable independent predictor of reduced quality of life (Fenn et al., 2014). Cancer and its treatment result in the loss of economic resources and opportunities for patients, families, employers, and society overall. These losses include financial loss, morbidity, reduced quality of life, and premature death (Yabroff, Lund, Kepka, & Mariotto, 2011).

Hence, loss of productivity costs due to any cancer-related premature deaths are significant. Thus, productivity costs provide an alternative outlook on the burden of cancer. The figure below shows that in the year 2000, the economy lost approximately $115.8 billion due to cancer deaths, which will steadily increase to $147.6 billion in 2020.

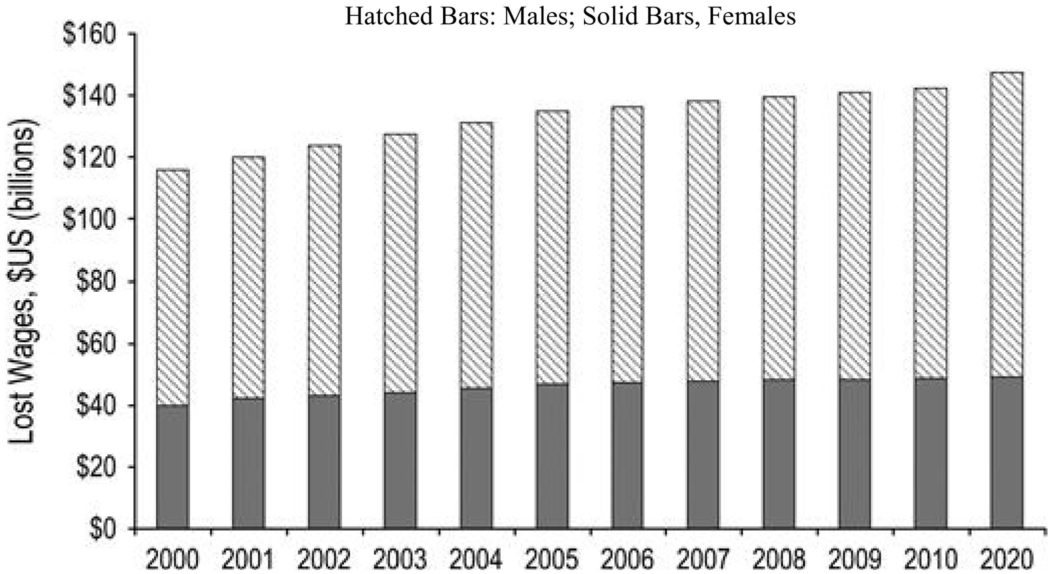

Figure 3. Present value of lifetime earnings lost due to cancer mortality in adults age 20 and older, years 2000–2020. From Bradley, C. J., Yabroff, K. R., Dahman, B., Feuer, E. J., Mariotto, A., & Brown, M. L. (2008, December 17). Productivity costs of cancer mortality in the United States: 2000–2020, *JNCI: Journal of the National Cancer Institute*, *100*(24), 1763–1770, https://doi.org/10.1093/jnci/djn384

Significant disparities exist for delivering patient-centered and equitable cancer care by race/ethnicity, immigration status, and for vulnerable populations with lung cancer (Shavers & Brown, 2002; Shugarman et al., 2009). In a recent study by John et al. (2014), patients with perceived unmet need lung cancer treatment (9% overall) included 7% White–U.S.-born, 9% White–foreign-born, 13% Black–U.S.-born, 8% Latino–U.S.-born, 24% Latino–foreign-born, 4% Asian/Pacific Islander–U.S.-born, 14% API–foreign-born and 11% Other. These data indicate that Black–U. S.-born, Latino–foreign-born, and Asians who are foreign-born were more likely to perceive unmet need compared to U. S.-born Whites. Unmet need included being younger, never married, uninsured, a current smoker, having comorbidities, depression, or a cost barrier to tests and treatment for cancer screenings (Houston et al., 2014; John et al., 2014).

Lung Cancer Screening: Effective and Cost-Effective

There are an estimated 94 million current or former smokers who remain at risk for lung cancer (CDC, 2013; Jemal et al., 2010b). In California, 3.8 million adults ages 18 and over are smokers (Max et al., 2014). Furthermore, smoking behavior has a substantial influence on the overall effect of lung cancer screening.

Lung cancer screenings are essential because screening can help find cancer at an early stage before symptoms appear; hence, when physicians find abnormal tissue early, it is easier for them to treat and cure. It is critical to target a distinct population of high-risk persons because those who are at the highest risk are most likely to benefit from lung cancer screening. That is why it is significant to note the impact of lung cancer, the burden on the economy, current policies, and the factors to consider regarding lung cancer screening. In summary, screening is a valid and reliable means for diagnosing lung cancer early in its development (Midthun, 2016). There seems to be some controversy associated with image-based screening related to false-positive results, incidental findings, overdiagnoses, radiation risks (Lam, Pandharipande, Lee, Lehman, & Lee, 2014), recruitment of appropriate screening population, and costs and barriers to screening (de Groot et al., 2014). However, physicians still consider screening as useful because it will detect more cancers earlier than no screening at all.

Substantial evidence shows that low-dose spiral computed tomography screening (LDCT) is significantly effective to reduce mortality and incidence. The National Lung Screening Trial Research Team (NLST, 2011) published a study which found that LDCT compared to chest radiography reduced mortality from lung cancer in participants ages 55–74 with a history of smoking 30 or more packs annually. The NCI (2014b) reported that individuals who received an LDCT scan had a 15% to 20% lower risk of dying from lung cancer than participants who received standard chest x-rays and that screening for lung cancer can lead to early detection (ACS, 2018). Because recovery chances are highest when lung cancer is detected and treated early, the screening of asymptomatic individuals who have a history of smoking and are age 55 and older could result in significant reduction of personal and economic costs related to lung cancer. Typically, those who are screened have higher levels of income and education while nonusers tend to be racial minorities, those who lack a usual source of care, and those who live in communities with fewer physicians per capita.

When mammograms and colorectal exams became mandated, decision-makers and policymakers were provided with robust information to decide whether or not to offer services. The type of information provided includes costs, outcomes, and impact of coverage for screenings and the context in which the screenings need to take place, the target population, and finally, the infrastructure and the capacity needed for policy adoption and to mandate screening (Bitler & Carpenter, 2014). Specifically, decision-makers were provided with information on (a) risk versus benefit, (b) guidelines concerning which conditions to cover, (c) the importance of screening, (d) instructions about who will perform the screening and how, (e) the type of action to take if the results are positive, (f) county-level rates to justify screening, (g) financial information about who pays for screening, (h) number of staff members needed, (i) number of machines needed, (j) number of deaths that can be prevented, and (k) the overall potential impact from screening.

According to the CDC (2013), three screening tests have been studied to determine the decrease in the risk of dying from lung cancer: chest x-ray, sputum cytology, and LDCT scans (Doll, 1950; Frost et al., 1984; de Groot et al., 2014; Marcus, 2000). Of these tests, observational studies showed that only LDCT scan of the lungs detects lung cancers better than traditional CT scans, instead of chest x-rays (Baldwin et al., 2011; Doria-Rose & Szabo, 2010). The LDCT scan continuously rotates in a spiral motion and takes many 3-D x-rays of the lungs resulting in a detailed demonstration of early-stage lung cancers that may be too small to be detected by a traditional x-ray (Swedish Medical Center, n.d.). Additionally, LDCT scans of the chest take very little time with current generation scanners and are noninvasive and painless, while having high sensitivity for pulmonary nodules (de Groot et al., 2014).

Cancers that are found on annual screenings are most often identified in the previous round of screening (Xu et al., 2016). The potential savings in resources would be significant enough to justify a revision in criteria based on the size of the nodule (Vannier, 2014). A recent study noted that while policy has yet to establish lung cancer screening as a public health practice, the cost per life-year saved among the U.S. population ages 50–64 and those at high risk screened for lung cancer would be below $19,000 (Field, 2014; Pyenson et al., 2012). Essentially, screening for lung cancer with LDCT would cost $81,000 per QALY gained (Black et al., 2014).

Furthermore, the lung cancer five-year survival rate is 54% for cases detected when the disease is within the lungs; however, physicians diagnose only 15% of lung cancer cases at an early stage (ACA, 2014). According to the SEER, the estimated percentage of deaths in 2014 from lung cancer and bronchus cancer was 27.2% of the 13.5% of all new cancer cases (NCI, 2014b). These studies have also projected that lung cancer screenings for eligible Medi-Cal members who smoke have the potential to be an excellent long-term investment.

Currently, LDCT scans are recommended for lung cancer screening for high-risk populations who smoke more than 30 packs a year (NLST, 2011; de Groot et al., 2014; Doo et al., 2014).

Availability and use of lung cancer screening. A study that analyzed the current availability of LDCT screening centers in the U.S. reported that more than 200 institutions now offer LDCT screening, with California having the most substantial number of screening centers (see Table 1), while Los Angeles County alone had six.

Most LDCT screening centers are in the Northeast and East North Central States where lung cancer incidence and mortality are high. States with high lung cancer burden and smoking prevalence had no screening centers while the average number of centers per state was four centers per 100,000 persons aged 55–79 (Eberth et al., 2014).

According to the Lung Cancer Foundation, 15 new community centers were to be expected by the end of 2014 and another 30 by the end of 2015 (Addario Lung Cancer Foundation, 2014). Further research needs to assess whether these sites are registered sites for appropriate LDCT screening and whether or not they adhere to the criteria set by CMS. Having screening sites available addresses one barrier to accessing care. Other barriers to lung cancer screening include potential harms of screening such as radiation, managing a large number of small nodules, quality of life in the course of screening (Humphrey et al., 2013; Mulshine & D’Amico, 2014), anxiety caused by the high false positive rate, overdiagnoses, consequent overtreatment as well as radiation exposure (Wilson, 2014) and perspectives. CT screening for lung cancer has been associated with high frequency of false-positive results. However, according to a study by Vannier (2014) that examined the influence of lung nodule sizes on overdiagnoses, raising the nodule size threshold for a positive screen would reduce false-positive screenings in addition to the utilization of medical resources (Gierada et al., 2014). Evidently, protocols need to be identified clearly to reduce false-positives.

Current smokers are less likely than nonsmokers to be willing to receive a lung cancer screening (de Groot et al., 2014). Some studies have reported that smokers will agree to have a screening if advised by their primary care physician (Delmerico, Hyland, Celestino, Reid, & Cummings, 2014; Klabunde et al., 2012). However, data suggest that smokers are less likely to have a primary care physician even if they are insured (Jonnalagadda et al., 2012). Most smokers do not believe outcomes are affected by early detection (Jonnalagadda et al., 2012; Patel et al., 2012). In fact, some active smokers avoid getting screened because they are frightened to learn they have cancer (Delmerico et al., 2014). There is also fear of pain and discomfort during the screening process associated with lack of knowledge about lung cancer screening among vulnerable populations (de Groot et al., 2014; Jonnalagadda et al., 2012; Silvestri et al., 2007).

False-positives have been noted to be of great concern in lung cancer screening (Mayo Clinic, 2014). For example, a lung cancer screening trial in the Netherlands called the NELSON, factored in the false-positive problem into their 12-year trial. They focused particular attention on patients returning for follow-up scans. A physician only performed a biopsy if the nodule had grown sufficiently in that time, rather than a biopsy being taken immediately upon the physician's suspicion of a tumor. Hence, the threshold for a positive CT is the volume and growth rate rather than the diameter of the nodule (Bourzac, 2014; Wilson, 2014).

Table 1

Lung Cancer Screening Sites in California

Cedars-Sinai Samuel Oschin Comprehensive Cancer Institute
City of Hope Comprehensive Cancer Center
Desert Regional Medical Center Comprehensive Cancer Center
Pomona Valley Hospital Medical Center Cancer Care Center
Hoag Family Cancer Institute
Huntington Hospital Cancer Center
John Muir Health Cancer Services
Loma Linda University Cancer Center
MemorialCare Cancer Institute at Orange Coast Memorial
Pomona Valley Hospital Medical Center Cancer Care Center
Scripps Green Hospital
Scripps Memorial Encinitas
Scripps Memorial La Jolla
Scripps Mercy Hospital Chula Vista Campus
Scripps Mercy Hospital San Diego Campus
Sequoia Hospital
Sharp Grossmont Hospital
Sharp Memorial Hospital
St Joseph Hospital of Orange, the Center for Cancer Prevention and Treatment
Stanford Cancer Center
Torrance Memorial Medical Center
University of California Davis Comprehensive Cancer Center
University of California, Los Angeles Jonsson Comprehensive Cancer Center
University of California Medical Center – Chao Family Comprehensive Cancer Center
University of California, San Diego Moores Medical Center
University of California San Francisco Helen Diller Family Comprehensive Cancer Center

There are different sets of microRNAs, called miRNAs, found to be highly sensitive and specific biomarkers for early lung cancer detection (Guo, Zhao, & Zheng, 2014; Liao et al., 2014). These indicate that a microRNA has a predictive, diagnostic value and could reduce false-positives of LDCT. As a result, it improves the efficacy of lung cancer screening (Sozzi et al., 2014). Researchers recommended establishing protocols, using sophisticated software, and interpreting results appropriately to tackle the problem of CT false-positives, (Bourzac, 2014; Mayo Clinic, 2014; Wilson 2014). Although performing the actual CT scan is simple, the problem lies in the interpretation and reduction of unintended consequences (Mayo Clinic, 2014).

A study that assessed the impact of undergoing LDCT scans for early detection on health-related quality of life and state of anxiety indicated that undergoing lung cancer screening in the context of a well-designed screening and follow-up protocol poses almost no psychological harm (Ostroff, 2014). Successful lung cancer screening sites need appropriate protocols and a well-trained multidisciplinary team to work with lung cancer patients.

The U.K. and the U.S. have defined criteria for implementing lung cancer screening with LDCT scans (O'Dowd, McKeever, Baldwin, & Hubbard, 2016). There are 23 criteria in the U.K. for an effective national screening program. However, some of the barriers to implementation include recruitment, level of harm, optimal clinical pathways, and cost-effectiveness. There is also a perceived perception that harm may result from radiation; though, LDCT reduced the radiation dose to one-fifth of a traditional CT screening (Humphrey et al., 2013; Mulshine & D'Amico, 2014).

Notwithstanding strong findings from the NLST trial, Europe has not moved forward with lung cancer screening. Instead, officials are awaiting the outcomes of the NELSON trial in the Netherlands and Belgium and data from smaller European trials within the next two years, which could provide data on the mortality and cost-effectiveness in Europe (Field, 2014). Although NLST has not published the results of its cost analysis, other researchers have been trying to estimate the cost of lung cancer screening. Joshua Roth, a health economist and epidemiologist, stated that the results of the study considers only the price of the screening and not the gain of a person living a healthier, longer life (Bourzac, 2014). Meanwhile, there is increasing recognition that when practitioners follow specific criteria, lung cancer screening trials critically influence mortality and incidence. The question to consider is how to bring clinical trials to reality in rural areas. Specific geographic areas need health outcomes data for feasibility purposes.

It is essential to consider health outcomes, benefits, and risks of lung cancer screenings when deciding whether or not to implement a screening program. Screening tests are individualized and standard. The value of screening tests needs to be evaluated by assessing the simplicity, acceptability, accuracy, costs, precision, sensitivity, and specificity (Cochrane & Holland, 1971) (see Table 2). Although LDCT has yet to be tested broadly in a community setting, it is important to understand the features that are needed to put lung cancer screening programs into practice. There must be (a) the capacity and infrastructure for lung cancer screening needed to recruit, (b) a workforce and a facility, (c) capacity for screening, (d) diagnoses and treatment, (e) health professional training, and (f) participant information and support (Marshall et al., 2013). Other features need to include ongoing evaluation and monitoring of the program to ensure high standards, high-quality care to track and assess nodules over time, screening performed by radiologists with specific LDCT training, and qualified centers (CMS, 2014). Specific data needs to be collected to confirm patient screening selection, radiation dose, standard nodule reporting and test positivity, follow-up diagnostic screening, and health outcomes (Kinsinger et al., 2014).

Specifically, CMS (2015) noted that beneficiary eligibility criteria for LDCT needs to include (a) lung cancer screening counseling, (b) shared decision-making visits based on specific criteria, (c) smoking cessation counseling, (d) standardization of LDCT screening, and (e) follow-up of abnormal findings. Moreover, radiologist eligibility criteria and radiology imaging center eligibility criteria must be met to have an eligible screening facility. This includes a facility that has participated in a lung cancer screening trial like the NLST or an accredited advanced diagnostic imaging center with training and experience in LDCT lung cancer screening, uses a radiation dose less than 1.5 mSv, and that collects and submits data to a CMS-approved national registry for each LDCT screening performed. That would also include several types of data characteristics such as (a) facility, (b) radiologist, (c) patient, (d) ordering practitioner, (e) demographics, (f) indication, (g) smoking history, (h) CT scanner, (i) effective radiation dose, (j) screening exam results, (k) diagnostic follow-up of abnormal findings within one year, (l) lung cancer incidence within one year, and (m) health outcomes.

Per Wilson and Jungner (1968), essential criteria to consider for screening are the (a) costs balanced against the benefits, (b) risks are less than the benefit, (c) appropriate health services provision is made for the extra clinical workload as result of screening, (d) frequency of screening is determined, (e) tests are designed for early detection, and (f) natural history of lung cancer is understood and a significant health issue. The decision to implement lung cancer screening programs needs to be informed by data on resource utilization and costs. A study by Cressman et al. (2014) noted that the average per person cost for lung cancer screening with LDCT scan was $453 for the first 18 months of screening of which the cost was highly dependent on the size of the nodule, presence of cancer, screening intervention, and screening center. Meanwhile, the mean per person cost of treating cancer with curative surgery was $33,344 over two years (a lower cost than the cost of treating cancer with advanced-stage lung cancer with chemotherapy, radiotherapy, or supportive care, $43,254–$52,200) (Cressman et al., 2014). On the contrary, a separate study noted that most health care expenditures are incurred during the first year after diagnoses regardless of the cancer stage (Lanuti et al., 2014). The estimated average cost at any stage is $40,500 where 63% of cost was for the first year after diagnoses. The most significant category was chemotherapy at 13% and surgery at 5%. For those who were surgically treated, the costs were twice as much as chemotherapy costs. However, specific information on lung cancer screening costs based on geographic area is needed because LDCT will potentially result in more lung cancers due to earlier stages of diagnoses and increased expenditures. Evidence suggests that the first five years of screening would cost the California about $9.3 billion and $1.9 billion annually. This cost is considerably less compared to mammograms, which cost Medicare about $41.1 billion and prostate-cancer tests, which cost $500 million (Bourzac, 2014).

Table 2

Assessing the value of screening tests

Simplicity	In many screening programs, more tests are used to detect one disease; and, in a multiphasic program, the individual will be subjected to a number of tests within a short space of time. It is, therefore, essential that the tests used should be easy to administer and should be capable of use by para-medical and other personnel.
Acceptability	As screening is, in most instances, voluntary and a high rate of co-operation is necessary in an efficient screening program, it is important that tests should be acceptable to the subjects.
Accuracy	The test should give a true measurement of the attribute under investigation.
Cost	The expense of screening should be considered in relation to the benefits resulting from the early detection of disease, i.e., the severity of the disease, the advantages of treatment at an early stage, and the probability of cure.
Precision	The test should give consistent results in repeated trials.
Sensitivity	This may be defined as the ability of the test to give a positive finding when the individual screened has the disease or abnormality under investigation.
Specificity	This may be defined as the ability of the test to give a negative finding when the individual screened does not have the disease or abnormality under investigation.

Note. Information derived from CMS (2014).

Rural residents face significant barriers in accessing LDCT screening and may need to travel to near metropolitan areas for services. Use of telemedicine for lung cancer screening may be a more viable option as well as policy level changes to implement screening at a Federally Qualified Health Center (Eberth et al., 2014). It will be necessary to educate the primary care workforce about the importance, risk benefits, eligibility criteria, process of LDCT screening, and availability of high-quality screening centers. Thus, the public health impact of screening will be met if utilization is high (Eberth et al., 2014).

Coverage for screening. The introduction of the ACA has resulted in an expansion of the number of people from vulnerable communities in California whose care is funded by Medi-Cal. With Medi-Cal enrollment reaching 12.7 million in 2015 (Karlamangla, 2015), many of the members come from groups at risk for smoking-related illnesses, such as low socioeconomic status and incomes at or below 138% of poverty (Garfield, Damico, Stephens, & Rouhani, 2014). For these populations, smoking rates are higher than the general population, including 27.9% of adults who are below the poverty level and 30% of Medicaid enrollees (Bach, 2018). Thus, the Medi-Cal expansion provides an opportunity to provide screening to a high-risk group previously denied coverage. The ACA requires insurers, such as Medi-Cal, to provide coverage without cost-sharing for preventive services rated “A” or “B.” Lung cancer screening is rated as “B” and thus may fall under this mandate (Eberth et al., 2014; Mulshine & D’Amico, 2014;). Reimbursement for lung cancer screening is essential for low-income smokers and former smokers who could potentially benefit from screening and are likely unable to afford the service in the absence of third-party support primarily because tobacco use has a strong association with socioeconomic status (Mulshine & D’Amico, 2014). Currently, there is no specific protocol in place for screening or literature for the opportunity to optimize screening benefits by integrating smoking cessation with lung cancer screening and evidence of any benefits (Slatore et al., 2014). As reimbursement improves, utilization will rise accordingly (Eberth et al., 2014).

The accumulation of evidence of the clinical benefits of lung cancer screening has recently led the CMS (2014) to add a preventative service benefit for Medicare members to receive lung cancer screening and counseling. Specifically, the benefit suggests lung cancer screening with LDCT once per year for members who are ages 55–74. Moreover, the member must be asymptomatic (no signs or symptoms of lung disease) and must have a history of tobacco smoking of at least 30 pack-years (one pack-year = smoking one pack per day for one year; one pack = 20 cigarettes). Furthermore, it would include members who are current smokers or ones who have quit smoking within the last 15 years and who have a written order for LDCT lung cancer screening for either an initial or subsequent screening. Thus, for the first time, Medicare members will have access to lung cancer screening. Such access was a change from previous practice, whereby testing for lung cancer was restricted to individuals who were symptomatic, and thus, used primarily for diagnosis. Given the benefits that can result from early detection (Jemal et al., 2010a), the change in Medicare policy has the potential to increase life expectancy for Medicare enrollees who smoke significantly.

Despite the effectiveness of screening, it remains underutilized with screening rates far below target rates (CDC, 2013). The advent of the prevention measure by CMS provides an opportunity to address these challenges. There is a prospect to expand prevention services, primarily to at-risk and vulnerable populations. on the cost of lung cancer and lost QALYs by county and stage of lung cancer can help counties understand the scope of the problems facing their region and identify high priority areas to target interventions and programs. On a larger scale, politicians and decision-makers need data on costs to make sound policies to invest in lung cancer screening programs.

Challenge – Coverage for ages 55 to 64-years. There is a challenge in covering beneficiaries between ages 55 and 64. Although there are nearly 47 million Medicare beneficiaries in the United States (CMS, 2014), fewer than 10% are between the ages of 55 and 64. Nearly 90% of people in this age group are covered either through private insurance or Medicaid. Thus, the Medicare expansion will not cover the vast majority of smokers ages 55 to 64; and, expanding screening to this group will require private insurers or Medicaid purchasers to agree to expand their coverage as well.

Although lung cancer screening is not widely available outside of clinical trials and pilot programs, Bourzac (2014) noted that private insurers in the U.S. would begin covering the cost of screening in January 2015 based on the outcomes of the NLST trial. Because most Medicare enrollees are 65 or older, this policy leaves many 55 to 64-year-olds without access to lung cancer screening. This policy is of great concern because an estimated 22% of the people diagnosed with lung cancer are between the ages of 55 and 64 (NPCR, 2014). Although some in this age group might have access to screening through private insurance, the advent of the ACA in 2013 has dramatically expanded health care coverage for this age group in California (Medicaid, n.d.), particularly in areas with large numbers of Medi-Cal enrollees.

Medicaid or Medi-Cal covers a core set of services such as doctor visits, hospital care, and ambulatory services for enrollees (CMS, 2014). Medi-Cal agencies, such as the Alliance, are required by California Department of Healthcare Services (CDHS, 2018) contract to reimburse for all state-determined Medi-Cal benefits. Agencies can add services by board approval but cannot remove state-determined benefits. Although Medicare agencies reimburse for lung cancer screening, LHDs have the potential to save thousands of lives by promoting and spreading awareness of lung cancer screening programs which can, in turn, save millions of dollars while detecting early cases of lung cancer and increasing mortality.

The role of Medi-Cal and public health departments in providing lung cancer screening. Policymakers along with local governments need information on screening programs before they can offer them, cover them, or implement them. Currently, LHDs have defined their role in public health away from the traditional role public health played in the past as a result of discussions from health care reform to strengthen core functions in the delivery of basic public health services. What is more, while each LHD operates differently based on funding streams and availability of clinical services, it has become necessary to identify the type of information that is meaningful to health departments across the state based on their various involvement with clinical services. For instance, some LHDs might not be involved with lung cancer screening because the LHD offers limited clinical services. Nevertheless, one connection may be through tuberculosis screenings if the public health officer reviews x-rays on an active case. He or she could then refer out to the primary care provider. Alternatively, the LHD might be involved in promoting a lung cancer-screening program. LHDs have been mandated to offer preventive care. Since lung cancer screening is a prevention measure, LHDs would need to consider whether or not to promote lung cancer screening actively. Medi-Cal purchasers also must decide whether or not to offer lung cancer screening. In many counties in California, independent agencies administer Medi-Cal. Agencies, such as the Alliance, offer lung cancer screening as a reimbursable Medi-Cal benefit. These types of agencies are required by DHCS contract to reimburse all state-determined Medi-Cal benefits. They can add services but cannot remove state-determined benefits (Alliance, 2017).

Implementation of a lung cancer screening program for Medi-Cal recipients ages 55 to 65 would require the cooperation of the Medi-Cal purchaser and the LHD. It is unclear what criteria the Medi-Cal purchasers and the LHDs would use to make this distinction, but a commonly referred to metric is the Return on Investment (ROI). ROI analysis has been of increased interest in recent years with numerous examples of LHDs using ROI to help make or justify decisions (Crawley-Stout, Ward, See, & Randolph (2015). There are numerous examples of the use of economic-based analysis, such as ROI, in health care decision-making. For instance, the National Institute for Health and Care Excellence (NICE, 2018) in the United Kingdom is well known for using cost-effectiveness analysis to help guide decision-making. As part of their submissions, NICE routinely requests information on the direct and indirect costs to the health care providers, the patients and caregivers, and society at large. This information is paired with outcome information, such as the number of QALYs that are gained from a given treatment or intervention. This information is combined to form a single measure — the Incremental

Cost Utility Ratio —that reports the cost per QALY gained from a given intervention or treatment. This information is then combined with other information to determine the purchasing priorities of the National Health System.

For lung cancer screening, Medi-Cal purchasers and LHDs are likely to be interested in any savings that might result in a lower program cost. However, it is unclear what time horizon would be of interest and whether they would be interested in nonmonetary outcomes. For example, outcome such as the (a) potential number of people who might benefit, (b) potential number of early lung cancer stage diagnoses, (c) health gain if lung cancer is diagnosed at a later stage versus early-stage, (d) gain in QALY, or (e) whether they would want to have all benefits represented in monetary terms.

It is imperative to review what we know about lung cancer screening, the factors we must consider regarding lung cancer screening, current policies, the cost-effectiveness of screening, ROI, and the outcomes of recent trials. A way to gain insight into increasing screening for lung cancer is to understand the costs and lost QALYs associated with lung cancer at the county-level and to understand the decision-making process from a health economics point of view by providing a guide on ROI.

Health economics perspectives are becoming a standard tool for understanding the way political leaders and LHDs make decisions about implementing interventions. Naturally, health economics frames the decision-making process as an economic analysis. In other words, an LHD or decision-maker is more likely to invest in a screening program if the perceived benefits outweigh the perceived costs. The outcome of the economic analysis is the value of the screening. That is, if the benefit outweighs the costs, the screening is seen as valuable. Benefits and costs are prioritized; therefore, a central assumption of this research is that interventions be described through their attributes. To understand whether to invest in a new intervention, researchers must focus on understanding the global burden or features that would be of value to society.

The Current Study

Since the focus of this study is on local decision-making, the ultimate goal is to help counties in California understand the benefits and costs they could expect from implementing lung cancer screening. Thus, the following chapters will examine the different components of that decision.

Chapter 1 presents the results of the analysis of the burden of disease of lung cancer in California counties. This chapter will identify the cost of lung cancer per stage within the overall population, the Medi-Cal population, and the QALYs that are lost from lung cancer per county in California. The costs and QALYs will be estimated using the methodology from previous studies that estimated the cost of chronic conditions in California. This study required the identification by the stage of lung cancer diagnosis for people detected with lung cancer per county using the SEER database, as well as to estimate the cost per stage for each county in California using cancer costs from the literature. This burden of disease study will provide the impact of lung cancer measured by costs, mortality, and QALYs at the county-level. The burden of disease study is significant as it can provide information about how to prioritize actions in health and the environment, planning for preventive action, assessing performance, identifying high-risk populations, and planning for future needs. Providing cost estimates of cancer at the county-level will provide a monetary association with lung cancer. Information on lost QALYs will show the impact of lung cancer on society; and, in turn, this information will show lobbyists how having no interventions is detrimental to society while allowing LHDs to vouch for funding in their counties.

Chapter 2 will focus on decision-making within LHDs and Medi-Cal purchasers in California. The chapter will review the existing literature that identifies the criteria upon which they make their decisions; and, then, apply these criteria to lung cancer screening.

The final part of the study will examine the ROI by introducing lung cancer screening to eligible members in California counties. Information from the first two aims (costs and QALYS within the decision context) will be combined with information from previously published studies on lung cancer screenings and costs to provide estimates on the ROI to county public health departments for investing in lung cancer screening. Therefore, the question being addressed is whether lung cancer screening for those who smoke represents a good investment in counties in California. Finally, the study concludes with a discussion of the implications of this analysis for understanding local decision-making and for future research directions.

CHAPTER 1: The Burden of Lung Cancer in California Counties

Introduction

Lung cancer is the most common cause of cancer deaths in California (ACS, 2013; CDPH, 2014b; CCR, 2009; Medicaid, n.d.), currently affecting an estimated 40,000 people. Lung cancer prevalence is expected to increase in the coming decades as the population ages with lung cancer incidence increasing with age. Additionally, innovations in early detection and treatment of lung cancer may lead to improvements in detection of lung cancer.

Loss of productivity caused by cancer is a significant drain on the economy. The loss of productivity from lung cancer is three times more than any other cancer. Lost productivity amounted to $36.1 billion in 2005 (Bradley et al., 2008). Loss of productivity costs due to cancer-related premature deaths are significant, whereas the high premature mortality costs reflect upon high wages and rates of workforce participation (Hanly & Sharp, 2014). Essentially, costs and lost QALYs (see Table 3) will provide an alternative outlook on the burden of cancer.

Recent changes in recommendations regarding the detection and treatment of lung cancer have implications for the future burden of lung cancer in California. Specifically, the CMS (2014) recently changed the beneficiary eligibility criteria for low dose tomography to include lung cancer screening counseling, shared decision-making visits based on specific criteria and smoking cessation counseling, standardization of LDCT screening, and follow-up of abnormal findings. As a result, people who meet the criteria (such as being a heavy smoker) are provided with lung cancer screening.

Although screening was recommended for people ages 55 and older who meet the criteria, Medicare only covers individuals ages 65 and over. As a result, people ages 55 to 64 who are recommended for screening must rely on their health insurance to cover the cost. Although the increased coverage is guaranteed by CMS and by private insurance under the ACA, coverage under Medicaid or (Medi-Cal in California) is left up to the states.

In California, nearly 2,000 Medi-Cal recipients are diagnosed with lung cancer each year. Understanding the cost of lung cancer overall, but to Medi-Cal recipients in particular, will help LHDs and Medi-Cal purchasers in the state understand the economic and health burden associated with lung cancer. The purpose of this study was to estimate the impact of lung cancer in counties in California, including the cost and reductions in QALYs and information that can be used to prioritize actions in health planning at the local level.

This study identified the cost of lung cancer per stage of the overall population and the Medi-Cal population by counties in California and the lost QALYs from lung cancer per county in California. I estimated the costs and QALYs using the methodology from previous studies that estimated the cost of chronic conditions in

Table 3

Literature Review on QALYs Lost

Year	Location	QALYs lost
2013	US	The QALY for patients with small cell lung cancer, squamous cell carcinoma, and adenocarcinoma were 1.21, 2.37, and 3.03 quality-adjusted life year (QALY), with the corresponding loss-of-QALY of 13.69, 12.22, and 15.03 QALY, respectively.
2013	Israel	EuroQol five-dimensional (EQ-5D): stage I, .7086; stage II, .3412; stage III, .3412 and stage IV, .0832
2010	Netherlands	Healthy utility score .78 nonlung cancer
2013	US	Utility weights for lung cancer patients: stage A, .823 stage; stage B, .772; stage C, .573 cost per QALY
2008	England	When adjusted to match census data, stable disease with no additional symptoms had a utility value of .626. Health state values declined by .069 with the addition of pain; .050 for dyspnea; or .046 for cough. A treatment response would result in a utility gain of .086.
2003	US	Localized, .73-nonscreening; localized screening, .83; advanced non-small cell lung cancer, .66
2015	Italy	Average QALYs 1.7, 1.49, 1.07, screening participants, invite to screen and control group

Notes. Data derived from Yang (2013).

California (Brown et al, 2014). This study identified the stage of lung cancer diagnosis for people detected with lung cancer per county using the SEER database and estimated the cost per stage for each county in California using cancer costs from the literature.

Comparable information about rates of disease, lost QALYs, and mortality rates are broken down by stage of cancer, age, and geography. Still, generating meaningful comparisons of rates of disease involved addressing many data and estimation challenges, which included combining data from multiple sources and across populations. It also encompassed adjusting for cost, survival data, and quality issues as well as appropriately synthesizing data from specific resources such as cancer registries. Additionally, it comprised developing robust analytical strategies to estimate the cost and QALY specific data. The analysis in this study provided a standardized approach to addressing these problems, thus increasing the capacity to make meaningful comparisons across stages of cancer, age, and location.

Methods

Estimates for Cost of Treatment

Cost estimates for lung cancer by stage were formed using existing literature (see Table 4). The goal was to estimate the cost by stage for each age group. However, reported cost estimates were incomplete for several reasons, including not reporting the cost by phases of care or treatment, only reporting costs for Medicare recipients or privately insured, or having samples that were nongeneralizable (see ACS, 2014; Chang, 2004; Cipriano et al., 2011; Kalseth et al., 2011; Luengo-Fernandez, Leal, Gray, & Sullivan, 2013; Mariotto, Yabroff, Shao, Feuer, & Brown, 2011; NCI, 2010; NCI, 2014a; Shmueli et al., 2013; Tan et al., 2009; Tangka et al., 2010; Villanti, Jiang, Abrams, & Pyenson 2013; Wynes, 2014; Yabroff et al., 2011). Most recently, Cressman et al. (2014) noted that the average cost per person for at least two annual LDCT screens and all the necessary follow-ups or repeat scans for those without lung cancer was $453 versus $2248 for those with lung cancer.

Table 4

Review of Costs Based on the Literature Reviewed

Year	Location	Cost
2011	US	For a 72-year-old diagnosed with lung cancer in the year 2000, the monthly costs for the first six months of care = $2,687 (no active treatment) to $9,360 (chemo-radiotherapy) and varied by stage based on diagnosis and histologic type.
2011	US	Annualized means net costs of care in 2010 in U.S. dollars for lung cancer, <65 years of age through last year of life, initial = $72,639, continuing = $8,130, cancer death = $138,785. Greater than 65 years of age, initial = $60,533, continuing = $8130, cancer death = $92,524.
2013	US	Average annual cost of LDCT screening = $210 per stage; stage A = $82,087, stage B = $132,464, and stage C = $142,750.
2014	Canada	The average per-person cost for screening individuals with LDCT is stage I = $2248, stage II = $33,344, and stage IV = $47,792.
2014	Canada	The average cost per person for at least two annual LDCT screens without lung cancer = $453. Stage I= $2248 including a diagnostic work-up, curative intent surgical treatment, and stage II = $33,344. Treatment with chemotherapy, radiotherapy, or supportive care alone was $47,792.

Notes. Data derived from Cipriano (2011).

The mean per-person cost for a diagnostic work-up, curative intent surgical treatment, and two years of follow-up was $33,344 for those diagnosed with lung cancer. In comparison, the cost for treating advanced-stage lung cancer with chemotherapy, radiotherapy, or supportive care alone was $47,792. These estimates were used in the current study because they were the most recent and comprehensive per person estimates of lung cancer by stage.

The attributable cost by stage was multiplied by the number of people diagnosed with lung cancer in each county by its stage to compile the cost estimates. This procedure resulted in estimates of lung cancer in each of the 58 counties by stage of lung cancer, age, gender, and ethnicity. These estimates were then combined to calculate a total attributable cost per county.

Adjustment of Cost of Lung Cancer by County

The cost per case of lung cancer in each county of California was adjusted for the price differences in health care services between counties using the geographic adjustment factor reported by the Institute of Medicine and based on the CMS Geographic Practice Cost Index (GPCI) for California (see CMS, 2014). The geographic adjustment factor takes into account the geographic differences due to three factors: the cost of physician services, practice expenses due to location (e.g., rent and cost of operating a facility), and malpractice or professional indemnity. The geographic adjustment factor, which divides California into nine distinct regions for GPCI calculations, was applied to the cost estimate for each condition, age, and gender for each region of California. The cost adjusters, ranging from 1.0323 to 1.1817, were applied to the cost estimates from the literature.

Prevalence and Number of Cases for California

The prevalence and number of cases of lung cancer within each county of California by age, gender, and race/ethnicity of the overall population and Medicare-only population was stratified by five ages, two gender categories, five race/ethnicity categories, and three lung cancer stage categories (stage I-IV). Estimates of the prevalence and number of lung cancer cases in the overall population and Medicare-only population in California were derived from SEER (2013). The rates summarized in Table 5 were derived from SEER-Medicare data. Lung cancer cases in each age strata by race/ethnicity and gender were retrieved for each of the 58 counties using the program, SEER Stat 2009 and 2010 SEER (see NCI, 2014a). I estimated the county-level prevalence and number of cases for the following strata to match the age groups used by SEER: 0–19, 20–44, 45–64, 65–79 and 80-years or older and by the stage of cancer: Stage I, localized; stage II/III, regional; and stage IV, remote. Because SEER categorizes stages of diagnoses in nine stages, stages were lumped to fit three stages of cancer categorization. Due to the small sample sizes, no estimates were available for small counties or small demographic subgroups within the counties. Therefore, small counties were combined and average rates were applied to each small county.

Utility Scores and Life Expectancy

Utility scores (see Table 5) are a metric that allows quantification of the impact of a disease on an individual's well-being and functioning and are increasingly used as a significant outcome measure in health care to support decision-making and are essential to inform public health policies (Prigent, Auraaen, Kamendje-Tchokobou, Durand-Zaleski, & Chevreul, 2014). Amid a wide range of instruments developed to assess the quality of life, common factors allow comparisons of distinct conditions because they can be applied across populations. Through a set of questions, the perceptions of an individual's quality of life are assessed, a score is assigned to responses on a scale of 0–1, where 1 indicates optimal health. In these cases, utility scores are acquired through a general population survey based on responses about the quality of life elicited from participants (Drummond et al., 1997).

Table 5

Utility Scores and Life Expectancy by Stage of Lung Cancer

	Utility scores				
Stage	Ages 1 to 1	Ages 22 to 44	Ages 45 to 64	Ages 65 to 79	Ages 80 plus
Healthy	0.92	0.84	0.80	0.68	0.48
I	0.80	0.74	0.70	0.60	0.42
II/III	0.46	0.42	0.40	0.34	0.24
IV	0.12	0.11	0.10	0.09	0.06

	Years of life left				
Stage	Ages 1 to 19	Ages 22 to 44	Ages 45 to 64	Ages 65 to 79	Ages 80 plus
Healthy	70.00	49.00	27.00	13.00	6.00
I	70.00	35.00	18.00	7.50	1.50
II/III	4.50	22.00	7.50	3.10	1.24
IV	1.50	5.50	1.98	1.20	0.76

Years of life lost (YLL) is an estimate that provides the average number of years a person would have lived if he or she had not died prematurely (see Table 6). In other words, it is a measure of premature death (World Health Organization–WHO, 2006). The estimate for YLL is calculated from the number of deaths multiplied by a standard of life expectancy at the age at which death occurs. Most often, life tables identifying all-cause mortality rates by age and sex are used to calculate life expectancy figures. However, life tables for lung cancer in the specific age strata by stage of lung cancer were not available and not at a fine level of granularity. As a result, five-year survival rates with lung cancer in 2008 were used to estimate life expectancy by age and stage of cancer.

There are numerous published utility estimates and life-years for lung cancer with a broad range of values but not at the level needed for this study. For instance, it is not available for individual ages, nor is there any information on county of residence, social class, or other measures or indicators of access to care. It is an immense limitation. Variations in utility values exist because different standards are used, rating scales vary, and study methodologies differ (Chouaid et al., 2013; Doyle, Lloyd, & Walker, 2008; Villanti et al., 2013; Yang et al., 2013). There is insufficient literature on years of life left for lung cancer because existing study methodologies differ in the scope of the study (see Brustugun, Moller, & Helland, 2014; Burnet, Jefferies, Benson, Hunt, & Treasure, 2005; Liu, Wang, & Keating, 2013; Medicaid, n.d.; NCI, 2015). For this study, healthy life expectancy by age for lung cancer was retrieved from the social security website (Social Security Administration, n.d.) An age adjustment was made to estimate the age groups with cancer by stage and by retrieving survival rates from the SEER database by age and stage to estimate a weighted life expectancy based on the number of people alive, dead, newly dead, and the percentage of deaths in five years.

Table 6

Expected Years of Life Lost (EYLL) Based on the Literature Reviewed

Year	Location	Life expectancy
2013	US	Liver cancer and lung cancer had an average EYLL of over 13 years while the EYLL for prostate cancer was under two years. When considering the annual incidence in 2012, lung cancer would cause the greatest subtotal of EYLL (3.1 million years) followed by female breast cancer (1.4 million years) and colorectal cancer (932,000 years).
2014	US	Females lose, on average, more life-years to cancer than men (14.9 versus 12.7 years)
2013	Israel	Stage I = 1.5 years, stage II = 3.3 years, and stage IV = 4.5 years. Life expectancy at diagnoses is 13.9 years.
2012	Australia	Five-year survival rates: After surviving 10 years, conditional five-year survival was over 95% for six localized, six regional, three distant, and three unknown stage cancers. For the remaining patient groups, conditional five-year survival ranged from 74% (for distant-stage bladder cancer) to 94% (for four cancers at different stages), indicating that they continue to have excess mortality 10–15 years after diagnosis.
2014	UK	Five-year survival rates: Overall, around 30% will survive for one year or more after they are diagnosed. Around 10% will survive for five years or more. And, about 5% will survive for 10 years or more after they are diagnosed.
2005	US	The mean EYLL is 12.5 years.

Lost QALYs of lung cancer per stage in each county of California were derived by multiplying (see Table 7):

- The utility score for lung cancer and years of life left, providing QALY average.
- Subtracting the difference in healthy average and by stage average in years of life left and utility scores.
- Multiply the differences (Health-Stage).
- Multiply the QALYs by the number of people in each county by age, race, gender, providing lost QALYs.

The procedure resulted in estimates of lung cancer in each group by stage of lung cancer.

Table 7

Lost QALY Estimates by Age and Stage of Lung Cancer

Stage	Ages 1 to 19	Ages 22 to 44	Ages 45 to 64	Ages 65 to 79	Ages 80 plus
Stage I	8.05	15.44	9.00	4.38	2.25
Stage II/III	62.33	31.92	18.60	7.79	2.58
Stage IV	64.23	40.58	21.40	8.74	2.83

Analysis

The analysis of costs of lung cancer in California was stratified by age, gender, and race/ethnicity of the overall population and Medicare-only population. The stratification included five age groups (0–19, 20–44, 45–64, 65–79, and 80 years and over), two gender categories (male and female), five race/ethnicity categories (Hispanic, nonHispanic White, nonHispanic Black, and nonHispanic Asian), and three lung cancer stage categories (stage I–IV). STATA™ software was used to run the cost analysis. Estimates of the prevalence and number of lung cancer cases in the overall population and Medicare-only population derived from SEER was cleaned and organized into the above categories. Price adjustments were applied to the cost by county; then, the cost was applied to the number of cases per county to calculate the cost per case. I estimated lost QALYs by obtaining a healthy utility score and estimating utility scores by age and stage of cancer by doing an age adjustment using the average utility score for the 45–64 age group from the literature. Healthy life expectancy was retrieved from the social security site while life expectancy by age and stage of lung cancer was derived by estimating life-years lost from five-year survival rates obtained from the SEER.

Results

Table 8 summarizes the number of cases, costs, and lost QALYs in the overall California population and the Medi-Cal population with lung cancer. Overall, there were 41,714 cases of lung cancer in California and about 1,996 cases of lung cancer in the Medi-Cal only population. The overall cost of lung cancer in California is approximately $1.2 billion and the overall cost for the Medi-Cal population is $33.3 million. Lung cancer-related QALYs lost among the overall California population was 250,889 life-years. 36,169 life-years were lost among the Medi-Cal population.

The cost/QALY differences between counties reflected their relative populations with total costs varying from a high of $4.5 million for San Diego County, $2.8 million for Alameda County, $2.6 million for San Bernardino County, $35,344 for Lassen County, and $4,765 for Trinity County for the Medi-Cal population. Counties with higher spending tended to be those with an older age distribution, whereas the counties with the lowest spending included young populations. The overall cost of lung cancer in Los Angeles County was a high $2.5 billion, $8.8 million for Orange County; $8.5 million for San Diego County. Alpine had the lowest cost of lung cancer at $70,689. Los Angeles County had the most QALYs lost due to lung cancer among the Medi-Cal population of 5,239 life-years lost; and, the overall California population had 61,229 life-years lost in Los Angeles County (see Table 9). Most dollars per county were spent on people who were in later stages of lung cancer. Among the Medi-Cal population, Los Angeles County had the most significant number of cases (628) with the majority of them being between the ages of 45–64. Of the overall population in California, the most substantial number of lung cancer cases was the 65–79 age group followed by the 80 and over age group.

Table 8

Number of Cases, Cost and Lost QALYs from the Medi-Cal-Only and Overall California Population

Population	Number of lung cancer cases	Cost	Lost QALYs
California	41,039	$1,021,665,793	250,889
Medi-Cal	1,996	$33,384,059	36,169

Table 9

Lung Cancer Cases by County, Cost, and QALYs Lost – 2014

	Number of lung cancer cases		Cost of lung cancer		QALYs lost	
County	Medi-Cal population	Overall County population	Medi-Cal population	Overall County population	Medi-Cal population	Overall County population
Alameda	101	1636	$2,842,632	$42,100,000	1401	10706
Alpine	0	2	$0	$70,689	0	10
Amador	0	72	$0	$1,666,820	0	435
Butte	24	391	$628,189	$8,982,313	377	2348
Calaveras	8	97	$148,578	$2,348,002	107	616
Colusa	2	11	$37,727	$206,335	12	40
Contra	43	1345	$1,301,061	$32,200,000	647	8280
Del Norte	2	42	$37,727	$1,127,882	27	300
El Dorado	6	266	$143,812	$6,189,696	102	1607
Fresno	57	837	$2,085,546	$22,200,000	979	5494
Glenn	6	47	$113,182	$1,060,890	83	261
Humboldt	16	148	$396,041	$3,593,883	249	973
Imperial	9	128	$249,846	$3,348,455	123	794
Inyo	3	39	$7,148	$1,019,516	24	245
Kern	21	691	$699,947	$17,900,000	937	4823
Kings	12	97	$322,918	$2,688,270	398	772
Lake	10	163	$236,914	$3,677,903	348	996
Lassen	1	23	$35,344	$717,696	62	139
Los Angeles	628	9568	$1,552,918	$245,000,000	5239	61229
Madera	5	157	$156,744	$4,032,172	48	1035
Marin	8	402	$20,861	$10,500,000	54	2226
Mariposa	2	43	$37,727	$917,179	10	283
Mendocino	9	125	$216,884	$2,955,093	262	807
Merced	8	240	$181,539	$5,630,983	231	1455
Modoc	1	11	$50,659	$305,220	41	76
Mono	0	11	$0	$188,688	0	85
Monterey	12	413	$318,254	$10,400,000	307	2573
Napa	7	209	$18,253	$5,394,566	22.41	1141
Nevada	9	180	$183,922	$3,720,744	27	988
Orange	82	3710	$2,564,293	$88,900,000	1319	22956
Placer	12	497	$256,994	$11,300,000	5.08	3127

County	Number of lung cancer cases: Medi-Cal population	Number of lung cancer cases: Overall County population	Cost of lung cancer: Medi-Cal population	Cost of lung cancer: Overall County population	QALYs lost: Medi-Cal population	QALYs lost: Overall County population
Plumas	2	43	$53,042	$1,226,819	30	304
Riverside	54	2119	$1,702,835	$50,200,000	789	12775
Sacramento	76	1792	$2,379,200	$43,800,000	1245	11956
San Benito	0	35	$0	$895,784	0	288
San Bernardino	86	1660	$2,650,399	$40,900,000	3467	10971
San Diego	172	3758	$4,491,754	$85,400,000	5966	23174
San Francisco	114	1176	$315,214	$34,000,000	4634	7556
San Joaquin	34	722	$1,040,564	$17,000,000	1405	4735
San Luis	15	368	$459,582	$8,702,761	545	2408
San Mateo	46	1088	$126,157	$31,100,000	436	6625
Santa Barbara	22	511	$671,700.80	$11,800,000	202	2884
Santa Clara	86	1857	$233,926.90	$50,300,000	625	11838
Santa Cruz	10	247	$333,467.50	$6,359,839	96	1739
Shasta	15	322	$428,952.30	$8,066,770	430	1809
Sierra	0	8	$0.00	$199,186	0	37
Siskiyou	5	106	$93,152.80	$2,440,035	119	713
Solano	20	560	$679,917.90	$15,000,000	501	3896
Sonoma	14	637	$342,999.00	$15,000,000	451	3784
Stanislaus	36	549	$832,244.20	$12,600,000	350	3416
Sutter	5	111	$126,114.60	$2,559,154	72.33	729
Tehama	11	129	$401,773.90	$3,381,468	39.25	803
Trinity	2	26	$4,765.76	$645,938	4.5	142
Tulare	19	305	$613,943.50	$8,486,716	377	2097
Tuolumne	8	145	$181,539.80	$3,452,556	148	980
Ventura	28	879	$69,867.84	$21,400,000	484	5394
Yolo	8	203	$117,948.30	$4,695,139	87	1476
Yuba	4	82	$187,323.20	$1,710,628	225	516
Totals	1966	41039	$33,384,059	$1,021,665,793	36,169	259,889

In the overall California population, most lung cancer cases were stage I with 18,354 cases, followed by stage II at 12,694 cases, and stage III at 9,747 cases. The relative cost for stage I was $43.3 million, $462.1 million for stage II, and $1.02 million for stage III. The associated lost QALYs from stage I were 74,068, 93,656 for stage II and 259,889 for stage III. Costs and the associated lost QALYs were highest for stage III lung cancer. Among the Medi-Cal population, most lung cancer cases were stage III with 725 cases, followed by stage I with 648 cases, and stage II with 623 cases. The relative cost for stage III was $18.3 million, $1.59 million for stage I, and $13.5 million for stage II. The associated lost QALYs from stage III were 17,248; 4,424 lost QALYs from stage I, and 14,496 lost QALYs from stage II.

Utility scores retrieved from the literature and survival rates retrieved from the SEER database were used to estimate lost QALYs. For example, a person who was between the ages of 1–19 and had stage I lung cancer lost 8.05 quality-adjusted life-years.

As demonstrated in Table 8, as age increases (holding diagnoses stage constant), people have fewer years of life to lose, on average.

Conclusion

The purpose of this study was to estimate the cost of lung cancer in California by county, age, and stage of lung cancer in the overall population and Medi-Cal population. Estimates from the literature regarding cost per stage of lung cancer were: stage I, $2,382; stage II/III, $35,344; and, stage IV, $50,659. Prevalence and counts from the SEER database were used to develop estimates of the costs associated with lung cancer. The results suggested that $1.02 billion is being spent on treating lung cancer in California while $33.3 million is being spent on the Medi-Cal population. Additionally, the data suggested that the associated QALYs lost to adults due to lung cancer in the overall California population is 250,889 and 36,169 for the Medi-Cal population.

Previous studies have estimated the cost of lung cancer and QALYs at the national level with some estimates available for individual states and counties (ACS, 2014; Chang, 2004; Cipriano et al., 2011; Grutters et al., 2010; Luengo-Fernandez et al., 2013; Mariotto et al., 2011; NCI, 2010; NCI, 2014a; Shmueli et al., 2013; Tan et al., 2009; Tangka et al., 2010; Villanti et al., 2013; Wynes, 2014; Yabroff et al., 2011; Yang et al., 2013). However, while researchers have attempted to estimate the cost of lung cancer in specific regions, this is the first attempt to estimate the cost of lung cancer in multiple counties in a state of lung cancer in the overall population and Medi-Cal population.

A significant attribute of a well-functioning health system is to prolong healthy life into old age. For this to occur, decision-makers in health care need comprehensive and disaggregated evidence about comparable rates of disease and outcome measures, like lost QALYs, across populations; particularly for conditions that are mostly preventable through policy action whether through health services or increasing capacity for prevention programs. Traditionally, this evidence has been limited to the findings of conventional cost analysis. As the results of this study show, a more novel approach can provide a more detailed and systematic description of cost and outcome measures at a granular level, which is becoming increasingly relevant for policy because the current political climate is changing along with health policies.

Overall population health is likely to improve more rapidly in places where relationships between determinants of health and the associated cost and outcome measures are understood, particularly in areas where addressing these gradients is a priority for health and policy development. This study provides essential new evidence concerning where the most sizeable gradients in cost and outcome measures are among populations across the state. Thus, understanding the savings that could be made through enhanced prevention activities is vital for policymakers.

Although there is an opportunity for policymakers to reduce the burden of lung cancer by investing in valuable prevention activities mainly because predictive factors for cost variables, such as rural versus urban is significant, budgets and funding are limited. Therefore, the need to identify prevention activities that are *worth the money* become increasingly significant. Future studies can also compare screening programs with treatment strategies when carrying out economic assessments to improve patients' value.

As summarized, a majority of lung cancer cases (57%) are diagnosed after the cancer has spread (ACS, 2018a). In 2010, results from the NLST trial showed 20% fewer cancer deaths among current and former heavy smokers who were screened with LDCT compared to a standard chest x-ray. The ACS issued guidelines for early detection of lung cancer in January 2013. Consequently, it is important that estimates of lung cancer costs and QALYs lost be made available to determine effective interventions for lung cancer screenings.

The literature shows that adults ages 45–64 and 65–84 have the highest average cost per stay of $12,100 and $12,300 respectively. These age groups cost hospitals nearly two-thirds of their expenditures and about half of all hospital stays. The current study confirms that these age groups have the largest number of lung cancer cases, and thus, appropriate and effective prevention measures for the screening of lung cancer need to be taken. The literature also suggests it is useful to quantify the impact of particular modifiable risk factors, analyzing disparities in QALYs from small socio-demographic subgroups, and examining changes over time. However, before the year 2000, these analyses could not be conducted in the U.S. due to the lack of a dataset that contains health utility scores in a representative sample of the population. Using the EQ–5D scores, an estimate has been made of the burden of disease attributable to lung cancer in the general U.S. population. This analysis used the proportion of the population to calculate QALYs lost.

Limitations

As this was the first attempt to estimate lung cancer costs at the county-level, there were some methodological issues:

Accuracy of estimates for small counties/younger ages. As lung cancer prevalence rates were obtained by strata, race/ethnicity, and gender for each of the 58 California counties using SEER data, small populations in some counties or demographic subgroups within counties made it necessary to pool the small counties when determining cancer rates.

Adjusting for differences in health services usage between counties. The estimates presented earlier accounts for differences in the cost to counties based on age, gender, prices in the region, population in the region, and (to some degree) rates of lung cancer per county. Left unaccounted for were differences in the intensity of health care usage. These can arise because of differences in the availability of medical facilities, differences in practice between regions, and differences in ability to pay. However, this study did examine predictive factors for cost variables and found that there is a constant linear relationship between costs and the number of hospitals and population size.

Adjusting for differences in estimating utility scores and years of life lost. Although the age adjustments to estimate utility scores by age and stage of cancer shown earlier account for the differences by age, differences by stage, and differences by counties, there was a limitation in retrieving utility scores at the granular level needed for this study. Most often, life tables identifying all-cause mortality rates by age and sex are used to compute life expectancy figures. However, life tables for lung cancer in the specific age strata by stage of lung cancer were not available. Nor were they available at a fine level of granularity. As a result, five-year survival rates with lung cancer in 2008 were used to estimate life expectancy by age and stage of cancer. There were numerous published utility estimates and life-years for lung cancer with a broad range of values but not at the level needed for this study. For instance, it was not available for an individual age nor was there any information on county of residence, social class or other measures, or indicators of access to care.

Implications

This study represents an initial attempt to estimate the cost and lost QALYs of lung cancer in counties in California. Additional information is needed to help counties and policymakers identify the ROI from prevention activities, including the health gains that would result, the agencies that would incur additional costs, those who would financially benefit, and the health care providers and other parties that would need to be involved to make the prevention activities successful. Additional economic information is needed for most public health programs to determine the most effective investment. Nevertheless, we must determine the costs and benefits that should be included in an ROI. Consequently, it is necessary to obtain information on the criteria that should be included in an ROI to base LHDs and policymakers' decisions.

The next chapter will focus on decision-making within LHDs and Medi-Cal purchasers in California. The chapter will review the existing literature that identifies the criteria upon which they make their decisions; and then, apply these criteria to lung cancer screening. Although decision-making at this level will undoubtedly involve political considerations, the study will attempt to characterize the decision context in which LHDs make decisions, how they decide to fund new programs, and the types of decisions they make when deciding to invest in programs. Specifically, the study will help explain the LHDs prioritization process about which costs and benefits they should include in their ROI. The chapter will also include a discussion of three types of economic analyses—cost-effectiveness, budget impact analysis, and ROI—and how they are used in LHDs health decision-making processes using lung cancer as an example. The chapter will include a hypothetical case study taking the example of lung cancer in California and presenting the application of ROI to help guide LHDs decision-making processes.

CHAPTER 2: Return on Investment from Public Health Interventions: A Guide for Local Health Departments and Medi-Cal Purchasers

Introduction

Traditionally, LHDs are charged with helping meet the needs of vulnerable populations, primarily by providing a safety net (Brousselle, Benmarhnia & Benhadj, 2016). The changes brought on by the implementation of the ACA have changed the role of LHDs in many ways. However, LHDs still have to decide what services to provide to vulnerable communities. In some cases, that would include deciding which new services to provide. In this time of change, LHDs are faced with having to decide whether or not to keep existing services or adopt new services. The three cases presented below exhibit the typical decisions faced by LHDs.

Case 1: Sometimes, LHDs decide to provide a service by a funder. For instance, the California Endowment might provide LHDs with funding to build healthy communities. In which case, the LHD is told how to provide the service and reach specific goals.

Case 2: LHDs are given funding to provide a service but are left to decide how to achieve their goals best. For instance, the states require LHDs to provide tobacco control services. The funding needs specific objectives/activities to be completed, such as, at least one housing development must adopt a smoke-free policy or an incorporated city within a county must adopt a smoke-free ordinance. Although, the LHDs have the freedom to decide how to achieve these outcomes best.

Case 3: LHDs might need to decide to implement a specific intervention *and* determine their methods. For example, should LHDs want to invest in implementing a lung cancer-screening program, they would need to know methods to use and decide whether or not to perform the intervention.

The type of information needed for each of these decisions varies. For instance, in the first case, the organization is told what to do and ways to do it. They are given a budget; and, they decide whether they can accomplish what is required within that budget. This requires cost analysis. In this assumption, there is no need to consider the advantage of alternative methods or outcomes.

In the second case, the organization must consider and compare the costs of alternative approaches to provide a service. They must also review and analyze the impact that would result from the various methods. The results, however, would be shared across each methodology. For instance, in the case of tobacco control, the LHD might compare approaches based on their ability to reduce smoking and increase knowledge; all outcomes would be the same.

In the third case, the organization might decide the type of new program to make available or the types of services to discontinue. Both these decisions require comparing the costs and outcomes across potentially different kinds of programs.

Historically, LHDs received funding from the state in block grants. Consequently, many of their decisions were like the third case. Some programs were mandated (e.g., decisions made in the second case), but much of their funds were not necessarily tied to specific activities. Thus, the decision was left to the supervisors. Over time, these block grants have been eliminated or been reduced. Therefore, 23% of LHD revenue is through federal investments, and 21% is through the state (National Association of County & City Health Officials–NACCHO, 2017). Consequently, much of the funding is through grants (e.g., case 1 or 2).

Other funders of health services face similar problems. For instance, Medi-Cal purchasers in many regions of California must decide which services to fund for their enrolled population. Although Medi-Cal mandates that providers deliver the following 10 services (CDHS, 2018), other services are left to their discretion.

1. Outpatient (ambulatory) services.
2. Emergency services.
3. Hospitalization.
4. Maternity and newborn care.
5. Mental health and substance use disorder services.
6. Prescription drugs.
7. Programs such as physical and occupational therapy and devices.
8. Laboratory services.
9. Preventive and wellness services and chronic disease management.
10. Children's (pediatric) services, including oral and vision care.

For example, in Merced County, the Central California Alliance for Health–Alliance (2018) provides coverage for these 10 services but also covers acupuncture and a variety of activities aimed at incentivizing physicians in the region. Although these are consistent with the services listed above, the Alliance has some degree of discretion as to the types of services they purchase.

Unfortunately, little is known about how LHDs and Medi-Cal purchasers make these types of decisions. No published studies detail the decision process or the criteria they used to make these decisions. There is, however, literature concerning the process that organizations experienced when they reduced funding, or 'disinvestment.' Most of the research about disinvestments outside of the U.S. were concerned with health technology. Some examples of health technology included devices, medicines, and vaccines. The studies tended to focus on comparing the benefits of two systems where the outcomes were instead well defined. For example, one of the studies focused on routine B12 testing versus the use of diabetes test strips; another study focused on IVF and ICSI treatment (Paprica, 2015; Watt, 2012).

Most local health departments do not have a predetermined and optimal process to review the effectiveness and cost-effectiveness of programs, technologies, and procedures that are in active use or for those they want to invest in (Watt et al., 2012). Recent evidence suggests that the options local health departments have on priority setting and decision-making include cost effectiveness analysis, budget impact analysis, and return on investment. An economic evaluation can be useful to analyze any situation where local health departments want to know if the resources invested in a program or intervention are justified by the results of the intervention. There is no concrete rationale for which cost allocations are based upon; rather, local health departments use budgeting strategies. Prioritization seems to be based upon local factors such as population needs, organizational priorities, budgets, capacity or capability, and political factors (Harris et al., 2017). However, there is no standardized process through which programs are prioritized and thus, it is difficult to understand how and why departments and investing or disinvesting in projects.

There was complimentary literature about how surgeons and transplant centers make decisions. Traditionally, decisions are made based on a list of those needing surgeries and transplants. The criteria included age, household provider status, and income brackets. Since this type of measure was selective, many people who were in dire need of surgery or a transplant did not receive care and died. However, standards have changed. Currently, surgeons and transplant centers make decisions based on more stringent criteria, such as selecting patients with severe disease who are likely to benefit (Schneider, 2017).

Some international government organizations determine the types of services and technologies to adopt. For instance, NICE in the U.K. developed guidelines to make informed decisions based on the tradeoff between benefit and harm of an intervention and the quality of evidence (NICE, 2017). The approach these organizations take is to conduct cost-effectiveness or cost-utility evaluation that considers society-level costs and outcomes from the various competing technologies and services.

The purpose of this chapter was to provide organizations such as LHDs and Medi-Cal purchasers with guidelines to conduct an ROI for a newly proposed intervention or service. These organizations have some options available to them, ranging from budget impact analysis (BIA), cost analysis, ROI, or a complete cost-effectiveness study. These studies differ in the scope and types of health outcomes measured (such as life expectancy) that are considered when assessing the potential impact of a program or service (see Rabarison, Bish, Massoudi, & Giles, 2015). A budget impact analysis summarizes the net financial impact of a specific program over a short period (see Sullivan, Mauskopf, Augustovski, Caro, & Lee, 2014). An ROI analysis monetizes health outcomes in the calculation of benefits over time (see Mays, 2013).

The next section describes the differences between the various types of cost analyses. The studies differed both in their time horizon (the length of time the analysis followed costs and outcomes) and the kinds of results they measured. The following section provides an example of how to conduct an ROI for a specific service: the introduction of lung cancer screening. The study ended with recommendations for the types of study organizations might use.

Cost-Effectiveness, Budget Impact Analysis, and Return on Investment

Budget Impact Analysis (BIA). BIA analysis focuses on the financial values of adopting an intervention or program over a short period (Garatinni & Vooren, 2011; Sullivan et al., 2014;). Therefore, a BIA can be distinguished from an ROI in that it is concerned with the perspective of a single program or intervention. The impact is over a short time and involves primarily direct health costs and the net financial result (change in revenue minus variation in costs) (Drummond et al., 1997). Having said this, BIA can be seen as a complement to an ROI rather than a substitute (Trueman et al., 2001). For example, studies have shown that while BIA and ROI use similar types of data and methodologies, there are important differences in the way the data and methods are incorporated in the models because of their different intended uses (Chaikledkaew, n.d.). The following study of a new drug conducted both a BIA and an economic evaluation. The BIA study health outcomes were excluded while the QALYs were considered in the economic analysis. In this study, the BIA was used from a contractual point of view for negotiation purposes while the economic analysis was used to assess the health impact (Dervaux, LeFur, Dubois, & Josseran, 2017).

Cost-Effectiveness (CE). Cost effectiveness studies compare programs using a single outcome measure (i.e., change in life expectancy or reported satisfaction) (Jamison, 2006). A subtype cost study of a CE is the cost-utility, which reports variations in costs and QALYs (WHO, 2006). QALYs are a combination of the utility scores (such as EQ-5D and life expectancy). Utility scores are a metric that allows quantification of the impact of a disease on an individual's well-being and functioning. Through a set of questions, the perceptions of an individual's quality of life are assessed, and a score is assigned to responses on a scale of 0–1, where 1 indicates optimal health.
Another subtype cost study of a CE is the cost-benefit analysis, which represents both costs and outcomes (e.g., monetary value of life years lost) in monetary terms with the option of highest benefit preferred (WHO, 2017).

Although cost-effectiveness is commonly used by government agencies to assess the value of interventions and programs, it might be of limited value when dealing with smaller entities such as LHDs, health care funders such as Medi-Cal purchasers, and health care providers such as hospitals. Cost effectiveness analysis incorporates long-term costs and outcomes but typically does not identify the short-term costs required, the parties that must pay those costs, and those likely to financially benefit. Additionally, many parties care more about relatively short outcomes than those outcomes that might occur in the future.

Owing to these limitations, it has become the standard to conduct other forms of analysis, such ROI analysis. Unlike cost-effectiveness analysis, which is used for global priority setting, ROI is used to summarize the net financial impacts on specified organizations (rather than society as a whole). Moreover, it is used to recap the impacts of the intervention or treatment on that organization (rather than effects on all other organizations or funders), and the influences over a relatively short time horizon (e.g., one year rather than the long-term). Finally, it is used summarize the direct health care costs (rather than including indirect and intangible costs) and the net financial effect (changes in revenue minus variation in costs).

Return on Investment (ROI). Return on investment is a performance measure used to evaluate efficiency of an investment or compare the efficiency of a number of different investments. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment in which case the result is expressed as a percentage or ratio. ROI differs from other type of analysis in that; it can measures health outcomes such as QALY's. ROI is a term that encompasses techniques for comparing the costs and benefits generated by public health investments (Pokhrel et al., 2014). Traditionally ROIs have been a standard in the business sector, providing rates of return (RR) from any money invested in an economic activity that would decide whether to undertake that investment. Typically, ROI can be easily used to compare investment priorities in the context of projecting return. The investment with the highest RR is given priority over the ones with lowest RR (Local Government Association, 2013).

The strength of this model lies in its simplicity to allow decision-makers to stimulate various investments by testing different options, such as improving program efficacy, reaching out to a broader population, cutting implementation costs, or comparing different programs (NICE, 2012). Consequently, public health decision-makers can use ROI to make their cases explicit for either investment or disinvestment. The problem in using ROI for public health is that it is difficult to monetize outcomes. However, it can be done.

Hypothetical Examples of an ROI

To illustrate, consider the following three examples. Each example will demonstrate how the following types of information are relevant:

1. Costs
    a. Development costs
    b. Implementation costs
    c. Yearly operating costs
    d. Direct medical costs
    e. Indirect costs
2. Outcomes
    a. Measure of service delivery output; cases investigated, cases detected.
    b. Measure of production time; time to complete investigation, time to investigate urgent cases.
    c. Percent of target population reached by service; percent of cases reported.
    d. Measure of health-related outcomes: QALYs, LYL, number of patients who received service.
    e. Monetizing health outcomes: QALYs using a QALY per dollar value

Table 10

Differences in Economic Analyses

Costs & benefits	BIA	ROI	CE
Implementation	X	X	
Program	X	X	X
Hospital short-term		X	X
Hospital long-term		X	X
Other medical short-term		X	X
Other medical long-term		X	X
Patient short-term		X	X
Patient long-term			
Benefits			
Organization short-term		X	X
Organization long-term			X
Patient short-term		X	X

Example 1. This approach is resource-based costing. An LHD wants to identify an improved method to deliver smoking diagnostic screening pamphlets to physicians' offices. Previously, they had been sending the brochures by FedEx. However, they were wondering if they could save money if they had a staff person deliver them directly to the offices.

In this situation, there would be no difference in the outcome because the providers would continue to receive smoking diagnostic screening pamphlets. This example only considers the costs of brochures and the cost to deliver them; in which case, the only difference is in the cost per person because the cost of delivery increased. The costs incurred are included in Table 11.

Example 2. An LHD wants to deliver smoking diagnostic screening booklets to doctors' offices using a county employee. In this situation, there would be a difference in outcomes. The county employee would deliver the pamphlets personally to each person; and therefore, more people would be reached. Whereas, using FedEx, the brochures would only be delivered to the offices. In Table 12, note that the cost per person in the current situation remains the same as in the first example. However, in this example, the county employee distributed information directly to patients concerning lung cancer screening. Accordingly, 10 more people were diagnosed versus five. Thus, having the county employee distribute the pamphlets is more effective while costs remain the same.

Table 11

Costs Incurred in Example 1

	No. of pamphlets	Cost per pamphlet	Cost of delivery	Total cost	No. of people reached	Cost per person
Current delivery method	100,000	$1	$35000	$1,035	400	$259
New delivery method	100,000	$1	$50000	$1,500	400	$375

Table 12

Costs Incurred in Example 2

	No. of pamphlets	Cost per pamphlet	Cost of delivery	Total cost	No. of people reached	Cost per person	No. of people diagnosed
Current delivery method	100,000	$1	$35,000	$1,035	400	$259	5
New delivery method	100,000	$1	$50,000	$1,500	400	$375	10

Although it will cost more to deliver using the new method in Example 1, it will be less costly in the long run as there will be better health outcomes given the early diagnoses. Cost savings can be quantified by an increased life expectancy and these patients will have a better quality of life.

Health outcomes can be measured by an increased life expectancy, a gain in QALYs, and in a better quality of life. For example, by diagnosing these cases early, QALYs will be gained. QALYs are a measure of disease burden, including both the quality and the quantity of life lived. It is used in economic evaluation to assess the value of money toward medical interventions. One QALY equates to one year of good health (Prigent et al., 2014). Life expectancy measures the average length a person may expect to live (WHO, 2006). Quality of life (QOL) is a general means to measure the well-being of people and societies while outlining negative and positive features of life, such as life satisfaction from physical health, family, education, employment, wealth, religious beliefs, finance, and the environment. Table 13 details how to use this type of information.

Table 13 demonstrates that Example 2, the new delivery method, with 10 new diagnoses, had higher cost savings. Although the table displays the cost per QALY, the difficulty is that the county that spends the money is not necessarily the one that is saving money. For example, from a cost standpoint with 10 new diagnoses, there was no cost to the LHD; therefore, no money would be returned to them. However, other agencies will see cost savings. Cost savings include costs, such as hospital long-term and short-term expenses. Nevertheless, the LHD will see societal cost savings while the people being diagnosed will realize savings in QALYs. These examples are hypothetical. However, counties would be interested in doing an ROI because they want to know how much they can save.

A county's perspective is essential when completing ROIs. If the LHD is only concerned in the cost to them, they might see it as not worth the cost (example 1). If the LHD is concerned in all costs, then comparing the program and its cost savings will be necessary to them. Nevertheless, the LHD will not see cost savings; someone else will. If the LHD is interested in all costs and health outcomes, they would need to either place a dollar value on the outcomes or separate them. If they are kept separate, it means the LHD would report outcomes such as cost/QALY gains.

Table 13

Cost Savings by Life Expectancy Gains and Better Quality of Life

No. of patients diagnosed	Cost savings	Life expectancy gains	QOL utility measure	Total cost	Total QALY gained	Total cost savings
5	$100,000	5	0.25	$150,000	50	$148,965
10	$500,000	5	0.25	$300,000	100	$298,500

Examples of an ROI Using Real Data

Examining the differences in outcomes beyond the number of people reached and diagnosed requires undertaking an ROI. For example, an ROI can consider the cost of cancer and QALYs. If the cost of cancer is $30,000 per QALY, the total cost is $150,000 in the first scenario (5 *30,000) and 300,000 in the new scenario. The total QALY is 50 (5 *10) in the first scenario and 100 QALYs compared to the new scenario. The difference in total cost/QALYs is $150,000 and 50 QALYs, which is a $3,000 cost difference.

Example 3. The county chose to promote a lung cancer-screening program. Recent evidence suggested that screening for lung cancer in smokers over the age of 55 was cost-effective. This service was already paid for by Medicare (for recipients over the age of 65); therefore, they are curious as to what the ROI would be to invest in screening Medi-Cal recipients between the ages of 55 and 65. The following information would be needed to conduct the ROI.

1. Target Population: The first step would be to identify the number of people who would likely benefit, i.e., the number of smokers in the county between the ages of 55 and 80. This information might be available from surveys. For instance, in California, the California Health Interview Survey is the largest state health survey and a critical source of information on the state's various demographic and comprehensive health data, such as smoking status among various age groups.
2. Options for promoting screening: The second step would be to identify options to promote screening. Currently, no programs exist that promote lung cancer screening; however, other screening programs exist. For instance, the breast cancer and cervical early detection program has provided low income, uninsured, underserved women access to timely breast and cervical cancer screening and diagnostic services (CDC, 2013). The Colorectal Cancer Program provides screening among men and women over the age of 50.

A count, then, would have several options:

1. Opportunistic screening
2. Health promotion campaigns
3. Diagnostic program

Opportunistic screening. The tradeoff would be that while opportunistic screening is less costly, it is also likely to be less effective. A patient might ask a physician for a checkup or test or a physician might offer a test. However, unlike an organized screening or diagnostic program, the opportunistic screening might not be monitored.

Health promotion campaigns. A health promotion campaign is another option to achieve prevention outcomes as is done with cervical, breast screening, and immunizations. Although a health promotion campaign increases public awareness, the total cost of the campaign might not increase with the number of consumers. For instance, health promotion campaigns are one-time events. It is possible that no one would be willing to pay for programs because the social benefit is more significant than the personal benefit. Since health promotion campaigns are bound by time preference (people would rather buy an aspirin to eliminate a headache now than pay now to avoid lung disease in the future), cost savings are not necessarily produced in each person. Diagnostic programs, such as the Lung Nodule Clinic (LNC) located in Fresno, California (a program where individuals are screened for initial diagnoses and referred to the LNC for further testing/treatment based on positive results treatment), provide an organized care plan for people who have been diagnosed with cancer. These programs are costly; however, they are also more likely to be effective. This information would give the county an approximation of those who are eligible for lung cancer screening. The county would then need information about detection and treatment of lung cancer.

Diagnostic program. The LHD would require information about the number of lung cancer cases per county and by stage of cancer to have the appropriate number of cases to provide for the diagnostic program. Additionally, the LHD would need information on the number of true negatives—those who were screened but had negative results. This piece of information would provide the true cost because the additional incurred costs by individuals who had positive results would not be applied. Finally, the LHD would need the cost per stage of cancer. In return, these factors would provide the true cost of the current financial situation.

The following information would be needed to project the benefit of the diagnostic program considering a specific retention rate and rate of positive results. The LHD would need to know the number of people who would benefit from a lung cancer screening program.

Costs of screening program. The county would need information on costs of the screening program, such as program costs, screening costs, and cost to follow-up.

Program costs.

- Program development costs may include administrative costs, facility cost/rent, personnel, office operations, equipment, and construction.
- Implementation costs would be lower, if opportunistic and incurred each year of the program

Screening costs. The county would need to know the cost to screen ($271), which would apply to all who are screened. This cost could be estimated based on the data found on the Medicare website (www.medicare.gov).

Cost to follow-up. The county would need the rate of detection for positive results, false positive results, and true positive results per stage of cancer. This would give a sharp picture of the actual cost to screen based on the number of cases.

Cost of cancer. The cost of cancer figures per stage would be required.

Determining the ROI. Once the county has the necessary information, the LHD could determine the ROI. A comparative analysis between a screening program and no screening program would provide data about the benefit of implementing a screening program. For instance, the effectiveness of breast screening has a 25% reduction in mortality with regular screening in women 50 to 69 years of age. The effectiveness of cervical cancer screening is 90% preventable and a 16% reduction in mortality with regular Pap tests. The effectiveness of colorectal screening with regular fecal adult blood has a 20% reduction in incidence (Mai, 2006). Consequently, with the implementation of a screening program, there would be early detection and a decrease in mortality compared to no screening program at all.

The LHDs would need to ask themselves what matters most to them before conducting their ROI.

Option 1, program and implementation costs matter most to the LHD. There is no interest in cost savings of avoiding cancer because they do not pay the cost of cancer in the long term. To conduct an ROI, the LHD would need to provide a cost of the outcomes as well. With this option, it would be difficult to accomplish. An alternative approach would be to report costs and outcomes. In which case, the ROI would include the cost to operate and implement the screening program as well as outcomes, such as the cases of early detection and decreased mortality.

Option 2, LHDs care about all of the costs. In this situation, the LHD is concerned about the cost of screening to themselves and society. The LHD is also concerned with the outcomes, such as QALYs, life years saved, early detection, and the number of people who are screened. If this option were chosen, the ROI would look like the following.

Based on the comparisons of the current situation with no screening program and in the event of having a screening program, the LHD would see the decrease in costs to the county, early detection rates, and reduced cases of lung cancer. The outcome and benefit noted here are the number of cases that would be detected early; thus, preventing premature mortality and a better quality of life. Table 14 presents (a) the number of current smokers between the ages of 55–80 from three different regions, (b) the number of cases by stage of lung cancer, (c) true negatives, (d) the cost to screen, and (e) the cost of treatment per stage; which provides a total cost of lung cancer by stage for the specific region. As shown, costs increase as the number of cancer cases and cancer stages progress. Table 15 presents an illustration of lung cancer screening, including a retention rate of 5%, the rate of detection in positive results, the rate of cancer in true positives, and a new total. As shown, costs decreased due to screening and early detection. Table 16 presents the return on investment for the specific region based upon costs. The ROI is calculated using the following method, which takes into account (total new cost- baseline costs) / new screening costs-baseline screening costs). For instance, in region one there would be $34.57 return for every dollar spent.

ROI= (Gain from investment-Cost of investment) / cost of investment

Conclusion

The purpose of this chapter was to provide LHDs with a guide to conduct an ROI for a newly, proposed intervention. A second aim was to help LHDs understand the differences between the cost studies. The ROI estimates, the financial impact, value on outcomes of an intervention, the timing of outcomes and costs, and the factors that organizations will consider will determine the worth and monetary feasibility of a program. Although it is possible that LHDs might value a BIA or cost-effectiveness analysis, LHDs should consider the possibility that the organization might also value an analysis that identifies the financial impact as well as outcomes, the value that participants place on an intervention (including a monetary value), and the value the organization places on its return on investment from adopting the intervention.

The literature suggests two main approaches when conducting an ROI. One is described by Tim Brown, who uses aggregate data that determines the monetary value using the “subjective well-being valuation method” (Norris, 2016, para. 11), but the data could not be broken down to learn what precisely was working. The other approach is to analyze the intervention; and, then attempt to estimate the impact of each activity with the whole picture.

Another aim of this chapter was to provide information concerning how to monetize outcomes because the problem in undertaking an ROI is determining the cost value of outcomes, such as QALYs. In such a case, different factors can be considered as outcomes, such as the number of people to whom the LHD provides service. In this situation, the QALY's would need to be monetized based upon a dollar value using the US threshold per dollar value and then the QALY dollar value would be applied to the ROI calculation.

LHDs are likely to be more interested in BIA and ROI analyses that reveal the net impact on their organization rather than in cost-effectiveness or cost-utility analysis. Although this might seem to be an undeniable argument, the implications for an LHD to decide to provide a new service is likely substantial regarding how they decide to conduct their analysis and the type of information they want to collect.

Outcomes could be short-term or long-term depending on the economic analysis. They could be categorized by overall strategic goals and might include clinical performance (QALYs, DALYs, YLL), reduced overhead costs and improved operational performance (see Adler-Milstein et al., 2013), reduced inappropriate utilization, improved outcomes, increased productivity (see Botchkarev & Andru, 2011), and efficiency (see Mays, 2013). These can be categorized by the type of benefit, such as reduction in administrative costs, absenteeism or presenteeism, laboratory utilization (see Driessen et al., 2013), and QALYs saved (see Morphew et al., 2013). As a result, some of the benefits, improved outcomes, and reduced readmission costs of an LDCT lung cancer screening program can easily be attributed to avoiding unnecessary laboratory tests and early detection.

Costs would include development, implementation, yearly operating costs, direct medical costs, and indirect costs. Expenses can be identified by categories, such as productivity loss (see California Tobacco Control Program (2017), staffing, consulting costs, technology costs, maintenance, training (see Adler-Milstein et al., 2014), personnel, equipment (see Kaushal et al., 2006), IT/program infrastructure (see Botchkarev & Andru, 2011), staff workflow optimization, initial software configuration; routine operating costs, such as electricity and consumables; program costs, Medicare costs, lost workplace productivity, development costs, evaluation, and analysis costs. These categories then could be categorized in two ways—initial implementation and ongoing costs—to differentiate between one-time costs during initial investment and ongoing costs.

The type of information to include in an ROI depends on the organization. It is contingent on what matters to the LHDs, i.e., whether it is the cost to them only or the cost to society and outcomes. Ill-advisedly, LHDs tend to be short-sighted when using an ROI because they do not realize immediate savings from the investments that they make.

It is important to identify health outcomes that local health departments value to make use of return on investments in making decisions to invest or disinvest. For instance, in the example of lung cancer screenings, it is critical to understand the conditions under which local health departments will fund such a discretionary service. There is little empirical evidence on priority settings for investment in local health departments to clearly answer that question. Thus, there is an acknowledged need for pragmatic and systematic method, which will utilize objective data in standardization comparisons allowing decision makers to rely more on hard evidence.

Information on the return on investment of lung cancer by county, age, race and gender, and stage of lung cancer can help counties understand the scope of the problems facing their region and identify high priority areas to target interventions and programs. Consequently, state and local public health departments would be able to calculate their implicit return from investing in lung cancer screening, tobacco prevention and control efforts, and to identify, the conditions, geographic location and population they need to focus on and where priorities must be changed through disinvestment.

A more concrete follow-up study will be conducted to examine the context in which local health departments and medical purchasers make the decision to disinvest from previous priorities. In recent years, there has been an increased interest in disinvestment research activities at the county level. However, because almost no comprehensive literature review on local health department and medical purchasers disinvestment practices has been published until now, a research gap exists concerning methods for the implementation of disinvestment activities at the county level (Polisena et al., 2013). There is no concrete rationale for which cost allocations are based upon, rather local health departments use budgeting strategies. Prioritization seems to be based upon local factors such as population needs, organizational priorities, budgets, capacity or capability, and political factors (see Harris et al., 2017). However, there is no standardized process through which programs are prioritized and thus, it is difficult to understand how and why departments are investing or disinvesting in projects.

Currently, there are many barriers that prevent disinvestment methods from being developed in health care and local health department settings (Polisena et al., 2013). Overutilizing practices and programs that are not as effective while underutilizing practices and programs that are effective cause inefficiencies and unsustainable resource allocation. This is especially true in a local health department setting where alternative interventions can be cost-saving and offer substantial return on investment for the community (Elshaug et al., 2008; Masters et al., 2017).

The follow-up study will use return on investment to help us in determining what calls for a disinvestment, a useful tool for programs that require long-term application and extensive investment as well as a useful advocacy tool to help government officials understand programs in a political context (Brousselle et al., 2016). The follow-up study will explore the types of decisions they make, the purpose of such decisions, the types of information used to guide such decisions and the types of information reported in the process by using a mixed methods approach that combines a quantitative survey instrument with a qualitative portion to elicit more contextual information (see Appendix).

The next chapter will examine the ROI for introducing lung cancer screening to eligible members in California counties. Information from the first two aims (costs, QALYS, and the decision context) will be combined with information from previously published studies on lung cancer screenings and costs to provide estimates for the ROI to county public health departments for investing in lung cancer screening.

Table 14

Current Situation

Region name	No. of current smokers 55–80	From cancer registry				True negatives	Costs of screening for people without cancer	Costs of stage I	Costs of stage II and III	Cost of stage IV	Total
		Stage I	Stage II & III	Stage IV	Total	Screened but Negative 0.42	241 Cost of scan	$2,248	$33,344	$47,792	
Region 1	33000	681	515	440	1636	2820.689655	$1074062.207	$1,530,888	$17,172,160	$21,028,480	$ 40,805,590
Region 2	7000	183	130	78	391	1386.6774321	$94197.58107	$ 411,384	$ 4,334,720	$ 3,727,776	$ 8,568,078
Region 3	19000	612	415	318	1345	1181.204973	$608815.3984	$1,375,776	$13,837,760	$15,197,856	$ 31,020,207

Table 15

Situation with Lung Cancer Screening Intervention

Region name	No. of current smokers 55–80	Screening program	Stage I	Stage II & III	Stage IV	Total	Cost of screening	Rate of detection for positive result			Rate of cancer for true positive			Cost of cancer			Total cost of new cases with intervention
		0.5 % screened					$241	.24	.233 False positive	.767 True positive	.038 Stage I	.024 Stage II & III	0.052 Stage IV	$2,248 Stage I	$33,344 Stage II & III	$47,792 Stage IV	
Region 1	33000	16500	340	174	265	779	$187,739	3960	922.68	3037.32	115	72	157	$258,520	$2,400,768	$7,503,344	$10,162,972
Region 2	7000	3500	91	38	39	168	$40,488	840	195.72	644.28	24	51	33	$53,952	$1,700,544	$1,577,136	$3,331,723
Region 3	19000	9500	306	109	209	624	$150,384	2280	531.24	1748.76	66	22	90	$148,368	$733,568	$4,301,280	$5,183,522

Table 16

ROI Estimates by Region

	Region 1	Region 2	Region 3
Total new cost	$10,162,972	$3,331,723	$5,183,522
Baseline cost	$40,805,590	$8,568,078	$31,020,207
New screening cost	$187,739	$40,488	$150,384
Baseline screening cost	$1,074,062	$94,197	$608,815
ROI Estimate	34.57	97.49	$56

CHAPTER 3: Return on Investment from Implementing a Lung Cancer Screening Program

Introduction

Recent evidence suggests cancer is the second leading cause of death, with lung cancer being the single most significant source of cancer (ACS, 2014). The estimated cost of treating this condition is well above $12.1 billion and could potentially reach $18.8 billion by 2020 (de Groot et al., 2014). Currently, about 40,000 people in California have lung cancer. Accordingly, unless lung cancer cases are detected early, California will be impacted by an increased burden of lung cancer cases.

The U.S. Preventative Task Force recommends annual screening for lung cancer with LDCT in adults aged 55–80 years who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years (CMS, 2014). Screening has been found useful in identifying patients who have the disease in its early stages, thereby enabling improved outcomes with early treatment. In this era of intense focus on health care costs, LDCT has proven to be cost-effective. Moreover, adults ages 55–80 tend to have Medi-Cal coverage. Whether it would be cost-effective for Medi-Cal to screen this group remains unanswered.

In California, more than 70% of patients with lung cancer are diagnosed at stage III or IV(Neubaur et al., 2010). Patients with stage II have an estimated five-year survival rate of 20.9% versus only 1.9% for patients with stage IV lung cancer (NCI, 2014a). Outcomes are worse among Latino/Hispanics, immigrants, and people from low socioeconomic areas (Shugarman et al., 2009). Contributing factors for poor outcomes include, but are not limited to inadequate access to diagnostic services, delays in detection, lack of coordinated treatment, and inadequate follow-up care (Shavers & Brown, 2002; Shugarman et al., 2009; AACR, 2013). Although the incidence rate of lung cancer increases with age (from 23 per 100,000 for 45–49 years old to over 540 per 100,000 for 80–84 years old), the number of new diagnoses is relatively constant from age 55–60 (19,000 new cases) to age 80–84 (24,000 new cases; NPCR, 2014). Interventions to detect lung cancer, therefore, typically consider targeting people 55 years of age and older.

Theoretically, implementing lung cancer screening programs in each county is economically beneficial in reducing costs and saving lives. As mentioned earlier, cancer treatment is more expensive during its late-stage compared to early stages: Stage I cost of treatment is about $2,200 whereas stage IV treatment costs are near $40,000 annually. Nonetheless, vulnerable populations are often diagnosed with late-stage cancer for many reasons causing an economic strain on the health care system. For this reason, I conducted a burden of disease study to observe the burden of lung cancer.

Both public and private health insurers have introduced lung cancer screening programs. For older Americans, Medicare has already agreed to fund screening programs for its members. Consequently, older Americans who meet the criteria (e.g., age 55–80 years, a history of smoking at least 30 packs a year, and either an active smoker or quit within the past 15 years) are eligible for lung cancer screening (U.S. Preventive Services, 2013). Under the ACA, private insurers are required to provide lung cancer screening to eligible policyholders; however, it is less clear for those insured by Medicaid. The agencies that administer Medicaid programs in their states decide whether or not to cover lung cancer. In California, lung cancer screening is a reimbursable Medi-Cal benefit (Alliance, 2018).

If lung cancer screening is made available to eligible recipients, LHDs must decide whether or not to promote those services to the public. Such a program could reduce health disparities among vulnerable populations; however, LHDs would need to consider whether a lung cancer screening program is worth their investment.

The purpose of this study was to examine whether a lung cancer-screening would yield positive ROI for Medi-Cal purchasers and LHDs in California. ROI is a technique for comparing the costs and benefits generated by public health investments. ROI can be easily used to compare investment priorities in the context of projecting return (Local Government Association, 2013)

The advent of the new prevention measure by CMS provides an opportunity to address these challenges. There is a chance to expand prevention services primarily to at-risk and vulnerable populations. Reducing costs and rates of lung cancer will require LHDs to implement successful prevention activities. Information on the return on investment by county and stage of lung cancer could help counties understand the scope of the problems facing their region and identify high priority areas to target interventions and programs. The purpose of conducting an ROI study is to report the cost savings as well as increases in the number of early detection associated directly with a lung cancer screening program versus no screening program at all. This study calculated the ROI of investing in a lung cancer screening program.

Methods

The overall goal was to estimate the ROI from investing in a lung cancer screening program. This estimate involves comparing the costs and outcomes with a screening program to those with no screening program. The costs and outcomes with no screening program were based on the *Current Situation* described in Chapter 2. It was necessary to identify the number of people eligible for screening, the number who actually could be screened, and the number of new cases of lung cancer that could be found from the screening program to estimate the costs and outcomes. The study focused on people ages 55– 80, but with a particular focus on those between the ages of 55–64. The introduction of a screening program is expected to increase the number of lung cancer cases detected in the first year of the program but should not impact the average or expected cases in the long-term. I calculated the ROI for the initial screening program. The general approach was to (a) identify the number of smokers who would meet the criteria for screening, (b) determine the number of people screened under three screening rates (20%, 50%, and 80% of the population), (c) estimate the number of new cases that could be detected in the first year, (d) calculate the costs and outcomes of these new cases, and (e) estimate the cost and outcomes of screening during the first year (f) conduct a break even analysis to show the effectiveness level of the screening program. Table 16 describes the data sources used in the calculations.

Table 17

Data Sources

Type of data	Source	Methodology
Number of smokers.	AskCHIS online data query system	Variable: Tobacco smoking. Current Adult Smokers, multiple years up to 2016 at the county-level in California, age 55–80, 55–64, 65>.
Type of health coverage.	AskCHIS online data query system	Variable: type of current health insurance coverage for child, teen, & adult, multiple years up to 2016 Variable: Health insurance for age 55–64 at the county-level. Medicare only and privately purchased.
County-level population estimates.	Census Summary File 1, Table PCT12	Ages 55–80, 55–64 & 65>. Data used to develop the number of smokers with Medi-Cal versus no Medi-Cal & number of people with private health insurance versus Medi-Cal.
Cost of screening.	CMS (Dec et al, 2014)	The cost of screening ($241) was obtained to estimate cost of lung cancer screening.
Rates of cancer screening for true positive & true negative.	National Lung Screening Trial Research Team (CMS, 2014).	Derived from the Reduced Lung-Cancer Mortality with Low-Dose Computed Tomographic Screening study.

Estimates for Cost of Treatment

I derived the estimates of medical expenditure (cost) associated with lung cancer in the State of California by stage of lung cancer from previous research findings. The literature suggested detailed estimates are required to project costs if an intervention or screening program causes a shift in incidence or treatment patterns. However, cost estimates in the literature were incomplete for several reasons: categories of phases of care or treatment were collapsed or not reported, costs were provided for Medicare or other payers only, and samples were nongeneralizable (Villanti et al., 2013). The Cressman et al. study is the most recent and comprehensive data with per person costs of lung cancer by stage. Other studies from the literature reviewed were inconclusive.

Number of Cases in California

I obtained the number of cases of lung cancer within each county in California with three lung cancer stage categories (stage I-IV). I derived estimates of the number of lung cancer cases in the overall population in California from SEER-Medicare data (see SEER, 2013). Since SEER categorizes nine stages of diagnoses, stages were grouped to fit into the three-stage categorization. Also, due to small sample sizes, no estimates were available for small counties or small demographic subgroups within counties. Small counties, therefore, were combined and average rates were applied to each small county.

Estimates of Smoking Rates

Population-level estimates were retrieved from the census by county for ages 55–80, 55–64, and 65+. Smoking rates were retrieved from AskCHIS by county and for the same age strata. Smoking rates were applied to the population level estimates to estimate the number of smokers.

I extracted the percent of people with private insurance (PI) and Medi-Cal by county from AskCHIS and aggregated these numbers at the regional level. The percentage of those with PI and Medi-Cal were applied to the number of smokers by county to provide the number of smokers with PI and Medi-Cal coverage. I estimated rates by using the number of people with PI, Medi-Cal and no Medi-Cal divided by the number of smokers per region.

The methodology included the following steps:

1. Identified the number of people in each county ages 55–80, 55–64 and 65 and over using census data, the number of smokers within the three age categories, and the number of people who have either private insurance or Medicare only.
2. Used the market price ($241) to estimate the cost of screening for these populations.
3. Used the screening costs and the changes in the cost of treatment to estimate the additional cost and the cost savings associated with lung cancer screening.
4. Used the number of current smokers in these populations to estimate the numbers of smokers who could go through a lung cancer screening program.
5. Estimated the number of people who could be screened with a 20%, 50%, and 80% screening rate taking into account the cost of screening and rates of screening.
6. Estimated the total cost of new cases with the intervention and the return on investment
7. Used sensitivity analysis to compare the robustness of the results to variations in parameters.

Compiling the different screening rates to determine the number of diagnoses. I aggregated the number of cases for baseline by stage of lung cancer at the regional level based on the current number of lung cancer cases. A rate of .30 for true positives was applied to the current cases of lung cancer to derive the total number of true positives of the overall smoking population ages 55–64. I retrieved this rate from Dr. Paul Brown who received the data from Dr. Michael Peterson of UCSF School of Medicine. I estimated the rates for baseline by finding the difference using the number of current cases per region and the total number of cases. I estimated the rates for a 100% screening program by using the total number of current smokers ages 55–64 and estimating the differences using the number of cases per region and the total number of cases. Finally, I estimated the three screening rates (20% 50%, and 80% of the population) by finding the difference in the screening rates versus baseline. These screening rates were then applied to the varying screening rate of the population to estimate the number of diagnosis.

Screening rate differences vs. Baseline

	Stage I	Stage II and III	Stage IV	Total
100% vs. baseline	0.0087	-0.0058	-0.0029	0.0000
20% vs. baseline	0.0017	-0.0012	-0.0006	0.0000
50% vs. Baseline	0.0044	-0.0029	-0.0015	0.0000
80% vs. baseline	0.0070	-0.0047	-0.0023	0.0000

Screening rates per percent of people screened

Stage I	Stage II and III	Stage IV	Total
0.457	0.305	0.238	1.000
0.450	0.310	0.240	1.000
0.453	0.308	0.239	1.000
0.455	0.306	0.239	1.000

Compiling the Utility Loss estimates and monetizing the QALY losses. Utility loss was estimated using the utility scores and estimated QALYs from study 1, specifically using the QALYs of the 45–64 years of age population. The QALYs were applied to the number of diagnoses per stage of cancer to get the total QALY loss by stage and age of lung cancer. As stated previously, QALYs are a metric for health and longevity assessed on a zero-one scale (with zero representing a health state no better than death and one perfect health). QALYs are seen as a measure of effectiveness and in recent years converted to dollars using some type of a conversion factor and added to the monetized costs to determine overall net monetized benefits, for example $50,000 per QALY (Adler, 2005). I conducted a literature review to retrieve the QALY threshold value in the US. As a result, the US threshold $50,000–per–QALY was applied. (see Neumann et al., 2014). For the purpose of this study, the $50,000–per–QALY value was applied to the utility loss scores by stage of cancer to monetize QALY losses.

Utility Loss scores ages 45-64 by stage of cancer (Social Security, 2014)

Utility loss ages 45 to 64
9.0
18.6
21.402

Compiling screening costs. I estimated screening costs using the Medi-Cal market price ($241) for an LDCT scan and applying this cost to the number of people who could be screened at baseline and across screening rates (20%, 50%, 80%, and 100% of the population).

Compiling the ROI estimates This procedure resulted in estimates of ROI for investing in a screening program across varying rates (20%, 50%, 80%, and 100% of the population). The ROI was estimated with and without utility loss. The formula used to calculate ROI= Net benefits/Investment. To estimate ROI, I estimated the difference in total cost, utility loss, and screening costs at baseline and across screening rates. The change in screening costs was deemed as the investment. The differences in costs and utility costs were deemed as the net benefits. The same methodology was applied to estimate the ROI per county. The results included the number of people who could be diagnosed early to provide counties with information on the relative importance of lung cancer screening in their county.

Compiling level of effectiveness. I performed a two-way sensitivity analysis using screening rates (20%, 50%, 80%, and 100% of the population) and number of early diagnoses to estimate a break-even point for effectiveness. The total health care costs plus screening costs based upon the screening rates (20%, 50%, 80%, and 100% of the population) were compared to the differences in varying screening rates for stage 1 cancer to the point where there were almost no differences in costs. The break even analysis illustrates the rate of the screening program that would be most effective (have the greatest return) based upon a specific stage 1 screening rate. Typically break even analysis are used to set a price to understand the economic impact of various price-volume scenario (Harvard Business Review, 2014). In other words break even points are a way to calculate when the program will be profitable by equating its total revenues with total expenses. It is important to understand that to calculate break even point, the cost needs to be applied to the number of units. This method will give us the total dollar amount that will need to be achieved to have nearly a zero loss and zero profit, no differences.

Results

Table 17 compares the number of smokers, smoking rates, and population in California and the seven main regions: Bay Area, Central Coast, Los Angeles, Northern/Sierra, Other Southern California, Sacramento Area, and the San Joaquin Valley. Overall, there were 10.85 million people ages 55 and over in California with a majority of that population ages 55–64. 857,646 of that population were current smokers, which was higher than the 65+ age group. Needless to say, the smoking rate in California was highest (13%) among the 55–64 age group with more smokers in the Northern Sierra region (23%) than its regional counterparts. On the basis of previous studies suggesting that there were fewer smokers in California than a decade ago, four million adults and adolescents still smoke (see Max, Sung, Shi, & Stark, 2014). The current estimates suggested that among adults over the age of 55, there were more smokers in the 55–64 age group.

In the event smokers in the 55–64 age group were diagnosed with lung cancer; the out-of-pocket costs would be monumental as the cancer progressed. This particular age group, also called the *preMedicare* group, was at a disadvantage for health insurance and medical coverage as they faced rising out-of-pocket costs and declining access to health insurance. The number of insured Americans in this age group was 8.9 million in 2010. Uninsured Americans did not have coverage through employers or had no feasible state health plan available to them. Many of those who had access to state health plans could not afford the higher premiums charged based on their age and health status. In fact, adults 55–64 had difficulty securing health care coverage and most of their insurance applications were rejected (AARP, 2012). In 2014, the ACA helped this group access affordable coverage by eliminating preexisting health conditions. Therefore, applications could no longer be rejected. Furthermore, age-based premium variations were also limited. The expansion of Medicaid to provide coverage for poor individuals and families benefited low-income older adults who had previously not qualified for Medicaid and did not have access or could not afford private insurance (AARP, 2012).

Table 18 presents the number and rates of smokers who had private insurance, medical insurance versus those who did not among the 55–64 age group. The results showed that the majority of the population who smoked (58%) did not have Medi-Cal coverage. Sixteen percent of people who smoke, ages 55–64, had private insurance coverage, and about 25% had Medi-Cal coverage. As reported in Chapter 1, smoking leads to substantial health costs and lost productivity from illness and premature death, especially from lung cancer. Not having Medi-Cal coverage leaves such individuals without access to timely care.

Table 18

Estimates of the Population, Number of Smokers and Rates Among the Overall Population in California at the Regional Level

Region	Population			Smokers			Smoking rates		
	Age 55-80	Age 55-64	Age 65+	Age 55-80	Age 55-64	Age 65+	Age 55-80	Age 55-64	Age 65+
Bay Area	2,252,556	1,374,327	878,229	260,526	200,261	60,265	11.6%	14.6%	6.9%
Central Coast	691,044	420,375	270,669	51,041	35,918	15,122	7.4%	8.5%	5.6%
Los Angeles	2,741,060	1,675,361	1,065,699	253,555	172,562	80,993	9.3%	10.3%	7.6%
Northern / Sierra	538,408	313,988	224,420	97,873	73,196	24,677	18.2%	23.3%	11.0%
Other Southern California	2,948,314	1,789,126	1,159,188	295,086	198,011	97,076	10.0%	11.1%	8.4%
Sacramento Area	660,145	401,737	258,408	96,521	72,049	24,472	14.6%	17.9%	9.5%
San Joaquin Valley	1,014,032	624,131	389,901	148,443	105,648	42,795	14.6%	16.9%	11.0%
California State Total	10,845,559	6,599,045	4,246,514	1,203,046	857,646	345,400	11.1%	13.0%	8.1%

Table 19

Number of Smokers Ages 55–64 with Private Insurance, Medi-Cal Versus No Medi-Cal

Region	Rate of smokers with PI	Rate of smokers with Medi-Cal	Rate of smokers with no Medi-Cal	Number of smokers Age 55-64	Number of smokers with PI	Number of smokers with Medi-Cal	Number of smokers with no Medi-Cal
Bay Area	27.50%	35.40%	37.20%	200,261	54,938	70,849	74,474
Central Coast	2.70%	32.60%	64.70%	35,918	954	11,722	23,242
Los Angeles	1.70%	23.10%	75.20%	172,562	2,934	39,862	129,767
Northern / Sierra	17.07%	38.60%	44.33%	73,196	12,498	28,253	32,445
Other Southern California	14.79%	17.73%	67.48%	198,011	29,287	35,109	133,615
Sacramento Area	25.92%	10.15%	63.93%	72,049	18,678	7,310	46,062
San Joaquin Valley	13.51%	25.77%	60.72%	105,648	14,276	27,221	64,151
Total	16.00%	25.69%	58.74%	857,646	133,564	220,326	503,756

Table 19 presents the current number of cases and costs of lung cancer in California regions. Overall, Southern California counties had the most cases of cancer with over 5,000 cases of stage I lung cancer; 3,474 cases of stages II and III lung cancer; and 2,634 cases of stage IV lung cancer. Consequently, this region incurred the highest cost of lung cancer. The Central Coast had the least number of lung cancer cases with 2,453, and the lowest cost at $55.3 million. Previous estimates of the cost of lung cancer have been conducted for the state, including some studies for the U.S., which disaggregate findings by state. Costs and cases of cancer data were aggregated to show regional estimates.

Tables 20–29 display the costs and cases of lung cancer with no screening program with the associated utility cost and with a screening program for the screening rates (20%, 50%, 80%, and 100% of the population) within the seven regions in California. To summarize (Tables 30–31), the total number of cases (41,039) remain the same as baseline throughout the screening programs; however, the number of people receiving an early diagnoses shifts from more diagnoses being detected during stage I than stages II/III and stage IV. At baseline, the number of lung cancer cases was 18,396. Based on the screening rates (20%, 50%, 80%, and 100% of the population), the shift to more diagnoses in stage I was 18,468; 18,575; 18,683; and 18,755. As the screening rate increases, there were more diagnoses of cancer for stage I. Screening costs increase as more people are screened based on the varying screening rates (Baseline: $32,967,997–100% screening: $206,692,638). Consequently, the total cost of treatment increases as more people are being detected early (Baseline: $939,209,776–100% screening: $926,322,130). Utility loss decreased as more people were detected early (Baseline: 30,721,358,700–100% screening: 30,532,226,700). Consequently, the total cost with utility loss also decreased as more people were diagnosed early and lost fewer life years (Baseline: $31,660,568,476–100% screening: $31,458,548,830).

As indicated earlier, screening is the investment. Overall, there was an investment of $67,712,925 dollars with a screening program of 20% of the population, an investment of $119,830317 with a screening program of 50%, an investment of $171,947,748 with a screening program of 80% of the population, and $206,692,638 with a screening program of 100% of the population.

Table 32 provides the ROI estimates including utility loss and without utility loss. An ROI that considers utility loss with a screening program where 20% of the population is screened resulted in a $1.12 return for every dollar spent. The ROI for a screening program where 50% of the population is screened would be $1.15. The ROI for a screening program where 80% and 100% of the population is screened would be $1.16. The return increases as more people are screened. The ROI estimates not including utility loss for a screening program where 20%, 50%, 80%, or 100% of the population is screened would provide about a $.07 return for every dollar spent. In this case, it would be worth monetizing health outcomes as the return increases, otherwise, there would not be enough cost savings. It is safe to say that the more significant the investment, the higher the return. However, at a screening program where 80% and 100% of the population is screened, the ROI remained the same ($1.16), but the investment was 1.2% greater for a screening program where 100% of the population was screened.

Table 33 provides the level of effectiveness for each of the screening rates using a two-way sensitivity analysis. These results show how effective the screening program must be. These rates provide the break-even point where the screening program would be most effective for the screening rates (20%, 50%, 80%, and 100% of the population). A screening program that screens 20% of the population would be most effective with a stage I screening rate of .4835. For instance, in the event the screening rate is .450 (table 22) there are 18,468 diagnoses for stage 1 lung cancer, if the screening rate increased for stage 1 to .4835 there would be 19,842 diagnoses (table 33) at which point there will be the greatest return. A screening program that screens 100% of the population would be most effective with a stage I screening rate of .5719. In this case, in the event the screening rate is .457 (table 28) for stage 1, there would be 18,755 diagnoses where as with the .5719 level of effectiveness there would be 23,470 diagnoses, which yields the greatest return. This two-way analysis demonstrates the level of effectiveness needed to save money while catching as many diagnoses as possible given the rate. These results provided the robustness of the overall results, depending upon the rate of screening: There will be more early diagnoses and savings.

Table 20

Current Number of Cases and Costs of Lung Cancer in California Regions

Region	Stage I	Stage II and III	Stage IV	Cost stage 1	Cost stage II and III	Cost stage IV
Bay Area	3,939	2,739	2,232	$8,854,872	$91,329,216	$106,671,744
Central Coast	1,102	813	538	$2,477,296	$27,108,672	$25,712,096
Los Angeles	4,222	2,920	2,426	$9,491,056	$97,364,480	$115,943,392
Northern / Sierra	1,080	786	511	$2,427,840	$26,208,384	$24,421,712
Other Southern California	5,267	3,474	2,634	$11,840,216	$115,837,056	$125,884,128
Sacramento Area	1,259	850	649	$2,830,232	$28,342,400	$31,017,008
San Joaquin Valley	1,527	1,174	897	$3,432,696	$39,145,856	$42,869,424
California State Total	18,396	12,756	9,887	$41,354,208	$425,336,064	$472,519,504

Table 21

Current Costs by Region

Region Name	No. of current smokers 55-64	From cancer registry				True Positive	Cost of screening for cancer	Cost of treatment stage I	Cost of stage II and III	Cost of stage IV	Total
		Stage I	II and III	Stage IV	Total	0.3	241	$2,248	$33,344	$47,792	
		0.448	0.311	0.241			Cost of scan	True positive stage I	True positive stage II and III	True positive stage IV	
Bay Area	200261	3939	2739	2232	8910	29700	$7,157,700	$8,854,872	$91,329,216	$106,671,744	$206,855,832
Central Coast	35918	1102	813	538	2453	8177	$1,970,577	$2,477,296	$27,108,672	$25,712,096	$55,298,064
Los Angeles	172562	4222	2920	2426	9568	31893	$7,686,293	$9,491,056	$97,364,480	$115,943,392	$222,798,928
Northern / Sierra	73196	1080	786	511	2377	7923	$1,909,523	$2,427,840	$26,208,384	$24,421,712	$53,057,936
Other Southern California	198011	5267	3474	2634	11375	37917	$9,137,917	$11,840,216	$115,837,056	$125,884,128	$253,561,400
Sacramento Area	72049	1259	850	649	2758	9193	$2,215,593	$2,830,232	$28,342,400	$31,017,008	$62,189,640
San Joaquin Valley	105648	1527	1174	897	3598	11993	$2,890,393	$3,432,696	$39,145,856	$42,869,424	$85,447,976
California State Total	857646	18396	12756	9887	41039	136797	$32,967,997	$41,354,208	$425,336,064	$472,519,504	$939,209,776

Table 22

Current Utility Loss by Stage of Cancer

Region Name	Utility loss				Utility cost			
	Stage I	Stage II and III	Stage IV	Total	Stage I	Stage II and III	Stage IV	Total
Bay Area	35451	50945	47769	134166	$1,772,550,000	$2,547,270,000	$2,388,463,200	$6,708,283,200
Central Coast	9918	15122	11514	36554	$495,900,000	$756,090,000	$575,713,800	$1,827,703,800
Los Angeles	37998	54312	51921	144231	$1,899,900,000	$2,715,600,000	$2,596,062,600	$7,211,562,600
Northern / Sierra	9720	14620	10936	35276	$486,000,000	$730,980,000	$546,821,100	$1,763,801,100
Other Southern California	47403	64616	56373	168392	$2,370,150,000	$3,230,820,000	$2,818,643,400	$8,419,613,400
Sacramento Area	11331	15810	13890	41031	$566,550,000	$790,500,000	$694,494,900	$2,051,544,900
San Joaquin Valley	13743	21836	19198	54777	$687,150,000	$1,091,820,000	$959,879,700	$2,738,849,700
California State Total	165564	237262	211602	614427	$8,278,200,000	$11,863,080,000	$10,580,078,700	$30,721,358,700

Table 23

Costs and Results by Region for 20% Screening for Smokers 55–64

Region Name	Number of current Smokers 55-64	Current smokers 55–64 who would be screened at 20%				20% screened	Cost of screening for cancer	Cost of treatment stage I	Cost of stage II and III	Cost of stage IV	Total
		0.450	0.310	0.240	Total	0.2	241	$2,248	$33,344	$47,792	
							Cost of scan	True positive stage I	True positive stage II and III	True positive stage IV	
Bay Area	200261	4010	2759	2141	8910	63812	$15,378,734	$9,013,461	$91,998,756	$102,340,529	$203,352,745
Central Coast	35918	1104	760	590	2453	13725	$3,307,725	$2,481,484	$25,328,053	$28,175,232	$55,984,768
Los Angeles	172562	4306	2963	2300	9568	60027	$14,466,532	$9,679,101	$98,792,828	$109,898,337	$218,370,266
Northern / Sierra	73196	1070	736	571	2377	20978	$5,055,676	$2,404,601	$24,543,327	$27,302,294	$54,250,222
Other Southern California	198011	5119	3522	2734	11375	69935	$16,854,440	$11,507,084	$117,450,713	$130,653,593	$259,611,389
Sacramento Area	72049	1241	854	663	2758	21765	$5,245,252	$2,790,025	$28,477,280	$31,678,471	$62,945,777
San Joaquin Valley	105648	1619	1114	865	3598	30724	$7,404,565	$3,639,779	$37,150,564	$41,326,736	$82,117,079
California State Total	857646	18468	12708	9863	41039	280966	$67,712,925	$41,515,535	$423,741,521	$471,375,191	$936,632,247

Table 24

Utility Loss by Stage of Cancer at 20% Screening Rate

	Utility loss				Utility cost			
	Stage I	Stage II and III	Stage IV	Total	Stage I	Stage II and III	Stage IV	Total
Bay Area	36,090	51,317	45,821	133,229	$1,804,500,000	$2,565,870,000	$229,1084,100	$6,661,454,100
Central Coast	9,936	14,136	12,627	36,699	$496,800,000	$706,800,000	$631,359,000	$1,834,959,000
Los Angeles	38,754	55,111	49,224	143,090	$1,937,700,000	$2,755,590,000	$2,461,230,000	$7,154,520,000
Northern / Sierra	9,630	13,689	12,220	35,540	$481,500,000	$684,480,000	$611,027,100	$1,777,007,100
Other Southern California	46,071	65,509	58,513	170,093	$2,303,550,000	$3,275,460,000	$2,925,653,400	$8,504,663,400
Sacramento Area	11,169	15,884	14,189	41,242	$558,450,000	$794,220,000	$709,476,300	$2,062,146,300
San Joaquin Valley	14,571	20,720	18,512	53,804	$728,550,000	$1,036,020,000	$925,636,500	$2,690,206,500
California State Total	166,221	236,368	211,109	613,699	$8,311,050,000	$11,818,440,000	$10,555,466,400	$30,684,956,400

Table 25

Costs and Results by Region for 50% Screening for Smokers 55–64

Region Name	Number of current Smokers 55-64	Current smokers 55–64 who would be screened at 50%				50% screened	Cost of screening for cancer	Cost of treatment stage I	Cost of stage II and III	Cost of stage IV	Total
		0.453	0.308	0.239	Total	0.5	241	$2,248	$33,344	$47,792	
							Cost of scan	True positive stage I	True Positive Stage II and III	True Positive stage IV	
Bay Area	200261	4033	2744	2134	8910	114980	$27,710,286	$9,065,999	$91,479,468	$101,967,865	$202,513,332
Central Coast	35918	1110	755	587	2453	22048	$5,313,448	$2,495,948	$25,185,088	$28,072,634	$55,753,670
Los Angeles	172562	4331	2946	2291	9568	102228	$24,636,890	$9,735,520	$98,235,190	$109,498,152	$217,468,862
Northern / Sierra	73196	1076	732	569	2377	40560	$9,774,905	$2,418,617	$24,404,792	$27,202,875	$54,026,284
Other Southern California	198011	5149	3503	2724	11375	117964	$28,429,224	$11,574,157	$116,787,760	$130,177,830	$258,539,748
Sacramento Area	72049	1248	849	660	2758	40621	$9,789,740	$2,806,288	$28,316,540	$31,563,117	$62,685,945
San Joaquin Valley	105648	1629	1108	862	3598	58821	$14,175,823	$3,660,995	$36,940,867	$41,176,249	$81,778,111
California State Total	857646	18575	12636	9827	41039	497221	$119,830,317	$41,757,525	$421,349,705	$469,658,723	$932,765,953

Table 26

Utility Loss by Stage of Cancer at 50% Screening Rate

	Utility loss				Utility cost			
	Stage I	Stage II and III	Stage IV	Total	Stage 1	Stage II and III	Stage IV	Total
Bay Area	36,297	51,038	45,671	133,007	$1,814,850,000	$2,551,920,000	$2,283,593,400	$6,650,363,400
Central Coast	9,990	14,043	12,562	36,595	$499,500,000	$702,150,000	$628,148,700	$1,829,798,700
Los Angeles	38,979	54,795	49,031	142,806	$1,948,950,000	$2,739,780,000	$2,451,599,100	$7,140,329,100
Northern / Sierra	9,684	13,615	12,177	35,476	$484,200,000	$680,760,000	$608,886,900	$1,773,846,900
Other Southern California	46,341	65,155	58,299	169,795	$2,317,050,000	$3,257,790,000	$2,914,952,400	$8,489,792,400
Sacramento Area	11,232	15,791	14,125	41,148	$561,600,000	$789,570,000	$706,266,000	$2,057,436,000
San Joaquin Valley	14,661	20,608	18,448	53,718	$733,050,000	$1,030,440,000	$922,426,200	$2,685,916,200
California State Total	167,184	235,048	210,317	612,549	$8,359,200,000	$11,752,410,000	$10,515,872,700	$30,627,482,700

Table 27

Costs and Results by Region for 80% Screening for Smokers 55–64

Region Name	Number of current Smokers 55-64	Current smokers 55-64 who would be screened at 80%				80% screened	Cost of screening for cancer	Cost of treatment stage 1	Cost of stage II and III	Cost of stage IV	Total
		0.455	0.306	0.239	Total	0.8	241	$2,248	$33,344	$47,792	
							Cost of scan	True positive- stage 1	True Positive Stage II and III	True Positive stage IV	
Bay Area	200261	4056	2728	2126	8910	166149	$40,041,861	$9,118,538	$90,960,179	$101,595,202	$201,673,919
Central Coast	35918	1117	751	585	2453	30370	$7,319,106	$2,510,412	$25,042,123	$27,970,037	$55,522,573
Los Angeles	172562	4356	2929	2283	9568	144428	$34,807,212	$9,791,938	$97,677,553	$109,097,967	$216,567,459
Northern / Sierra	73196	1082	728	567	2377	60141	$14,494,093	$2,432,634	$24,266,257	$27,103,456	$53,802,346
Other Southern California	198011	5178	3483	2714	11375	165992	$40,004,104	$11,641,231	$116,124,808	$129,702,067	$257,468,107
Sacramento Area	72049	1256	844	658	2758	59478	$14,334,166	$2,822,551	$28,155,800	$31,447,763	$62,426,113
San Joaquin Valley	105648	1638	1102	858	3598	86917	$20,947,013	$3,682,211	$36,731,170	$41,025,762	$81,439,143
California State Total	857646	18683	12565	9791	41039	713476	$171,947,748	$41,999,515	$418,957,890	$467,942,254	$928,899,659

Table 28

Utility Loss by Stage of Cancer at 80% Screening Rate

Region Name	Utility loss				Utility cost			
	Stage I	Stage II and III	Stage IV	Total	Stage I	Stage II and III	Stage IV	Total
Bay Area	36,504	50,741	45,501	132,745	$1,825,200,000	$2,537,040,000	$2,275,032,600	$6,637,272,600
Central Coast	10,053	13,969	12,520	36,542	$502,650,000	$698,430,000	$626,008,500	$1,827,088,500
Los Angeles	39,204	54,479	48,861	142,544	$1,960,200,000	$2,723,970,000	$2,443,038,300	$7,127,208,300
Northern / Sierra	9,738	13,541	12,135	35,414	$486,900,000	$677,040,000	$606,746,700	$1,770,686,700
Other Southern California	46,602	64,784	58,085	169,471	$2,330,100,000	$3,239,190,000	$2,904,251,400	$8,473,541,400
Sacramento Area	11,304	15,698	14,083	41,085	$565,200,000.	$784,920,000	$704,125,800.	$2,054,245,800
San Joaquin Valley	14,742	20,497	18,363	53,602	$737,100,000	$1,024,860,000	$918,145,800	$2,680,105,800
California State Total	168,147	233,709	209,547	611,403	$8,407,350,000	$11,685,450,000	$10,477,349,100	$30,570,149,100

Table 29

Costs and Results by Region for 100% Screening for Smokers 55–64

Region Name	Number of current Smokers 55-64	Current smokers 55-64 who would be screened at 100%				100% screened	Cost of screening for cancer	Cost of treatment stage 1	Cost of stage II and III	Cost of stage IV	Total
		Stage I	Stage II and III	Stage IV	Total	1	241	$2,248	$33,344	$47,792	
		0.457	0.305	0.238	Total		Cost of scan	True positive stage 1	True positive stage II and III	True positive stage IV	
Bay Area	200261	4072	2718	2121	8910	200261	$48,262,871	$9,153,564	$90,613,987	$101,346,759	$201,114,310
Central Coast	35918	1121	748	584	2453	35918	$8,656,320	$2,520,055	$24,946,814	$27,901,639	$55,368,508
Los Angeles	172562	4373	2918	2277	9568	172562	$41,587,486	$9,829,551	$97,305,795	$108,831,178	$215,966,523
Northern / Sierra	73196	1086	725	566	2377	73196	$17,640,288	$2,441,978	$24,173,900	$27,037,177	$53,653,055
Other Southern California	198011	5198	3469	2707	11375	198011	$47,720,532	$11,685,947	$115,682,840	$129,384,892	$256,753,679
Sacramento Area	72049	1260	841	656	2758	72049	$17,363,887	$2,833,393	$28,048,639	$31,370,860	$62,252,892
San Joaquin Valley	105648	1644	1097	856	3598	105648	$25,461,254	$3,696,355	$36,591,372	$40,925,437	$81,213,164
California State Total	857646	18755	12517	9767	41039	857646	$206,692,638	$42,160,842	$417,363,347	$466,797,941	$926,322,130

Table 30

Utility Loss by Stage of Cancer at 100% *Screening Rate*

Region Name	Utility loss				Utility cost			
	Stage I	Stage II and III	Stage IV	Total	Stage I	Stage II and III	Stage IV	Total
Bay Area	36,648	50,555	45,394	132,596	$1,832,400,000.00	$2,527,740,000	$2,269,682,100	$6,629,822,100
Central Coast	10,089	13,913	12,499	36,501	$504,450,000.00	$695,640,000	$624,938,400	$1,825,028,400
Los Angeles	39,357	54,275	48,732	142,364	$1,967,850,000.00	$2,713,740,000	$2,436,617,700	$7,118,207,700
Northern / Sierra	9,774	13,485	12,114	35,373	$488,700,000.00	$674,250,000	$605,676,600	$1,768,626,600
Other Southern California	46,782	64,523	57,935	169,241	$2,339,100,000.00	$3,226,170,000	$2,896,760,700	$8,462,030,700
Sacramento Area	11,340	15,643	14,040	41,022	$567,000,000.00	$782,130,000	$701,985,600	$2,051,115,600
San Joaquin Valley	14,796	20,404	18,320	53,520	$739,800,000.00	$1,020,210,000	$916,005,600	$2,676,015,600
California State Total	168,795	232,816	209,033	610,645	$8,439,750,000.00	$11,640,810,000	$10,451,666,700	$30,532,226,700

Table 31

Summary of Cases and Cost Estimates

	Cases				Costs				
	Stage I	Stage II and III	Stage IV	Total	Screening	Stage I	Stage II and III	Stage IV	Total
Baseline	18396	12756	9887	41039	$32,967,997	$41,354,208	$425,336,064	$472,519,504	$939,209,776
20%	18468	12708	9863	41039	$67,712,925	$41,515,535	$423,741,521	$471,375,191	$936,632,247
50%	18575	12636	9827	41039	$119,830,317	$41,757,525	$421,349,705	$469,658,723	$932,765,953
80%	18683	12565	9791	41039	$171,947,748	$41,999,515	$418,957,890	$467,942,254	$928,899,659
100%	18755	12517	9767	41039	$206,692,638	$42,160,842	$417,363,347	$466,797,941	$926,322,130

Table 32

Summary of Utility Loss and Costs

Utility loss				Total cost with utility loss			
Stage I	Stage II and III	Stage IV	Total	Stage I	Stage II and III	Stage IV	Total
8,278,200,000	11,863,080,000	10,580,078,700	30,721,358,700	$8,319,554,208	$12,288,416,064	$11,052,598,204	$31,660,568,476
8,311,050,000	11,818,440,000	10,555,466,400	30,684,956,400	$8,352,565,535	$12,242,181,521	$11,026,841,591	$31,621,588,647
8,359,200,000	11,752,410,000	10,515,872,700	30,627,482,700	$8,400,957,525	$12,173,759,705	$10,985,531,423	$31,560,248,653
8,407,350,000	11,685,450,000	10,477,349,100	30,570,149,100	$8,449,349,515	$12,104,407,890	$10,945,291,354	$31,499,048,759
8,439,750,000	11,640,810,000	10,451,666,700	30,532,226,700	$8,481,910,842	$12,058,173,347	$10,918,464,641	$31,458,548,830

Table 33

ROI Estimates

ROI with utility loss		ROI without utility loss	
20%	$1.12	20%	$0.074184328
50%	$1.15	50%	$0.074184328
80%	$1.16	80%	$0.074184307
100%	$1.16	100%	$0.074184328

Table 34

Break Even Analysis

Screening rate	Level of effectiveness
20%	0.4835
50%	0.5167
80%	0.5498
100%	0.5719

Conclusion

The purpose of this study was to determine whether it would be worth the cost for LHD and Medi-Cal purchasers to invest in screening programs of the smoking population ages 55–64 in California. This current study demonstrates that lung cancer screening represents a worthy investment in California regions because there would be a noticeable difference in the increase of early detection and a promising return on investment. The break-even analysis illustrates the level of effectiveness counties would need to have to have in order to save money, it is important for counties considering whether or not to invest in a lung cancer screening program.

However, LHDs are likely not the ones who would see any savings from the screening program, Medi-Cal purchasers would. Medi-Cal purchasers are the ones who provide health coverage for lung cancer screenings, and it is a reimbursable benefit. In this case, they are the ones who would see the return on the investment because they are providing coverage, receiving the bills and making payouts.

Previous studies have estimated the ROI of cancer and other illnesses at the national level with some estimates available for individual states and counties (Mays, 2013). A more recent systematic review study on the Cost- effectiveness analysis of lung cancer screening strategies using low dose computed tomography (Raymakers et al, 2016) found varied outcomes related to reported outcomes using either additional survival (life years gained) or QALY's for repeat screening, as a key result, the cost effectiveness findings depended largely on identifying an appropriate group of high risk subjects as the analysis for the study was sensitive to prevalence of lung cancer, cost of LDCT for screening, proportion of lung cancer detected, lead time bias and characteristics of smoking cessation program. My study is the first attempt to estimate the ROI with and with out utility scorse at the county level in CA. Although a number of attentive cost effectiveness analyses of the costs and benefits of ROI studies on various topics have been published, these studies did not report outcomes at the county level in CA (see Driessen et al., 2013; Henke et al., 2011; Richard, West & Ku, 2012; Zank & Friedsam, 2005).

Given the rates of lung cancer across regions in California and the recommendation by the U.S. Preventative Task Force to conduct screenings, analyzing ROI is essential to report the cost savings. Analyzing these data could increase the number of early detection directly associated with a lung cancer screening program versus no screening program. Furthermore, this information would be helpful to policymakers who are considering the value of lung cancer screening of the Medi-Cal population. This knowledge might help stakeholders make better decisions about which programs hold merit for health plans and Medi-Cal.

The overall adult cigarette-smoking rate in California in 2014 was 11.6%, which was the second-lowest smoking prevalence rate in the nation. However, California had the highest number of smokers because it was the most populous state (see CDPH, 2016). In fact, the number of smokers in California exceeds the population of more than 20 states.

Although the downward trend in California's adult tobacco use has stalled in recent years, the loss of momentum means that the rate could increase in the future. Such an increase would have severe implications for reversing the substantial progress California has made to reduce tobacco-related diseases and its associated health care cost savings that accrued as a result of the decline in smoking (CDPH, 2016). Accordingly, lung cancer screening can offer cost savings and early detection.

Limitations

Since this was the first attempt to estimate ROI by implementing a lung cancer-screening program at the regional level, there were some methodological concerns. LDCT screening programs have not been implemented outside of clinical trials. There are no set standards; therefore, the implementation may vary in different settings. Consequently, retrieving data to conduct an ROI could be challenging. There is limited academic research regarding measuring ROI and even less on lung cancer screening programs, which limited direct comparisons.

Implications

This study represents an initial attempt to estimate the ROI of implementing a lung cancer screening program. Additional information is needed to help counties and policymakers identify the ROI specific to the region of interest from prevention activities, the gains that would result, and the additional costs that would incur.

Medi-Cal does not provide health care services but works with health care providers to reimburse them for the provision of services. Medi-Cal contracts with providers so that members have a primary care medical home, which allows providers to promote the right care at the right time in the right place. Thus, the role that Medi-Cal or LHDs play might promote lung cancer screening programs by touting ROI analysis. Medi-Cal and LHDs are very distinct in the type of services they provide; both would play different roles in promoting lung cancer screening. Medi-Cal purchasers would be more invested because they provide coverage for these services, whereas LHDs are more detached from lung cancer screening because they provide already provide many services and competing health priorities. Also, because LHDs are board-driven, unless the board finds spending money on promoting lung cancer screening worth it, it is not likely to take place, primarily because they are not receiving any monetary return.

Activities such as health education, screening, provider education, laboratory testing, treatment, follow-ups, and case management, could promote social marketing and outreach through collaborative partnerships. Medical communities might support screening activities if it becomes a clinical guideline for the at-risk population. Overall, there is a need for coordinated effort, standardization, and a balance between clinical efficacy and economic worth.

Unless the mortality and morbidity from lung cancer exceed other health issues, it is unlikely there will be any local fiscal support to accomplish a prevention campaign for lung cancer screening. Most of the tobacco funding is targeted at LHDs doing primary prevention and environmental change, not secondary or tertiary changes or treatment. For small counties, such as Madera, and medium counties, such as Tulare, lung cancer screening may not be a priority unless the state allocates funding for the effort. However, larger counties, such as Fresno, Los Angeles, and Alameda, might increase their roles due to the higher prevalence of lung cancer.

CHAPTER 4

Discussion

The purpose of these studies was to examine the costs and outcomes among Californians ages 55–80 years old with a specific focus concerning what California could expect by implementing lung cancer screening for ages 55 to 64-year-old Medi-Cal recipients in the state. Since the focus was on local decision-making, the ultimate goal was to help counties in California understand the benefits and costs that they could expect by implementing lung cancer screening. Thus, this study examined the different components of that decision.

Chapter 1 presented the results of the analysis of the burden of disease of lung cancer in California counties. This chapter identified the cost of lung cancer per stage within the overall population, the Medi-Cal population, and the QALYs that were lost from lung cancer per county in California. I estimated the costs and QALYs using methodology from previous studies that estimated the cost of chronic conditions in California. This study required the identification of the stage of lung cancer diagnosis for people detected with lung cancer per county using the SEER database, as well as estimating the cost per stage for each county in California using cancer costs from the literature. The burden of disease study provided the impact of lung cancer measured by costs, mortality, and QALYs at the county-level. Studying the burden of disease study was significant as it provided information on how to prioritize actions in health and the environment, planning for preventive action, assessing performance, identifying high-risk populations, and planning for future needs. Providing cost estimates of cancer at the county-level provided a monetary association with lung cancer. Information on lost QALYs showed the impact of lung cancer on society; and, in turn, this information can provide lobbyists with data on how no interventions is detrimental to society, while allowing LHDs to vouch for funding in their counties.

Chapter 2 focused on decision-making within LHDs and Medi-Cal purchasers in California. The chapter reviewed the existing literature that identified the criteria upon which they make their decisions; and then, applied these criteria to lung cancer screening. Although decision-making at this level will undoubtedly involve political considerations, the study attempted to characterize the decision context in which LHDs make decisions, how they decide to fund new programs, and the types of decisions they make when deciding to invest in programs. Specifically, the study explained the LHDs prioritization process and which costs and benefits they should include in their ROI. This chapter also included a discussion of three types of economic analyses—cost-effectiveness, budget impact analysis, and RO —and how they are used in LHDs health decision-making processes, using lung cancer as an example. This chapter included a hypothetical case study taking the example of lung cancer in California and presenting the application of ROI to help guide LHDs decision-making processes.

Chapter 3 examined the ROI by introducing lung cancer screening to eligible members in California counties. Information from the first two aims (costs, QALYS, and the decision context) were combined with information from previously published studies on lung cancer screenings and costs to provide estimates of the ROI to county public health departments for investing in lung cancer screening. Therefore, addressed in this chapter was whether lung cancer screening for those who smoke represents a good investment in counties in California. Chapter 3 concluded with a discussion of the implications of this analysis for understanding local decision-making and for future research directions.

Lung cancer cost information is needed to illustrate the burden of disease in California counties. This information is imperative as it provides data concerning ways to prioritize actions in health care, planning for preventive action, assessing performance, identifying high-risk populations, and planning for future needs. Information on costs could then be used to prepare an ROI analysis from which any agency, such as an LHD, can determine whether investing in a particular service or program is worth the investment. The drawback is that agencies like LHDs are unaware of methods to prepare an ROI analysis. Therefore, a guide has been created for them to address this gap.

Moreover, there is limited literature about how LHDs make decisions concerning services or programs in which to invest or divest or whether they are concerned about long-term or short-term costs. The principal issue in performing an ROI from a public health perspective is attempting to determine ways to monetize outcomes. The LHDs have the option of choosing from undertaking a complete cost-effectiveness analysis to performing a budget impact analysis to conducting an ROI.

LHDs county boards typically are politically driven when making their decisions. The LHD makes the case for funding by providing cost and benefit information. Then, the county board decides which department in the county should be allocated the funding. Therefore, it is difficult for LHDs to select programs in which to invest or divest. Local health departments are funded from a combination of sources, such as monies from fee-for-services, local tax support, state funding, federal funding, and nongovernmental grant sources. Needless to say, a board of health has full budgetary approval authority. There is no requirement for the number of staff, buildings and infrastructure, minimum size population to serve, types of programs offered, or grant requirements. All local decisions are dependent concerning how the health department is organized (IOM, 2011).

Because the majority of the funding comes from the state or federal government, LHDs tend to withdraw from programs that are no longer being funded or programs where the same services are provided elsewhere, such as a local health clinic. Variations in health care services have been well documented across LHDs in California. Decision-making in public health policy represents a complicated process with both formal and informal influences. Thus, it becomes necessary to present to the county board specific information when relying on county funds.

Assumptions

The U.S. has no government organizations, such as NICE, to support the public health system to determine which services and technologies to adopt. Guidance from a government entity like NICE could provide guidance, quality standards, and information services for public health as well as resources to help maximize the use of evidence and guidance. Based on the evidence provided above, two assumptions were made: (a) the current U.S. government is set to roll back regulations that control or impede business. Therefore, in this political climate, no federal government entity would endorse enacting national public health standards, ethics, best-evidence, or policies, and (b) there is no evidence to suggest that LHDs have any interest in increasing long-term costs even if those costs would add societal benefits.

Future Research

By reviewing study methods as well as results, this dissertation was able to provide some perspective regarding how to perform an ROI analysis when there are inconsistencies and limitations in the research. As entities like LHDs decide whether or not to invest in programs like lung cancer screening, it is recommended that researchers provide as many details as possible about their samples and that they consider including standardized analysis on predictors and possible outcomes to ensure comparability across heterogeneous study designs and statistical models.

The original aim of this study was to identify the context in which LHDs make decisions to invest or disinvest from programs like lung cancer screening. However, there was limited literature regarding LHD decision-making in this context. However, the literature did provide a rationale regarding why general disinvestments are made and why the allocation of funding for specific programs is valued differently.

LHDs do not have a determined optimal process to review the effectiveness and cost-effectiveness of programs, technologies, and procedures currently in use or for future use (Watt, 2012). The majority of services and programs have not been assessed before; however, there is a growing interest in their detection and evaluation. Disinvesting has been seen as a factor to broaden the scope of activities and decrease the use of repetitive or less effective services by offering insight into effectiveness, cost-effectiveness, and the impact on the health care budget (Rabarison et al., 2015).

Implications for Future Study

Future study will investigate how LHDs make decisions to disinvest from programs and to demonstrate the types of costs and benefits they are interested in pursuing. Disinvestment from ineffective or inappropriately applied practice is growing both for improved investments in new programs and sustainability of resource allocation. The new study will include the following methodologies.

1. Form a reference group to help identity key priorities.
    a. Conduct an informal survey to assess what the LHDs priorities.

   b. Use the snowball technique to identify decision-makers.
2. Conduct individual semistructured interviews with all recruited decision-makers.
   a. Provide stakeholders with preparatory reading materials (e.g., tobacco control or diabetes education).
   b. Present two case studies with the aim to use a specific example to explore the broad issues related to decision-making.
   c. Create a questionnaire and frame questions around a specific case study to be used on the first day of the session, e.g., tobacco control or diabetes education.
3. Analyze and interpret the results

A reference group will be formed to help identify key priorities for LHDs. The reference group will include representatives from county public health departments, such as Merced County California Alliance for Health, Dignity Health, and Sutter Medical Foundation. The snowball technique will be used to identify and recruit decision-makers. Stakeholders will be prepared for a potential disinvestment case study (tobacco control or diabetes education) and take part in individual semistructured interviews that focus on mechanisms and challenges to support disinvestment. Interviews will be recorded and transcribed for thematic analysis. The attached Appendix includes questions that will be adapted for stakeholder semistructured interviews and an interview schedule demonstrating fundamental questions and factors requiring further attention.

Conclusion

Although access to lung cancer screening has improved in recent years, it is evident that this approach alone has not reached its full potential as indicated by screening rates. Therefore, there is a need for nuanced approaches that focus on all consumers by providing individualized recommendations, particularly to motivate those who are unaware of such screenings or those who prefer no screening at all. On the one hand, understanding socio-demographic factors that create disutility in a small but substantial number of people will significantly improve screening uptake rates beyond current rates. On the other hand, agencies like LHDs need information concerning burden of disease and ROI to determine whether or not screening programs are worth the investment. In the event a health program is determined to be worth the investment, as is the case with lung cancer, there will be a societal benefit in early detection and a decrease in costs. Policymakers, program coordinators, and practitioners should use the information found in this study to guide their investments and improve effectiveness of their programs. Future researchers should study the ways in which LHD decisions are made and should continue to explore how LHDs prioritize health programs and services.

References

AARP (2012). Health insurance costs and coverage for 50- to 64-year-olds [Article]. Retrieved from https://www.aarp.org/health/health-care-reform/info-02-2012/health-insurance-costs-for-older-adults-before-medicare.html

Addario Lung Cancer Foundation (2018). Centers of excellence [Webpage]. Retrieved from https://www.lungcancerfoundation.org/patients/centers-of-excellence/

Adler, Matthew D. (2005). QALYs and policy evaluation: A new perspective. *Scholarship at Penn Law, 59.*

Adler-Milstein, J., Daniel, G., Grossmann, C., Mulvany, C., Nelson, R., Pan, P., . . . Perlin, P. (2013). *Return on information: A standard model for assessing institutional return on electronic health records.* Discussion paper presented at the Digital Learning Collaborative of the IOM Roundtable on Value & Science-Driven Health Care, Washington, D.C. Retrieved from the National Academy of Sciences website https://nam.edu/

American Association for Cancer Research. (2013). AACR cancer progress report 2013 [Website]. Retrieved from http://cancerprogressreport.org/

American Cancer Society. (2013). Cancer facts and statistics 2009. Retrieved from http://www.cancer.org/research/cancerfactsstatistics/

American Cancer Society. (2014). California cancer facts & figures report 2014 [Website]. Retrieved from California Cancer Registry website http://www.ccrcal.org/

American Cancer Society. (2015). Cancer treatment & survivorship facts & figures, 2014–2015 [Website]. Estimated numbers of cancer survivors by state as of January 1, 2014. Retrieved from https://www.cancer.org/

American Cancer Society. (2018a). Cancer treatment & survivorship facts & figures [Web article]. Retrieved from http://www.cancer.org/

American Cancer Society. (2018b). Key statistics for lung cancer [Webpage]. Retrieved from https://www.cancer.org/cancer/nonsmall-cell-lung-cancer/about/key-statistics.html

AskCHIS. (n.d.) AskCHIS™ gives you the answers [Web query system]. Retrieved from http://ask.chis.ucla.eduBach, L. (2018, January). Tobacco and socioeconomic status [Webpage]. Retrieved from the Campaign for Tobacco-Free Kids website https://www.tobaccofreekids.org/assets/factsheets/0260.pdf

Baldwin, D. R., Duffy, S. W., Wald, N. J., Page, R., Hansell, D. M., & Field, J. K. (2011). UK Lung Screen (UKLS) nodule management protocol: Modelling of a single screen randomised controlled trial of low-dose CT screening for lung cancer. *Thorax, 66*, 308–313.

Bitler, M. P., & Carpenter, C., S. (2016, August). Health insurance mandates, mammography, and breast cancer diagnoses. *American Economic Journal: Economic Policy, American Economic Association*, *8*(3), 39–68.

Black, W. C., Gareen, I. F., Soneji, S. S., Sicks, J. R. D., Keeler, E. B., & Aberle, D. R., . . . Gatsonis, C. (2014) Cost-effectiveness of CT screening in the National Lung Screening Trial. *New England Journal of Medicine, 371*(19), 1793–1802.

Botchkarev, A., & Andru, P. (2011). A return on investment as a metric for evaluating information systems: Taxonomy and application. *Interdisciplinary Journal of Information, Knowledge and Management*, 6, 245–269. Retrieved from http://www.ijikm.org/

Bourzac, K. (2014) Diagnosis: Early warning system. *Nature, 513*(7517), S4–S6.

Bradley, C. J., Yabroff, K. R., Dahman, B., Feuer, E., Mariotto, J. A., & Brown, M. L. (2008). Productivity costs of cancer mortality in the United States: 2000–2020. *Journal of the National Cancer Institute, 100*(24), 1763–1770.

Brousselle, A., Benmarhnia, T., & Benhadj, L. (2016). What are the benefits and risks of using return on investment to defend public health programs? *Preventive Medicine Reports, 3*, 135–138. https://doi.org/10.1016/j.pmedr.2015.11.015

Brown, P. M., Gonzalez, M., Dhaul, R. S., (2015, January/February). Cost of chronic disease in California: Estimates at the county level. *Journal of Public Health Management and Practice*, *21*(1), E10–E19. doi: 10.1097/PHH.0000000000000168

Brustugun, O., Moller, B., & Helland, A. (2014). Years of life lost as a measure of cancer burden on a national level. *British Journal of Cancer, 111*, 1014–1020. Retrieved from http://www.nature.com/

Burnet, N. G., Jefferies, S. J., Benson, R. J., Hunt, D. P., & Treasure, F. P. (2005). Years of life lost (YLL) from cancer is an important measure of population burden – and should be considered when allocating research funds. *British Journal of Cancer*, *92*(2), 241–245.

Cabato, E. (2016, May 25). Not-for-profit hospitals must join the fight against climate change [Blog post]. Retrieved from California Pan-Ethnic Health Network website http://cpehn.org/

California Cancer Registry. (2009, September). California cancer facts and figures 2010 [Sourcebook]. Retrieved from http://www.ccrcal.org/pdf/Reports/ACS2010-9-29-09.pdf

California Department of Public Health. (2014a). The burden of chronic disease and injury in California, 2013 [Webpage]. Retrieved from the UCLA Center for Health Policy Research website http://healthpolicy.ucla.edu/publications/search/pages/detail.aspx?PubID=1544

California Department of Public Health. (2014b). Lung cancer [Webpage]. Retrieved from 10-14-09

California Department of Public Health. (2016). California tobacco control program, California tobacco facts and figures [Report]. Retrieved from https://www.cdph.ca.gov/

California Tobacco Control Program. (2017). Funding opportunities and resources. California Health Collaborative [Project directory]. Retrieved from https://otis.catcp.org/

Centers for Disease Control and Prevention. (2013*). Introduction to NCD epidemiology. Using economic analysis* [PowerPoint Presentation]. Retrieved from the Centers for Disease Control and Prevention website https://www.cdc.gov/

Centers for Disease Control and Prevention. (2014). Smoking and tobacco use 2008: Costs and expenditures [Fact sheet]. Retrieved from http://www.cdc.gov/tobacco/data_statistics/fact_sheets/fast_facts/

Centers for Medicare & Medicaid Services. (2014). Medicare and Medicaid beneficiaries. Retrieved from Centers for Medicare and Medicaid website http://www.cms.gov/

Centers for Medicare & Medicaid Services. (2015). Decision memo for screening for lung cancer with low dose computed tomography (LDCT) (CAG-00439N) [Memo]. Retrieved from https://www.cms.gov/medicare-coverage-database/details/nca-decision-memo.aspx?NCAId=274&NcaName=Screening+for+Lung+Cancer+with+Low+Dose+Computed+Tomography+(LDCT)&TimeFrame=7&DocType=All&bc=AQAAIAAAAgAAAA%3d%3d&amp

Central California Alliance for Health (Alliance). (2017). Provider manual [Webpage]. Retrieved from http://www.ccah-alliance.org/provider-manual-toc.html

Central California Alliance for Health (Alliance). (2018). Medi-Cal Summary of Benefits [Website]. Retrieved from https://www.ccah-alliance.org/

Chaikledkaew, U. (n.d.). Budget impact analysis and return on investment [Slides]. Retrieved from the Health Intervention and Technology Assessment Program website https://www.sph.nus.edu.sg/sites/default/files/Budget%20Impact%20Analysis%20and%20Return%20on%20Investment%20%28day%201_session%208%29.pdf

Chang, S. (2004). Estimating the cost of cancer: Results on the basis of claims data analyses for cancer patients diagnosed with seven types of cancer during 1999 to 2000. *Journal of Clinical Oncology, 22*(17), 3524–3530.

Chouaid, C., Agulnik, J., Goker, E., Herder, G. J., Lester, J. F., Vansteenkiste, J., . . . Mitchell, P. L. (2013). Health related quality of life and utility in patients with advanced non-small cell lung cancer: A prospective cross-sectional patient survey in a real-world setting. *Journal of Thoracic Oncology, 8*(8), 997–1003.

Cipriano, L. E., Romanus, D., Earle, C. C., Neville, B. A., Halpern, E. F., Gazelle, G. S., & McMahon, P. M. (2011). Lung cancer treatment costs, including patient responsibility, by disease stage and treatment modality, 1992 to 2003. *Value in Health, 14*(1), 41–52.

Cochrane, A., & Holland, W. (1971). Validation of screening procedures. *British Medical Bulletin, 27*(1), 3–8.

Crawley-Stout, L. A., Ward, K. A., See, C. H., & Randolph, G. D. (2015, February). Lessons learned from measuring return on investment in public health quality improvement initiatives. *Journal of Public Health Management and Practice: JPHMP, 22*(2). doi: 10.1097/PHH.0000000000000229

Cressman, S., Lam, S., Tammemagi, M. C., Evans, W. K., Leighl, N. B., Regier, D. A., . . . Peacock, J. (2014). Resource utilization and costs during the initial years of lung cancer screening with computed tomography in Canada. *The Journal of Thoracic Oncology, 9*(10), 1449–1458. doi: 10.1097/JTO.0000000000000283

de Groot, P. M., Carter, B. W., Godoy, M. C. B., & Munden, R. F. (2015). Lung cancer screening – Why do it? Tobacco, the history of screening, and future challenges. *Seminars in Roentgenology, 50*(2), 72–81. doi: 10.1053/j.ro.2014.10.010

Delmerico, J., Hyland, A., Celestino, P., Reid, M., & Cummings, K. M. (2014). Patient willingness and barriers to receiving a CT scan for lung cancer screening. *Lung Cancer (Amsterdam, Netherlands), 84*(3), 307–309. http://doi.org/10.1016/j.lungcan.2014.03.003

Dervaux, B., Le Fur, C., Dubois, S., & Josseran, A. (2017, February). What is the budget impact of a new treatment or new health technology arriving on the market? *Thérapie, 72*(1), 93–103. https://doi.org/10.1016/j.therap.2016.12.003

DeVol, R., & Bedroussian, A. (2007, October). An unhealthy America: The economic burden of chronic disease [Report]. Retrieved from Milken Institute website http://assets1c.milkeninstitute.org/assets/Publication/ResearchReport/PDF/chronic_disease_report.pdf

Doll, R. (1950). On the etiology of lung cancer. *Journal of the National Cancer Institute, 11*(3), 638–640.

Doo, K. W., Kang, E. Y., Yong, H. S., Woo, O. H., Lee, K. Y., & Oh, Y-W. (2014) Accuracy of lung nodule volumetry in low-dose CT with iterative reconstruction: An anthropomorphic thoracic phantom study. *The British Journal of Radiology 87*(1041), 20130644.

Doria-Rose, V., & Szabo, E. (2010). Screening and prevention of lung cancer. In K. H. Kernstine, & K. L. Reckamp (Eds.). *Lung cancer: A Multidisciplinary Approach to Diagnosis and Management.* New York: Demos Medical Publishing, pp. 53–72.

Doyle, S., Lloyd A., & Walker M. (2008). Health state utility scores in advanced non-small cell lung cancer. *Lung Cancer, 62*(3), 374–80.

Driessen, J., Cioffi, M., Alide, N., Landis-Lewis, Z., Gamadzi, G., Gadabu, O. J., & Douglas, G. (2013). Modeling return on investment for an electronic medical record system in Lilongwe, Malawi. *Journal of the American Medical Informatics Association, 20*(4), 743–748. https://doi.org/10.1136/amiajnl-2012-001242

Drummond, M., O'Brien, B., Stoddart, G., & Torrance, G. (1997). *Methods for the economic evaluation of health care programmes, 2nd ed.* New York, NY: Oxford Medical Publications.

Eberth, J. M., Qiu, R., Adams, S. A., Salloum, R. G., Bell, N., Arrington, A. K., . . . Munden, R. F. (2014) Lung cancer screening using low-dose CT: The current national landscape. *Lung Cancer 85*(3), 379–384.

Elshaug, A. G., Hiller, J. E., & Moss, J. R. (2008). Exploring policy-makers' perspectives on disinvestment from ineffective healthcare practices. *International Journal of Technology Assessment in Healthcare, 24(1),* 1-9. doi:10.1017/S0266462307080014

Fenn, K. M., Evans, S. B., McCorkle, R., DiGiovanna, M. P., Pusztai, L., Sanft, T., . . . Chagpar, A. B. (2014). Impact of financial burden of cancer on survivors' quality of life. *Journal of Oncology Practice, 10*(5), 332–338. Retrieved from doi: 10.1200/jop.2013.001322

Field, J. K. (2014) Perspective: The screening imperative. *Nature, 513*(7517), S7–S7.

Frost, J. K., Ball, W. C. Jr., Levin, M. L., Tockman, M. S., Baker, R.R., Carter, D., … Khouri, N. F. (1984, October). *American Review of Respiratory Disease, 130*(4), 549–554.

Garatinni, L., & Vooren, K. (2011). Budget impact analysis in economic evaluation: A proposal for a clearer definition. *The European Journal of Health Economics, 12*(6), 499. doi:10.1007/s10198-011-0348-5

Garfield, R., Damico, A., Stephens, J. & Rouhani, S. (2014, November). The coverage gap: Uninsured poor adults in states that do not expand Medicaid – An update [Issue brief]. Retrieved from the Kaiser Family Foundation website http://files.kff.org/attachment/the-coverage-gap-uninsured-poor-adults-in-states-that-do-not-expand-medicaid-issue-brief

Gierada, D. S., Pinsky, P., Nath, H., Chiles, C., Duan, F., Aberle, & D. R. (2014) Projected outcomes using different nodule sizes to define a positive CT lung cancer screening examination. *JNCI Journal of the National Cancer Institute, 106*(11), dju284–dju284.

Grutters, J. P.C., Kessels, A. G. H., Pijls-Johannesma, M., De Ruysscher, D., Joore, M. A., & Lambin, P. (2010, April). Comparison of the effectiveness of radiotherapy with photons, protons and carbon-ions for non-small cell lung cancer: A meta-analysis. *Radiotherapy and Oncology, 95*(1), 32– 40

Guo, Z., Zhao, C., & Wang, Z. (2014) MicroRNAs as ideal biomarkers for the diagnosis of lung cancer. *Tumor Biology 35*(10), 10395–10407.

Hanly, P. A., & Sharp, L. (2014, March). The cost of lost productivity due to premature cancer-related mortality: An economic measure of the cancer burden. *BMC Cancer, 14*, 224. doi: 10.1186/1471-2407-14-224

Harris, C., Allen, K., King, R., Ramsey, W., Kelly, C., & Thiagarajan, M. (2017). Sustainability in Health care by Allocating Resources Effectively (SHARE) 2: Identifying opportunities for disinvestment in a local healthcare setting. *BMC Health Services Research, 17*(328), 1-12. doi:10.1186/s12913-017-2211-6

Henke, R. M., Goetzel, R. Z., McHugh, J., & Isaac, F. (2011). Recent experience in health promotion at Johnson & Johnson: Lower health spending, strong return On investment. *Health Affairs, 30*(3), 490–499. https://doi.org/10.1377/hlthaff.2010.0806

Houston, K. A., Henley, S. J., Li, J., White, M. C., & Richards, T. B. (2014) Patterns in lung cancer incidence rates and trends by histologic type in the United States, 2004–2009. *Lung Cancer, 86*(1), 22–28.

Humphrey, L. L., Deffebach, M., Pappas, M., Baumann, C., Artis, K., Mitchell, J. P., . . . Slatore, C. G. (2013, September). Screening for lung cancer with low-dose computed tomography: A systematic review to update the US Preventive services task force recommendation. *Annals of Internal Medicine, 159*, 411–20. doi: 10.7326/0003-4819-159-6-201309170-00690

IOM (Institute of Medicine). (2011). For the public's health: Revitalizing law and policy to meet new challenges. Washington, DC: The National Academies Press.

Jacobson, P. D., & Neumann, P. J. (2009). A framework to measure the value of public health services. *Health Services Research, 44*(5 Pt 2), 1880–1896. http://doi.org/10.1111/j.1475-6773.2009.01013.x

Jamison, D. T. (2006). Cost-Effectiveness Analysis. In D. T. Jamison, J. G. Breman, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, . . . P. Musgrove (Eds.), *Priorities in Health.* Retrieved from https://www.ncbi.nlm.nih.gov/

Jemal, A., Center, M. M., DeSantis, C., & Ward, E. M. (2010a). Global patterns of cancer incidence and mortality rates and trends. *Cancer Epidemiology Biomarkers Prevention, 19*, 1893–1907.

Jemal, A., Siegel, R., Xu, J., & Ward, E. (2010b). Cancer statistics. Cancer Journal. 10 no.60: 277-300.

Jia, H., & Lubetkin, E. (2010a). Obesity-related quality-adjusted life-years lost in the U.S. from 1993 to 2008. *American Journal of Preventive Medicine, 39*(3), 220–227. Retrieved from https://www.ncbi.nlm.nih.gov/

Jia, H., & Lubetkin, E. (2010b). Trends in quality-adjusted life-years lost contributed by smoking and obesity. *American Journal of Preventive Medicine, 38*(2), 138–144. Retrieved from http://www.ajpmonline.org/

John, D. A., Kawachi, I., Lathan, C. S., & Ayanian, J. Z. (2014) Disparities in perceived unmet need for supportive services among patients with lung cancer in the Cancer Care Outcomes Research and Surveillance Consortium. *Cancer, 120*(20), 3178–3191.

Jonnalagadda, S., Bergamo, C., Lin, J. J., Lurslurchachai, L., Diefenbach, M., Smith, C., . . . Wisnivesky, J. P. (2012, September). Beliefs and attitudes about lung cancer screening among smokers. *Lung Cancer, 77*(3), 526–531. doi: 10.1016/j.lungcan.2012.05.095

Kalseth, J., Halsteinli, V., Halvorsen, T., Kalseth, B., Anthun, K., Peltola, M., . . . Kilsmark, J. (2011). Costs of cancer in the Nordic countries [Web Report]. Retrieved from http://www.ncu.nu/

Karlamangla, S. (2015, December 31). Under Obamacare, Medi-Cal ballooned to cover 1 in 3 Californians. *Los Angeles Times.* Retrieved from http://www.latimes.com/

Kaushal, R., Jha, A. K., Franz, C., Glaser, J., Shetty, K. D., Jaggi, T., . . . Brigham and Women's Hospital CPOE Working Group. (2006). Return on investment for a computerized physician order entry system. *Journal of the American Medical Informatics Association: JAMIA, 13*(3), 261–266. http://doi.org/10.1197/jamia.M1984

Kazerooni, E. A., Armstrong, M. R., Amorosa, J. K., Hernandez, D., Liebscher, L. A., Nath, H., . . . Wilcox, P. A. (2014) ACR CT accreditation program and the lung cancer screening program designation. *Journal of the American College of Radiology, 12*(1), 38–42. doi: 10.1016/j.jacr.2014.10.002

Kinsinger, L. S., Atkins, D., Provenzale, D., Anderson, C., & Petzel, R. (2014). Implementation of a new screening recommendation in health care: The Veterans Health Administration's approach to lung cancer screening. *Annals of Internal Medicine, 161*(8), 597–598.

Klabunde, C. N., Marcus, P. M., Silvestri, G. A., Han, P. K. J., Richards, T. B., Yuan, G., . . . Vernon, S. W. (2010, November). U.S. primary care physicians' lung cancer screening beliefs and recommendations. *American Journal of Preventive Medicine, 39*(5), 411–420. doi: 10.1016/j.amepre.2010.07.004

Lam, D. L., Pandharipande, P. V., Lee, J. M., Lehman, C. D., & Lee, C. I. (2014). Imaging-based screening: Understanding the controversies. *American Journal of Roentgenology, 203*(5), 952–956.

Lanuti, M., Hong, H-J, Ali, S., Stock, C., Temel, J., Mathisen, D., & Michaelson, J. S. (2014) Observations in lung cancer over multiple decades: An analysis of outcomes and cost at a single high-volume institution. *European Journal of Cardio-Thoracic Surgery, 46*(2), 254–261.

Liao, Q-B, Guo, J-Q, Zheng, X-Y, Zhou, Z-F, Li, H., Lai, X-Y, & Ye, J-F. (2014, August). Test performance of sputum microRNAs for lung cancer: A meta-analysis. *Genetic Testing and Molecular Biomarkers, 18*(8), https://doi.org/10.1089/gtmb.2014.0005

Liu, P., Wang, J., & Keating, N. L. (2013). Expected years of life lost for six potentially preventable cancers in the United States. *Preventive Medicine, 56*(5), 309–313.

Local Government Association. (2013, November). Money well spent? Assessing the cost-effectiveness and return on investment of public health interventions [briefing]. Retrieved from https://www.local.gov.uk/

Luengo-Fernandez, R., Leal, J., Gray, A., & Sullivan, S. (2013, November). Economic burden of cancer across the European Union: A population-based cost analysis. *The Lancet Oncology, 14*(12), 1165–1174.

Mai, V. (2006, May). The *challenges of implementing screening programs across cancer types.* Paper presented at the International Breast Cancer Screening Network Biennial Meeting, Ottawa, Canada. Retrieved from https://health caredelivery.cancer.gov/

Marcus, P. M., Bergstralh, E. J., Fagerstrom, R. M., Williams, D. E., Fontana, R., Taylor, W. F., & Prorok, P. C. (2000, August). Lung cancer mortality in the Mayo Lung Project: Impact of extended follow-up. *Journal of the National Cancer Institute, 92*(16), 1308–16.

Mariotto, A. B., Yabroff, K. R., Shao, Y., Feuer, E. J., & Brown, M. L. (2011). Projections of the cost of cancer care in the United States: 2010–2020. *JNCI Journal of the National Cancer Institute*, *103*(2), 117–128. http://doi.org/10.1093/jnci/djq495

Marshall, H. M., Bowman, R. V., Yang, I. A., Fong, K. M., & Berg, C. D. (2013). Screening for lung cancer with low-dose computed tomography: A review of current status. *Journal of Thoracic Disease, 5*(5), 524–39.

Masters, R., Anwar, E., Collins, B., Cookson, R., & Capewell, S. (2017). Return on investment of public health interventions: A systematic review. *Journal of Epidemiology and Community Health, 71*(8), 827-834. doi:10.1136/jech-2016-208141

Max, W., Sung H-Y., Shi, Y., & Stark, B. (2014). The cost of smoking in California, 2009 [Report]. Retrieved from http://www.trdrp.org/files/cost-smoking-ca-final-report.pdf

Mayo Clinic. (2014). Screening for lung cancer: The evolving challenge [Email newsletter]. Retrieved from https://www.mayoclinic.org/medical-professionals/clinical-updates/general-medical/screening-lung-cancer-evolving-challenge

Mays, G. P. (2013). Estimating return on investment: Approaches and methods. *Health Management and Policy Presentations. 21*. Retrieved from hpps://uknowledge.uky.edu/

McKee, B. J., Regis, S. M., McKee, A. B., Flacke, S., & Wald, C. (2015, March). Performance of ACR Lung-RADS in a clinical CT lung screening program. *Journal of the College of Radiology, 12*(3), 273–276. doi: 10.1016/j.jacr.2014.08.004

Medicaid. (n.d.). Affordable Care Act [Webpage]. Retrieved from https://www.medicaid.gov/affordable-care-act/index.html

Midthun, D. E. (2016). Early detection of lung cancer. *F1000Research, 5*, *F1000 Faculty Rev–739*. http://doi.org/10.12688/f1000research.7313.1Mills, P. K. (2011, April). Analysis of California cancer registry data. Used with permission. Fresno CA.

Mills, P. K., Yang, R. C., & Dodge, J. L. (2007, March). *Cancer incidence and mortality in the Central Valley region, California, 1988–2004.* Retrieved from Cancer Registry of Central California website: http://www.ccrcal.org/

Morphew, T., Scott, L., Li, M., Galant, S. P., Wong, W., Garcia Lloret, M. I., . . . Jones, C. A. (2013). Mobile health care operations and return on investment in predominantly underserved children with asthma: The Breathmobile Program. *Population Health Management, 16*(4). http://doi.org/10.1089/pop.2012.0060

Mulshine, J. L., & D'Amico, T. A. (2014) Issues with implementing a high-quality lung cancer screening program. *CA: A Cancer Journal for Clinicians, 64*(5), 351–363.

Nafees, B., Stafford, M., Gavriel, S., Bhalla, S., & Watkins J. (2008). Health state utilities for non-small cell lung cancer. *Health Quality Life Outcomes, 6*(84). doi: 10.1186/1477-7525-6-84.

National Association of Chronic Disease Directors. (2009). A practical guide to ROI analysis [Report]. Retrieved from http://c.ymcdn.com/sites/www.chronicdisease.org/

National Association of County & City Health Officials (NACCHO). (2017.). How funding reaches local health departments [Website]. Retrieved from http://www.naccho.org/

National Cancer Institute. (2010). Cancer prevalence and cost of care projections [Fact sheet]. Retrieved from National Institutes of Health website https://costprojections.cancer.gov/

National Cancer Institute. (2014a). *Cancer Stat Facts: Lung and Bronchus Cancer.* Retrieved from https://seer.cancer.gov/statfacts/html/lungb.html

National Cancer Institute. (2014b). National lung screening trial [Article]. Retrieved from http://www.cancer.gov/clinicaltrials/noteworthy-trials/nlst

National Cancer Institute. (2015). Cancer trends progress report [Report]. Retrieved from National Institutes of Health website http://progressreport.cancer.gov/

National Institute for Health and Care Excellence. (2012, September). Methods for development of NICE public health guidance (3rd ed.) [Manual]. Retrieved from https://www.nice.org.uk/process/pmg4/chapter/introduction

National Institute for Health and Care Excellence. (2018). Making decisions using NICE guidelines [Article]. Retrieved from https://www.nice.org.uk/

National Institute of Health. (2011, January). Cancer costs projected to reach at least $158 billion in 2020. Retrieved from http://www.nih.gov/news/health/jan2011/nci-12.htm

National Lung Screening Trial Research Team. (2011). Reduced lung-cancer mortality with low-dose computed tomographic screening. *New England Journal of Medicine, 36,* 395–409. doi: 10.1056/NEJMoa1102873

National Lung Screening Trial Research Team. (2013, May). Results of initial low-dose computed tomographic screening for lung cancer. *New England Journal of Medicine, 368*(21), 1980–1991. doi: 10.1056/NEJMoa1209120

National Program of Cancer Registries, 2014, accessed on 11/28/14 from http://apps.nccd.cdc.gov/uscs/cancersbyraceandethnicity.aspx

Neubauer, M. A., Hoverman, J. R., Kolodziej, M., Reisman, L., Gruschkus, S. K., Hoang, S., . . . Beveridge, R. A. (2010). Cost effectiveness of evidence-based treatment guidelines for the treatment of non–small-cell lung cancer in the community setting, *Journal of Oncology Practice, 6*(1), 12–18.

Neumann, P. J., Cohen, J. T., & Weinstein, M. C. (2014). Updating cost-effectiveness — The curious resilience of the $50,000-per-QALY threshold. *New England Journal of Medicine*, *371*(9), 796–797. https://doi.org/10.1056/NEJMp1405158

Norris, J. (2016, June 16). California county health programs yield high returns [Article]. Retrieved from the UC Berkeley website http://news.berkeley.edu/

O'Dowd, E. L., McKeever, T. M., Baldwin, D. R., & Hubbard, R. B. (2016, August). Place of death in patients with lung cancer: A retrospective cohort study from 2004–2013. *PLOS One.* https://doi.org/10.1371/journal.pone.0161399

Ostroff, J. S. (2014) Quality lung cancer screening protects quality of life: No harm, no foul. *Cancer, 120*(21), 3275–3276.

Paprica, P. Al., Elshaug, A. G., Culyer, A. J., Peffer, J., & Sandoval, G. A. (2015). From talk to action: Policy stakeholders, appropriateness, and selective disinvestment. *International Journal of Technology Assessment in Health Care, 31*(4), 236–240. doi:10.1017/S0266462315000392

Pokhrel, S., Evers, S., Leidl, R., Trapero-Bertran, M., Kalo, Z., de Vries, H., . . . Coyle, D. (2014). EQUIPT: protocol of a comparative effectiveness research study evaluating cross-context transferability of economic evidence on tobacco control. *BMJ Open, 4*(11), e006945. http://doi.org/10.1136/bmjopen-2014-006945

Prigent, A., Auraaen, A., Kamendje-Tchokobou, B., Durand-Zaleski, I., & Chevreul, K. (2014). Health-related quality of life and utility scores in people with mental disorders: A comparison with the nonmentally ill general population. *International Journal of Environmental Research and Public Health*,*11*(3), 2804–2817.

Polisena, J., Clifford, T., Elshaug, A. G., Mitton, C., Russell, E., & Skidmore, B. (2013). Case Studies That Illustrate Disinvestment and Resource Allocation Decision-Making Processes In Health Care: A Systematic Review. *International Journal of Technology Assessment in Health Care, 29*(02), 174-184. doi:10.1017/s0266462313000068

Pyenson, B., Sander, M., Jiang, Y., Khan, H., & Mulshine, J. (2012). An actuarial analysis shows that offering lung cancer screening as an insurance benefit would save lives at relatively low cost. *Health Affairs, 31*(4), 770–779.

Rabarison, K., Bish, C., Massoudi, M., & Giles, W. (2015). Economic evaluation enhances public health decision-making. *Frontiers in Public Health, 3*(164). Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4478374/

Richard, P., West, K., & Ku, L. (2012, January). The return on investment of a Medicaid tobacco cessation program in Massachusetts. *PLOS One.* Retrieved from https://doi.org/10.1371/journal.pone.0029665

Schneider, M.-J. (2017). *Introduction to public health, 5th Ed.* Burlington, MA: Jones & Bartlett Learning.

Shavers, V., & Brown M. (2002). Racial and ethnic disparities in the receipt of cancer treatment. *Journal of National Cancer Institute*, *94*(5) 334–357.

Shmueli, A., Fraifeld, S., Peretz, T., Gutfeld, O., Gips, M., Sosna, J., & Shaham, D. (2013). Cost-effectiveness of baseline low-dose computed tomography screening for lung cancer. *Value Health, 16*(6), 922–931. doi: 10.1016/j.jval.2013.05.007

Shugarman, L., Mack, K., Sorbero, M., Tian, H., Jain, A., Ashwood, S., & Ash, S. (2009) Race and sex differences in the receipt of timely and appropriate lung cancer treatment. *Medical Care*, *47*(7), 774–781.

Silvestri, G. A., Nietert, P. J., Zoller, J., Carter, C., & Bradford, D. (2007). Attitudes towards screening for lung cancer among smokers and their nonsmoking counterparts. *Thorax, 62*(2), 126‑130. http://doi.org/10.1136/thx.2005.056036

Slatore, C., Baumann, C., Pappas, M., & Humphrey, L. L. (2014). Smoking behaviors among patients receiving computed tomography for lung cancer screening: Systematic review in support of the U.S. Preventive Services Task Force. *Annals of American Thoracic Society, 11*(4), 619–627.

Smith, K. R., Kim, S., Recendez, J. J., Teague, S. V., Ménache, M. G., Grubbs, D., . . . Pinkerton, K. E. (2003, June). Airborne particles of the California Central Valley alter the lungs of healthy adult rats. *Environmental Health Perspectives, 111*(7), 902–908, discussion A408-A409. Retrieved from https://www.ncbi.nlm.nih.gov/

Social Security Administration. (n.d.). Retrieved from https://www.ssa.gov

Sozzi, G., Boeri, M., Rossi, M., Verri, C., Suatoni, P., Bravi, F., … Pastorino, U. (2014). Clinical utility of a plasma-based miRNA signature classifier within computed tomography lung cancer screening: A correlative MILD trial study. *Journal of Clinical Oncology, 32*(8), 768–773. http://doi.org/10.1200/JCO.2013.50.4357

Sullivan, S. D., Mauskopf, J. A., Augustovski, F., Caro, J. J., & Lee, K. M. (2014). Budget impact analysis—Principles of good practice: Report of the ISPOR 2012 Budget Impact Analysis Good Practice II Task Force. *The International Society for Pharmacoeconomics and Outcomes Research. 17*(1), 5–14. Retrieved from http://www.valueinhealthjournal.com/

Surveillance, Epidemiology, and End Results Program (SEER). (2013). SEER stat fact sheets: Lung and bronchus cancer [Website]. Retrieved from National Institutes of Health website http://seer.cancer.gov/

Swedish Medical Center. (n.d.). Low-dose CT scan for Lung Cancer Screening [Webpage]. Retrieved from http://www.swedish.org/services/thoracic-surgery/thoracic-surgery-services/lung-cancer-screening-program/low-dose-ct-scan-for-lung-cancer-screening

Tan, A., Freeman, D. H., Freeman, J. L., Zhang, D. D., Dayal, H., & Phillips, B. (2009). The cost of cancer in Texas, 2007 [Report]. Retrieved from http://www.cprit.state.tx.us/

Tangka, F. K., Trogdon, J. G., Richardson, L. C., Howard, D., Sabatino, S. A. & Finkelstein, E. A. (2010), Cancer treatment cost in the United States. *Cancer, 116*, 3477–3484. doi:10.1002/cncr.25150

Trueman, P., Drummond, M., & Hutton, J. (2001). Developing guidance for budget impact analysis. *Pharmacoeconomics 19*, 609–621.

Vannier, M. W. (2014) Nodule size and overdiagnosis in lung cancer CT screening. *JNCI Journal of the National Cancer Institute, 106*(11), dju325–dju325.

Villanti, A., Jiang, Y., Abrams, D., & Pyenson, B. (2013). A cost-utility analysis of lung cancer screening and the additional benefits of incorporating smoking cessation interventions. *PLOS ONE, 8*(8).

Watt, A. M., Hiller, J. E., Braunack-Mayer, A. J., Moss, J. R., Buchan, H., Wale, J., … Elshaug, A. G. (2012). The ASTUTE Health study protocol: Deliberative stakeholder engagements to inform implementation approaches to healthcare disinvestment. *Implementation Science, 7*(1), 101. https://doi.org/10.1186/1748-5908-7-101

Wilson, D. O. (2014) Lung cancer screening with low-dose CT (LDCT) is ready for prime time in the USA. *Evidence-Based Medicine 19*(4), 150.

Wilson, J. M. G, & Jungner, G. (1968). Principles and practice of screening for disease. Geneva: World Health Organization. Retrieved from http://www.who.int/iris/handle/10665/37650

World Health Organization. (2006). Cancer. Early diagnosis [Webpage]. Retrieved from http://www.who.int/cancer/prevention/diagnosis-screening/en/

World Health Organization. (2017). Indoor air pollution. Cost-benefit analysis of interventions [Article]. Retrieved from http://www.who.int/

Wynes, M. W. (2014, September) Less costly to screen for and treat early-stage lung than to treat late-stage lung cancer. International Association for the Study of Lung Cancer [Web article]. Retrieved from https://www.iaslc.org/

Xu, W. Y., Dowd, B., & Abraham, J. (2016, March). Lessons from state mandates of preventive cancer screenings. *European Journal of Health Economics, 17*(2), 203–215. doi: 10.1007/s10198-015-0672-2

Yabroff, K. R., Lund, J., Kepka, D., & Mariotto, A. (2011). Economic burden of cancer in the US: Estimates, projections, and future research. *Cancer Epidemiology, Biomarkers & Prevention*, *20*(10), 2006–2014. http://doi.org/10.1158/1055-9965.EPI-11-0650

Yang, S., Lai, W., Su, W., Wu, S., Chen, H. H., Wu, Y., . . . Wang, J. (2013). Estimating the lifelong health impact and financial burdens of different types of lung cancer. *BMC Cancer, 13*(1), 579.

Zank, D., & Friedsam, D. (2005, September) Employee health promotion programs: What is the return on investment? *Wisconsin Public Health & Health Policy Institute, 6*(5). Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.170.8203&rep=rep1&type=pdf

Appendix

Utilizing Return on Investment as an Approach for Disinvestment Decisions in California Local Health Departments and medical purchasers

Abstract

In recent years, there has been increased interest in disinvestment research activities at the county level. However, almost no comprehensive literature review on local health department and medical purchasers disinvestment practices has been published until now, creating a research gap concerning methods for the implementation of disinvestment activities at the county level. The purpose of this study is to examine the context in which local health departments and medical purchasers make the decision to disinvest from previous priorities. This study will explore the types of decisions they make, the purpose of such decisions, the types of information used to guide such decisions, and the types of information reported in the process. Return on investment can be a critical metric for local public health departments (LHDs) to use in allocating resources toward the prevention of conditions and deciding when to disinvest from these programs. However, it is not yet being used in most health departments or among medical purchasers. This project is part of a three-part study that explores the process in which local health departments make decisions to disinvest in programs and use of return on investment (ROI) to determine which projects to disinvest using a discretionary service, like lung cancer screening, to project return on investment. With a survey tool to be administered to a convenience sample of California public health officials, I will explore the process associated with decision-making to develop a rationale for using return on investments and options to conduct them. The results will then be used to give the argument for using return on investments at local health departments and among medical purchasers as well as considerations for conducting a return on investment and development of subsequent program priorities.

Background

Most local health departments do not have a predetermined and optimal process to review the effectiveness and cost-effectiveness of programs, technologies, and procedures that are in active use or for those they want to invest in (Watt et al., 2011). Most medical purchasers, such as the Alliance, are required by DHCS contract to reimburse for all state determined Medi-Cal benefits. These entities are able to add service benefits (by Alliance board approval), but they cannot remove state determined benefits. Recent evidence suggests that the options local health departments have on priority setting and decision-making include cost effectiveness analysis, budget impact analysis, and return on investment. An economic evaluation can be useful to analyze any situation where local health departments want to know if the resources invested in a program or intervention are justified by the results of the intervention. However, in most local health department reports, investments are measured in monetary units, while outcomes are measured in diverse and often unstandardized ways. There is no concrete rationale for cost allocations; rather, local health departments use budgeting strategies. Prioritization seems to be based on local factors, such as population needs, organizational priorities, budgets, capacity or capability, and political factors (Harris et al., 2017). However, there is no standardized process through which programs are prioritized and thus, it is difficult to understand how and why departments are investing or disinvesting in projects.

Currently, health departments are in the midst of acquiring accreditation. In doing so, they focus on fitting into the health equity lens and the political landscape, which is mainly board driven (Crawley-Stout et al., 2015; Jacobson & Neumann, 2009). In this political climate, returns on investments remain a critical yet underused part of the decision-making process. In contrast to budget analysis, which ignores health outcomes and looks at only one way to make decisions, return on investment is multi-dimensional and includes specified outcomes. Additionally, the topic of disinvestment is critical because health care costs rise across the country for state and local governments. As California proposes a $430 million decrease in the 2017–18 General Fund budget for its federal/state Medicaid program: Medi-Cal (McConville et al., 2017; Taylor, 2017). This proposed budget is a 2% below the estimated General Fund spending level for 2016–17 (Taylor, 2017). Changes to Medi-Cal spending reflect a variety of factors, such as an increase in higher state costs for optional expansion population in the Patient Protection and Affordable Care Act, higher anticipated General Fund spending based on expectations of a decrease in federal Children's Health Insurance Program funding, and substantial growth in state special funding (Taylor, 2017). Medi-Cal spending clearly depends on federal and state funding and other programs in the state.

It is important to identify health outcomes that local health departments value to make use of return on investments in making decisions to invest or disinvest. For instance, in lung cancer screenings, it is critical to understand the conditions under which local health departments will fund such a discretionary service. There is little empirical evidence on priority settings for investment in local health departments to clearly answer that question. Thus, there is an acknowledged need for pragmatic and systematic methods, which will utilize objective data in standardization comparisons allowing decision makers to rely on hard evidence.

The advent of the new prevention measure by Centers for Medicare & Medicaid Services (CMS) provides an opportunity to address these challenges. For example, about 40,000 people in California have lung cancer. Unless preventative measures are taken, the projected growth of lung cancer will impact California. This means that there will be a $6.7 billion increase in health expenditures in coming years where adjustments in spending will be necessary. The loss of productivity from lung cancer is three times more than any other cancer with loss of productivity amounting to $36.1 billion in 2005 alone (Bradley et al., 2008). Loss of productivity caused by cancer is a huge drain on the economy.

There is an opportunity to expand prevention services, especially to at-risk and vulnerable populations. Reducing costs and rates of lung cancer will require local health departments to implement successful prevention activities, such as lung cancer screening while also using an evidence-based method to make decisions to disinvest from priorities that do not yield the needed returns on investment. Information on the return on investment of lung cancer by county and stage of lung cancer can help counties understand the scope of the problems facing their regions and identify high priority areas to target interventions and programs. Consequently, state and local public health departments would be able to calculate their implicit return from investing in lung cancer screening, tobacco prevention and control efforts, and to identify, the conditions, geographic location, population to focus on, and where priorities must be changed through disinvestment.

Currently, there are many barriers that prevent disinvestment methods from being developed in health care and local health department settings (Polisena et al., 2013). Overutilizing practices and programs that are not effective while underutilizing practices and programs that are effective cause inefficiencies and unsustainable resource allocation. This is especially true in a local health department setting where alternative interventions can be cost-saving and offer substantial return on investment for the community (Elshaug et al., 2008; Masters et al., 2017). I will use return on investment to determine what programs call for disinvestment. ROI is a useful tool for programs that require long-term application and extensive investment as well as a useful advocacy tool to help government officials understand programs within a political context (Brousselle et al., 2016). According to Brousselle et al. (2016), some limitations in using return on investment are its failures to account for equity benefits, its attribution of economic value to life-years saved, and its assumption that lower return on investment scores automatically imply reallocating funding. Although I was aware of these limitations for using return on investment, I learned about the types of factors to include in protocols for disinvestment and inform local health departments of these limitations. Given that using return on investment for discretionary programs, like lung cancer screening, is extremely complex, the aim of this study will be to inform future research on local health department disinvestment choices and to help close the gap that exists in research on disinvestment.

Aims

The specific aims are:

- To use a combination of survey tools and secondary data analysis to explore the decision-making process in local health departments.
- To identify critical gaps in the process of decision-making that can be strengthened to improve health outcomes.
- To create a standardized best practice to guide program disinvestment processes and decisions with an emphasis on using return on investment as a tool for decision-making.

Research Methodology

This study will employ a mixed methods approach that combines a quantitative survey instrument with a qualitative portion to elicit more contextual information. I will administer a survey with open-ended questions and answers based on a Likert-type scale of 1 to 5. This scale will enable the survey to elicit different factors that may influence disinvestment and provide metrics to quantitatively analyze the input from study participants. Through the survey, I will elicit participants' perceptions of their local health department's governance and decision-making structure, work culture, and prioritization structure. Harris et al. (2017) suggested that there are some limitations to consider when organizing a disinvestment method or program, such as how to create generalizability for such a method, because some counties may have centralized decision-making systems. The aim of this study is to explore these limitations by asking specific questions about the support and governance of county board members and the board of health.

The survey questions will ask the local health departments for their disinvestment patterns in programs for the most recent fiscal year to gain knowledge of how these patterns compare across different counties, as well as numeric data concerning disinvestment for the regression analysis. It will also ask for the county's lung cancer rates and demographics to learn about health outcomes. The study will employ secondary data analysis methods to assess the records of health departments to determine if there is a relationship between the participants' perceptions elicited through the surveys and the number of disinvestments occurring in a year. Where these are not available, I will make use of the survey answers provided by the participants.

Participant selection for survey. I will select 30 participants who are public health professionals in counties in California. The list of these participants will be sourced from a list of 30 attendees of a conference presentation on utilizing return on investment in local public health departments. I will select these 30 attendees to participate because they are familiar with return on investment in the local health department setting. Moreover, the survey questions related to return on investment will capture their opinions on using it as a method. I will use a convenience sample given the ease of access to a purposeful group of experts. This will serve as a pilot to inform more representative sampling of the health workforce.

Survey administration. I will administer a survey to participants to understand decision-making in local health departments via a Qualtrics survey link sent to the attendees' email addresses. The survey will explore the following factors:

- The number of cases, costs, and patient demographics of lung cancer at the county level, such as how much in USD lung cancer costs in the county, how many lung cancer deaths are in the county, and the loss of productivity in USD.
- The amount in USD of disinvestment in programs in the most recent year, the types of programs that were disinvested, and the reasons for disinvestment in these programs.
- How much the participant agrees on statements regarding the local health department's:
    - Governance and decision-making structure, such as the amount of autonomy and authority given to the top official or project coordinator.
    - Work culture, such as the leadership dynamics and adaptability to new programs.
    - Prioritization structure, such as the way the department identifies priorities and whether the department has principles that guide these decisions.

Survey analysis. For the first part of the survey, I will identify the participant demographics by listing the counties in which they are located and the departments for which they work (i.e., community health, environmental health). I will organize lung cancer data with a table sorted by county with information on rates, patient demographics, and the cost in USD. In addition to participant demographics and county lung cancer data, I will provide a list, in no particular order, of the programs that local health departments have disinvested from in the past year by and an average number of disinvestments from all counties.

To analyze the second part of survey data, I will use regression analysis to understand which independent variables (structure, culture, or prioritization methods of local health departments) are related to the dependent variable I will examine (disinvestment). To begin, I will conduct a descriptive analysis of the second survey set where I will count the frequency of each scale per question and describe this with a percentage. This will answer questions, such as the number of participants who agree that their local health departments' structures hinders the success of their implementation of programs. I will then calculate the mean of each question's scale to answer the mean of agreement overall of participants for that question. I will calculate a standard deviation for each metric.

With a regression analysis, I will analyze survey data from each of the survey categories. Because survey responses will be in a Likert-type scale, the analysis will be based on the correlation between participants' perceptions of the agency structure, culture, prioritization, and the year's number of disinvestments. This will help me understand potential factors that influence disinvestments. The information provided by participants, as well as the information unavailable to them, will also inform me about which metrics to collect to inform health system decisions and learn how transparent the records and decisions are in such departments.

Creating a decision-making guide with return on investment for lung cancer screening programs. Results from the second survey portion of this study aim to find correlations in agency structure, culture, and prioritization and disinvestment decisions. These results will argue for the use of return on investment by identifying factors that influence disinvestment and providing an alternative to method to making disinvestment decisions. For example, if a lack of agency structure is correlated with higher disinvestment rates in programs, then this can argue for the use of return on investment to better guide prioritization methods to disinvest in programs. With county lung cancer data, we will calculate the return on investment for each participant's county health department. This will be used to inform a lung cancer screening program to serve as an example of how to model program decisions with return on investment. Return on investment will be calculated using the following formula (see Brown, 2016) where PV means present value:

$$\frac{\Sigma_{i=1}^{10}(PV\ of\ avoided\ deaths) + \Sigma_{i=1}^{4}(PV\ of\ improved\ health\ status) - (PV\ of\ expenditures)}{(PV\ of\ expenditures)}$$

I will use this return on investment formula because expenditures are scaled up to adjust to California local health departments (see Brown, 2016). I will provide this formula in the guide created for local health departments, using sample calculations with sources of present values of avoided deaths, improved health status, and expenditures (see Brown, 2016) to help the reader understand how to calculate return on investment. For local health departments with current lung cancer screening initiatives, I will use this formula to calculate their return on investment using data taken from the survey as well as additional data available through county public health records. For departments without initiatives, I will use this to calculate a projected return on investment for use to argue for lung cancer screening programs.

When developing a guide for the lung cancer screening program, I will refer to the Sustainability in Healthcare by Allocating Resources Effectively (SHARE) Program's SEAchange model for Sustainable, Effective, and Appropriate change in health services (see Harris et al., 2017). This SEAchange model includes four steps, which I will tailor to this study:

1. Identifying the need for a lung cancer screening program,
2. Developing a proposal to meet the need for this program,
3. Implementing the proposal for the program, and
4. Evaluating the extent and impact of the program.

I chose this guide because each step utilizes evidence-based practices to inform decision-making that take into account data health service staff expertise and consumer values and views (see Harris et al., 2017). Within this guide, I will incorporate calculations for return on investment from Brown et al. (2016) to help inform local health departments of its use. Once the guide has been distributed to the participants, I will follow-up with input and suggestions to the guide through contact with study participants. The guide will be revised with these suggestions.

Expected Results and Impact

This study will produce reports that identify the importance of different organizational factors concerning disinvestment and return on investment values for each of the participants' counties in California. The methods and results of the study will inform efforts to develop and deploy appropriate policies essential to making decisions and prioritization for local health departments, especially lung cancer screening programs. I aim for this study to provide a standardized guide for making disinvestment decisions using return on investment because there is little information to help guide local health authorities and departments in systematic approaches towards disinvestment, (Harris et al., 2017).

Although disinvestment decisions can happen at the central level, there are still barriers to applying these decisions to local health departments where disinvestment may depend on community factors or factors within the organization (Harris et al., 2017). Exploring local health department decision-making processes through surveys and regression analysis will allow for a comprehensive examination of the different organizational factors of decision-making within agencies that are dependent on multiple levels of surveillance and funding. These results can help close the critical gaps in decision-making processes for local health departments. I expect that closing this gap will contribute to creating better health outcomes with the use of return on investment to implement lung cancer screening programs.

Dissemination Strategy

I plan to disseminate the findings by publishing in academic journals with interests in health policy and regional health. I will also offer to present the results and consult individually with counties as part of regional or statewide meetings. Academic journals and conferences are the two most common methods of dissemination, but in a report, 75% of public health researchers believe that dissemination should also be targeted to nonresearch audiences (Brownson et al., 2018). This is particularly critical for such a study as this that can inform practice. I will, therefore, disseminate findings from the study directly to the participants' county public health departments by preparing an individualized report detailing the costs of lung cancer in their region (including information on age, gender, and race) in California, and the return on investment values. Along with this report, I will prepare a guide on how to conduct a return on investment using lung cancer screening as an example. Because policy makers are key decision makers and play a large role in local health department funding, I aim to share my findings with them and their staff in a concise and understandable manner by providing locally relevant data that could be of great use to help them understand the scope and need of our findings (see Brownson et al., 2018). I will also indicate a willingness to offer training to policymakers and the staff of health departments at the local and state levels regarding how to calculate returns on investment, how to organize their county data to facilitate effective decision-making, and how to build their staff capacity for evidence-based investment and disinvestment decision-making.

Table A 1

Baseline Case Costs and Utility Costs

County	Stage I	Stage II and III	Stage IV	Total Cases	Baseline Screening cost	Treatment Costs Stage I	stage II and III	stage IV	Total Treatment Cost with stage I–IV	Utility Loss Stage I	Stage II and III	Stage IV	Total	Utility Cost 50,000	Total treatment cost with utility
Alameda	681	515	440	1636	394,276	1,530,888	17,172,160	21,028,480	39,731,528	2813.156	3855.352	4037.9	10706.408	535320400	$575,051,928
Butte	183	130	78	391	94,231	411,384	4,334,720	3,727,776	8,473,880	752.287	904.482	691.74	2348.509	117425450	$125,899,330
Contra	612	415	318	1345	324,145	1,375,776	13,837,760	15,197,856	30,411,392	2498.53	3020.25	2761.92	8280.7	414035000	$444,446,392
Del Norte, Siskiyou, Lassen, Trinity, Modoc, Plumas, and Sierra County	103	97	59	42	10,122	231,544	3,234,368	2,819,728	6,285,640	400.89	777.5	537.534	1715.924	85796200	$92,081,840
El Dorado	123	88	55	266	64,106	276,504	2,934,272	2,628,560	5,839,336	495.046	605.49	506.794	1607.33	80366500	$86,205,836
Fresno	331	276	230	837	201,717	744,088	9,202,944	10,992,160	20,939,192	1258.904	2124.566	2110.882	5494.352	274717600	$295,656,792
Humboldt	65	50	33	148	35,668	146,120	1,667,200	1,577,136	3,390,456	276.534	398.526	298.502	973.562	48678100	$52,068,556
Imperial	51	44	33	128	30,848	114,648	1,467,136	1,577,136	3,158,920	232.817	286.926	274.87	794.613	39730650	$42,889,570
Kern	237	175	35	691	166,531	532,776	5,835,200	1,672,720	8,040,696	1170.724	1898.722	1753.95	4823.396	241169800	$249,210,496
Kings	35	35	27	97	23,377	78,680	1,167,040	1,290,384	2,536,104	155.218	341.508	275.614	772.34	38617000	$41,153,104
Lake	79	50	34	163	39,283	177,592	1,667,200	1,624,928	3,469,720	304.306	392.114	299.636	996.056	49802800	$53,272,520
Los Angeles	4222	2920	2426	9568	2,305,888	9,491,056	97,364,480	115,943,392	222,798,928	16980.92	21467.74	22780.46	61229.12	3061456000	$3,284,254,928
Madera	66	48	43	157	37,837	148,368	1,600,512	2,055,056	3,803,936	276.697	364.234	394.334	1035.265	51763250	$55,567,186
Marin	184	124	94	402	96,882	413,632	4,134,656	4,492,448	9,040,736	679.808	754.832	791.888	2226.528	111326400	$120,367,136
Mendocino	56	44	25	125	30,125	125,888	1,467,136	1,194,800	2,787,824	207.751	340.594	258.986	807.331	40366550	$43,154,374
Merced	113	70	57	240	57,840	254,024	2,334,080	2,724,144	5,312,248	475.122	486.166	493.882	1455.17	72758500	$78,070,748

County	Stage I	Stage II and III	Stage IV	Total Cases	Baseline Screening cost	Treatment Costs Stage I	stage II and III	stage IV	Total Treatment Cost with stage I–IV	Utility Loss Stage I	Stage II and III	Stage IV	Total	Utility Cost 50,000	Total treatment cost with utility
Monterey	179	124	110	413	99,533	402,392	4,134,656	5,257,120	9,794,168	693.34	889.21	990.804	2573.354	128667700	$138,461,868
Napa	95	70	44	209	50,369	213,560	2,334,080	2,102,848	4,650,488	383.382	416.478	341.448	1141.308	57065400	$61,715,888
Nevada	95	53	32	180	43,380	213,560	1,767,232	1,529,344	3,510,136	337.241	336.578	314.244	988.063	49403150	$52,913,286
Orange	1690	1138	882	3710	894,110	3,799,120	37,945,472	42,152,544	83,897,136	6659.033	8115.474	8181.784	22956.291	1147814550	$1,231,711,686
Placer	239	154	104	497	119,777	537,272	5,134,976	4,970,368	10,642,616	948.147	1155.232	1024.24	3127.619	156380950	$167,023,566
Riverside	968	681	470	2119	510,679	2,176,064	22,707,264	22,462,240	47,345,568	3848.82	4707.402	4218.884	12775.106	638755300	$686,100,868
Sacramento	799	552	441	1792	431,872	1,796,152	18,405,888	21,076,272	41,278,312	3319.682	4288.518	4348.37	11956.57	597828500	$639,106,812
San Benito	15	10	10	35	8,435	33,720	333,440	477,920	845,080	71.185	83.87	132.976	288.031	14401550	$15,246,630
San Bernardino	736	502	422	1660	400,060	1,654,528	16,738,688	20,168,224	38,561,440	3038.06	3840.13	4093.672	10971.862	548593100	$587,154,540
San Diego	1822	1109	827	3758	905,678	4,095,856	36,978,496	39,523,984	80,598,336	7299.474	8237.69	7637.126	23174.29	1158714500	$1,239,312,836
San Francisco	518	345	313	1176	283,416	1,164,464	11,503,680	14,958,896	27,627,040	2153.969	2326.614	3075.578	7556.161	377808050	$405,435,090
San Joaquin	330	238	154	722	174,002	741,840	7,935,872	7,359,968	16,037,680	1374.464	1891.4	1469.62	4735.484	236774200	$252,811,880
San Luis	171	110	87	368	88,688	384,408	3,667,840	4,157,904	8,210,152	652.34	864.5	891.962	2408.802	120440100	$128,650,252
San Mateo	476	334	278	1088	262,208	1,070,048	11,136,896	13,286,176	25,493,120	1857.009	2307.36	2460.992	6625.361	331268050	$356,761,170
Santa Barbara	232	189	90	511	123,151	521,536	6,302,016	4,301,280	11,124,832	900.592	1245.13	739.212	2884.934	144246700	$155,371,532
Santa Clara	866	533	458	1857	447,537	1,946,768	17,772,352	21,888,736	41,607,856	3458.001	3930.536	4450.048	11838.585	591929250	$633,537,106
Santa Cruz	97	96	54	247	59,527	218,056	3,201,024	2,580,768	5,999,848	431.122	746.786	561.7575	1739.6655	86983275	$92,983,123
Shasta	134	116	72	322	77,602	301,232	3,867,904	3,441,024	7,610,160	539.383	847.94	422.464	1809.787	90489350	$98,099,510
Solano	219	184	157	560	134,960	492,312	6,135,296	7,503,344	14,130,952	909.581	1371.398	1615.718	3896.697	194834850	$208,965,802
Sonoma	288	219	130	637	153,517	647,424	7,302,336	6,212,960	14,162,720	1174.376	1458.69	1151.36	3784.426	189221300	$203,384,020
Stanislaus	263	162	124	549	132,309	591,224	5,401,728	5,926,208	11,919,160	1091.164	1209.118	1116.048	3416.33	170816500	$182,735,660
Sutter	53	33	25	111	26,751	119,144	1,100,352	1,194,800	2,414,296	206.947	275.37	247.17	729.487	36474350	$38,888,646
Tehama,Glenn, and Colusa County	79	66	42	129	31,089	177,592	2,200,704	2,007,264	4,385,560	305.59	443.404	356.056	1105.05	55252500	$59,638,060

County	Stage I	Stage II and III	Stage IV	Total Cases	Baseline Screening cost	Treatment Costs Stage I	stage II and III	stage IV	Total Treatment Cost with stage I–IV	Utility Loss Stage I	Stage II and III	Stage IV	Total	Utility Cost 50,000	Total treatment cost with utility
Tulare	110	108	87	305	73,505	247,280	3,601,152	4,157,904	8,006,336	454.383	818.188	824.43	2097.001	104850050	$112,856,386
Tuolumne, Calaveras, Amador, Inyo, Mariposa, Mono, and Alpine County	190	123	96	409	98,569	427,120	4,101,312	4,588,032	9,116,464	761.74	1003.151	914.888	2679.779	133988950	$143,105,414
Ventura	408	284	187	879	211,839	917,184	9,469,696	8,937,104	19,323,984	1619.465	2099.258	1675.502	5394.225	269711250	$289,035,234
Yolo	98	56	49	203	48,923	220,304	1,867,264	2,341,808	4,429,376	427.078	568.598	480.542	1476.218	73810900	$78,240,276
Yuba	43	24	15	82	19,762	96,664	800,256	716,880	1,613,800	174.327	183.668	158.094	516.089	25804450	$27,418,250

Table A 2

Diagnoses, Costs and Utility loss 20% Screening Rate

Diagnoses Stage I	Stage II and III	Stage IV	Total	Screening costs	Treatment costs Stage I	Stage II and III	Stage IV	Total cost	Utility loss Stage I	Stage II and III	Stage IV	Total	Utility cost 50,000	Total cost w/utility
0.45	0.31	0.24												
306.45	159.65	136.4	602.5	$145,203	$688,900	$5,323,370	$6,518,829	$12,531,098	2758.05	2969.49	2919.2328	8646.7728	432338640	$444,869,738
82.35	40.3	24.18	146.83	$35,386	$185,123	$1,343,763	$1,155,611	$2,684,497	741.15	749.58	517.50036	2008.23036	100411518	$103,096,015
275.4	128.65	98.58	502.63	$121,134	$619,099	$4,289,706	$4,711,335	$9,620,140	2478.6	2392.89	2109.80916	6981.29916	349064958	$358,685,098
46.35	30.07	18.29	94.71	$22,825	$104,195	$1,002,654	$874,116	$1,980,965	417.15	559.302	391.44258	1367.89458	68394729	$70,375,694
55.35	27.28	17.05	99.68	$24,023	$124,427	$909,624	$814,854	$1,848,905	498.15	507.408	364.9041	1370.4621	68523105	$70,372,010
148.95	85.56	71.3	305.81	$73,700	$334,840	$2,852,913	$3,407,570	$6,595,322	1340.55	1591.416	1525.9626	4457.9286	222896430	$229,491,752
29.25	15.5	10.23	54.98	$13,250	$65,754	$516,832	$488,912	$1,071,498	263.25	288.3	218.94246	770.49246	38524623	$39,596,121
22.95	13.64	10.23	46.82	$11,284	$51,592	$454,812	$488,912	$995,316	206.55	253.704	218.94246	679.19646	33959823	$34,955,139
106.65	54.25	10.85	171.75	$41,392	$239,749	$1,808,912	$518,543	$2,567,204	959.85	1009.05	232.2117	2201.1117	110055585	$112,622,789
15.75	10.85	8.37	34.97	$8,428	$35,406	$361,782	$400,019	$797,207	141.75	201.81	179.13474	522.69474	26134737	$26,931,944
35.55	15.5	10.54	61.59	$14,843	$79,916	$516,832	$503,728	$1,100,476	319.95	288.3	225.57708	833.82708	41691354	$42,791,830
1899.9	905.2	752.06	3557.16	$857,276	$4,270,975	$30,182,989	$35,942,452	$70,396,416	17099.1	16836.72	16095.58812	50031.40812	2501570406	$2,571,966,822
29.7	14.88	13.33	57.91	$13,956	$66,766	$496,159	$637,067	$1,199,992	267.3	276.768	285.28866	829.35666	41467833	$42,667,825
82.8	38.44	29.14	150.38	$36,242	$186,134	$1,281,743	$1,392,659	$2,860,537	745.2	714.984	623.65428	2083.83828	104191914	$107,052,451
25.2	13.64	7.75	46.59	$11,228	$56,650	$454,812	$370,388	$881,850	226.8	253.704	165.8655	646.3695	32318475	$33,200,325
50.85	21.7	17.67	90.22	$21,743	$114,311	$723,565	$844,485	$1,682,360	457.65	403.62	378.17334	1239.44334	61972167	$63,654,527
80.55	38.44	34.1	153.09	$36,895	$181,076	$1,281,743	$1,629,707	$3,092,527	724.95	714.984	729.8082	2169.7422	108487110	$111,579,637

Diagnoses Stage I	Diagnoses Stage II and III	Diagnoses Stage IV	Total	Screening costs	Treatment costs Stage I	Treatment costs Stage II and III	Treatment costs Stage IV	Total cost	Utility loss Stage I	Utility loss Stage II and III	Utility loss Stage IV	Total	Utility cost 50,000	Total cost w/utility
0.45	0.31	0.24												
42.75	21.7	13.64	78.09	$18,820	$96,102	$723,565	$651,883	$1,471,550	384.75	403.62	291.92328	1080.29328	54014664	$55,486,214
42.75	16.43	9.92	69.1	$16,653	$96,102	$547,842	$474,097	$1,118,041	384.75	305.598	212.30784	902.65584	45132792	$46,250,833
760.5	352.78	273.42	1386.7	$334,195	$1,709,604	$11,763,096	$13,067,289	$26,539,989	6844.5	6561.708	5851.73484	19257.94284	962897142	$989,437,131
107.55	47.74	32.24	187.53	$45,195	$241,772	$1,591,843	$1,540,814	$3,374,429	967.95	887.964	690.00048	2545.91448	127295724	$130,670,153
435.6	211.11	145.7	792.41	$190,971	$979,229	$7,039,252	$6,963,294	$14,981,775	3920.4	3926.646	3118.2714	10965.3174	548265870	$563,247,645
359.55	171.12	136.71	667.38	$160,839	$808,268	$5,705,825	$6,533,644	$13,047,738	3235.95	3182.832	2925.86742	9344.64942	467232471	$480,280,209
6.75	3.1	3.1	12.95	$3,121	$15,174	$103,366	$148,155	$266,696	60.75	57.66	66.3462	184.7562	9237810	$9,504,506
331.2	155.62	130.82	617.64	$148,851	$744,538	$5,188,993	$6,252,149	$12,185,680	2980.8	2894.532	2799.80964	8675.14164	433757082	$445,942,762
819.9	343.79	256.37	1420.06	$342,234	$1,843,135	$11,463,334	$12,252,435	$25,558,904	7379.1	6394.494	5486.83074	19260.42474	963021237	$988,580,141
233.1	106.95	97.03	437.08	$105,336	$524,009	$3,566,141	$4,637,258	$8,727,407	2097.9	1989.27	2076.63606	6163.80606	308190303	$316,917,710
148.5	73.78	47.74	270.02	$65,075	$333,828	$2,460,120	$2,281,590	$5,075,538	1336.5	1372.308	1021.73148	3730.53948	186526974	$191,602,512
76.95	34.1	26.97	138.02	$33,263	$172,984	$1,137,030	$1,288,950	$2,598,964	692.55	634.26	577.21194	1904.02194	95201097	$97,800,061
214.2	103.54	86.18	403.92	$97,345	$481,522	$3,452,438	$4,118,715	$8,052,674	1927.8	1925.844	1844.42436	5698.06836	284903418	$292,956,092
104.4	58.59	27.9	190.89	$46,004	$234,691	$1,953,625	$1,333,397	$3,521,713	939.6	1089.774	597.1158	2626.4898	131324490	$134,846,203
389.7	165.23	141.98	696.91	$167,955	$876,046	$5,509,429	$6,785,508	$13,170,983	3507.3	3073.278	3038.65596	9619.23396	480961698	$494,132,681
43.65	29.76	16.74	90.15	$21,726	$98,125	$992,317	$800,038	$1,890,481	392.85	553.536	358.26948	1304.65548	65232774	$67,123,255
60.3	35.96	22.32	118.58	$28,578	$135,554	$1,199,050	$1,066,717	$2,401,322	542.7	668.856	477.69264	1689.24864	84462432	$86,863,754
98.55	57.04	48.67	204.26	$49,227	$221,540	$1,901,942	$2,326,037	$4,449,519	886.95	1060.944	1041.63534	2989.52934	149476467	$153,925,986
129.6	67.89	40.3	237.79	$57,307	$291,341	$2,263,724	$1,926,018	$4,481,083	1166.4	1262.754	862.5006	3291.6546	164582730	$169,063,813
118.35	50.22	38.44	207.01	$49,889	$266,051	$1,674,536	$1,837,124	$3,777,711	1065.15	934.092	822.69288	2821.93488	141096744	$144,874,455
23.85	10.23	7.75	41.83	$10,081	$53,615	$341,109	$370,388	$765,112	214.65	190.278	165.8655	570.7935	28539675	$29,304,787

Diagnoses														
Stage I	Stage II and III	Stage IV	Total	Screening costs	Treatment costs				Utility loss					Total cost w/utility
0.45	0.31	0.24			Stage I	Stage II and III	Stage IV	Total cost	Stage I	Stage II and III	Stage IV	Total	Utility cost 50,000	
35.55	20.46	13.02	69.03	$16,636	$79,916	$682,218	$622,252	$1,384,386	319.95	380.556	278.65404	979.16004	48958002	$50,342,388
49.5	33.48	26.97	109.95	$26,498	$111,276	$1,116,357	$1,288,950	$2,516,583	445.5	622.728	577.21194	1645.43994	82271997	$84,788,580
85.5	38.13	29.76	153.39	$36,967	$192,204	$1,271,407	$1,422,290	$2,885,901	769.5	709.218	636.92352	2115.64152	105782076	$108,667,977
183.6	88.04	57.97	329.61	$79,436	$412,733	$2,935,606	$2,770,502	$6,118,841	1652.4	1637.544	1240.67394	4530.61794	226530897	$232,649,738
44.1	17.36	15.19	76.65	$18,473	$99,137	$578,852	$725,960	$1,403,949	396.9	322.896	325.09638	1044.89238	52244619	$53,648,568
19.35	7.44	4.65	31.44	$7,577	$43,499	$248,079	$222,233	$513,811	174.15	138.384	99.5193	412.0533	20602665	$21,116,476

Table A 3

Diagnoses Costs, and Utility loss 50% Screening

Stage I	Stage II and III	Diagnoses Stage IV	Total cases	Screening cost	Treatment costs				Utility loss			Total		Total cost w/ utility
0.453	0.308	0.239			stage I	Stage II and III	Stage IV	Total cost	Stage I	Stage II and III	Stage IV		Utility cost 50,000	
308.493	158.62	105.16	572.273	137,918	693,492	5,289,025	5,025,807	11,008,324	2776.437	2950.332	2250.63432	7977.40332	398870166	$409,878,490
82.899	40.04	18.642	141.581	34,121	186,357	1,335,094	890,938	2,412,389	746.091	744.744	398.976084	1889.811084	94490554.2	$96,902,943
277.236	127.82	76.002	481.058	115,935	623,227	4,262,030	3,632,288	8,517,544	2495.124	2377.452	1626.594804	6499.170804	324958540.2	$333,476,084
46.659	29.876	14.101	90.636	21,843	104,889	996,185	673,915	1,774,990	419.931	555.6936	301.789602	1277.414202	63870710.1	$65,645,700
55.719	27.104	13.145	95.968	23,128	125,256	903,756	628,226	1,657,238	501.471	504.1344	281.32929	1286.93469	64346734.5	$66,003,972
149.943	85.008	54.97	289.921	69,871	337,072	2,834,507	2,627,126	5,798,705	1349.487	1581.1488	1176.46794	4107.10374	205355187	$211,153,892
29.445	15.4	7.887	52.732	12,708	66,192	513,498	376,936	956,625	265.005	286.44	168.797574	720.242574	36012128.7	$36,968,754
23.103	13.552	7.887	44.542	10,735	51,936	451,878	376,936	880,749	207.927	252.0672	168.797574	628.791774	31439588.7	$32,320,338
107.361	53.9	8.365	169.626	40,880	241,348	1,797,242	399,780	2,438,369	966.249	1002.54	179.02773	2147.81673	107390836.5	$109,829,206
15.855	10.78	6.453	33.088	7,974	35,642	359,448	308,402	703,492	142.695	200.508	138.107106	481.310106	24065505.3	$24,768,997
35.787	15.4	8.126	59.313	14,294	80,449	513,498	388,358	982,305	322.083	286.44	173.912652	782.435652	39121782.6	$40,104,087
1912.566	899.36	579.814	3391.74	817,409	4,299,448	29,988,260	27,710,471	61,998,179	17213.094	16728.096	12409.17923	46350.36923	2317518461	$2,379,516,640
29.898	14.784	10.277	54.959	13,245	67,211	492,958	491,158	1,051,327	269.082	274.9824	219.948354	764.012754	38200637.7	$39,251,964
83.352	38.192	22.466	144.01	34,706	187,375	1,273,474	1,073,695	2,534,544	750.168	710.3712	480.817332	1941.356532	97067826.6	$99,602,371
25.368	13.552	5.975	44.895	10,820	57,027	451,878	285,557	794,462	228.312	252.0672	127.87695	608.25615	30412807.5	$31,207,270
51.189	21.56	13.623	86.372	20,816	115,073	718,897	651,070	1,485,040	460.701	401.016	291.559446	1153.276446	57663822.3	$59,148,862
81.087	38.192	26.29	145.569	35,082	182,284	1,273,474	1,256,452	2,712,209	729.783	710.3712	562.65858	2002.81278	100140639	$102,852,848
43.035	21.56	10.516	75.111	18,102	96,743	718,897	502,581	1,318,220	387.315	401.016	225.063432	1013.394432	50669721.6	$51,987,942
43.035	16.324	7.648	67.007	16,149	96,743	544,307	365,513	1,006,563	387.315	303.6264	163.682496	854.623896	42731194.8	$43,737,758

765.57	350.504	210.798	1326.872	319,776	1,721,001	11,687,205	10,074,458	23,482,665	6890.13	6519.3744	4511.498796	17921.0032	896050159.8	$919,532,825

Diagnoses Stage I	Stage II and III	Stage IV	Total	Screening cost	Treatment costs				Utility loss			Total	Utility cost	Total cost w/ utility
0.453	0.308	0.239			Costs stage I	Stage II and III	Stage IV	Total cost	Stage I	Stage II and III	Stage IV		50,000	
108.267	47.432	24.856	180.555	43,514	243,384	1,581,573	1,187,918	3,012,875	974.403	882.2352	531.968112	2388.606312	119430315.6	$122,443,190
438.504	209.748	112.33	760.582	183,300	985,757	6,993,837	5,368,475	13,348,070	3946.536	3901.3128	2404.08666	10251.93546	512596773	$525,944,843
361.947	170.016	105.399	637.362	153,604	813,657	5,669,014	5,037,229	11,519,899	3257.523	3162.2976	2255.749398	8675.569998	433778499.9	$445,298,399
6.795	3.08	2.39	12.265	2,956	15,275	102,700	114,223	232,198	61.155	57.288	51.15078	169.59378	8479689	$8,711,887
333.408	154.616	100.858	588.882	141,921	749,501	5,155,516	4,820,206	10,725,223	3000.672	2875.8576	2158.562916	8035.092516	401754625.8	$412,479,848
825.366	341.572	197.653	1364.591	328,866	1,855,423	11,389,377	9,446,232	22,691,032	7428.294	6353.2392	4230.169506	18011.70271	900585135.3	$923,276,167
234.654	106.26	74.807	415.721	100,189	527,502	3,543,133	3,575,176	7,645,812	2111.886	1976.436	1601.019414	5689.341414	284467070.7	$292,112,882
149.49	73.304	36.806	259.6	62,564	336,054	2,444,249	1,759,032	4,539,334	1345.41	1363.4544	787.722012	3496.586412	174829320.6	$179,368,655
77.463	33.88	20.793	132.136	31,845	174,137	1,129,695	993,739	2,297,571	697.167	630.168	445.011786	1772.346786	88617339.3	$90,914,910
215.628	102.872	66.442	384.942	92,771	484,732	3,430,164	3,175,396	7,090,292	1940.652	1913.4192	1421.991684	5276.062884	263803144.2	$270,893,436
105.096	58.212	21.51	184.818	44,541	236,256	1,941,021	1,028,006	3,205,283	945.864	1082.7432	460.35702	2488.96422	124448211	$127,653,494
392.298	164.164	109.462	665.924	160,488	881,886	5,473,884	5,231,408	11,587,178	3530.682	3053.4504	2342.705724	8926.838124	446341906.2	$457,929,084
43.941	29.568	12.906	86.415	20,826	98,779	985,915	616,804	1,701,498	395.469	549.9648	276.214212	1221.648012	61082400.6	$62,783,899
60.702	35.728	17.208	113.638	27,387	136,458	1,191,314	822,405	2,150,177	546.318	664.5408	368.285616	1579.144416	78957220.8	$81,107,398
99.207	56.672	37.523	193.402	46,610	223,017	1,889,671	1,793,299	3,905,988	892.863	1054.0992	803.067246	2750.029446	137501472.3	$141,407,460
130.464	67.452	31.07	228.986	55,186	293,283	2,249,119	1,484,897	4,027,300	1174.176	1254.6072	664.96014	3093.74334	154687167	$158,714,467
119.139	49.896	29.636	198.671	47,880	267,824	1,663,732	1,416,364	3,347,920	1072.251	928.0656	634.269672	2634.586272	131729313.6	$135,077,234
24.009	10.164	5.975	40.148	9,676	53,972	338,908	285,557	678,438	216.081	189.0504	127.87695	533.00835	26650417.5	$27,328,855
35.787	20.328	10.038	66.153	15,943	80,449	677,817	479,736	1,238,002	322.083	378.1008	214.833276	915.017076	45750853.8	$46,988,856
49.83	33.264	20.793	103.887	25,037	112,018	1,109,155	993,739	2,214,912	448.47	618.7104	445.011786	1512.192186	75609609.3	$77,824,521
86.07	37.884	22.944	146.898	35,402	193,485	1,263,204	1,096,540	2,553,229	774.63	704.6424	491.047488	1970.319888	98515994.4	$101,069,224

184.824	87.472	44.693	316.989	76,394	415,484	2,916,666	2,135,968	5,468,119	1663.416	1626.9792	956.519586	4246.914786	212345739.3	$217,813,858

Diagnoses														
Stage I	Stage II and III	Stage IV	Total	Screening cost	Treatment costs				Utility loss			Total	Utility cost	Total cost w/ utility
0.453	0.308	0.239			Costs stage I	Stage II and III	Stage IV	Total cost	Stage I	Stage II and III	Stage IV		50,000	
44.394	17.248	11.711	73.353	17,678	99,798	575,117	559,692	1,234,607	399.546	320.8128	250.638822	970.997622	48549881.1	$49,784,488
19.479	7.392	3.585	30.456	7,340	43,789	246,479	171,334	461,602	175.311	137.4912	76.72617	389.52837	19476418.5	$19,938,020

Table A 4

Diagnoses   Costs and Utility loss 80% Screening

Stage I	Diagnoses Stage II and III	Stage IV	Total	Screening cost	Treatment costs				Utility loss			Total	Utility cost	Total cost w/utility
0.455	0.306	0.239			Costs Stage I	Stage II and III	Stage IV	Total cost	Stage I	Stage II and III	Stage IV		50000	
309.855	157.59	134.64	602.085	$145,102	$696,554	$5,254,681	$6,434,715	$12,385,950	2788.695	2931	2882	8601	430071714	442457664
83.265	39.78	23.868	146.913	$35,406	$187,180	$1,326,424	$1,140,699	$2,654,303	749.385	740	511	2000	100005797	102660100
278.46	126.99	97.308	502.758	$121,165	$625,978	$4,234,355	$4,650,544	$9,510,877	2506.14	2362	2083	6951	347536991	357047867
46.865	29.682	18.054	94.601	$22,799	$105,353	$989,717	$862,837	$1,957,906	421.785	552	386	1360	68013095	69971001
55.965	26.928	16.83	99.723	$24,033	$125,809	$897,887	$804,339	$1,828,036	503.685	501	360	1365	68237073	70065109
150.605	84.456	70.38	305.441	$73,611	$338,560	$2,816,101	$3,363,601	$6,518,262	1355.445	1571	1506	4433	221629968	228148230
29.575	15.3	10.098	54.973	$13,248	$66,485	$510,163	$482,604	$1,059,251	266.175	285	216	767	38343620	39402871
23.205	13.464	10.098	46.767	$11,271	$52,165	$448,944	$482,604	$983,712	208.845	250	216	675	33769640	34753352
107.835	53.55	10.71	172.095	$41,475	$242,413	$1,785,571	$511,852	$2,539,837	970.515	996	229	2196	109788021	112327858
15.925	10.71	8.262	34.897	$8,410	$35,799	$357,114	$394,858	$787,771	143.325	199	177	519	25967716	26755487
35.945	15.3	10.404	61.649	$14,857	$80,804	$510,163	$497,228	$1,088,196	323.505	285	223	831	41537570	42625766
1921.01	893.52	742.356	3556.886	$857,210	$4,318,430	$29,793,531	$35,478,678	$69,590,639	17289.09	16619	15888	49796	2489823256	2559413895
30.03	14.688	13.158	57.876	$13,948	$67,507	$489,757	$628,847	$1,186,111	270.27	273	282	825	41253716	42439827
83.72	37.944	28.764	150.428	$36,253	$188,203	$1,265,205	$1,374,689	$2,828,096	753.48	706	616	2075	103742276	106570373
25.48	13.464	7.65	46.594	$11,229	$57,279	$448,944	$365,609	$871,831	229.32	250	164	643	32173785	33045616
51.415	21.42	17.442	90.277	$21,757	$115,581	$714,228	$833,588	$1,663,397	462.735	398	373	1234	61722034	63385432
81.445	37.944	33.66	153.049	$36,885	$183,088	$1,265,205	$1,608,679	$3,056,972	733.005	706	720	2159	107957736	111014708
43.225	21.42	13.464	78.109	$18,824	$97,170	$714,228	$643,471	$1,454,870	389.025	398	288	1076	53779676	55234546
43.225	16.218	9.792	69.235	$16,686	$97,170	$540,773	$467,979	$1,105,922	389.025	302	210	900	45012409	46118331

Diagnoses						Treatment costs			Utility loss					
Stage I	Stage II and III	Stage IV	Total	Screening cost								Total	Utility cost	Total cost w/utility
0.455	0.306	0.239			Costs Stage I	Stage II and III	Stage IV	Total cost	Stage I	Stage II and III	Stage IV		50000	
768.95	348.228	269.892	1387.07	$334,284	$1,728,600	$11,611,314	$12,898,678	$26,238,592	6920.55	6477	5776	19174	958690969	984929562
108.745	47.124	31.824	187.693	$45,234	$244,459	$1,571,303	$1,520,933	$3,336,694	978.705	877	681	2536	126815432	130152126
440.44	208.386	143.82	792.646	$191,028	$990,109	$6,948,423	$6,873,445	$14,811,977	3963.96	3876	3078	10918	545898762	560710739
363.545	168.912	134.946	667.403	$160,844	$817,249	$5,632,202	$6,449,339	$12,898,790	3271.905	3142	2888	9302	465089125	477987915
6.825	3.06	3.06	12.945	$3,120	$15,343	$102,033	$146,244	$263,619	61.425	57	65	184	9191556	9455175
334.88	153.612	129.132	617.624	$148,847	$752,810	$5,122,039	$6,171,477	$12,046,325	3013.92	2857	2764	8635	431739313	443785639
829.01	339.354	253.062	1421.426	$342,564	$1,863,614	$11,315,420	$12,094,339	$25,273,373	7461.09	6312	5416	19189	959455366	984728740
235.69	105.57	95.778	437.038	$105,326	$529,831	$3,520,126	$4,577,422	$8,627,379	2121.21	1964	2050	6135	306732638	315360017
150.15	72.828	47.124	270.102	$65,095	$337,537	$2,428,377	$2,252,150	$5,018,064	1351.35	1355	1009	3714	185724932	190742997
77.805	33.66	26.622	138.087	$33,279	$174,906	$1,122,359	$1,272,319	$2,569,583	700.245	626	570	1896	94804252	97373836
216.58	102.204	85.068	403.852	$97,328	$486,872	$3,407,890	$4,065,570	$7,960,332	1949.22	1901	1821	5671	283541987	291502319
105.56	57.834	27.54	190.934	$46,015	$237,299	$1,928,417	$1,316,192	$3,481,907	950.04	1076	589	2615	130758174	134240081
394.03	163.098	140.148	697.276	$168,044	$885,779	$5,438,340	$6,697,953	$13,022,072	3546.27	3034	2999	9579	478967015	491989087
44.135	29.376	16.524	90.035	$21,698	$99,215	$979,513	$789,715	$1,868,444	397.215	546	354	1297	64862762	66731206
60.97	35.496	22.032	118.498	$28,558	$137,061	$1,183,579	$1,052,953	$2,373,593	548.73	660	472	1680	84024223	86397816
99.645	56.304	48.042	203.991	$49,162	$224,002	$1,877,401	$2,296,023	$4,397,426	896.805	1047	1028	2972	148612714	153010140
131.04	67.014	39.78	237.834	$57,318	$294,578	$2,234,515	$1,901,166	$4,430,258	1179.36	1246	851	3277	163859598	168289856
119.665	49.572	37.944	207.181	$49,931	$269,007	$1,652,929	$1,813,420	$3,735,355	1076.985	922	812	2811	140555084	144290440
24.115	10.098	7.65	41.863	$10,089	$54,211	$336,708	$365,609	$756,527	217.035	188	164	569	28429155	29185682
35.945	20.196	12.852	68.993	$16,627	$80,804	$673,415	$614,223	$1,368,443	323.505	376	275	974	48710455	50078898

	Diagnoses													
Stage I	Stage II and III	Stage IV	Total	Screening cost		Treatment costs			Utility loss			Total	Utility cost	Total cost w/utility
0.455	0.306	0.239			Costs Stage I	Stage II and III	Stage IV	Total cost	Stage I	Stage II and III	Stage IV		50000	
50.05	33.048	26.622	109.72	$26,443	$112,512	$1,101,953	$1,272,319	$2,486,784	450.45	615	570	1635	81745342	84232126
86.45	37.638	29.376	153.464	$36,985	$194,340	$1,255,001	$1,403,938	$2,853,279	778.05	700	629	2107	105341098	108194376
185.64	86.904	57.222	329.766	$79,474	$417,319	$2,897,727	$2,734,754	$6,049,800	1670.76	1616	1225	4512	225591982	231641782
44.59	17.136	14.994	76.72	$18,490	$100,238	$571,383	$716,593	$1,388,214	401.31	319	321	1041	52047059	53435274

Table A 5

ROI With and Without Utility With 20%, 50%, and 80% Screening

County	20% Screening		50% Screening		80% Screening	
	ROI w/out utility	ROI with utility	ROI w/out utility	ROI with utility	ROI w/out utility	ROI with utility
Alameda	-$109.21	-$522.67	-$112.04	-$644.31	-109.745	-532.136
Butte	-$98.38	-$387.52	-$100.84	-$482.39	-98.930	-395.057
Contra	-$102.41	-$422.45	-$105.15	-$532.97	-102.968	-430.576
Del Norte, Siskiyou, Lassen, Trinity, Modoc, Plumas, and Sierra County	$338.87	$1,708.73	$384.83	$2,255.40	341.389	1744.192
El Dorado	-$99.55	-$395.02	-$102.06	-$493.00	-100.100	-402.786
Fresno	-$112.05	-$516.85	-$114.83	-$640.92	-112.571	-526.975
Humboldt	-$103.44	-$556.36	-$106.00	-$657.67	-103.981	-564.940
Imperial	-$110.59	-$405.55	-$113.27	-$525.48	-111.110	-415.598
Kern	-$43.74	-$1,091.49	-$44.59	-$1,109.27	-43.987	-1094.570
Kings	-$116.32	-$951.30	-$118.98	-$1,063.71	-116.814	-961.969
Lake	-$96.94	-$428.84	-$99.54	-$526.98	-97.501	-435.885
Los Angeles	-$105.21	-$491.70	-$108.03	-$607.83	-105.757	-500.346
Madera	-$109.04	-$540.16	-$111.93	-$663.44	-109.583	-549.517
Marin	-$101.92	-$219.57	-$104.64	-$333.97	-102.470	-227.561
Mendocino	-$100.86	-$526.76	-$103.25	-$618.85	-101.398	-534.972
Merced	-$100.56	-$399.37	-$103.37	-$511.07	-101.123	-406.984
Monterey	-$106.99	-$429.17	-$109.88	-$552.50	-107.540	-438.116
Napa	-$100.76	-$197.46	-$103.27	-$301.48	-101.304	-205.465
Nevada	-$89.50	-$249.28	-$91.94	-$336.95	-90.064	-254.546

County	20% Screening		50% Screening		80% Screening	
	ROI w/out utility	ROI with utility	ROI w/out utility	ROI with utility	ROI w/out utility	ROI with utility
Orange	-$102.44	-$432.70	-$105.19	-$543.55	-102.994	-440.819
Placer	-$97.45	-$487.43	-$100.04	-$584.56	-98.010	-494.633
Riverside	-$101.23	-$384.27	-$103.85	-$489.21	-101.778	-392.272
Sacramento	-$104.16	-$586.00	-$106.94	-$696.48	-104.711	-594.474
San Benito	-$108.84	-$1,080.56	-$111.86	-$1,192.66	-109.395	-1089.591
San Bernardino	-$105.00	-$562.13	-$107.83	-$676.67	-105.548	-570.707
San Diego	-$97.68	-$445.00	-$100.39	-$547.90	-98.248	-452.100
San Francisco	-$106.13	-$497.07	-$109.05	-$618.48	-106.686	-505.784
San Joaquin	-$100.64	-$561.93	-$103.18	-$659.05	-101.183	-569.923
San Luis	-$101.24	-$556.61	-$104.02	-$663.85	-101.799	-564.464
San Mateo	-$105.79	-$387.02	-$108.61	-$506.78	-106.337	-395.797
Santa Barbara	-$98.55	-$266.06	-$100.74	-$352.60	-99.084	-273.951
Santa Clara	-$101.71	-$498.62	-$104.58	-$611.77	-102.277	-506.445
Santa Cruz	-$108.71	-$684.11	-$111.07	-$780.32	-109.214	-693.971
Shasta	-$106.25	-$229.19	-$108.73	-$338.39	-106.773	-238.596
Solano	-$112.92	-$641.99	-$115.73	-$764.67	-113.447	-652.178
Sonoma	-$100.63	-$356.72	-$103.07	-$454.28	-101.170	-364.808
Stanislaus	-$98.78	-$459.37	-$101.52	-$564.48	-99.344	-466.691
Sutter	-$98.93	-$574.92	-$101.66	-$676.99	-99.494	-582.340
Tehama, Glenn, and Colusa County	-$207.65	-$643.18	-$207.81	-$835.14	-208.628	-660.999
Tulare	-$116.79	-$597.10	-$119.49	-$722.78	-117.281	-608.218
Tuolumne, Calaveras, Amador, Inyo, Mariposa, Mono, and Alpine County	-$101.14	-$559.03	-$103.90	-$665.48	-101.701	-566.883

County	20% Screening		50% Screening		80% Screening	
	ROI w/out utility	ROI with utility	ROI w/out utility	ROI with utility	ROI w/out utility	ROI with utility
Ventura	-$99.73	-$425.86	-$102.30	-$525.83	-100.284	-433.599
Yolo	-$99.36	-$807.60	-$102.25	-$910.73	-99.928	-815.056
Yuba	-$90.27	-$517.18	-$92.75	-$602.17	-90.839	-522.901

References

Bradley, C. J., Yabroff, K. R., Dahman, B., Feuer, E. J., Mariotto, A., & Brown, M. L. (2008). Productivity costs of cancer mortality in the United States: 2000–2020. *Journal of the National Cancer Institute,100*(24), 1763–1770. doi:10.1093/jnci/djn384

Brousselle, A., Benmarhnia, T., & Benhadj, L. (2016). What are the benefits and risks of using return on investment to defend public health programs? *Preventive Medicine Reports, 3*, 135–138. doi:10.1016/j.pmedr.2015.11.015

Brownson, R. C., Eyler, A. A., Harris, J. K., Moore, J. B., & Tabak, R. G. (2018). Getting the word out: New approaches for disseminating public science. *Journal of Public Health Management and Practice, 24*(2), 102–111. doi:10.1097/phh.0000000000000673

Crawley-Stout, L. A., Ward, K. A., See, C. H., & Randolph, G. (2016). Lessons learned from measuring return on investment in public health quality improvement initiatives. *Journal of Public Health Management and Practice*, 22(2). doi:10.1097/phh.0000000000000229

Elshaug, A. G., Hiller, J. E., & Moss, J. R. (2008). Exploring policy-makers' perspectives on disinvestment from ineffective healthcare practices. *International Journal of Technology Assessment in Healthcare, 24(1),* 1–9. doi:10.1017/S0266462307080014

Elshaug, A. G., Moss, J. R., Littlejohns, P., Karnon, J., Merlin, T. L., & Hiller, J. E. (2009). Identifying existing health care services that do not provide value for money. *The Medical Journal of Australia, 190*(5), 269–273.

Harris, C., Allen, K., King, R., Ramsey, W., Kelly, C., & Thiagarajan, M. (2017). Sustainability in health care by allocating resources effectively (SHARE) 2: Identifying opportunities for disinvestment in a local healthcare setting. *BMC Health Services Research, 17*(328), 1–12. doi:10.1186/s12913-017-2211-6

Jacobson, P. D., & Neumann, P. J. (2009). A framework to measure the value of public health services. *Health Services Research, 44*(5p2), 1880–1896. doi:10.1111/j.1475-6773.2009.01013.x

Masters, R., Anwar, E., Collins, B., Cookson, R., & Capewell, S. (2017). Return on investment of public health interventions: A systematic review. *Journal of Epidemiology and Community Health, 71*(8), 827–834. doi:10.1136/jech-2016-208141

McConville, S., Warren, P., & Danielson, C. (2017, March). *Funding the Medi-Cal Program* [Report]. Retrieved http://www.ppic.org/publication/funding-the-medi-cal-program/

Neubauer, M. A., Hoverman, J. R., Kolodziej, M., Reisman, L., Gruschkus, S. K., Hoang, S., . . . Beveridge, R. A. (2010). cost effectiveness of evidence-based treatment guidelines for the treatment of non–small-cell lung cancer in the community setting. *Journal of Oncology Practice, 6*(1), 12–18. doi:10.1200/JOP.091058

Polisena, J., Clifford, T., Elshaug, A. G., Mitton, C., Russell, E., & Skidmore, B. (2013). Case studies that illustrate disinvestment and resource allocation decision-making processes in health care: A systematic review. *International Journal of*

Technology Assessment in Health Care, 29(02), 174–184. doi:10.1017/s0266462313000068

Shugarman, L. R., Mack, K., Sorbero, M. E., Tian, H., Jain, A. K., Ashwood, J. S., & Asch, S. M. (2009). Race and sex differences in the receipt of timely and appropriate lung cancer treatment. *Medical Care, 47*(7), 774–781. doi:10.1097/mlr.0b013e3181a393fe

Taylor, M. (2017, March 9). *The 2017–18 Budget: Analysis of the Medi-Cal Budget* [Report]. Retrieved http://www.lao.ca.gov/Publications/Report/3612

Watt, A. M., Elshaug, A. G., Willis, C. D., & Hiller, J. E. (2011). Assisted reproductive technologies: A systematic review of safety and effectiveness to inform disinvestment policy. *Health Policy, 102*(2-3), 200–213. doi:10.1016/j.healthpol.2011.07.007

Appendix – Survey Tools

Part I. Lung Cancer and Screening and Disinvestments

1. How many current cases of lung cancer do you have in your county? If you do not know, do you have the most recent data available, and could you provide us this data?

2. Could you provide us the demographics of those who are currently affected? (i.e., race, gender)

3. How many lung cancer deaths do you have per year?

4. About how much (in USD) does lung cancer cost in your county, i.e., treatments, other medical expenses? How much loss in productivity is this?

5. How much (in USD) is disinvested from programs in the most recent year?

6. Which programs were disinvested in that year?

7. What were some reasons these programs were disinvested?

Part II. Organization in Local Health Departments

Please indicate on the scale (1 (*strongly disagree)* to 5 (*strongly agree*) how much you agree with each statement.

#	Question or Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Organizational Capacity: Governance and Decision-Making Structure						
1.	The structure of my local health department is conducive to implementing effective programs.	1	2	3	4	5
2.	The board of political appointees plays a significant role in the decision-making processes for my local health department.	1	2	3	4	5
3.	The staff of my local health department have the freedom to act independently when it comes to implementing programs.	1	2	3	4	5
4.	The top official of my local health department has a lot of authority.	1	2	3	4	5

5.	The project coordinator of my local health department has a lot of autonomy.	1	2	3	4	5
6.	The board of health's governance at my local health department matters.	1	2	3	4	5
7.	The county board members are engaged when it comes to my local health department's program development and implementation.	1	2	3	4	5
8.	The county board members are supportive.	1	2	3	4	5
Organizational Culture						
9.	My local health department's leadership and teamwork dynamic is positive.	1	2	3	4	5
10.	My local health department has a shared leadership approach.	1	2	3	4	5
11.	My local health department can easily adapt and innovate to new programs.	1	2	3	4	5
12.	My local health department believes in constructive feedback for improvement when it comes to innovating and implementing programs successfully.	1	2	3	4	5
Organizational Prioritization Structure						
13.	My local health department knows how to identify priorities.	1	2	3	4	5
14.	My local health department has guiding principles or criteria for prioritizing decisions.	1	2	3	4	5
15.	My local health department can prioritize decisions.	1	2	3	4	5
16.	There are factors or barriers that limit my local health department's prioritization decisions.	1	2	3	4	5

17.	My local health department follows evidence-based practices.	1	2	3	4	5
18.	My local health department has considered using/currently uses Return on Investment (ROI).	1	2	3	4	5
19.	My local health department has considered using/currently uses budget analysis.	1	2	3	4	5

Is there anything else you would like to tell us in regard to decision-making and prioritization at your local health department?

Are there any questions from above that you would like to provide more context to or propose solutions for?